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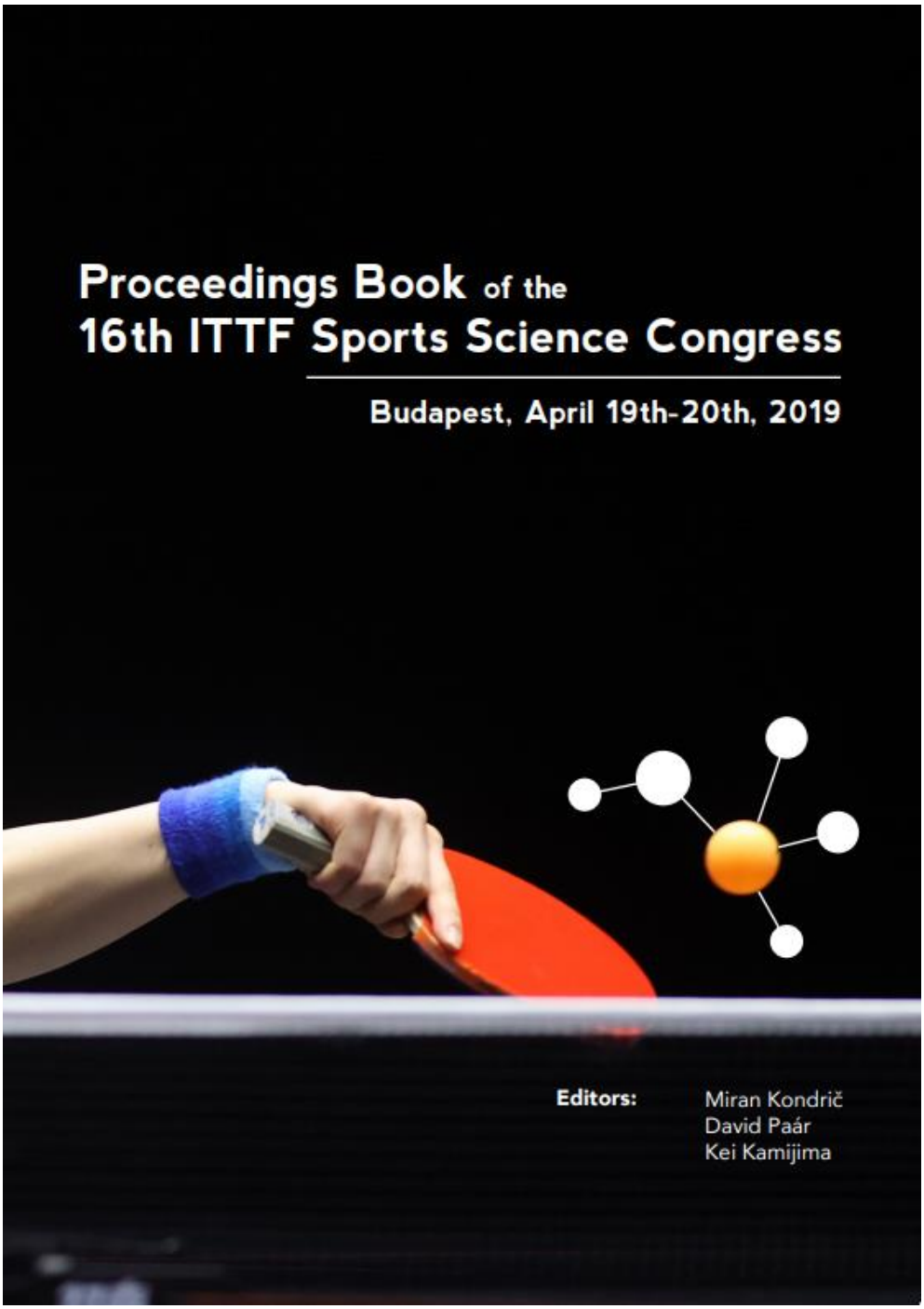
Budapest, April 19th-20th, 2019



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David Paár
Kei Kamijima

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CONTENT

PART 2 – Professional and review papers

Foreword

Sports science research presentations at the 16th International Table Tennis Sports Science Congress are published in this book. They are the newest useful knowledge for people related to table tennis.

I am pleased if this book is used as a guidepost of future table tennis sports science research. When we meet with a guidepost, we reconfirm the accuracy of a way toward the destination and encourage ourselves toward the following target.

I hope that this book will become a good guidepost on the path to your future.

Masahiro Maehara
ITTF EC member

Message from the Editors

It is a great honour and pleasure for the Editors to issue this Proceedings book of the 16th International Table Tennis Sports Science Congress. This Proceedings book contains selected papers from the congress held in Budapest on April 19th - 20th, 2019.

Due to Covid-19 situation this proceedings book is delayed in its publishing. Table tennis belongs to the most popular sports in the world and due to Corona virus crisis also our activities have been focused on daily problems and preparation of guidelines for table tennis family. It is envisaged that this Proceedings book of the congress will contain papers that will eventually be regarded as a major source of knowledge and material for the advancement of table tennis science.

We express our thanks to the International Table Tennis Federation, the Hungarian Table Tennis Association, University of Pécs and the Organising Committee of the World Table Tennis Championships for hosting the 16th International Table Tennis Sports Science Congress. The congress was organized by members of University of Pécs, Hungarian Table Tennis Association and members of ITTF Sports Science and Medical Committee with the support of International Table Tennis Federation. We are truly grateful to all those people who helped to organize this congress.

We hope that this and future publications will contribute to the major goal of the table tennis, that is, to bridge the gap between sports scientists and practitioners in teaching, coaching, training and rehabilitation. We would like to thank all the reviewers for their insightful comments on the papers, as these comments led us to an improvement of the book.

Miran Kondrič
David Paár
Kei Kamijima

PART 1
Science papers

Comparing the kinematic characteristic of lower limb between diagonal and straight shot in forehand loop from world-class table tennis athlete

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Abstract: Diagonal shot (DS) and straight shot (SS) of forehand loop are the most common techniques in table tennis. The aim of this study was to investigate the differences in lower-limb kinematics between the DS and SS. A male Chinese table tennis participants performed the DS and SS in random order. Three-dimensional kinematic data were captured using eight-camera Vicon motion analysis system with a frequency of 200 Hz. Key findings from the study were that in the backwards-end (BE) phase, large significant differences in joint angles between DS and SS were found in the sagittal and transverse planes. Compared with DS, SS showed significantly larger knee external rotation with larger ankle external rotation and larger ankle adduction. In the forward-end (FE) phase, SS showed significantly larger knee adduction compared with DS. SS showed larger ankle abduction and internal rotation compared with DS. SS showed significantly larger knee internal rotation compared with DS. The results demonstrated that the SS requires a higher lower limb activity than a DS. These biomechanical findings may be beneficial for table tennis athletes and coaches as a method of optimizing performance characteristics for both competition and training.

Keywords: table tennis, kinematic comparison, lower limb, angular changing rate

1. INTRODUCTION

Table tennis is considered as one of the most popular racket sports in the world. Among various techniques of table tennis, forehand loop is considered as the most frequent and aggressive stroke in competitions (Qian, Zhang, Baker, & Gu, 2016). It possesses the characteristics of high velocity and fast rotation (Poizat, Thouvarecq, & Seve, 2004). Performing a perfect topspin forehand stroke is difficult for players, it is essential to recognize the skill levels of performance (Iino & Kojima, 2009, 2011). Obviously, understanding the biomechanical characteristics of the topspin forehand stroke is necessary for players and coaches.

Few studies have been researched and compared kinematical characters of lower limbs on forehand loop that is a complicated course of joint movement. Research reported that the high angular speed and great energy transduction from the pelvis to the racket petiole through the upper limb and rotation of the upper body were relevance to flawless execution of this shot (Iino & Kojima, 2009, 2011). The same research group also quantified joint forces and torques of the racket petiole as well

as the gross of mechanical energy produced and transferred in this petiole during topspin forehand, reported that internal rotation torque of shoulder exerted by excellent players was significantly larger, which promoted energy transferring from trunk to arm at a higher rate (Qian, Zhang, Baker, & Gu, 2016). In addition, a greater contribution of the lower trunk axial rotation at ball impact and larger energy transduction from the pelvis to the shoulder have been reported in excellent players compared to intermediate players (Lanzoni, Bartolomei, Di Michele, & Fantozzi, 2018).

Many studies have tried to research the kinematics of table tennis, which contrasted the relationship between diverse ball speed and athletes of diverse performance levels (Bootsma & Van Wieringen, 1990; Marinovic, Iizuka, & Freudenheim, 2004; Yu, Shao, Baker, & Gu, 2018). High-quality forehand loop not only demands wonderful upper body co-ordination, but also required support from the lower limbs to supply stability and accuracy during competitions (Yu, Shao, Baker, & Gu, 2018). Mansec et al. (2017) had contrasted the activity level of the lower limb muscles across seven typical strokes of table tennis. The forehand smash and the forehand top exhibited significant more intense EMG amplitude when compared with other typical of strokes. Gluteus and biceps femoris were strongly activated during the forehand spin, smash and forehand top. Qian et al. (2016) researched indicated that contrasted with intermediate players, excellent athlete possessed stronger ability to give play to lower limb drive in forehand loop. Lanzoni et al. (2018) studied indicated that the differences of kinematic exist between the long-line and the cross-court top spin forehand in table tennis players. Significant differences were detected for lower-limb angles, with larger mean angles among the feet - the table - pelvic rotation angles in long-line compared to cross-court. The results at the present stage would seem to indicate that the feet position with respect to the table may have a main effect on the kinematics of both the cross-court and long-line executions. Nevertheless, their study did not specify the angle change rate of various joints of athletes' lower limbs in the long-line and the cross-court top spin forehand batting modes. Those studies lack the detailed investigation on the kinematics of lower limb when shooting the balls to different directions using forehand loop. Therefore, the aim of this study was to compare the lower-limb kinematic characteristics between diagonal shots (DS) and straight shots (SS) in forehand loop. Our team will attempt to prove a hypothesis that compared with DS, SS will show larger joint Angle and joint Angle change rate.

2. MATERIAL AND METHODS

2.1. Participants

A male Chinese table tennis male athlete (age: 22 years, body mass: 68 kg; body height: 174 cm) volunteered to participate in the study.

Participant held the racket with their left hand and had 10 years of experience in competitive table tennis. The participant joined the Chinese national table tennis team. Besides, he has won the world table tennis championship twice.

The participants had not sports injuries for six months. Besides, the participants were asked not to consume caffeine at least 4 hours prior to the study procedure and sign the experimental informed agreement. The study was approved by the University of Ningbo Bioethics Committee. Testing procedures were fully explained to the participant.

2.2. Experimental procedures

Figure 1 shows the experimental set-up including the two target zones of 40 × 65 cm, traced upon a regular playing table (Lanzoni, Bartolomei, Michele, & Fantozzi, 2018). Participants were asked to return balls projected by a ball machine for familiarization with the experimental setting and have sufficient time to familiarize themselves with the experimental environment and warm up. Then, the participants returned diagonal and straight forehand loop at their maximum effort to the two target areas placed on the other side of the table. In order to the normalization of the experiment, we set the ball machine at a constant speed and frequency. And set the point of each serve at the Impact Zone. The participants were asked to start with a set of SS shots followed by a set DS shot, with a three-minute break between sets. Trials were recorded until the player correctly performed 10 shots on the left target (Straight shot) and 10 shots on the right target (diagonal shot). At the beginning of the trials, there was no specific instruction on how to place the players' feet while shooting the ball. In the meantime, player wears the professional table tennis shoes and use the professional table tennis racket that himself.

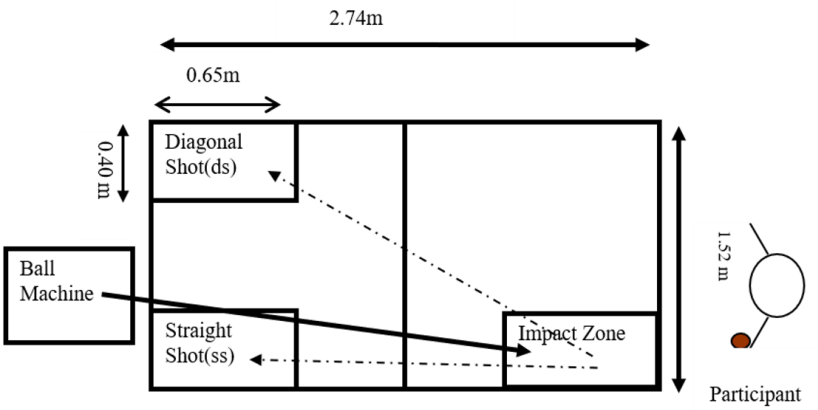

Fig. 1. Experimental set-up of the study (ds = Diagonal shot; ss = Straight shot).

2.3. Data collection

Tests took place in Ningbo University table tennis training gymnasium. The floor is made of wood which is commonly used in daily training and competitions. An 8-camera Vicon motion analysis system (Oxford Metrics Ltd., Oxford, UK) was used to

capture kinematic data at a frequency of 200 Hz. 16 reflective markers (diameter: 14 mm) were attached with adhesive on bilateral lower limbs respectively. The marker locations included: anterior superior iliac spine, posterior-superior iliac spine, lateral mid-thigh, lateral knee, lateral mid-shank, lateral malleolus, second metatarsal head and calcaneus (Qian, Zhang, Baker, & Gu, 2016). Smoothness of the motion was judged by players themselves and the quality of the balls' effect was supervised by the coaches.

2.4. Data processing

For all variables, the mean values measured in the two examined conditions were compared using Student's tests for paired data. This study divided the entire forehand loop motion into two phases of backswing and forward swing. Backswing phase referred to the period between two certain events of neutral position (NP) and backwards-end (BE, maximum knee flexion) and forward swing phase referred to the period between events of BE and forward-end (FE, maximum hip internal rotation). Joint angles in three planes were time-normalized to 100 data points. Variables of the dominant side as joint angles at BE and FE, joints range of motion (ROM) and joints angular changing rate in three planes were processed for analysis.

2.5. Statistical analysis

All statistical tests were performed using SPSS version 19.0 software (SPSS Inc., Chicago, IL, USA). The kinematic data were time-normalized to an entire motion cycle (100 data points). To examine the differences between the two types of table tennis forehand loop shot, the independent-samples T test was taken for each variable including the time of entire motion, joint angles at BE and FE, joints ROM. The significance level for all tests was set at $p < 0.05$.

3. RESULTS

Table 1. *Comparison of joint angles at the phase of backwards-end (BE) and forward-end (FE) between DS and SS, mean ± SD.*

	ANKLE		KNEE		HIP	
	BE	FE	BE	FE	BE	FE
X(DS)	8.8±1.2	21.3±3.6	30.9±3.4	50.2±2.3*	35±2.6	62.7±2.3
X(SS)	10.4±1.9	18.2±5.4	36±2.6	56.5±2.5*	35.4±4.1	63.9±1.6
Y(DS)	2.4±0.8*	6.1±0.3*	4.2±0.7*	7.1±1.9*	12.4±1.7	24.1±0.9
Y(SS)	4.9±0.4*	10±1.5*	8.9±0.8*	16.9±1.2*	12.9±0.8	24.3±2.3
Z(DS)	7.5±2.7*	18.1±0.8*	14.2±1.9*	29.8±1.5*	23.6±1.9*	33.1±2.1
Z(SS)	16.3±1.6*	28.9±3.2*	24.2±1.5*	42.5±4.0*	19±0.2*	32.1±4.2

Note: x–the sagittal plane; y–the frontal plane; z–the transverse plane.
**indicates significant difference at the hip, knee and ankle (respectively) (P < 0.05).*

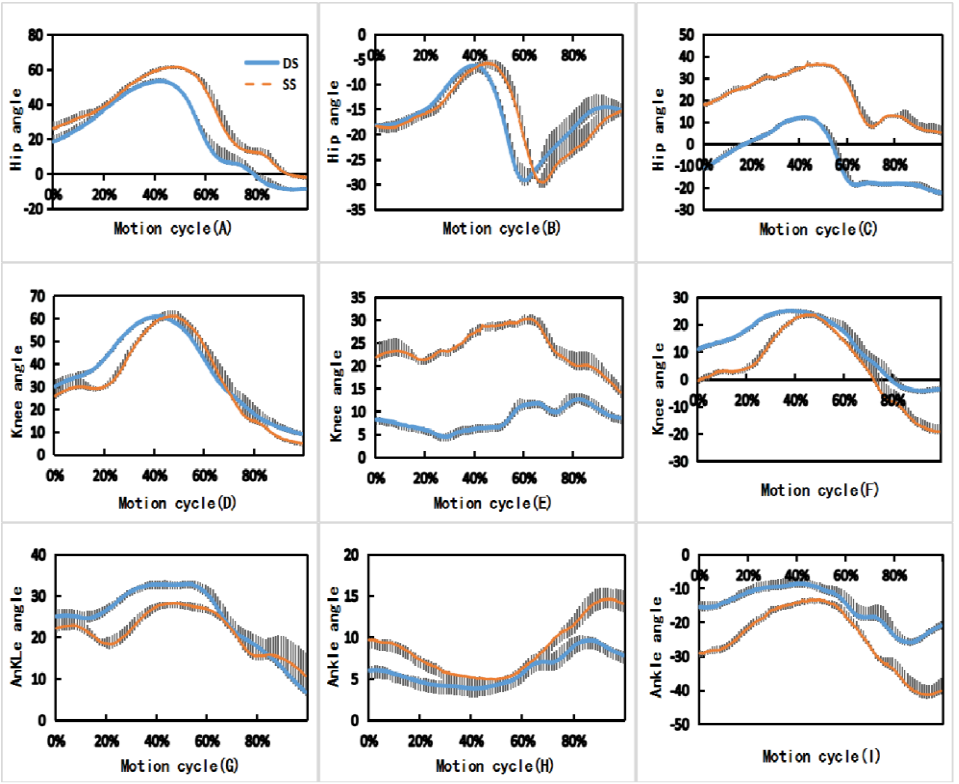

Fig. 2. Changes of lower limb joints during one motion cycle in three planes (Left: in the sagittal plane; Middle: in the frontal plane; Right: in the transverse plane. Top: ankle; Middle: hip; Bottom: knee).

The time to perform one forehand loop was 1.002 ± 0.045 s and 1.027 ± 0.038 s for DS and SS, respectively, with no significance (P=0.458). Changes of joint angles during one motion cycle in the sagittal, frontal and transverse planes for both DS and SS were generally comparable (Table 1). Significant differences in joint angles at whole phase between DS and SS were found in the frontal plane and the transverse planes (Table 1). In the backwards-end (BE) phase, Significant differences in joint angles between DS and SS were found in the sagittal and transverse planes. Compared with DS, SS showed significantly larger knee external rotation with larger ankle external rotation and larger ankle adduction. In the forward-end (FE) phase, SS showed significantly larger knee adduction compared with DS. Besides, SS showed larger ankle abduction and internal rotation compared with DS (ankle abduction (Mean(SD)=6.1(0.3)); internal rotation (Mean(SD)=18.1(0.8)). SS showed significantly larger knee internal rotation compared with DS.

Figure 3 and Table 2 indicated that in the BE phase, compared with DS, ankle showed larger change rate of eversion at the frontal plane and larger change rate of adduction in the transverse plane, knee showed larger change rate of abduction in the transverse plane and hip showed lesser change rate of abduction at the

transverse plane with SS. In the FE phase, compared with DS, knee showed larger change rate of extension in the sagittal plane and larger change rate of internal rotation in the transverse plane. Ankle showed larger change rate of inversion at the frontal plane and larger change rate of abduction at the transverse plane in the SS.

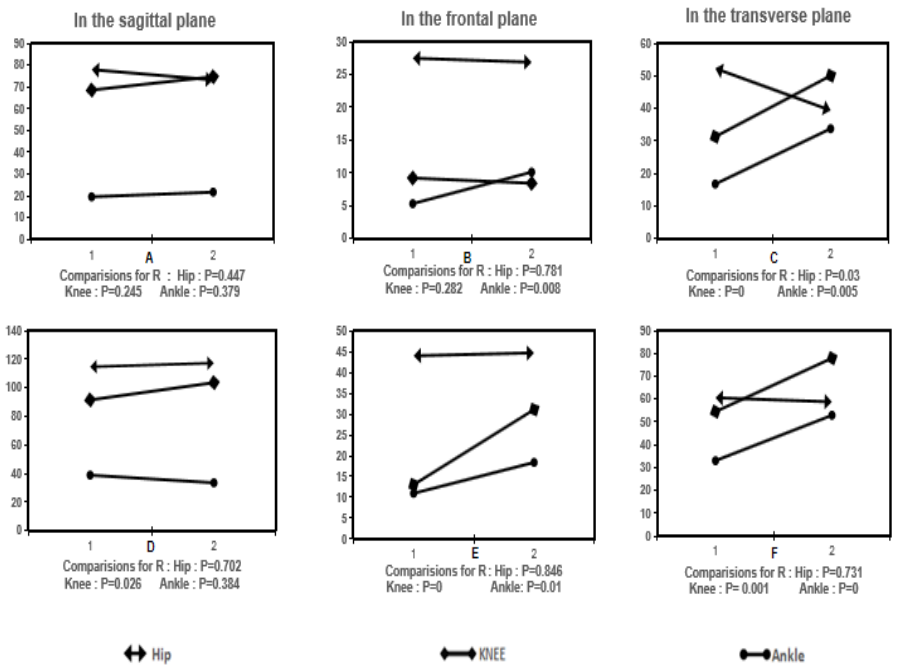

Fig. 3. Angular changing rate of lower limb joints during BE and FE in three planes ((A) In the sagittal plane (B) in the frontal plane; (C) in the transverse plane; (D) in the sagittal plane; (E) in the frontal plane; (F) in the transverse plane. A, B and C expression the BE; D, E and F expression the FE; 1= Diagonal shot, 2= Straight shot).

Table 2. *Comparison of joints angular changing rate at the phase of BE and FE between DS and SS, mean ± SD.*

	ANKLE		KNEE		HIP	
	BE	FE	BE	FE	BE	FE
X(DS)	19.5±2.6	38.8±5.9	68.6±7.7	91.5±6.8*	78±9.3	114.6±10.9
X(SS)	21.7±3.9	33.5±10.6	74.7±2.6	103.6±2*	73.3±4.5	117.3±3.6
Y(DS)	5.3±2.0*	11±1.2*	9.2±1.8	13±2.3*	27.5±4.4	44±4.0
Y(SS)	10.1±0.6*	18.4±2.3*	8.4±0.8	31.1±3.4*	26.9±1.4	44.7±5.9
Z(DS)	16.8±6.5*	33±3.3*	31.4±2.6*	54.5±5.7*	52.4±5.1*	60.6±7.4
Z(SS)	33.8±2.5*	52.9±4.6*	50.1±0.3*	77.9±5.2*	39.4±2.3*	58.8±5.9

Note: x–the sagittal plane; y–the frontal plane; z–the transverse plane.
"" indicates significant difference at the hip, knee and ankle (respectively) (P < 0.05).*

4. DISCUSSION

There are not a great many types of research on the most crucial sports biomechanics of table tennis batting scheme, particularly on the kinematics of lower body joints of forehand loop shot in different directions of world-class table tennis players. It is a large significance to understand the movement patterns of lower limb joints of forehand loop in different directions for the improvement of athletic performance and the prevention of injury of high-level athletes. Key findings from the study were that compared with the DS, the knee and ankle angles and the rate of change of the joint angles of the SS are large. There was no significant difference in the time of the two types of forehand loop in each phase, but SS showed larger change speed of joint angle. Comparisons of the force-velocity curves in natural locomotion conditions and in constant speed have indicated that muscular output can be enhanced by a stretch-shortening cycle (SSC) muscle function. This has been manifested in dissimilar experimental set-ups (Gregor et al., 1988; Stevens, 1993; Komi, 2000; Finni et al., 2003). Finni et al. (2003) studied indicated that comparison of the force-velocity curves in isokinetic knee extensions and in jumping revealed that the muscle- tendon force in sub maximal jumping conditions could be increased over that found in maximal isokinetic condition. According to the force-velocity Curve, we can conclude that athletes showed stronger explosive force of lower limbs when doing SS. This conclusion may help the coach to realize that the enhancement athlete lower limb explosiveness power level has the vital function to the athlete straight forehand loop ability enhancement. Meanwhile, Abrams et al. (2012) reported the whole occurrence rate and prevalence of injuries to tennis athletes in their study, along with the injury rate of more tennis characteristic diseases. The general tendency was that acute injuries were more common in the lower extremities, while chronic and overuse injuries were more familiar in extremities and trunk of the upper. The constructed ratio proposed by Croisier and Crielaard (2000) combines two extremely different velocities. Hamstring strains usually reflect during joint movement at high speed. Hewett et al. measured the neuro muscular control of 3d kinematics (joint angle) and joint load (joint moment) of 205 female athletes major in high-risk sports such as volleyball, football and basketball in the assignment of platform jumping. There are nine athletes were confirmed to have suffered ACL injuries. Compared with the healthy athletes, the knee abduction angle enhanced obviously when the side-bending athletes landed. Besides, the movement, strength and torque of the injured athletes enhanced more rapidly than that of the healthy athletes. That could mean that compared with the DS, the athletes have a higher risk of knee and ankle injuries in the SS. Athletes who often use the SS technique should pay attention to the prevention of knee and ankle injuries. Excessive fatigue of joints and the rate of change of joint angle too fast will bring great trouble to high-level athletes. In order to shun sports injuries and extend athletes' sports lives, coaches should reasonably arrange the training load and intensity from this factor when making training plans.

In the FE phase, SS show significantly larger ankle and knee adduction compared with DS. SS show larger ankle internal rotation compared with DS. SS show significantly larger knee internal rotation compared with DS. On the whole,

compared with DS, the knee and ankle angles of the SS are large. This may mean that, compared with DS, players use SS to hit the ball with a higher degree of movement completion and more fully stroke. It is beneficial for table tennis players to be able to enhance speed of wielding the racket in less time in hard shots because a limited time is generally allowed for them to execute a stroke in table tennis. It is suggested that the ability to accelerate the racket in less time in the topspin forehand may be an important factor that affects the performance level. The excellent players tended to require less time to enhance speed of wielding the racket and the contribution of lower trunk axial rotation was significantly smaller for the intermediate players than for the excellent (Iino & Kojima, 2011).

There are some limitations of the study must be mentioned. First, the participator of this study was left-handed handedness, and there may be individual differences when compared with right-handed athletes. Second, the differences in the biomechanical characteristics between bilateral lower limb were not compared in the study. In addition, due to some objective conditions in this study, lower limb kinetics data of participator were not measured, which was a pity that could not be ignored. In future studies, lower limb kinematics data and kinetics data should be measured simultaneously. The last but not least, in this study, the serving frequency of the server is fixed, but in the actual game, the ball speed may be faster, in order to better sports performance, the athletes' joint movement will be faster, in this case, the lower limb joint kinematics data may be different from this study.

5. CONCLUSIONS

This study is the first systematic quantitative analysis of lower limb kinematics for the forehand loop technique with different trajectories of world-class athletes. It provides a thorough understanding of lower limb joint movement patterns of excellent male table tennis player when using the two styles of different forehand loop technique, which have important implications on sports performance enhancement. As the results of this study indicated that compared with the DS, the SS has a larger range of motion at the hip, knee and ankle joints at the same time. Meanwhile, The SS technique needs the stronger explosive force of lower limbs. Therefore, the coach can improve the forehand loop skill according to the athletes' physical quality and technical characteristics.

REFERENCES

Abrams, G.D., Renstrom, P.A., & Safran, M.R. (2012). Epidemiology of musculoskeletal injury in the tennis player. *Br J Sports Med, 46*, 492-498.

Bootsma, R.J., & Van Wieringen, P.C. (1990). Timing an attacking forehand drive in table tennis. *Journal of Experimental Psychology: Human Perception and Performance, 16*(1), 21-29.

Croisier, J.L., & Crielaard, J.M. (2000). Hamstring muscle tear with recurrent complaints: an isokinetic profile. *Isokinetics Exerc Sci, 8,* 175-180.

Finni, T., Ikegawa, S., Lepola, V., & Komi, P.V. (2003). Comparison of force–velocity relationships of vastus lateralis muscle in isokinetic and in stretch-shortening cycle exercises. *Acta Physiol Scand, 177*, 483-491.

Gregor, R.J., Roy, R.R., Whiting, W.C., Lovely, R.C., Hodgson, J.A., & Edgerton, V.R. (1988). Mechanical output of the cat soleus during treadmill locomotion: in vivo vs. In situ characteristics. *J Biomech, 21*, 721-732.

Hewett, T.E., Meyer, G.D., Ford, K.R., Heidt, R.S.Jr., Colosimo, A.J., McLean, S.G., van den Bogert, A.j., Paterno, M.V., & Succop, P. (2005). Biomechanical measures of neuro muscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. *Am J Sports Med, 33*, 492-501.

Iino, Y., & Kojima, T. (2009). Kinematics of table tennis topspin forehands: effects of performance level and ball spin. *Journal of Sports Sciences, 27*(12), 1311-1321.

Iino, Y., & Kojima, T. (2011). Kinetics of the upper limb during table tennis topspin forehands in advanced and intermediate players. *Sports Biomechanics, 10*(4), 361-377.

Iino, Y., & Kojima, T. (2015). Effect of the racket mass and the rate of strokes on kinematics and kinetics in the table tennis topspin backhand. *Journal of Sports Sciences, 34*(8), 721-729.

Komi, P.V. 2000. Stretch-shortening cycle: a powerful model to study normal and fatigued muscle. *J Biomech, 33*, 1197– 1206.

Le Mansec, Y., Dorel, S., Hug, F., & Jubeau, M. (2017). Lower limb muscle activity during table tennis strokes. *Sports Biomechanics, 17*(4), 442-452.

Malagoli Lanzoni, I., Bartolomei, S., Di Michele, R., & Fantozzi, S. (2018). A kinematic comparison between long-line and cross-court top spin forehand in competitive table tennis players. *Journal of sports sciences, 36*(23), 2637-2643.

Malagoli Lanzoni, I., Di Michele, R., & Merni, F. (2014). A notational analysis of shot characteristics in top level table tennis players. *European Journal of Sport Science, 14*(4), 309-317. DOI:10.1080/17461391.2013.819382.

Maquet, D., Croisier, J.L., & Crielaard, J.M. (2000). Fibromyalgia in the year. *Rev Med Liege, 55*(11), 991-997.

Marinovic, W., Iizuka, C.A., & Freudenheim, A.M. (2004). Control of striking velocity by table tennis players. *Perceptual and Motor Skills, 99*(3Pt1), 1027-1034.

Poizat, G., Thouvatecq, R., & Seve, V. (2004). A descriptive study of the rotative topspin and of striking topspin of expert table tennis players. In A. Lees, J.-F. Kahn, & I. W. Maynard (Eds.), *Science and racket sports III.* (pp. 110–115). Abington: Routledge.

Qian, J., Zhang, Y., Baker, J.S., & Gu, Y. (2016). Effects of performance level on lower limb kinematics during table tennis forehand loop. *Acta of Bioengineering and Biomechanics, 18*(3), 149-155.

Stevens, E.D. (1993). Relation between work and power calculated from force–velocity curves to that done during oscillatory work. *J Muscle Res Cell Motil 14*, 518–526.

Yu, C., Shao, S., Baker, J.S., & Gu, Y. (2018). Comparing the biomecanical characteristics between squat and standing serves in female table tennis athletes. *PeerJ, 6*, 11.

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Active methodologies combined in the teaching of racket sports at the university. An experience with students of science of physical activity and sports of the University of Seville (Spain)

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Abstract: ICTs have been a revolution in all areas of society in general and in education and sports in particular. In parallel, the incorporation into the EHEA has led to the need to adapt the teaching practice to its lines of action, determined, basically, by adjusting education to the subjects that interact in these changing societies, in which a more active, autonomous learning is pursued and flexible that facilitates a more efficient personal and professional development. Under this context, this experience arises through the application of active methodologies, in which the main purpose was to know if the student is able to acquire the knowledge of the subject without having to use the master class, showing besides the different tasks proposed, the results, the difficulties and advantages perceived by the teacher. The instruments used were the different active methodologies. Of the 25 students who participated in this educational experience, 90% managed to pass the subject, among which, around 34% achieved very high scores (9-10 points / 10). In addition, regarding the level of satisfaction of the students with respect to the methodology used, the scores obtained were around 8.5 / 10 points. Although the use of these methodological procedures implies a constant teaching evaluation, the results obtained, as well as the degree of satisfaction emitted by the students are very positive, so they have a great impact on their motivation and updating of their future teaching activities.

Keywords**:** active methodologies, racket sports, university

1. INTRODUCTION

Although active methodologies seem to be presented as a concept of recent creation, its use is reflected in numerous manuscripts and ideas that, on the didactic act, featured classic thinkers such as Pestalozzi, Herbart and others (García, in Labrador & Andreu, 2008). In any case, this term highlights the need to actively involve students in their learning, something in keeping with the requirements of the European Higher Education Area (EES), as well as the need to respond to an increasingly complex society and changing, where information and communication technologies (ICTs) have been a revolution in all sectors of society and in education and sports in particular. In this sense, the University, through its teaching staff, as a key element in student training (García-Ruiz et al., 2010; Guerra et al., 2010), is committed to organizing its contents in a different way as it had been doing traditionally, trying to adapt these methodologies to the peculiarities of their

different contents. Under this prism, active methodologies, that is, those that place emphasis on student participation in their learning (García, in Labrador & Andreu, 2008), offer a wide variety of typology (*challenge-based learning*, *learning based on problems*, cases or projects, collaborative and teamwork, *flipped classroom*, g*amification*, etc.), as well as the procedures for their evaluation (*self-evaluation*, *peer evaluation*, *peer review*, *feedforward*, and so on). The results of its use collected in numerous studies (Bouhuijs, 2011; García & Salmerón, 2010; Ostiguín & Aljama, 2008; Klenowski, 2005; Sanz, 2005, among others, in González, 2013) highlight the positive effects (stimulation of development cognitive, learning through action, intrinsic motivation towards a job well done, academic participation, others.) that they have about a university student. The use of active methodologies in teaching-learning processes can be unique or multiple, as is the case of this work in which, with the main purpose of knowing if the student is able to acquire specific sports content, both of a kind theoretical as practical, avoiding the traditional master class, different methodologies were used in combination: cooperative learning; *peer-review*, case study and continuous evaluation (feedforward).

1.1. Collaborative and teamwork

As Fernández (2006) points out, collaborative work and in the team can be considered a working method or philosophy. In any case, it is a teaching strategy in which the students are divided into small groups in the learning activities and are evaluated according to the productivity of the group, the use in this way, the development of academic competences, professionals and interpersonal skills.

1.2. Peer-review (peer evaluation)

Peer review (peer assessment or peer evaluation) is a technique designed, originally, for the review of scientific articles submitted for consideration for later publication. In a learning context, it consists of a horizontal evaluation carried out by the students themselves (experts) about the work of one of their classmates. With it, students increase their involvement both in the learning process and in the evaluation (Medina et al., 2003; Sluijsmans et al., 2003). This technique promotes the development of superior cognitive or metacognitive skills, as is the case of critical thinking, since students must use their own knowledge to analyse and evaluate the work of others, providing elements of constructive criticism to improve their work (Sitthiworachart & Joy, 2004). In addition, the peer evaluation is a teaching technique that can be beneficial for all the agents involved: the author of the work, the reviewer and the teacher (Bostock, 2002), especially if its application is optimized through computer tools or appropriate digital teaching platforms (Gehringer, 2001; Wolfe, 2004). The evaluation process under this technique also offers advantages for those who do it, understanding better the evaluation criteria after having applied them on an equal.

1.3. Case study

Case-based learning is a teaching strategy based on active and reflective student learning that incorporates the analysis of situations that may be equivocal, doubtful

and uncertain (Armengol et al., 2009) in order to recognize them, interpret them, generate hypotheses, compare data, complete knowledge, diagnose them (De Miguel, 2006) and, in which their resolution implies the non-existence of prefixed linear steps, but to integrate new understandings and adapt the following steps to new discoveries (Donoso-Vázquez & Sánchez, 2013).

1.4. Continuous evaluation (feedforward)

In the didactic processes, the feedforward supposes the successive comparison between the real and the expected final result, leading to a process of modelling by the student in relation to its purposes or objectives and the environment (Basso & Olivetti Belardinelli, 2006), highlighting the prospective character, that seeks and favours in the student those elements that allow him to advance to acquire the marked competences, which requires, on the part of the student, greater participation and commitment with his task, developing a more authentic character of the evaluation, establishing, At the same time, a dialogue shared with the teaching staff where, in a consensual way, they build the path for the acquisition of competences (García-Sanpedro, 2010).

2. OBJECTIVES

To know if third-year students of the degree in Physical Activity and Sports Science are able to acquire knowledge, both theoretical and practical, of the subject of Racket Sports Fundamentals and their Teaching, avoiding the use of the traditional master lesson. Analyse the level of knowledge acquired, as well as the degree of satisfaction achieved by the students.

3. METHODOLOGY

3.1. Participants

A total of 25 students (22 men and 3 women, aged between 21 and 24 years old) voluntarily enrolled in the Fundamentals of Racket Sports and their Teaching, optional subject attached to the Department of Physical Education and Sport of the University of Seville, participated in the present teaching experience.

3.2. Procedure

In the first session, students were informed about the active methodologies to be used and the optional nature of availing themselves of this or the traditional method of teaching. In addition, we proceeded to assess the level of knowledge on the subject to be developed. For this the students answered 5 open questions. The final score was established in the range 0-10. In addition, according to the characteristics of the collaborative and teamwork, the students were asked to organize themselves in small work groups. Subsequently, students were shown a table of timing of theoretical contents and / or tasks to be carried out in which the dates of delivery of the same were marked, as well as the basic lines that each of them had to contain in order to reach a minimum of requirement. These presentations that were verbally exposed on the first day of class, also remained, on a constant basis, in the virtual

teaching platform (PEV) of the University of Seville, leaving this information available throughout the academic year.

In the second theoretical class the students, organized in small groups of work and, with the guidance and guidance of the teacher, were prepared to work on the development of the first activity. Once the deadline for completion was completed, they sent it to the teacher for correction, offering it, a posteriori, indications on aspects to be improved, modifying it if necessary and being shared with the rest of the peers in the ENP. After a joint debate in which the activities were shared, the presentation and start of the following activity was carried out, in which the students had to review a scientific text about racquet sports (previously chosen by the teacher). Similarly, but in this case, the students selected, through the search in different databases, a scientific text recently published in journals referred to in the Journal Citation Reports, similar to that of activity 2. Both in the case of activity 2 and 3, the peer review technique was used, in which each work group (considered as if they were one person) would have an article that, in later classes, would defend the rest of the group. his colleagues as if it were his own responsibility. At the same time, we proceeded, in each case, to the random assignment of two pairs (to two different work groups, also understood as if they were only 2 people independently) and to the sending of the articles. Not knowing which colleagues were working on any article but, at the same time, knowing that each of these documents was being studied in triplicate (exhibitor and corresponding pairs), the teacher of the subject gave each student a guide to proceed to the evaluation of the submitted papers (final score: 0-10 points). That same guide was also used by the teacher in the evaluation of each presentation, thus serving as a reference.

During the presentation of the works (10 minutes) and, especially, in their defence before the questions of the other students (5-10 minutes), the pairs involved punctuated their partner by recording their comments or indications in the evaluation guide (Figure 1). Also, the peers were responsible for opening the question time at the end of the exposure of the student assigned, questioning or discussing those aspects that could be conflicting at work. In order to avoid feelings of responsibility manifested in relation to the evaluation process of the course, students were informed that the scores issued to their classmates were not going to be taken into account in the final grade of the activity. At the end of all the presentations, the teacher collected all the evaluation guides with the assigned score in each case. These guides were available to the students in the next session, allowing dialogue and cooperation between them in order to achieve a qualitative improvement in their work. In activity 4 students, each working group had to select a field of study of racquet sports (educational, leisure-health-recreation) establishing, among all groups, a consensus on what content to treat, in order that they did not repeat themselves. After the days of completion in class, we proceeded to the exhibitions and questions, by the other components. At the end of the session, each group was required to submit a summary of the main ideas collected from the colleagues' exhibitions. In the same way we proceeded for activity 5, in which they had to work in groups in relation to the racquet and shovel athlete, covering aspects related to the physical characteristics of the subject and other related areas (physical

preparation, injuries frequent, progression of training methodology according to age, treatment of disability in these sports, others).

At the end of the theoretical part, the initial questionnaire was returned to the student who was submitted to the beginning of the course, as well as being asked about the visual analog scale (0-10) to report on their level of satisfaction with the developed activities. On the other hand, the contents related to the regulation of these sports as well as the technical-tactical elements were carried out in the practical sessions, where, to acquire knowledge about the regulatory components, as well as to identify tactical aspects, the analysis of videos of real game situations and, on the other hand, for the learning of the technical elements, the case study was used, in which the student was the student. To do this, on a specific technical gesture, the students made a film and, later, proceeded to its analysis and the establishment of the necessary guidelines to achieve its improvement. With regard to the evaluation, activities 1, 4 and 5 were evaluated by the teacher, while in activities 2 and 3, the evaluation was calculated by making the average between the scores obtained by the students and the teacher. In general, the evaluation in this teaching-learning process tends to keep close sessions with the continuous evaluation (feedforward), where the errors of each of the tasks were taken into account so as not to re-produce them in the next one, establishing, at all times, the consensus dialogue between teacher and students that favoured a constructive learning environment.

PLANILLA DE EVALUACIÓN

Marque con una "X" sobre la línea para otorgar la puntuación que, a su juicio, corresponda en cada caso.

NOMBRE DEL REVISOR: _____

	VALORACIÓN DE LA EXPOSICIÓN Y DEFENSA DEL TRABAJO		
CONTENIDO	0 incompleto	_____	10 completo
COHERENCIA	0 poca	_____	10 mucha
CLARIDAD (dicción)	0 mala	_____	10 buena
DISEÑO	0 tosco	_____	10 ilustrativo
RESPUESTAS	0 insatisfactorias	_____	10 satisfactorias
VALORACIÓN GLOBAL	0 muy mala	_____	10 muy buena

Fig. 1. Worksheet for the evaluation of the works.

3.3. Statistical analysis

All the data obtained were subjected to a descriptive analysis, these being expressed as mean ± standard deviation. After verifying that most of the variables considered did not present a normal distribution of their data, nonparametric analyses were applied in order to proceed with their contrast. In this sense, the Wilcoxon rank test was applied for dependent samples (between the scores obtained at the beginning and end of the process) and the Mann-Whitney U test for

two independent samples (differences between students and teachers for the same activity).

3. RESULTS

The results obtained in the initial and final evaluation tests on the contents of the subject showed statistically significant results, being, in the latter case, 2.2 points higher than those initially obtained ($p \leq 0.001$, Figure 2).

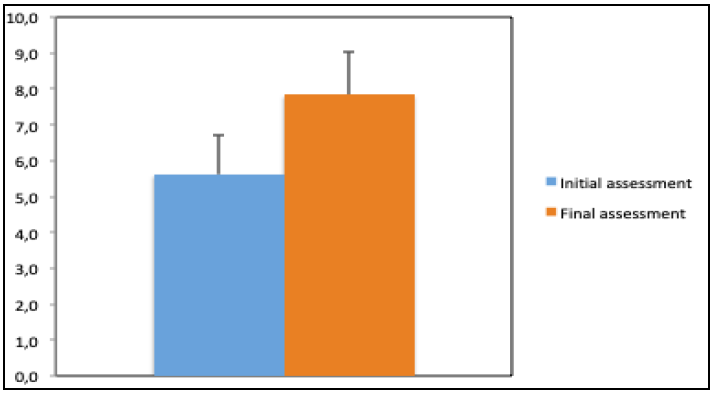

Fig. 2. Initial and final evaluation.

On the other hand, no significant differences were found between the scores issued by the students and the faculty in the assessments issued in activity 2 ($p = 0.254$), however, if they were found in the case of those related to activity 3 ($p = 0.037$). Of the 25 participants in this experience, only 2 did not present the activities, so they could not be evaluated through a summative evaluation. The remaining 23 obtained an average score of 7.5 ± 1.3 Finally, regarding the level of general satisfaction expressed by the students, through the visual analog scale (0-10), an average value of 8.5 ± 0.7 was reached.

4. CONCLUSIONS

Although, in the first instance, the selection and implementation of active methodologies may involve some difficulty in the planning and development of teaching, the results obtained, as well as the degree of satisfaction emitted by the students are very positive, so that they have a great impact on their motivation and updating of their future teaching activities.

REFERENCES

Armengol, C., Castro D., Durán M.M., Essomba, M.À., Feixas M., Gairín J., Navarro M., & Tomás M. (2009). La coordinación académica en la universidad. Estrategias para una educación de calidad. [Academic coordination at university: Strategies for high quality education]. *Revista electrónica interuniversitaria de formación del profesorado*, *12*(2), 121-144.

Basso, D., & Olivetti Belardinelli, M. (2006). The role of the feedforward paradigm in

cognitive psychology. *Cognitive Processing, 7*(2), 73-88.

Bostock, S. (2002). *Web Support for Student Peer Review*. Staffordshire: Keele University Innovation Project Report.

De Miguel, M. (Dir.). (2006). *Modalidades de Enseñanza centradas en el Desarrollo de Competencias. Orientaciones para promover el cambio metodológico en el Espacio Europeo de Enseñanza Superior*. [Teaching Modalities focused on Skills Development. Guidelines to promote methodological change in the European Higher Education Area]. Oviedo: Servicio de Publicaciones de la Universidad de Oviedo.

Donoso-Vázquez, T., & Sánchez, A. (2013). *Orientación educativa y profesional. Estudio de casos*. [Educational and professional guidance. Study of cases]. Barcelona: ISEP.

Fernández, A. (2006). Metodologías activas para la formación de competencias. [Active methodologies for skills training]**.** *Educatio siglo XXI, 24*, 35-56.

García, D., & Amante, B. (2006). *Algunas experiencias de aplicación del aprendizaje colaborativo y del aprendizaje basado en proyectos*. [Some experiences of application of collaborative learning and project-based learning]. Retrieved from http://upcommons.upc.edu/e-prints/handle/2117/9489.

García, T., Arias-Gundín, O., Rodríguez, C., Fidalgo, R., & Robledo, P. (2017). Metodologías activas y desarrollo de competencias en estudiantes universitarios con diferentes estilos de pensamiento. [Active methodologies and competence development in higher education students with different thinking styles]. *Revista d`Innovació Docent Universitària,* 9, 68-80.

García-Ruiz, R. (2006). Las competencias de los alumnos universitarios. [University students' competences] *Revista Interuniversitaria de Formación del Profesorado, 20*(3), 253-269.

García-Sanpedro, M.J. (2010) *Diseño y validación de un modelo de evaluación por competencias en la universidad.* [Design and validation of a competency assessment model at the university]. (Doctoral thesis). Universidad Autónoma de Barcelona: Barcelona.

Gehringer, E.F., Chinn, D.D., Ardis, M.A., & Pérez-Quiñones, M.A. (2005). *Using Peer Review in teaching Computing*. SIGCSE'05: St. Louis. February 23-27.

González, N. (2013). Metodologías activas en la docencia universitaria: importancia, conocimiento y uso en opinión del profesorado. [Active methodologies in university teaching: importance, knowledge and use in the opinion of teachers]. *Revista de evaluación educativa, 2*(2), 88-107.

Guerra, S., González, N., & García-Ruiz, R. (2010). Utilización de las TIC por el profesorado universitario como recurso didáctico. [Study on the Use of ICT as Teaching Tools by University Instructors] *Comunicar, 35* (18), 141-148.

Labrador, M.J., & Andreu, M.A. (2008). *Metodologías activas*. [Active methodologies]. Grupo de innovación en metodologías activas (GIMA). Universidad Politécnica de Valencia. Editorial UPV. Valencia.

Medina, V., Martins, L., & Dos Santos, RC. (2003). Peer Review in Education: Promoting Collaboration, Written Expression, Critical Thinking, and Professional Responsibility. *Education and Information Technologies, 8*(1), 37-46.

Sluijsmans, D.M.A., Brand-Gruwel, S., van Merrienboer, J.J.G., & Bastiaens, T.J. (2003). The Training of Peer Assessment Skills To Promote the Development of Reflection Skills in Teacher Education. *Studies in Educational Evaluation, 29*(1), 23-42.

Wolfe, W.J. (2004). *Online Student Peer Reviews*. Salt Lake City: SIGITE'04

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Investigation of varsity table tennis players' leisure preference in Taiwan

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Abstract: The purpose of this study was to investigate the attitude and views on leisure sports of varsity table tennis players in Taiwan. Twenty-five varsity table tennis teams were involved in the study with 368 questionnaires analysed. Frequencies, percentages, means, standard deviations, t tests, one-way ANOVA and Scheffe's method were used to calculate the results for the study. The findings showed: (1) Top three leisure sports with highest participation rate were table tennis, jogging, and weight training. There was no significant difference in the participation rate between male and female. Nearly one-third of varsity players were willing to spend more than 2000 NT per year for sport related expense. However, close to one-third of respondents hoped to spend 500 NT or less per year. (2) Top three motives for varsity players to participate in leisure sports were to be healthy, to learn new sport and to relax. Lack of time was the top reason to prevent respondents from participation. (3) Regardless of gender, players agreed on participating in leisure sports bring positive benefits that would keep them going. (4) Regardless of years of play, varsity players believed they benefited mentally, spiritually, and physically by participating in the leisure sports.

Keywords: table tennis, leisure motive, leisure preference, leisure sports

1. INTRODUCTION

Like many war torn countries after world war II., many Taiwanese people had to rebuild their home. They succeeded mostly by working long and laborious hours. As the economy eventually took off and Taiwan became known as one of Asia's four little dragons, Taiwanese became more aware of quality of life and started to allocate time for leisure sports. The change in mentality and lifestyle did not happen overnight. It took years of steady yet progressing mandates from the government to aid to this change.

In 1998, Taiwan's national health insurance system was implemented. It looked up to the developed countries for guidance. The working day was shortened to five days a week every other week, as opposed to the original six days a week every week (Cheng, 1998; Tasi, 1999; Wu & Lin, 1999, Xu, 2007). In 2001, the government further shortened the working days. Employees worked five days per week as opposed to every other week. More recently, for fulltime labor workers, the working hour was cut from 84 hours per two weeks to 40 hours per week in the beginning of 2016. Still, some workers had to work six days per week. So finally, in December 2016, the labor law yet changed again to have five working days per week truly implemented (Department of Information Services, 2016). All in all, it is evident that with these government mandates that the workers in Taiwan are more protected

than ever and that they have more free time.

During this time frame, Department of Sports Administration regularly sent out encouraging messages to the general public to exercise, and detailing ways to maintain healthy lifestyle. Many parks had exercise equipment installed. Schools were open before and after school for everyone to use. Having healthier citizens means less spending on medical insurance. To date, the department continues to work tirelessly to promote active lifestyle and give out guidance to exercise regularly and properly. It also targets to raise the awareness of good health and wellbeing, to protect the rights and interests of people with physical and mental disabilities, to reduce barriers to participation in sports structures, and to develop the exercise habits of the people (Pi & Huang, 2014).

Ideally speaking, everyone should get involved in some form of leisure sports and be health conscious. In order to promote exercise awareness, there needs to be an environment where people can be exposed to various kinds of leisure sports that will become part of their lives (Chang, 1998). The most sensible and easiest way to do this is to start from the schools. In Taiwan, most students are required to take physical education courses, even at the university level. Since schools are the primary source where students can learn sports in Taiwan, the schools naturally take up the responsibility of educating students about the leisure sports, and their close correlation to quality of life. The leisure sports students enjoy doing at school are very likely to become their lifelong sports.

If universities can offer a variety of physical education courses, students would get an opportunity to be exposed to these sports and it is always a goal of the physical education teachers to increase students' participation in leisure sports. The students would not have to worry about the cost of coaching or the equipment, or where to find partners. These incentives could motivate students to pick up new sports. Also, they may learn how to cooperate and socialize with people who have same interests. In general, people tend to change his/her leisure sport(s) according to age, education background, and social status. The more leisure sports that one could be familiar with, the more benefits he/she will get.

The subjects of the study were all varsity table tennis players. Their universities have a requirement of taking physical education courses before graduation. These varsity players practice and train regularly. They are the heavy users of the facility and hence should have good understanding of the school's sporting environment. By attempting to understand how the players think and feel about leisure sports, the teaching can be improved.

2. METHODS

The purpose of this study was to investigate the attitude and views on leisure sports of varsity table tennis players in Taiwan. Students who were on the varsity table tennis team were selected as subjects of the study. Questionnaire was developed for this study by the researcher. Information gathered from the literature review and research was used for developing questions. Professors with the area of expertise were asked to help to determine the content validity of the questionnaire. Also, pretest was done by choosing one each of male and female varsity table tennis

team to check clarity of the questionnaire. Item analysis and factor analysis were calculated to check the construct validity of the questionnaire. Cronbach's α was calculated to check reliability of the questionnaire. The Questionnaire was divided into four parts which were current leisure sports participation, motives in leisure sports participation, mentality on participating in leisure sports, and significance of participating in leisure sports.

There were 18 weeks in the semester, questionnaires were mailed out on the 14th week of school semester. Table tennis coaches from investigated universities were called and told exactly how to distribute the questionnaires.

After collecting the questionnaires, questionnaires were mailed back to the researcher. Questionnaires were done toward the end of semester to get a more accurate views on varsity table tennis players' feelings toward table tennis school practice and leisure attitude. Total of 375 questionnaires were distributed, with 368 questionnaires returned. The return rate of the survey was 98.1%. SPSS 20.0 in Chinese version was used to calculate descriptive statistics, t test, one-way ANOVA and Scheffe's method to analyse data for the study. The significant level was defined as $p<.05$.

3. RESULTS AND DISCUSSION

The findings of the study were based on responses of 368 varsity table tennis players. Data was analysed from the 225 male and 143 female players.

3.1. Leisure sports participation in current state

From Table 1, one can see most of the respondents (94.3%) answered that table tennis was the leisure sports in which they currently got involved, with majority of them (32.6%) participated three times per week. Jogging and weight training were the next two most popular leisure sports among students with 93.6% and 90.1% of them participated less than once per week. Only the top five leisure sports students participated were shown in Table 1.

Study done by Chen, Chen and Huang (2015) regarding to motivation and sustained involvement of university students who played table tennis after school showed that students who had taken table tennis course tended to be more willing to get involved in table tennis sport after school and during their leisure time. Also, from the study done by Huang and Sung (2017) regarding to KUAS students' preference in participation in table tennis in the future if they chose table tennis course as their PE class showed that they were more willing to choose table tennis as leisure sport in later on of their lives. Same might be able to apply to the varsity table tennis players used in this study as one can see table tennis was the number one choice for them to attend currently in the leisure time. The study done by Huang and Sung (2017) had showed that the top three leisure sports students participated in were table tennis, jogging, and weight training which was consistent with the results got from this study.

Table 1. *Leisure sports participation in Current State*

Leisure Sports	Participation Rate	Participation Frequency
Table tennis	94.3 %	32.6 % (3/Week)
Jogging	93.6 %	44.0 % (< 1/Week)
Weight training	90.1 %	39.0 % (< 1/Week)
Badminton	83.0 %	68.1 % (< 1/Week)
Basketball	82.9 %	68.1 % (< 1/Week)

From Table 2, the mean value for male and female table tennis team players' participation level were 4.483 and 4.235 respectively. It showed that the leisure sports participation level was high for both players. The t value and p value for gender differences in table tennis team players' level of participation were 1.469 and .062 respectively. There was no significant difference found in participation level between male students (M = 4.483) and female students (M = 4.235).

The process of sport socialization affects how females get in touch with sport, thus forming different personalities and behaviours (Wang, 1996). Under social mechanism, what kind of activities a female participated in can easily being a focus in the public domain. This becomes a constraint on females' freedom to engage in leisure sports. It also served as a self-monitoring mechanism. These factors will affect females making decision of leisure sports participation. Certain leisure sports are often avoided which limit females' selection and narrowed the opportunities to try on new things.

Many studies had showed that females had lower participation rate in exercise than males. For example, from the study done by Wang, Fang, and Yang (2014) regarding to gender effects on college students' self-determined participation of leisure sports, it concluded that female students needed more encouragement than male students to nurture regular exercise behaviours. In order to improve and strengthen female students' self-determined participation, their psychological needs and leisure motivations were factors that needed to pay attention to. School-related units need to take these as consideration to promote leisure sports.

Study done by Yang and Chen (2016) regarding to excise participation and indoor stadiums using satisfaction, it also showed that unfriendly exercise environment toward females caused lower participation rate. Since varsity table tennis players were selected for the study, it is not a surprise to see there was no significant difference in male and female players.

Table 2. *Difference between male and female table tennis team players' participation level*

	Mean			
	Male	Female	t	p
Level of Participation	4.483	4.235	1.469	.062

From Table 3, it showed that nearly one-third of the respondents (32.6%) were willing to spend more than 2001 NT on leisure sports related expense. 28.5% of respondents were willing to spend less than 500 NT. From the data analysis done for this study, table tennis, jogging, and weight training were the top three leisure sports which varsity table tennis players were currently participating in.

These sports were not expensive to participate. For the university students on making decision of what kind of sports to participate, money usually is an issue. Since most of them don't have stable income, they can only pick the one that are within their budget. Results of Table 3 were consistent with the results of Table 1.

Table 3. *Expense on leisure sports*

	Frequency	Percentage
< 500 NT	105	28.5 %
Between500~1000 NT	55	14.9 %
Between 1001~1500 NT	47	12.8 %
Between 1501~2000 NT	41	11.2 %
>2001 NT	120	32.6 %

3.2. Factors in leisure sports participation

Motives are driven by behavioural efforts, so in the field of sports, athletes' motivation has always been a subject of great concern to coaches and sports psychology researchers (Chen, 2014). Same could be said in promotion one to participate in leisure.

It is very important to understand one's motive(s) in order to do it effectively. From the Table 4, the most frequently cited motives for participating in leisure sports was physical health (71.1%). Top 2 to top 5 factors were learning new sport skills (55.0%), tension release (50.9%), mental health factor (46.4%) and to have fun (42.2%).

Table 4. *Primary motives on participating in leisure sports.*

Primary motives	Frequency	Percentage
For physical health	229	71.1 %
Learning new sport skills	177	55.0 %
To release tension from other classes	164	50.9 %
For mental health	149	46.4 %
To have fun	136	42.2 %
For social purposes	132	41.0 %
To reinvigorate oneself	96	29.8 %
Others	3	0.9 %

Note: Percentages sum to more than 100.0 due to multiple selections.

From Table 5, the top reason preventing varsity table tennis players from the sport participation was not enough time (78.0%), following by heavy schoolwork/job (61.7%) and lack of companions (26.2%). Time constraint seems to be the biggest concern. One way to solve this problem, one could try to shorten the participation

time to meet individual needs. Also, time management is important. It is very important for one to learn how to use time effectively and wisely. By mastering this skill, usually one can find more times to do other things they enjoy to do.

Table 5. *Primary reasons preventing leisure sports participation*

Primary reasons	Frequency	Percentage
Not enough time	287	78.0 %
Heavy schoolwork/job	227	61.7%
Lack of companions	96	26.2%
Weather effect	91	24.8%
Lack of transportation	76	20.6 %
Expensive cost	68	18.4%
Health problem	60	16.3%
Poor equipment /facility	57	15.6%
Lack of family support	29	7.8%
Others	4	1.1%

Note: Percentages sum to more than 100.0 due to multiple selections.

3.3. Mentality of participating in leisure sports

People participate in leisure sports for all sorts of reasons. Knowing how they view, and think will help school teachers and coaches to encourage them to pursue their lifelong sports. Since most students need to take physical education course in universities in Taiwan, it will be important for teachers to create the teaching materials which will help students to discover what sports they may potentially like to participate in their daily life.

From Table 6, by doing data analysis on gender comparison regarding to leisure sports enjoyment, the mean for male and female respondents was 4.364, and 4.196 respectively. There was no significant difference found on table tennis enjoyment ($t = 1.576$, $p = .116$). Both male ($M = 4.423$) and female ($M = 4.196$) respondents agreed that they participated in leisure sports because they like the relaxing atmosphere surrounding the environment.

By participating in leisure sports, both male and female agreed that it would help them to release negative feelings and pressure, improve life quality, and discover new specialty. By joining in school table tennis team, both male and female respondents agreed that it motivated them to participate in leisure sports, experience different enjoyment, and make friends easier. Significant difference was found between male and female respondents on the response of social relationship enhancement ($t = -2.884$, $p = .005$). Female ($M = 4.402$) respondents tended to strongly agree that joining school table tennis team helps one with social relationship than male ($M = 4.075$) respondents. Significant difference was also found on leisure sports for life ($t = -2.770$, $p = .006$). Female ($M = 4.523$) respondents tended to strongly agree on joining school table tennis team helps one to develop leisure sports for life than male ($M = 4.225$) respondents.

Study done by Chang, Huang, Han, and Chang (2017) regarding to the effect of

recreational sport participation and positive emotion on mature age residents, it showed that high level of recreational sport participation could potentially brought positive emotion and created happiness for the participants. The result was consistent with this study.

Table 6. *Mentality on participating in leisure sports*

	Mean			
	Male	Female	t	p
Enjoy leisure sports	4.364	4.196	1.576	.116
Relaxing atmosphere	4.423	4.467	-.463	.644
Release negative feelings and pressure	4.444	4.449	-.048	.961
Improve one's life quality	4.321	4.374	-.488	.626
Discover new specialty	4.048	4.122	-.595	.552
Join school table tennis team triggers one to participate in leisure sports	3.909	4.131	-.1.727	.085
Experience different enjoyment different from Join school table tennis team	4.021	4.112	-.738	.461
Join school table tennis team helps one to make friends easier when participating in leisure sports	4.200	4.280	-.682	.496
Join school table tennis team helps one with social relationship	4.075	4.402	-2.884	.005*
Join school table tennis team helps one to develop leisure sports for life	4.225	4.523	-2.770	.006*

**p <.05*

3.4. Significance of participating in leisure sports

Participating in leisure sports mean different for everyone. What they want and expect to get which are different from one another. Through the participation process of sports, learning fair competition, stress management, cooperation, team interests, obedience, self-discipline, psychological skills, sports beliefs, and sports values, which can trigger one to think positively and have moral judgement (Yang & Chen, 2016).

From Table 7, significance of participating in leisure sports for varsity table tennis players which used as subjects for the study is summarized. One-way ANOVA and Scheffe's method were calculated to compare significance of participating in leisure sports among different grade varsity table tennis players. The F value and p value for "build confidence" were 1.372 and .252. Values for "become an idol for friends/relatives" were .829 and .479. Values for "challenge oneself" were 1.701 and .167. Values for "improve one's table tennis by participating in leisure sports" were 2.692 and .046. Values for "experience different sports training other than table tennis" were .704 and .550. Values for "able to have common interest with friends/relatives" were .596 and .618. Finally, the F value and p value for "create one's characteristics" were .997 and .395. Looking at the Table 7, it showed that there was a significant difference among different grade varsity table tennis players

view on wanting to participate in leisure sports in order to help to improve their table tennis. By computing Scheffe's method, no significant difference was found.

Table 7. *Significance of participating in leisure sports*

	F	p
Build confidence	1.372	.252
Become an idol for friends/ relatives	.829	.479
Challenge oneself	1.701	.167
Improve one's table tennis by participating in leisure sports	2.692	.046*
Experience different sports training other than table tennis	.704	.550
Able to have common interest with friends/relatives	.596	.618
Create one's characteristics	.997	.395

**p<.05*

4. CONCLUSION AND RECOMMENDATION

The following conclusions were drawn as a result of the research findings of the study regarding to varsity table tennis players' leisure preference.

(1) Table tennis, jogging, and weight training were the top three leisure sports that respondents indicated that they currently involved. There was no significant difference found in leisure sports participation between male and female respondents.

(2) Nearly one-third of respondents were willing to spend more than 2000 NT yearly on leisure sports related expense. On the other hand, close to one-third of respondents were only willing to spend less than 500 NT on leisure sports related expense.

(3) To be health conscious, to learn new sport skills and to release tension were the top three motives indicated by the respondents which triggered them to get involved in the leisure sports; whereas lack of time, heavy schoolwork/job, and lack of companions were the top three reasons which prevent them for participation in the leisure sports.

(4) Regardless of gender, respondents agreed on participating in leisure sports could bring positive benefits which triggered them to stick on.

(5) Regardless year of study of the respondents, participating in leisure sports brought meanings which they could benefit mentally, spiritually, and physically.

Findings of the study could be used as reference on how to promote leisure sports participation among varsity table tennis players in Taiwan. Understanding students' needs, school teachers and coaches could find a way to encourage them to participate in leisure sports on their own, special attention is required for female students. It would be easier for school teachers and coaches to guide varsity table tennis players regarding leisure sports. Since these table tennis players are currently involved in playing table tennis, it would be a good time to implant them how their life could become if they continue to exercise throughout their lives. To be well-being, health body is necessary.

REFERENCES

Chuang, L. J., & Huang, Y. P. (2005). An emerging model of sport socialization for collegiate female elite athlete. *Physical Education Journal, 38*(3), 75-87.

Chang, C.W., Huang, H.C., Han, C.F., & Chang, C.M. (2017). The effect of recreational sport participation and positive emotion on mature age residents' subjective well-being. *Journal of Sport and Recreation Management, 14*(2), 22-35.

Chang, H.W. (1998). On the programming of community leisure activity after the application of two days off. *Physical Education Quarterly, Taipei, Taiwan, 27*(3), 31-37.

Chen, Y.F., Chen, M. K., & Huang, C.C. (2015). A study of Motivation and Sustained Involvement of University Students Who Played Table Tennis After School. Proceedings Book of the 14th ITTF Sports Science Congress and 5th World Racket Sports Congress - Suzhou, China, May 23rd-25th 2015 (p. 157-163).

Cheng, K.C. (1998). Leisure sport and physical education teaching. *Physical Education Quarterly, 27*(3), 38-42.

Cheng, K.T. (1998). Leisure of physical education course in college. *Physical Education Quarterly, 27*(3), 24-30.

Department of Information Services (2016, October 26). Implementing the "weekly two-day break" for labors and set up consistent national holidays for all. Executive Yuan. Available from URL: https://www.ey.gov.tw/Page/5A8A0CB5B41DA11E/b2cf7469-d464-47bc-8239-b84e002785bf

Huang, C.H., & Sung, C.Y. (2017). Case study of National Kaohsiung University of Applied Sciences' students interest in leisure sports whom had taken table tennis courses. Proceeding Book of the 15th ITTF Sports Science Congress- Düsseldorf, Germany, May 27th-28th 2017 (p. 254-261)

Pi, Y. H., & Huang, H. H. (2014). A study of constraint and self-reported health condition of Yoga participants in Keelung City. *Journal of Sports Health and Leisure, 5*, 39-53.

Tsai, C.H. (1999). Talking about the pros and cons of the concept of working five days a week. *The University Physical Education & Sports, 43*, 24.

Wang, J.S., Fang, P.H., & Yang, H.T. (2014). Gender effects on college students' self-determined participation motivation of leisure sport. *Bulletin of Sport and Exercise Psychology of Taiwan, 14*(2), 51-65.

Wu, S., & Lin, J.L. (1999). Criticism of Formosa little swiss from the development of Taiwan's leisure industry. *The University Physical Education & Sports*, 175-181.

Xu, Y.P. (2007, January 24). An analysis of the effectiveness of government institutions in implementing the two days off every other week. National Policy Foundation. Available from URL: https://www.npf.org.tw/1/455

Yang, L.M., & Chen, C.M. (2016). The influence of sport experience and self-referenced competency on sport values. *NCYU Physical Education, Health & Recreation Journal, 15*(1), 136-148.

Yang, L.M., & Chen, C.M. (2016). The influences of exercise participation, indoor stadiums image and using satisfaction: An analysis in female perspectives. *NCYU Physical Education, Health & Recreation Journal, 15*(2),

1-13.
Wang, Z.J. (1996). *Sociology of sports*. Taipei: Yin He Culture Publisher.

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Technical analysis of men's singles final in the 2017 World Table Tennis Championships

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Abstract: This study was based on the men's singles champion Ma Long, who won the 2017 World Table Tennis Championships, and his final opponent, Fan Zhendong. Video recording was used to analyse and compare various technical performances of their competition. By doing the statistical analysis and discussion, the following conclusions were drawn: (1) The three-staged techniques scoring for Ma Long were: 'attack after serve' and 'rally' were rated "excellent", whereas 'attack after receive' was rated "fail". His technical characteristics were fast in movement, fast paced game, and powerful serve. In addition, usually he was able to score critical point. While playing, often he could make critical attacks and endure long rally with positive attitude to win the point. Although he rarely returned the ball using 'attack after receive' technique, he could effectively position the landing point of the ball when receiving the serve. Therefore, he was able to win the 2017 World Table Tennis Championships in Men's singles. (2) Fan Zhendong's three-staged techniques performance was solid, but it did not score as well as Ma Long's. Overall, he got "excellent" in 'attack after receive', but was rated "fail" in both 'attack after serve' and 'rally'.

Keywords: table tennis, attack after serve, attack after receive, rally

1. INTRODUCTION

In sports competitions, ball games are considered as an open technical competition, many variables can have impact on the outcomes; the game of table tennis is no exception. Because the rules of the table tennis game are carried out in the way that you make a mistake in return I score a point, there is a high degree of uncertainty in the outcome of the game (Wang, 2000). How to defeat the opponent in this fierce and constantly unpredictable game, become an important research topic for the table tennis coaches and researchers to study.

In recent years, Taiwanese men's table tennis players such as Zhuang Zhiyuan (as of December 2017) ranked 13th and Chen Jianan ranked 40th in the worlds. Several younger generations such as Lin Yuru and Li Yuyang participated in the world games, Asia games, and professional tour games, all had good results. These excellent performances show that the level of men's table tennis in Taiwan has been continuously improved, and gradually has more strength to confront high technical standards players from other countries.

In terms of table tennis, under the continuous development of sports training and the continuous improvement of sports technical skills, everyone competes with other good players from all over the world to win the gold medal. In order to increase the chance to win the table tennis competition, relying on the means of

scientific methods, systematic planning of sports training and research, and strengthening various factors that can influence players during the competition seems important (Hou, Chen, & Wu, 2008). By making a diagnosis and assessment of each player's technical use in each stage of table tennis competition, player can effectively control how it should be done when playing the games (Wu, Qin, & Zhang, 1993). Continuously tracking players performance in terms of technical skills and tactics, players will perform better in the future.

Huang (2000) proposed that in order to understand abilities of table tennis players, there are five kind of evaluation methods, which are the critical winning point recording method, the game observation recording method, the winning and losing decision recording method, the 15 points for offensive and defensive ability statistical analysis, and the table tennis segmentation evaluation method.

Among them, the table tennis segmentation evaluation method is published by mainland scholars Wu and Li (1990). They used China table tennis national team players as the research subjects. Table tennis technical skills were evaluated during table tennis competitions in terms of "attack after serve", "attack after receive", and "rally". BY evaluated these three-staged techniques statistically, game winning model could be developed (Zhu, 1990). Wu (1998) also pointed out that during the preparation period for the 1996 Olympic Games, the China Table Tennis Science and Technology Research Public Relations Team video recorded 538 games on live and analysed 200 pieces of data by using table tennis segmentation evaluation method. Moreover, the table tennis segmentation evaluation method has been applied to large-scale competitions in the world many times. For example, it has been used in Asia games, Olympics games, and the World Table Tennis Championships. Players had succeeded in knowing each other's abilities and was able to establish good results. Table tennis segmentation evaluation method played a pivotal role in area of table tennis technical analysis in mainland China.

From the literature above, table tennis segmentation evaluation method is the most commonly used method to analyse table tennis technical skills. This study is based on the men's singles champion Ma Long who won the 2017 World Table Tennis Championships and his opponent runner-up Fan Zhen Dong as the research subjects. Table tennis segmentation evaluation method was used to analyse these two players overall technical performances and technical skill differences. The results could provide both coaches and players with references to short- or long-term training and preparation for the major competitions.

2. METHODOLOGY

2.1. Subjects

This study is based on Ma Long, the men's singles champion in the 2017 World Table Tennis Championships, and Fan Zhen Dong, the runner-up of the final opponent. The basic information was shown in Table 1:

Table 1. *Basic information of the subjects.*

Name	Natio-nality	Playing Style	World Ranking Until 2017.12
Ma Long	Chinese	Right-handed, shakehand grip	No. 1
Fan Zhen Dong	Chinese	Right-handed, shakehand grip	No. 2

2.2. Method

Following tools were used to analyse data for the study. There were:

(1) Personal computer
(2) Table tennis competition recording table
(3) Game record developed by Con-Guin Guo in 1999 was used to record changes of each scoring process.
(4) Three-stage techniques

Three-stage techniques score rate method proposed by Huan-Qun Wu and Zhen-Biao Li in 1990 was used for the study. The grading system is shown as follows:

Excellent: Score rate of each "attack after serve", "attack after receive serve", and "rally has reached 70%, 50%, and 55%, respectively.

Good: Score rate of each "attack after serve", "attack after receive serve", and "rally" has reached 65%, 40%, and 50%, respectively.

Fail: Score rate of each "attack after serve", attack after receive serve", and "rally" has reached 60%, 30%, and 45%, respectively; usage rate of "attack after serve", "attack after receive serve", and "rally" has reached 25%, 15%, and 45%, respectively.

3. RESULTS AND DISCUSSIONS

3.1 . Comprehensive technical performance analysis of Ma Long

Ma Long was the men's singles champion in the 2017 World Table Tennis Championships. In the final, he won by the score of 4:3. His comprehensive technical performance was analysed as follows:

(1) Attack and Defence After Serve

As shown in Table 2, Ma Long in the final match against Fan Zhen Dong, after his serve, he used aggressive attack tactic 15 times which scored 13 points and lost 2 points, 87% of score rate and 60% of usage rate. Comparing his score rate and usage rate on "attack after serve" with three-stage techniques score rate method proposed by Huan-Qun Wu and Zhen-Biao Li in 1990, it reached "excellent" and "good" level. Looking at his attack style, Ma Long attacked opponent's return 10 times by using his forehand, and attacked opponent's return 5 times using his backhand, reached 80% of score rate. It showed that he was good in use both forehand and backhand attacks on "attack after serve" to score the points. He was able to effectively serve the ball and controlled the opponent.

In addition, looking at the defence style of returns from Ma Long, he used this style of returning ball only 6 times during the game which scored no point and lost 6 points, 0% of score rate and 24% of usage rate. It showed that his defence style of returning ball after three or above continuously rally was not effective. Overall, it showed that the aggressive attack tactic Ma Long used could effectively defeat the

opponent.

(2) Attack and Defence After Receive Serve

As shown in Table 2, during the final match, Ma Long used aggressive attack tactic only 2 times after receiving serve which scored 0 points and lost 2 points, 0% of score rate and 20% of usage rate, His performance reached “fail” level. Looking at the attack style of returns from Ma Long, he used both forehand attack and backhand attack 1 times each. In addition, looking at the defence style of returns from Ma Long, he used it 8 times, scored 6 points and lost 2 point, 75% of score rate and 80% of usage rate. From the statistical analysis, it revealed Ma Long hardly used aggressive attack after receive serve. It was not very effective when he used during the game. By using the defence after receiving serve tactic, it showed that he was able to control the ball’s dropping point. This way made up for his inadequacy of attacking the ball after received serve.

(3) Rally

As shown in Table 2, Ma Long in the final match had a total of 84 rallies, attacking return ball 65 times, which scored 36 points and lost 29 points, 55% of score rate and 77% of usage, reached “excellent” and “good” level. During the game, “rally” was the technique used the most in all three-stage techniques. Ma Long used all kinds of playing styles and played aggressively which enabled him to consistently achieve outstanding results in international competitions.

Table 2. *Technical performance analysis record table of Ma Long*

Total number of serve	Forehand attack after serve		Backhand attack after serve	
25	Total number	10	Total number	5
	Point gain	9	Point gain	4
	Point lose	1	Point lose	1
	Score rate	90	Score rate	80
	Usage rate	40	Usage rate	20
Serve	Attack after serve (forehand + backhand)		Defence After Serve	
Point gain 4	Total number	15	Total number	6
	Point gain	13	Point gain	0
	Point lose	2	Point lose	6
Point loss 0	Score rate	87	Score rate	0
	Usage rate	60	Usage rate	24
Total number of receiving serve	Forehand attack after receiving serve		Backhand attack after receiving serve	
10	Total number	1	Total number	1
	Point gain	0	Point gain	0
	Point lose	1	Point lose	1
	Score rate	0	Score rate	0
	Usage rate	10	Usage rate	10
Serving error by the opponent	Attack after receiving serve (forehand + backhand)		Defence after receiving serve	
0	Total number	2	Total number	8
	Point gain	0	Point gain	6
	Point lose	2	Point lose	2
	Score rate	0	Score rate	75
	Usage rate	20	Usage rate	80
Total number of consecutive balls playing	Consecutive attack		Consecutive defence	
84	Total number	65	Total number	19
	Point gain	36	Point gain	3
	Point lose	29	Point lose	16
	Score rate	55	Score rate	16
	Usage rate	77	Usage rate	23

who played against Fan Zhen Dong

*Results of the match (7:11) (11:6) (11:3) (11:8) (5:11) (7:11) (12:10) 4:3 Ma Long won

3.2 . Comprehensive technical performance analysis of Fan Zhen Dong

Fan Zhen Dong won a silver medal in the 2017 World Table Tennis

Championships. In the final, he was defeated by the score of 3:4 to his opponent. His comprehensive technical performance was analysed as follows:

(1) Attack and Defence After Serve

As shown in Table 3, Fan Zhen Dong in the final, after his serve, he used aggressive attack 18 times of which scored 4 points and lost 14 points, 22% of score rate, and 82% of usage rate. Comparing his score rate on "attack after serve" with three-stage techniques score rate model, it was at "fail" level. Looking at his attack style, Fan Zhen Dong attacked opponent's returns 6 times using his forehand and 12 times using his backhand. He scored 4 points on her forehand attack and lost 2 points, having 67% of score rate, which showed his performance on forehand attack reached "good" level. On his backhand attack, he scored 0 points and lost 12 points, having 0%of score rate, which showed his performance on backhand attack reached "fail" level. From the analysis, it showed that he used both forehand attack and backhand attack as a playing tactic on "attack after serve". It also showed that he scored better on using forehand attack than using backhand attack. Overall, comparing with Ma Long, he had lower score rate on "attack after serve" which might be due to unable to serve effectively to his opponent. From the viewpoint of defence style of returning the balls, he used "defence after serve" technique 0 times. His tactic was to attack aggressively which was unable to get an ideal score rate.

(2) Attack and Defence After Receive Serve

As shown in Table 3, Fan Zhen Dong in the final match, he used aggressive attack 12 times after receiving serve which scored 8 points and lost 4 points, 67% of score rate and 100% of usage rate. His performance reached "excellent" level. Looking at his attack style on returns, he used forehand attack 1 times and backhand attack 11 times. In addition, looking at Fan Zhen Dong defence style of returning ball, he used it 0 times. From the statistical analysis, it showed that Fan Zhen Dong attacked aggressively on "attack after receive" and "attack after serve". He mainly used backhand to attack, with the score rate of 64% which reached "excellent" level.

(3) Rally

As shown in Table 3, Fan Zhen Dong in the final match had a total of 88 times rallies, attacking return 78 times, which scored 34 points and lost 44 points, 44% of score rate and 89% of usage rate. He used "rally" technique the most among three-stage techniques. His performance on "rally" reached "fail" level.

Based on the above analysis and comparison of Fan Zhen dong's technique performance in the game, he only showed "attack after receive" reached at "excellent" level, and "attack after serve" by forehand reached at "good", others like "rally" were at "fail" level.

Fan Zhen Dong is a right-handed shakehand grip player with quick attack making the loop playing style. His technical skill characteristics are fast in movement and fast-paced. When rallying with the opponent, he could attack aggressively with a positive attitude. That's the reason he showed more stable on score rate of "attack after receive" than Ma Long, but he missed a lot on the critical points. His score rate on attack aggressively was not ideal on the first three rounds. He should work on his backhand attack the most. His score rate on "rally" was lower than Ma Long. That's why he was defeated by Ma Long and got the silver medal in the 2017 WTTC.

Table 3. *Technical performance analysis record table of Fan Zhen Dong*

Total number of serve	Forehand attack after serve		Backhand attack after serve	
22	Total number	6	Total number	12
	Point gain	4	Point gain	0
	Point lose	2	Point lose	12
	Score rate	67	Score rate	0
	Usage rate	27	Usage rate	55
Serve	Attack after serve (forehand + backhand)		Defence after Serve	
Point gain 4 Point loss 0	Total number	18	Total number	0
	Point gain	4	Point gain	0
	Point lose	14	Point lose	0
	Score rate	22	Score rate	0
	Usage rate	82	Usage rate	0
Total number of receiving serve	Forehand attack after receiving serve		Backhand attack after receiving serve	
12	Total number	1	Total number	11
	Point gain	1	Point gain	7
	Point lose	0	Point lose	4
	Score rate	100	Score rate	64
	Usage rate	8	Usage rate	92
Serving error by the opponent	Attack after receiving serve (forehand + backhand)		Defence after receiving serve	
0	Total number	12	Total number	0
	Point gain	8	Point gain	0
	Point lose	4	Point lose	0
	Score rate	67	Score rate	0
	Usage rate	100	Usage rate	0
Total number of consecutive balls playing	Consecutive attack		Consecutive defence	
88	Total number	78	Total number	10
	Point gain	34	Point gain	2
	Point lose	44	Point lose	8
	Score rate	44	Score rate	20
	Usage rate	89	Usage rate	11

who played against Ma Long

*Results of the match (11:7) (6:11) (3:11) (8:11) (11:5) (11:7) (10:12) 3:4 Ma Long won

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

From the analysis, comparison, and discussion, the following conclusions were made:

(1) Three-stage techniques score rate of Ma Long, showed his performance on both "attack after serve" and "rally" reached the "excellent" level. His performance on "attack after receive" was rated as "fail". Characteristics of his techniques were: fast in speed, fast tempo, powerful serve, able to give opponent fatal blow, positive attitude to attack opponent aggressively during rally, and stable rally ability. Although he rarely used "attack after receive" tactic to return the ball, but by using "defence after receive" tactic to return the ball enabled him to effectively control the change of ball's landing point, making up the weakness of attack aggressively after receiving the serve. Also, he was able to be in control when the opponent served the ball. With all these reasons, he was able to win the gold medal in the 2017 World Table Tennis Championship.

(2) Although three-stage techniques performance of Fan Zhen Dong had reached a certain level, but obviously was not as good as Ma Long. Overall, his performance on "attack after receive" was rated "excellent" but were rated "fail" on both "attack after serve" and "rally". In the future, when playing major games, he should try to enhance the stability of "attack after serve" and "rally" performance to achieve better results.

4.2. Recommendations

(1) In order to improve the technical level of table tennis, relevant authorities should actively organize coaching workshops and guide all levels of coaches on how effectively technical analysis doing to enhance training performance.

(2) To become a world-class table tennis player, one should possess comprehensive three-stage techniques.

REFERENCES

Chen, J.H., Hou, S.L., & Zheng, Y.K. (2006). Discussion on the correlation between the serve and score rate of Taiwanese Elite male table tennis players. *Hsing Kuo Journal, 6*, 109-118.

Chen, W.Z. (2000). *Comparison on the game technical skills of Asia elite junior male table tennis players*. Pingtung County: Rui Wei Publisher.

Guo, C.J. (1999). Discussion on the techniques of 12 years old male single table tennis division champion players who competed in National Free Cup Table Tennis Championship in year 1997 and year 1998. *Tajen Journal, 17*, 517-535.

Hou. S.L., Chen, J.H., & Wu, Y.G. (2008). Games technical analysis of elite male table tennis players. *Journal of Sport Health and Leisure, 8*, 33-45.

Huang, G.Y. (2000). *Discussion on the evaluation method of attack and defense ability in table tennis competition*. International college sports coach science conference, Taipei.

Lin, G.B., Qiu., M.Y., & Cen, Z.G. (1983). *Application on Chinese table tennis technical skills*. Tokyo: Magajin Publisher.

Li, L.H., Huang, Z.H., & Huang, Z.H. (2008). Analysis on the technical performance of

excellent table tennis players. *Chia Nan Journal, 34*, 920-926.

Wang, G. (2000). *Investigation on the evaluation method of offensive and defensive abilities in table tennis*. Taipei: Tianxia.

Wu, D.C. (1998). *Table Tennis*. Taoyuan: Technical Report of National Taiwan Sport College Coach Research Center.

Wu, H.Q., & Li, Z.B. (1990). Technical diagnosis method of table tennis players. *Ping Pong World in China*, 38, 38-40.

Wu, H.Q., Qin, Z.F., & Zhang, X.P. (1993). *Results and benefits done by 25th Olympic Games scientific research public relation for China team*. Beijing: China Table Tennis Association Research Committee, 169-181.

Wu, S.Q., Huang, Z.H., & Xiao, C.X. (2004). Research on the application of three-stage techniques of Taiwanese national male junior table tennis team players. *Ling Tung Journal, 16*, 321-338.

Zhu, C.Y. (1990). Analysis of three-stage techniques score rate on World Women's Table Tennis Championship in 1990. *Sports & Exercise Research, 41*, 53-58.

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Analysis on health-related fitness of table tennis course in university students

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Abstract: *Objective:* This study conducts the health fitness test for the table tennis students of NCHU, and hopes the statistical results can be used to evaluate the students' physical fitness status and serve as a reference for the arrangement of physical education curriculum. *Method:* the table tennis students in different academic years are tested in their testing time of physical fitness. The test includes BMI, explosion strength, flexibility, muscle fitness, and cardiopulmonary fitness. All the data has been analysed by descriptive statistics first, then compared by One-Way ANOVA. *Results:* 1) The students who take the table tennis courses during the 3 years have little change in body composition. 2) The 2 fitness indicators, flexibility and explosion strength, have significant differences in each academic year. *Conclusions:* The physical fitness indicators of male students have significant differences in flexibility and explosion strength and have a downward trend, which needs to be strengthened. However, they have better performances in muscle fitness in various fitness test indicators, but have no positive impacts on cardiorespiratory cardiopulmonary fitness, which can be continuously tracked.

Keywords: National Chung Hsing University, NCHU, table tennis course, health-related fitness

1. INTRODUCTION

1.1 Background of the Problem

With the advancement of electronic technology and the popularization of IC products, almost everyone holds a mobile phone or a computer, which has been gradually changing most people's lifestyle that becomes a sitting life. As for the promotion of health-related fitness, Taiwan (ROC)'s Ministry of Education has presented the "333 Plan for Promoting Students' Physical Fitness" in 1999, and hopes to enhance students' understanding of physical fitness and help students develop regular exercise habits in order to improve students' overall health and fitness. The NCHU also follows the policy of the Ministry of Education. Since 2000, it has carried out physical fitness testing for freshmen so as to let students know their personal fitness status. Physical fitness can be divided into two parts, skill-related physical fitness and health-related physical fitness (Hoeger & Hoeger, 2006). Which is also a comprehensive ability of the body to adapt to the environment and personal activities (Fang, 1995). Some studies pointed out that skill-related physical fitness includes agility, balance, coordination, explosion strength, reaction time and speed, and its main objective is to pursue better sports performance; while health-related physical fitness includes body composition, cardiopulmonary endurance, muscular

strength and muscular endurance and flexibility, and its main purpose is to build the ability of an individual to cope with the activities of daily life and maintain a good health state (Corbin C., Welk G., Corbin W., & Welk K., 2008).

According to the data released by the Ministry of Health and Welfare, Executive Yuan, Taiwan (ROC), unhealthy diet and lack of exercise are the main causes of obesity. Obesity is also an important factor leading to chronic diseases. Among the Taiwanese Top Ten Causes of Death, 8 are related to obesity. 41.1% Taiwan people over 18 years old are overweight or obese (51.2% of males and 31.3% of females), the underweight is 6.2%, the normal is 52.6% (45.3% of males and 59.8% of females), the overweight is 24.5% and the obese is 16.6% (45.3% of males and 59.8% of females are normal-weight) (Health Promotion Administration, 2018). Lack of physical activity in sitting lifestyle can easily lead to lower body metabolism and cause obesity, which increases various health problems and the risk of cardiovascular disease, and the expenditures on medical costs will be also increasing (Shih & Yang, 2015). Therefore, if the body weight can be effectively controlled by good physical fitness, not only the individuals can be healthier, but also the state's financial expenditure on health maintenance can be reduced. So, it is more and more important to maintain a dynamic (exercising) lifestyle. However, developing students' dynamic (exercising) lifestyle is also an important direction of school physical education. Regular physical activities and exercise habits can promote Physical health and improve obesity (Pan & Chen, 2016). Besides, in term of Social States, unhealthy diet and lifestyle are potential factors affecting physical fitness (Kuo, Yang, & Hung, 2003).

Based on the above background and in line with the physical fitness policy of the Ministry of Education, this study conducts the physical fitness tests of the students who take the table tennis elective courses in NCHU to understand and evaluate their physical fitness status. It is hoped that the results of this study can serve as a reference for the future curriculum arrangement of physical education.

1.2. Research Objective

This study conducts health fitness tests for the table tennis students of the National Chung Hsing University (NCHU) during the academic year 2015-2017 in order to understand the current physical fitness status of students in different academic years.

1.3. Operational Definitions of the Terms

1.3.1. Body Composition: *refers to the proportion of body fat and non-fat weight to the* whole-body weight. In this study, the indicator of body composition is Body Mass Index (BMI).

1.3.2. Muscular Strength and Muscular Endurance: *muscular strength refers to the* maximum strength of muscle contraction at one time; muscular endurance refers to the number of repeated contractions of muscle in the condition of static contraction for a period of time or under non-maximum load resistance. This study uses One-Minute Bent-Knee Sit-Ups as a muscle fitness indicator for muscular strength and muscular endurance.

1.3.3. Explosive Strength: This is mainly the increased proportion of muscular strength measured per unit time. This study takes Standing Long Jump as an indicator of explosion strength.

1.3.4 Flexibility: refers to the maximum mobility of a joint within its movement range. This study takes Sit and Reach Test as an indicator of flexibility.

1.3.5 Cardiopulmonary Endurance (CPT): refers to the ability of muscle groups to exercise under certain intensity for a certain period of time. This study takes the 800/1600 Meters Walk-Run as an indicator of cardiopulmonary endurance.

2. RESEARCH METHOD

2.1. Research Objects

This study takes the students of National Chung Hsing University (NCHU) during the academic years 2015-2017 as the research objects, including 9 colleges. They are the College of Liberal Arts, the College of Agriculture and Natural Resources, the College of Science, the College of Engineering, the College of Life Sciences, the College of Veterinary Medicine, the College of Management, the College of Law and Politics, and the College of Electrical Engineering and Computer Science. There are totally 5,959 male students and 4,447 female students that have completed the test.

2.2. Test Approach

2.2.1. Test items: Referring to the test items in the "The Republic of China Physical Fitness Passport (Applicable to College Students)" (NSPERC, 2007). The test items refer to the norm standards published on the website of the Ministry of Education (Ministry of Education, 2018).

2.2.2. Test Process: All tests are carried out in the physical education curriculum of NCHU, and the physical fitness testing time is arranged for implementation (Figure 1).

2.2.3 Data Processing: All the data of this study are analysed by SPSS 20.0 and Descriptive Statistics are used to present the physical fitness data of the male and female students participating in the table tennis courses in different academic years.

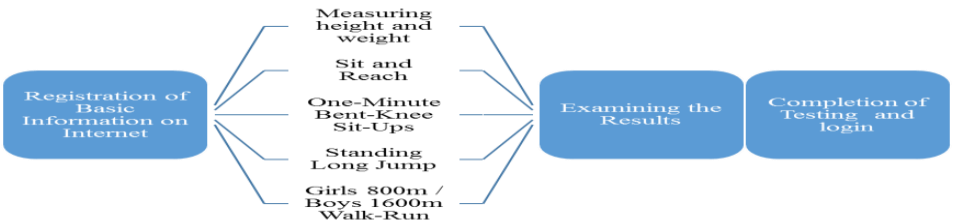

Fig. 1. Physical Fitness Testing Process

3. RESULTS AND DISCUSSION

3.1. Statistical Results of each Fitness Indicator

According to Table 1, the total tested number of male NCHU students during the 2015-2017 academic years is 643, including 203 in 2015, 197 in 2016, and 243 in

2017. The total number of female students tested is 364, including 99 in 2015, 111 in 2016, and 154 in 2017. The test results of different academic years are as follows:

3.1.1. Male students' fitness test results:

3.1.1.1 Academic Year 2015: The average value of the Height item is 172.9±5.96 cm, the average value of the Weight item is 65.4±12.87 kg, and the average BMI is 21.8±3.92. The average value of Sit and Reach test is 27.1±10.85 cm, the average value of Standing Long Jump test is 211.1±23.85 cm. The average value of the One-Minute Bent-Knee Sit-Ups test is 41.2±8.15 times, and the average value of the Walk-Run (1600m) test is 525.5±142.12 seconds.

3.1.1.2 Academic Year 2016: The average value of the Height item is 172.9±5.98 cm, the average value of the Weight item is 64.3±10.89 kg, the average BMI is 21.5±3.16, the average value of Sit and Reach test is 23.9±10.23 cm, the average value of Standing Long Jump test is 210.9±26.32 cm. The average value of the One-Minute Bent-Knee Sit-Ups test is 41.1±8.45 times, and the average value of the Walk-Run (1600m) test is 512.5±93.42 seconds.

3.1.1.3 Academic Year 2017: The average value of the Height item is 172.6±5.46 cm, the average value of the Weight item is 64.7±11.43 kg, the average BMI is 21.7±3.37, the average value of Sit and Reach test is 23.6±10.63 cm, the average value of Standing Long Jump test is 204.1±28.09 cm. The average value of the One-Minute Bent-Knee Sit-Ups test is 40.0±9.11 times, and the average value of the Walk-Run (1600m) test is 527.2±112.19 seconds.

3.1.2 Female students' fitness test results:

3.1.2.1 Academic Year 2015: The average value of the Height item is 159.8±5.67 cm, the average value of the Weight item is 51.5±8.27 kg, the average BMI is 20.1±2.61, the average value of Sit and Reach test is 32.6±10.67 cm, the average value of Standing Long Jump test is 152.9±23.72 cm. The average value of the One-Minute Bent-Knee Sit-Ups test is 32.1±7.91 times, and the average value of the Walk-Run (800m) test is 277.9±41.12 seconds.

3.1.2.2 Academic Year 2016: The average value of the Height item is 160.8±5.32 cm, the average value of the Weight item is 52.9±7.86 kg, the average BMI is 20.5±2.79, the average value of Sit and Reach test is 33.7±10.56 cm, the average value of Standing Long Jump test is 156.9±24.31 cm. The average value of the One-Minute Bent-Knee Sit-Ups test is 33.1±9.49 times, and the average value of the Walk-Run (800m) test is 279.7±50.89 seconds.

3.1.2.3 Academic Year 2017: The average value of the Height item is 160.6±5.26 cm, the average value of the Weight item is 52.8±7.91 kg, the average BMI is 20.4±2.79, the average value of Sit and Reach test is 33.6±10.74 cm, the average value of Standing Long Jump test is 157.8±24.49 cm. The average value of the One-Minute Bent-Knee Sit-Ups test is 32.5±8.95 times, and the average value of the Walk-Run (800m) test is 277.7±46.67 seconds.

Table 1. *Summary of the Fitness Indicator Tests of the Table Tennis Students*

Gender	**Male**			**Female**		
Year (Y)	104	105	106	104	105	106
Number (N)	203	197	243	99	111	154
Height (cm)	172.9±5.96	172.9±5.98	172.6±5.46	159.8±5.67	160.8±5.32	160.6±5.26
Weight (kg)	65.4±12.87	64.3±10.89	64.7±11.43	51.5±8.27	52.9±7.86	52.8±7.91
Body Mass Index (BMI)	21.8±3.92	21.5±3.16	21.7±3.37	20.1±2.61	20.5±2.79	20.4±2.79
Sit and Reach (cm)	27.1±10.85	23.9±10.23	23.6±10.63	32.6±10.67	32.1±11.62	33.5±10.40
Standing Long Jump (cm)	211.1±23.85	210.9±26.32	204.1±28.09	152.9±23.72	156.9±24.31	157.8±24.49
One-Minute Bent-Knee Sit-Ups (times)	41.2±8.15	41.1±8.45	40.0±9.11	32.1±7.91	33.1±9.49	32.5±8.95
Walk-Run (sec.)	533.6±113.83	515.7±90.06	522.0±92.08	277.9±41.12	279.7±50.89	277.7±46.67

3.1.3. The ANOVA Results of Each Physical Fitness Indicator

As shown in Table 2, in the ANOVA results of the fitness indicators of the male students in the table tennis courses, there is no significant difference in the BMI indicator $F(2, 640) = .46$, $p>.05$); in the indicator of Sit and Reach, $F(2,640) = 6.90$, $p<.05$), which shows that there are differences in the flexibility of male table tennis students in each academic year; in the indicator of Standing Long Jump, $F(2, 640) = 5.23$, $p < .05$), which shows that there are differences in the explosion strength of male table tennis students in each academic year; there is no significant difference in the indicator of One-Minute Sit-Ups $F(2, 640) = 1.40$, $p>.05$); And there is also no significant difference in the Walk-Run (1600m) indicator $F(2, 640) = 1.71$, $p>.05$).

As shown in Table 3, the analysis results of the physical fitness indicators of female students in the table tennis courses show that there is no significant difference in the physical fitness indicators of female students of the table tennis courses in each academic year. The indicators include: BMI, $F(2, 361) = .27$, $p>.05$); Sit and Reach, $F(2, 361) = .52$, $p>.05$); Standing Long Jump, $F(2, 361) = 2.33$, $p > .05$); One-Minute Sit-Ups, $F(2, 361) = 2.00$, $p > .05$); Walk-Run (800m), $F(2, 361) = .51$, $p>.05$).

Table 2. *ANOVA Summaries of Physical Fitness Indicators of Male Students in Table Tennis Courses*

Indicator	Source of Variation	*SS*	*df*	*MS*	*F*	Post Hoc Comparison
BMI	Between Samples	11.292	2	5.65	.461	
	Within Samples	7830.331	640	12.235		
	Total	7841.630	642			
Sit and Reach	Between Samples	1546.335	2	773.168	6.904*	104>105>106
	Within Samples	71673.367	640	111.990		
	Total	73219.703	642			
Standing Long Jump	Between Samples	7221.106	2	3610.553	5.230*	106<105<104
	Within Samples	441848.502	640	690.388		
	Total	449069.608	642			
Sit-Ups	Between Samples	207.723	2	103.861	1.399	
	Within Samples	47517.002	640	74.245		
	Total	47724.725	642			
Walk-Run	Between Samples	33349.236	2	16674.618	1.705	
	Within Samples	6259078.935	640	9779.811		
	Total	6292428.171	642			

**p<.05*

Table 3. *ANOVA Summaries of Physical Fitness Indicators of Female Students in Table Tennis Courses*

Indicator	Source of Variation	*SS*	*df*	*MS*	*F*	Post Hoc Comparison
BMI	Between Samples	5.106	2	2.553	.272	
	Within Samples	3392.437	361	9.397		
	Total	3397.542	363			
Sit and Reach	Between Samples	123.302	2	61.651	.523	
	Within Samples	42568.641	361	117.919		
	Total	42691.944	363			
Standing Long Jump	Between Samples	2448.721	2	1224.360	2.329	
	Within Samples	189808.960	361	525.787		
	Total	192257.681	363			
Sit-Ups	Between Samples	293.699	2	146.850	1.997	
	Within Samples	26549.078	361	73.543		
	Total	26842.777	363			
Walk-Run	Between Samples	2401.973	2	1200.986	.513	
	Within Samples	845219.464	361	2341.328		
	Total	847621.437	363			

**p<.05*

3.1.4 The Trends of Each Fitness Indicator

Based on the results of the above physical fitness tests, the trend of each fitness indicator for table tennis students of NCHU in the academic year 2015-2017 is as follows:

3.1.4.1 The trend of Body Mass Index (BMI) indicator (Figure 2).

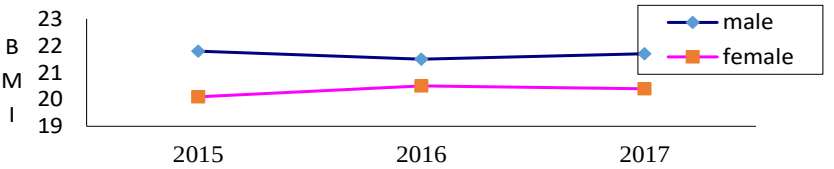

Figure 2. The trend of Body Mass Index (BMI) indicator

3.1.4.2 The trend of Flexibility indicator (Figure 3).

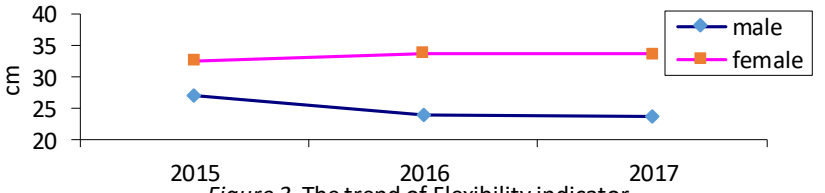

Figure 3. The trend of Flexibility indicator

3.1.4.3 The trend of Explosive Strength indicator (Figure 4).

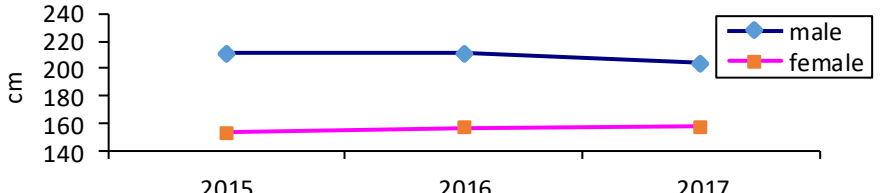

Figure 4. The trend of Explosion Strength indicator

3.1.4.4 The trend of Muscle Fitness indicator (Figure 5)

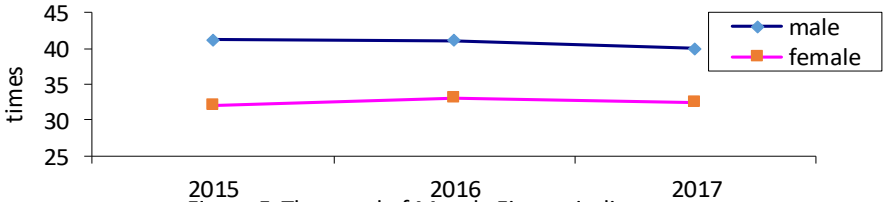

Figure 5. The trend of Muscle Fitness indicator

3.1.4.5 The trend of Cardiopulmonary Endurance indicator (Figure 6)

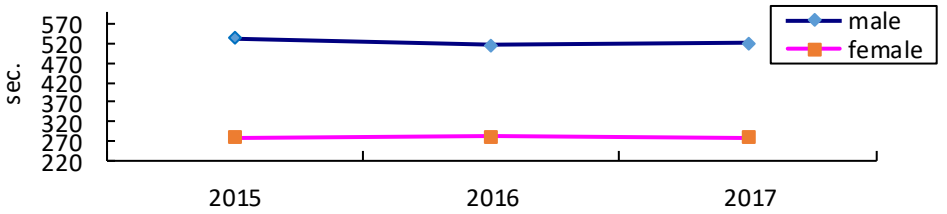

Figure 6. The trend of Cardiopulmonary Endurance indicator

3.2. Discussion

According to the above research results, the fitness status of male and female students in the table tennis courses of NCHU during the 2015-2017 academic year, compared with the average values of height and weight in the 2007 academic year (Huang, Hsu M., & Hsu C., 2008). The status of the table tennis students during the 3 years has not changed much. As to the situation of each health fitness indicator, the average value of Body Mass Index (BMI) is in located in the normal range of the BMI Norm published by the Ministry of Education of Taiwan (male: 18.5-23.9; female: 18.5-23.9). There is no significant difference in the comparison of difference analysis. BMI is an extremely important basis on affecting physical fitness (Lee & Hsu, 2003). Some studies have indicated that obesity is an important factor in many chronic diseases, such as hypertension, diabetes and cardiovascular diseases, and leads to higher kidney disease risk. Weight loss may be an important strategy to prevent obesity-related kidney disease (Shih & Yang, 2015), which shows the importance of weight control.

The Sit and Reach test is an indicator of flexibility. The average value of male students in each academic year is: 2015 academic year (27.1), 2016 academic year (23.9), and 2017 academic year (23.6). According to the grading standard of the 18 years old in the Norm published by the Ministry of Education, the 2015 academic year is located between 50% and 55% (25~27 cm). Through difference analysis, whether the different academic years have significant differences is compared. $F(2, 640) = 6.90$, $p<.05$). After the Post Hoc Test, the 2015 academic year (27.1) is significantly higher than the 2016 academic year (23.9) and the 2017 academic year (23.6). The trend chart shows that the flexibility has a downward trend (Figure 3); the average value of female students in each academic year is: the 2015 academic year (32.6), the 2016 academic year (32.1), and the 2017 academic year (33.5), the best is the 2017 academic year which is located at 55%. In flexibility, there is no significant difference between the academic years, but there is an upward trend (Figure 3). Flexibility refers to the maximum mobile ability of a joint in the moveable range. As the age increases, the flexibility will be gradually aging and deteriorating. As to the correlation of health-related fitness, the flexibility is significantly positively correlated with explosion strength and muscle fitness (Hsu, Chen, Lee L., Lee, S., & Hsu, 2009). Some related researches have mentioned that better flexibility is helpful for preventing sports injuries, reducing lower back pain, improving coordination, and

enhancing self-confidence. When performing softness training, static stretching works better and can reduce the sports injury caused by stretching (Hsu, Lee, & Kuo, 2014). This study finds that the flexibility of male students is an indicator that needs to be strengthened.

The Standing Long Jump test is an indicator of explosion strength. According to the grading standard of the 18 years old in the Norm published by the Ministry of Education, the male students in the 2017 academic year is located between 45% and 50% (203-206 cm), which is the worst. Through difference analysis, whether the different academic years have significant differences is compared. Through difference analysis, whether the different academic years have significant differences is compared. ($F(2, 640) = 5.23$, $p<.05$). After the Post Hoc Test, the 2017 academic year (204.1) is significantly lower than the 2016 academic year (211.0) and the 2015 academic year (211.1). The trend chart shows that the explosion strength has a declining and downward trend (Figure 4). From this study, it is found that the explosion strength of male students needs to be strengthened; the average value of female students in each academic year is: the 2015 academic year (152.9), the 2016 academic year (156.5), and the 2017 academic year (159.3). The 2017 academic year is located at 70%, which is the best. There is no significant difference in explosion strength during the academic years, but there is an upward trend (Figure 4). In term of the correlation of health-related fitness, the performance of explosion strength has a significant positive correlation with muscle fitness (Hsu et al., 2009). Some studies have mentioned that better muscular strength and explosion strength can be obtained through physical training, which is great helpful to the daily life of the elderly; since they can do many things on their own, without being too dependent on others, and can maintain independence (Malbute-Shennan & Young, 1999). The American College of Sports Medicine (ACSM) recommends some training principles about intensity, duration, and training frequency, etc., which needs to be progressive and individualized, contain all large muscle groups, and adopt multiple sets of training methods in order to achieve greater benefits (Huang et al., 2008).

The One-Minute Bent-Knee Sit-Ups test is an indicator of muscle fitness. According to the grading standard of the 18 years old in the Norm published by the Ministry of Education, the test results of male students are located between 60% and 70% (40 to 42 cm). The performance is poor in the 2017 academic year (40.0), and there is no significant difference during the academic years. The 2016 academic year (41.1) and the 2015 academic year (41.2) show a regressive trend (Figure 5). The average value of female students in each academic year is: the 2015 academic year (32.1), 2016 academic year (33.8), and 2017 academic year (31.8), the overall performance falls between 65% and 75% of the norm (31 to 34 times). There is no significant difference in muscle fitness during the academic years. There is a downward trend (Figure 5). Muscle fitness is a manifestation of muscular strength and muscular endurance. In term of correlation of health-related fitness, muscle fitness is significantly negatively correlated with cardiorespiratory fitness (Hsu et al., 2009). This study has found that the muscle fitness performance of male and female students in the table tennis courses is in the upper-middle level and should be maintained.

In the walk-run test, the male students run 1600m, and female students run 800m. This test is an indicator of cardiorespiratory fitness. According to the grading standard of the 18 years old in the Norm published by the Ministry of Education, the male students in 2016 academic year (515.7) is located at 50%, which is the best. The second is the 2017 academic year (522.0) at 45%, while the 2015 academic year (533.6) at 40% is the worst. The average value of female students in each academic year is: the 2015 academic year (277.9), 2016 academic year (284.5), 2017 academic year (282.5). The overall performance of the girls falls between 50% ~ 60% (276 ~ 286 seconds) of the norm. There is no significant difference between male and female students in each academic year. The trend chart of cardiorespiratory fitness shows a flat trend (Figure 6). In term of the correlation of health-related fitness, muscle fitness has a significant negative correlation with cardiopulmonary endurance (Hsu et al., 2009), which indicates that the better the muscle fitness, the better the cardiorespiratory strength. This study finds that the male and female students in the table tennis courses have middle to upper level performances in muscular endurance. The performance of cardiorespiratory fitness has no positive impact to be traced. Aerobic exercise and interval training can help to improve the cardiorespiratory endurance (Wu, 2006; Costigan, Eather, Plotnikoff, Taaffe, & Lubans, 2015).

4. CONCLUSIONS AND RECOMMENDATIONS

This study has completed the physical fitness tests of male and female students of the National Chung Hsing University in the elective table tennis Curriculum during the academic year 2015 ~ 2017. The following conclusions and recommendations are obtained from the research results:

4.1 Conclusions

4.1.1 The height and weight of the male and female students who have taken the table tennis courses have little change. The physical fitness indicators of male students have significant differences in flexibility and explosion strength and have a downward trend, which needs to be strengthened.

4.1.2 The male and female students who have taken the table tennis courses have better performances in muscle fitness in various fitness test indicators, but have no positive impacts on cardiorespiratory fitness. Which can be continuously tracked.

4.2. Recommendations

4.2.1 The physical fitness of students should be continuously tracked. It is recommended that the physical fitness of students in different elective courses can be compared.

4.2.2 To formulate individualized exercise prescriptions according to individual differences, and to establish students' good physical fitness concepts and develop their exercise habits for maintaining health and physical fitness.

REFERENCES

Hoeger, W.K.H., & Hoeger, A.H. (2006). *Principles and labs for fitness and wellness* (8th ed.). Belmont, CA: Thomson Wadsworth.

Fang, C.L. (1995). Fitness and Wellness. *Quarterly of Chinese Physical Education*, *9*(3), 62-69.

Corbin, C.B., Welk, G.J., Corbin, W.R., & Welk, K.A. (2008). *Concepts of physical fitness-active lifestyle for wellness* (14th ed.). New York: The McGraw-Hill.

Health Promotion Administration, MOHW. (2018). *Annual Report on Health Promotion Statistics of the Republic of China for 2016*. Taiwan Taipei: Health Promotion Administration, MOHW.

Shih, T.E., & Yang, L.H. (2015). Obesity, Weight Loss and Kidney Disease. *The Taiwan Society of Internal Medicine, 26*(4), 186-195.

Pan, Y.H., & Chen, C.H. (2016). Power of pedometers: A literature review on a pedometer-based approach to improve physical activity in students. *Physical Education Journal*, *49*(4), 377-390.

Costigan, S.A., Eather, N., Plotnikoff, R.C., Taaffe, D.R., & Lubans, D.R. (2015). Highintensity interval training for improving health-related fitness in adolescents: asystematic review and meta-analysis. *British Journal of Sports Medicine*, *49*(19), 1253-1261.

Hsu C.T., Lee, S.W., & Kuo, S.C. (2014). Research of Difference Health-Related Fitness of Students from 2012 and 2013 in Lee-Ming Institute of Technology. *Journal of the Lee-Ming Institute of Technology*, *25*(2), 15-23.

Hsu, C.T, Chen, K.F., Lee, L.C., Lee, S.W., & Hsu, H.C. (2009). A Research of the Differences in Health Related Fitness. *Journal of Recreation Sport and Health Promotion*, *2*, 95-105.

Huang, H.C., Hsu, M.H., & Hsu, C.T. (2008). The Study of Health-Related Fitness Level in Students of National Chung-Hsing University. *Journal of Physical Education of NCHU*, *9*, 25-33.

Kuo, S.C., Yang, T.M., & Hung, J.T. (2003). A Comparative Analysis on the Relationship between Physical Fitness and Lifestyle of College Students in Central Taiwan. *Sports & Exercise Research*, *5*(2), 87-94.

Lee, S.H., & Hsu, C.H. (2003). The Research of Physical Fitness of University Students in Taichung. *Journal of Physical Education of NCHU*, *7*, 63-70.

Malbute-Shennan, K., & Young, A. (1999). The physiology of physical performance and training in old age. *Coronary Artery Disease*, *10*(1), 37-42.

Ministry of Education. (2018). Ministry of Education Physical Fitness Website. Form http://www.fitness.org.tw/, 2018/12/01.

National Society of Physical Education of the Republic of China (2007). *The Republic of China Physical Fitness Passport (for students).* Taiwan Taipei: Ministry of Education.

Wu, I.T. (2006). The Effects of Aerobic Exercises and Nutrition Education on Blood Lipids, Health Related Fitness and Exercise Behavior of Students with High Cholesterols. *Sports and Exercise Research, 8*(3), 161-172.

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Comparative study of balance and walking capacity among elderly women table tennis players versus sedentary elderly women

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Abstract: *Background and Aim*: Aging is associated with decrease in functional walking capacity, balance and fitness. Moreover, sedentary lifestyle in older adults result in increased metabolic disorders including type 2 diabetes, obesity, metabolic syndrome and etc. in contrast, take part in different exercise training such as table tennis can improve physical fitness and balance in subjects with different age including older adults. The aim of present study was to comparison the physical fitness and balance in active (table tennis player) and sedentary older women. *Methods:* the present study subjects consist of 30 older women with the average age of 65.4±4.49 years, height 163.23±4.80 cm and the weight of 65.7±6.30 kg that assigned in two trained and sedentary groups. Sedentary subjects don't participate in any exercise training at least in last years, and trained group participated in table tennis training at least for two continuous years (three session per week, 2 hours per session). All of subjects don't have any metabolic and cardiovascular disease and they were healthy. The Berg (for determine the balance), 5 time sit to stand and time up and go tests performed by two groups. Data were analysed by SPSS software version 24 and between group differences determined by using the independent t test. *Results:* present study findings indicated that time up and go test score significantly higher in sedentary group compared to trained group ($p>0.001$). But there is no significant difference for sit to stand ($p=0.390$) and Berg ($p=0.270$) tests between sedentary and active groups. *Conclusion:* according to present study results it seem that table tennis training in old women cannot improve balance, however table tennis can be effective for some indicators of fitness in older women.

Keywords: balance, walking capacity, elderly women, table tennis

1. INTRODUCTION

One of the widespread and important problems in the elderly is the reduction of balance, increased falling down and fear of falling. Falling is one of the most important consequences of the loss of function in the elderly, which is associated with damage to their ability to perform daily activities (Adams, 2011). Fear of falling leads to risk of quality of life, limiting mobility, and reduced social interaction (Binda, Culham, & Brouwer, 2003). In addition, incidences that result in hip fractures are

fatal in 12% to 20% of cases, and 50% die among the elderly who are hospitalized each year due to fall and fracture (Binda et al., 2003).

The phenomenon of aging will be the issue of 14th century of Iranian. This is justifiable regarding the two basic causes of demography that have taken place in Iran, namely, increased life expectancy and the change of the population pyramid in favour of the old (Nemati & Agha Bakhshi, 2003). The 2017 census in Iran showed that 44.8% of the Iranian population were 30-64 years old, i.e. the middle aged, and 6.1% are older than 65 years old, i.e. the elderly, which indicates an increase in the aged population (Jafari & Behboodi, 2017). Forecasts suggest that this aged population will be double in the next 25 years (Jafari & Behboodi, 2017). Therefore, due to the rapid growth of the population of this age group, considering the different health aspects of the middle-aged and the elderly is necessary.

Elderly is a biological process that involves all living things, including human beings. The progressing reduction in the physiological capacities and the loss in the ability to respond to environmental stresses during this period can increase the vulnerability of elderly people to diseases (Puranik et al., 2012). Of course, it should be mentioned that if the lifestyle in the middle-ages is of desirable quality, then old age will be sweet and enjoyable (Puranik et al., 2012). One of the useful strategies to reduce the effects of aging is to participate in regular and appropriate sports activities before the onset of aging, namely, youth and middle-ages (Hadi & Soltani, 2016). Amongst the intrinsic factors, researchers name falling down, reduced balance and disorder in the walking pattern, as the key factors in reducing motor activity in the elderly and believe that balance is the basis of an independent and dynamic life (Babakhani, Oladghobadi, & Fatahi, 2016). Balance is an integral part of all of everyday activities and a complex motor skill that provide the body's postural dynamics to prevent it from falling. Balance is a multifactor capability that is affected by strength, deep sense and reaction time of the individual and it's the most important human capability to prevent from falling (Kashefi, Pour Azar, & Dehestani Ardakani, 2014). Balance can be static, dynamic, and functional; static balance includes the ability to maintain a supporting surface with minimal movement; dynamic balance includes the ability to perform an activity or task along while maintaining a stable physical stat; and functional balance includes performing several successive operating activities while maintaining the correct state of the body without the centre of gravity getting out of the limit of supporting surface (Kim et al., 2014).

From the point of view of scientists, the importance of posture and balance in performing activities such as sitting, standing and walking is independent, controversial, and non-deniable (Babakhani et al., 2016). Therefore, it is logical if the elderly, develop their level of balance and body control when they are young and middle-aged, they will face less problems in old ages (Hadi & Soltani, 2016; Farsi, Abdoli, & Baraz, 2015). The review of literature has shown the positive effect of exercise on improving health and various factors in the physical fitness of the elderly, including balance (Hadi & Soltani, 2016; Kashefi et al., 2014; Farsi et al., 2015; Lelard, Doutrellot, David, & Ahmaidi, 2010). Several studies have examined various methods of sports exercises, including strength, aerobic, endurance, balance, deep sense and

flexibility exercises on the balance of middle-aged and elderly people. However, there is no consensus on which of these sports exercises has a greater effect on the improvement and development of static, dynamic and functional balance of middle-aged or elderly people.

Footwork theory: There are six types of footwork in the table tennis, and players use a variety of footwork to reach the ball and hit it (Hiruta et al., 1992).

1) Single Step Movement: In this type of footwork, one leg is fixed and the other moves forward, backward and forth in three directions in which the left leg may be fixed and the other moving (to hit forehand), or the right leg may be fixed and the other moving in different directions (to hit backhand) (Hiruta et al., 1992).
2) Stride Step Movement: If the foot movement is more than one step, then this movement is used where first, the same leg moves toward one direction and the opposite leg is pulled to that direction. For example, if we want to move to the right, first the right leg moves towards that direction and the left leg is pulled to it (Hiruta et al., 1992).
3) Spring Step Movement: involves the short spring movement and the long spring movement (Hiruta et al., 1992).
   In this type of leg movement, we move the opposite leg to the direction that we want to go, and then we move the other foot towards it and if the opposite leg is placed beside the other leg, it's a short spring, and if it cut the place of the other foot, it will be a long spring. This movement is like running on the side while executing side jumping (Hiruta et al., 1992).
4) Cross Step: Use this type of leg movement to hit balls that go out of the third of the table's width. In this type of leg movement, first we turn the toe to the side that we want to go and then, as usual running, we go to that side, and when return, first the same leg goes behind the opposite leg and we return to our original state (Hiruta et al., 1992).
5) Swinging leg movement: this type of foot movement is for the time when we want to hit forehand from the region of backhand. Obviously, we should never stand along the length strips of the table (Hiruta et al., 1992).
6) Moving the leg with short and long steps: in this type of leg movement, short and long steps are used irregularly, and there is no order in this type of movement. Fast players mostly use this type of movement (Hiruta et al., 1992).

As you can see, the movements of the legs in this sport, like hopping or plyometric, are balanced and much less intense with movements and zigzag direction shifting and jump, and since researches have shown the beneficial effects of hopping exercises on improving balance and the performance of various groups of athletes and people other than the elderly (Anguish, 2010; Huang & Lin, 2010), therefore, conducting a study that compares the effect of table tennis exercises on the balance and walking capacity of active and sedentary elders seems necessary, hence, the aim of this study is to compare balance and walking capacity women table tennis players versus sedentary women.

2. RESEARCH METHODOLOGY

The present study was a cross-sectional and comparative study with available sampling method. The statistical population of the study was all elderly women of Rah Ahan Veterans' Table Tennis Club among which, 30 were selected with a mean age of 65.7 ± 4.49 years, height of 163.23 ± 4.80 cm, and weight of 65.7 ± 6.30 kg in two active (15 individuals) and sedentary (15 individuals) groups. So that the active group had at least two table tennis training sessions (three sessions a week and two hours per session) for at least two years, and the sedentary group did not participate in any exercise in the last year. The records of musculoskeletal and cardiovascular diseases of these individuals were investigated and there was no history of physical injury, surgery, or cardiovascular disease.

After identifying the research samples based on the inclusion and exclusion criteria and their randomly dividing them into two groups, the necessary explanations were given about the stages of the study and the voluntary participation consent form in the study was signed by the subjects of the study. In order to measure the pre-test, the samples were asked to come to the club in accordance with the timetable. After their attendance, the initial information form was completed by him first and then anthropometric measurements were made from each person.

The Scale Berg Balance test was used to measure static and dynamic balance. This test is the performance of balance function based on 14 things that are used in everyday life, such as simple motor actions (moving, standing without support, standing up, etc.), and more difficult actions (360 degrees rotating and standing on one leg ...). Total score is 56. The time required to perform this scale is 10 to 15 minutes. The reliability of each Scale Berg item was 0.98 and the reliability of the fourteen items was equal to 0.99. The internal consistency with Cronbach's alpha was reported to be 0.96 (80, 81). The Timed Up and Go (TUG) test with a reliability of 99% was used to predict the risk of falling, in order to measure the balance and agility of the participants in both experimental and control groups (Gasemi, Azamian Jazi, & Noori, 2011). The test was conducted in such a way that the participant, without using her hands, stood up from a chair without handles, comes back after going a three-meter path and again sits on the chair (Buchner et al., 1997).

To measure the strength of the lower extremity, the test of sitting and standing from the chair was used. This test included standing from the chair and sitting on it. The test's starting position was that the subject sat down on the chair, placed her legs on the ground with arm folded on the chest. The subject was asked to perform as many as possible standings and sittings on the chair in 30 seconds. The time was calculated from the sitting position and the number of sittings and standings from the chair in 30 seconds was considered as the subject's record (Różańska-Kirschke, Kocur, Wilk, & Dylewicz, 2006). Independent t-test was used to compare all variables. All statistical analyses were performed at the significance level of 0.05 and using SPSS version 24 software.

3. RESULTS

Significance level was considered as (p≤0.05) in all tests. Results showed that there was a significant difference between the two groups only at the time of standing and going test (p<0.05), so that the going time of the sedentary group was higher than the active group, but no significance difference was observed between the two groups in the variables of Berg balance and sitting and standing (p>0.05) (Table 1).

Table 1. *Demographic characteristics of the active and sedentary elderly*

	Active elderly		Sedentary elderly		P value
	Mean	Standard deviation	Mean	Standard deviation	
Age	65.00	3.52	65.80	5.40	0.09
Weight	66.66	7.17	64.83	5.39	0.06
Height	162.60	20.5	163.86	4.45	0.64

Comparison of research variables between active and inactive groups

Variable	Intergroup differences	t	df	P value
Berg balance	1.86 ± 1.55	1.20	28	0.24
Standing time and walking time test	-3.50 ± 0.52	-6.62	28	0.001
Sitting and standing	-0.53 ± 0.61	-0.83	28	0.39

4. DISCUSSION AND CONCLUSION

The purpose of this study was to compare the balance and walking capacity among elderly women table tennis players versus sedentary women. The results of this study showed that there is no significant difference between the two groups in the dynamic balance test and lower extremity muscles strength between the two groups of elderly table tennis players and sedentary women (p>0.05). However, there was a significance difference between the time of standing and walking tests between the two groups (p<0.05) so that the standing and walking test time in the sedentary group was longer than the active group.

This study is consistent with the study by Mannini et al. (2007), Henwood et al. (2006) and Roberts (1989). In the study by Roberts (1989), it was found that the activity of running 3 times a week for 30 minutes, although improved balance in the active group, no difference was observed in static balance between the two active and sedentary groups. Also, the present study is not consistent with the results of many studies, including Ha et al. (2019), Chou and Chen (2019), Ferraz et al. (2018), Gaedtke and Morat (2015), and Naderi et al. (2018) based on the effectiveness of the exercises on the balance of the elderly. It seems that the differences in the findings of these studies are due to differences in different training programs, differences in the age of the subject, the number of subjects in each group, as well as

the individual differences of subjects (Hue, Seynnes, Ledrole, Colson, & Bernard, 2004; Daniel, Vale, Giani, Bacellar, & Dantas, 2010).

According to the posture control system theory, musculoskeletal factors affecting balance regulation include muscle characteristics and features, range of joint motion, and the biomechanical relationship of different parts of the lower extremity, disorder in some physiological factors such as mass loss and muscle strength, especially knee flexor muscles and flexibility, it can be expected that physical activity, especially walking, can delay this degradation, and by increasing muscle mass and muscle strength, especially in knee flexors and increasing the flexibility, these physiological variables are moderated in the elderly and potentially prevents the decrease of balance and the risk of falling (Perrin, Gauchard, Perrot, & Jeandel, 1999; Evans & Lexell, 1995).

As Buchner et al. (1997) showed in a study, walking improves all the major factors, including endurance, strength, walking, balance, and health status. Therefore, considering this and given that the sedentary group may have activities like walking, although short-term and cross-sectional, it is probably one of the reasons for the lack of significant changes in the balance between the two groups. Studies have shown that the deep sense and inward sensory information of the palms are the most important sensory systems for maintaining normal balance (Perrin et al., 1999). Physical activity can play a role in improving some of the sensory-motor systems that contribute to the balance of elderly people (Lord & Castell, 1994). Therefore, based on the theory of systems, as well as the effect of exercise on each of these systems, it seems logical that athletes have a better balance than non-athletes. It also seems that athletes have a better deep sense for maintaining balance. The probable cause of this difference can be attributed to the effect of exercise on deep-sense receptors (Alizadeh, Raeisi, Shirzad, & Bagheri, 2009). In addition, studies have shown that sedentary people have a better performance of vision sense in balance control than active people. This suggests that non-athlete individuals have more reliance on their vision systems to maintain balance. The logic of this difference may also be due to the fact that athletes do not rely solely on one sensory system to maintain balance, and other systems, such as the deep sense, may have a greater role in controlling posture, and consequently, the role of the vision system becomes weaker (Alizadeh et al., 2009). Since the evaluation of the dynamic balance of the subjects was performed with opened eyes, according to the aforementioned, the other reason for the lack of a significant difference in the balance between the two groups may be known as the efficiency of the vision sense of the sedentary subjects.

Agility is the ability to quickly change the body or parts of it, which depends on strength, reaction time, movement speed, and muscle coordination. Agility is considered to be essential for doing functional tasks of the elderly such as getting on off the bus, hurriedly rising to pick up a phone, going to bathroom, and so on. About muscle coordination, it can be said that according to the nature of exercise, maybe table tennis exercises can challenge and strengthen neuromuscular coordination. In addition, there is evidence that good muscular strength is a predictive factor for recovery in mobility such as walking speed (Koohboomi, Norasteh, & Samami, 2015).

In justifying the effect of table tennis activity on agility, the greater pressure applied to neuromuscular systems and the nature of this activity in which athletes are constantly changing direction in space in the shortest possible time can be mentioned. Regardless of whether the individual has been physically active throughout the lifetime, helps multiple body systems that control balance and physical fitness, changes associated with aging are unavoidably occurring, while many of these changes are unobservable and affect how work is done on balance and physical fitness in different environments or in combination with existing illnesses such as diabetes or arthritis, as well as selective strategies for the elderly to do balance things.

One of the limitations of this research was the lack of control of nutritional, social, cultural, economic and health status of participants and the lack of control of muscle strength and its fatigue, as well as the limitation in scientific resources and specialized articles. It is recommended that in future studies, the effect of table tennis on individuals with specific conditions, such as illness and age-related abnormalities, be evaluated.

Given the ever-increasing number of elderly people in society, and the consequent increase in age-related complications, such as imbalance and falling, reduced strength, flexibility and agility, finding the best practices that are useful for the elderly, in terms of time, place and cost is very important for them.

According to the studied carried out in the research background, it is observed that the effect of regular movements and sports exercises has a significant effect in different parts of the systematic of the body in the elderly and increases the health of the elderly and as a result, the health of the family and society. Now that the average age of our country is increasing, the community needs research and study in this field and examinations in the challenges that this sport has or will come in the future. By studying more about this and by making practical strategies and creating the necessary field and proper establishment by the authorities and practitioners, our country moves towards a healthy old age society. On the other hand, the need to provide appropriate and useful solutions, makes our researchers determined to conduct research and study in this field.

REFERENCES

Adams, L.J. (2011). *The Impact of Balance Training on Balance, Confidence, and Functionality in Assisted Living Adults*. University of Central Oklahoma.

Alizadeh, M., Raeisi, A., Shirzad, A., & Bagheri, L. (2009). The effect of sensory information on balance control in standing status of athletes and non-athletes 9in Persian. *Journal of movement science and sport, 7*(13), 21-30.

Anguish, B.M. (2010). *The effects of a randomized four-week dynamic balance training program on individuals with chronic ankle instability*. West Virginia: University Libraries.

Babakhani, F., Oladghobadi, K., & Fatahi, F. (2016). Effect of Hip Abductor Muscle Fatigue on Static and Dynamic Balance in Elderly Women. *Iranian Journal of Ageing, 11*(2), 322-329.

Behm, D.G., Bambury, A., Cahill, F., & Power, K. (2004). Effect of acute static

stretching on force, balance, reaction time, and movement time. *Medicine & Science in Sports & Exercise, 36*(8), 1397-1402.

Binda, S.M., Culham, E.G., & Brouwer, B. (2003). Balance, muscle strength, and fear of falling in older adults. *Experimental aging research, 29*(2), 205-219.

Buchner, D.M., Cress, M.E., de Lateur, B.J.0 Esselman, P.C.0 Margherita, A.J.0 Price, R., & Wagner, E.H. (1997). The effect of strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 52*(4), M218-M224.

Chou, L.-N., & Chen, M.-L. (2019). Effects of Elastic Band Exercise on Lower Limb Rehabilitation of Elderly Patients Undergoing Total Knee Arthroplasty. *Rehabilitation Nursing Journal, 44*(1), 60-66.

Daniel, F., Vale, R., Giani, T., Bacellar, S., & Dantas, E. (2010). Effects of a physical activity program on static balance and functional autonomy in elderly women. *Macedonian Journal of Medical Sciences, 3*(1), 21-26.

Evans, W.J., & Lexell, J. (1995). Human aging, muscle mass, and fiber type composition. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 50*(Special_Issue), 11-16.

Farsi, A., Abdoli, B., & Baraz, P. (2015). Effect of Balance, Strength, and Combined Training on the Balance of the Elderly Women. *Iranian Journal of Ageing, 10*(3), 54-61.

Ferraz, D.D., Trippo, K.V., Duarte, G.P., Neto, M.G., Santos, K.O.B., & Oliveira Filho, J. (2018). The Effects of Functional Training, Bicycle Exercise, and Exergaming on Walking Capacity of Elderly Patients With Parkinson Disease: A Pilot Randomized Controlled Single-blinded Trial. *Archives of physical medicine and rehabilitation, 99*(5), 826-833.

Gaedtke, A., & Morat, T. (2015). TRX suspension training: A new functional training approach for older adults–development, training control and feasibility. *International journal of exercise science, 8*(3), 224-233.

Gasemi, B., Azamian Jazi, A., & Noori, P. (2011). The Effect of 12 Weeks Functional Training on Dynamic Balance in Healthy Older Women. *Salmand. Iranian Journal of Ageing, 5*(4), 0-0.

Ha, M.-S., Kim, J.-H., Ha, S.-M., Kim, Y.-S., & Kim, D.-Y., (2019). Positive influence of aqua exercise and burdock extract intake on fitness factors and vascular regulation substances in elderly. *Journal of clinical biochemistry and nutrition, 64*(1), 73-78.

Hadi, H., & Soltani, M. (2016). The Effect of Velocity-Balance Training on Balance in Middle-Aged Police Staff. *Journal of Police Medicine, 5*(3), 223-230.

Henwood, T.R., & Taaffe, D.R. (2006). Short term resistance training and the older adult: the effect of varied programmes for the enhancement of muscle strength and functional performance. *Clinical physiology and functional imaging, 26*(5), 305-313.

Hiruta, S., Shimaoka, M., Yoshimura, Y., Kasai, J., Shibata, Y., & Youza, N. (1992). The problem of physical training confronting table tennis players in Japan. *International Journal of Table Tennis Sciences, 1*, 105-109.

Hosseini, M.S.S., Rostamkhany, H., Naghiloo, Z., & Lotfi, N. (2010). The effects of balance, mental and concurrent training on balance in healthy older males.

Huang, P., & Lin, C. (2010). Effects of balance training combined with plyometric exercise in postural control: Application in individuals with functional ankle instability. In *6th World Congress of Biomechanics (WCB 2010). August 1-6, 2010* Singapore. Springer.

Hue, O.A., Seynnes, O., Ledrole, D., Colson, S.S., & Bernard, P.-L. (2004). Effects of a physical activity program on postural stability in older people. *Aging clinical and experimental research, 16*(5), 356-362.

Jafari, A., & Behboodi, M. (2017). The efficacy of aerobic exercises in reducing loneliness and promoting happiness in Elderly. *Iranian Journal of Psychiatric Nursing, 5*(5), 9-17.

Kashefi, M., Pour Azar, M., & Dehestani Ardakani, M. (2014). The Effect of Two Kinds of Aerobic Exercise on the Static and Dynamic Balance of Old Men. *Iranian Journal of Ageing, 9*(2), 134-141.

Kim, K., Lee, T., Kang, G., Kwon, S., Choi, S., & Park, S. (2014). The effects of diverse warm-up exercises on balance. *Journal of physical therapy science, 26*(10), 1601-1603.

Koohboomi, M., Norasteh, A.A., & Samami, N. (2015). Effect of Yoga Training on Physical Fitness and Balance in Elderly Females. *Salmand. Iranian Journal of Ageing, 10*(3), 26-35.

Lelard, T., Doutrellot, P.L., David, P., & Ahmaidi, S. (2010). Effects of a 12-week Tai Chi Chuan program versus a balance training program on postural control and walking ability in older people. *Archives of physical medicine and rehabilitation, 91*(1), 9-14.

Lord, S.R., & Castell, S. (1994). Physical activity program for older persons: effect on balance, strength, neuromuscular control, and reaction time. *Archives of physical medicine and rehabilitation, 75*(6), 648-652.

Manini, T., Marko, M., VanArnam, T., Cook, S., Fernhall, B., Burke, J., & Ploutz-Snyder, L. (2007). Efficacy of resistance and task-specific exercise in older adults who modify tasks of everyday life. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 62*(6), 616-623.

Naderi, A., Degens, H., Hosseini Rezvani, M., & Shaabani, F. (2018). A retrospective comparison of physical health in regular recreational table tennis participants and sedentary elderly men. *Journal of musculoskeletal & neuronal interactions*, *18*(2), 200-207.

Nemati, D., & Agha Bakhshi, H. (2003). Tehran Elderly Friendly City, Initial steps to realize the world's first ever aging capital. *Quarterly journal of social research, 8*(16), 15-44.

Perrin, P.P., Gauchard, G.C., Perrot, C., & Jeandel, C. (1999). Effects of physical and sporting activities on balance control in elderly people. *British journal of sports medicine, 33*(2), 121-126.

Puranik, M., Iyer, S., Gore, A., Prabha, L., Khachane, P., & Mehta, A. (2012). Effect of sensory-specific balance training in elderly. *Indian Journal of Physiotherapy & Occupational Therapy, 6*(3), 168-172.

Roberts, B.L. (1989). *Effects of walking on balance among elders*. Nursing research.
Różańska-Kirschke, A., Kocur, P., Wilk, M., & Dylewicz, P. (2006). The Fullerton Fitness Test as an index of fitness in the elderly. *Medical Rehabilitation, 10*(2), 9-16.

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Table tennis loop-drive training: a neuromotor exercise modality for the adult population

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Abstract: By practicing table tennis, the adult population can meet the American College of Sports Medicine's recommendations for neuromotor exercising. In this study, thirteen recreational players (age: 46.2 ± 18.3 yr., 8 males and 5 females) trained for improved spin rate (SR) and hitting speed (HS) of their forehand loop-drives (FLD). The eight-week program followed ACSM's guidelines for developing balance, agility, and proprioceptive abilities. Two practices per week were conducted which included a 20-min FLD training against consistent backspin balls served by a table tennis robot. In addition, participants studied instructional materials and utilized self-regulated peer feedback. Biweekly tests assessed average SR, HS, and ball contact location (CL) on the paddle from five consecutive FLDs. SR increased from 41.6 rs^{-1} to 60.7 rs^{-1}, while HS from 8.57 ms^{-1} to 9.71 ms^{-1} by the end of the program (both $p<0.05$). While SR increased consistently throughout the program, HS reached its peak after four weeks of training, then remained at that increased level. CL moved from 21 mm below the paddle's longitudinal axis (the paddle was usually in horizontal position at contact) to 35 mm below the axis. This study contributed to the knowledge base of training type, intensity, and methods for neuromotor exercising of adult population.

Keywords: adult table tennis, neuromotor exercise, forehand topspin, spin rate

1. INTRODUCTION

Table tennis is one of the best activities for lifelong fitness and brain health (Amen, 2006). It is a popular activity among all ages across the globe. There have been, however, a limited number of studies published on table tennis for the general adult population.

According to the American College of Sports Medicine (ACSM), exercising regularly has particular relevance to older adults because exercise preserves bone mass, reduces the risk of falling, enhances feelings of "energy", well-being, quality of life, and is associated with a lower risk of cognitive decline and dementia. Neuromotor exercise training incorporates motor skills such as balance, coordination, agility, and proprioceptive training. Due to its multifaceted nature, table tennis is one of the best neuromotor exercise training modalities. The frequency and duration of neuromotor exercise training to accrue health and fitness benefits have been studied at a lesser extent than cardiorespiratory, muscular strength, or flexibility training. Based on the limited body of data and ACSM's panel consensus judgment, the current recommendations for neuromotor exercise training are 2-3 d/wk with exercise sessions of 20–30 min in duration (Garber at al., 2011).

Recreational players often participate in table tennis more than the ACSM recommendations for exercise frequency and duration. These players are also learners of the technical and tactical characteristics of the modern game, which is characterized by a power-and-spin focus. The forehand loop-drive (FLD), a fast topspin shot against an incoming backspin ball is one of the most effective weapons in a player's arsenal. (Seemiller & Holowchak, 1997; McAfee, 2009). Pfeiffer et al. (2010) demonstrated that the two most commonly used shots are the FLD, representing 19.5% of all shots, and the counter-topspin forehand, which accounts for 16.7% of all shots at international level. These two shots are the most aggressive shots of all. (Malagoli et al., 2014)

In modern table tennis, the FLD is often performed as either the third or the fourth shot within a rally (Zhang et al., 2014). According to Tamaki et al. (2017), the quality of the fourth shot showed the biggest contribution to successful rallies, therefore the loop-drive could be the determining factor between winning or losing.

Experts agree that the three basic tactical means of any shot are (1) ball speed, (2) ball rotation, and (3) ball placement (Munivrana et al., 2015). Accordingly, the ultimate goals during the FLD are hitting a fast, spiny, and accurate return. Numerous studies focused on the kinematic and kinetic features of the FLD (Bańkosz and Winiarski, 2018; Bootsma and Van Wieriegen, 1990; Iino and Kojima, 2009), but limited number of studies examined hitting speed (HS) and spin rate (SR) before and after contact is made with the ball. From both motor learning and sport psychological standpoints, if HS and SR are provided as feedback, they lead to "external focus of attention" during skill practice, which in turn accelerates skill acquisition (Williams and Krane, 2015).

An incoming backspin ball can reach 41.7-58.3 rs^{-1} rotation (Iizuka et al., 2010), but this spin rate is always reduced by the bounce of the ball on the table. Iino and Kojima (2009) used 11.4 rs^{-1} (light) and 36.8 rs^{-1} (heavy) spin rates and 3.0-3.5 ms^{-1} incoming ball speed in their FLD study.

Four categories of FLD spin rates were identified by Santos et al. (2017). Professional players can hit fast spin (140 rs^{-1}), medium spin (105 rs^{-1}), slow spin (84 rs^{-1}), or flat hits (less than 60 rs^{-1}). Advanced players are able to hit the FLD with speeds between 13.6 and 18.7 ms^{-1} (Santos et al., 2017; Iino and Kojima, 2009). No SR and HS data had been published on developing or amateur club players.

The present study was designed to provide adult recreational table tennis players with an eight-week neuromotor exercise training program that follows ACSM recommendations and monitors FLD improvements.

2. METHODS

2.1. Participants

Thirteen healthy adult individuals, eight males and five females, participated in the study (age: 46.2 ± 18.3 yr., weight: 72.3 ± 21.5 kg). All of participants were active amateur table tennis club players with 4.85 ± 4.10 years of playing experience who could hit FLD returns on a ball with moderate backspin.

2.2. Measures

At the beginning of the eight-week training program (pre-test) and at weeks 2, 4, 6, and 8 (post-test), the following tests were carried out: a table tennis robot (Butterfly Amicus Advanced) delivered backspin balls to the forehand side of the participants at a frequency of 35 balls/min. The incoming balls had approximately 21 rs^{-1} backspin and 2.9 ms^{-1} speed before the players made contact. Participants were asked to hit the ball with as much topspin and as much speed as possible while not missing the opponent's side of the table. Five consecutive and successful FLDs were recorded by a high-speed camera (Sony RX10 IV Cyber-Shot) at 480 fs^{-1} frame rates from front view. The balls were marked with a non-symmetrical geometric shape to identify ball positions on each frame of the video and calculate SR. The contact location (CL) of the ball on the paddle was identified from the video using a nine-zone (3x3) matrix aligned with the longitudinal and transversal axes of the head of the paddle. A second camera (Canon ZR85A) recorded the action from a side view at 60 fs^{-1}. This camera was set perpendicularly to the flight path of the ball. Dartfish 7.0 software was used to retrieve HS data for the first 0.067 sec after ball contact. Average SR, HS, and CL of the five consecutive shots were calculated. Participants received their data as feedback for learning within 24 hours of each test.

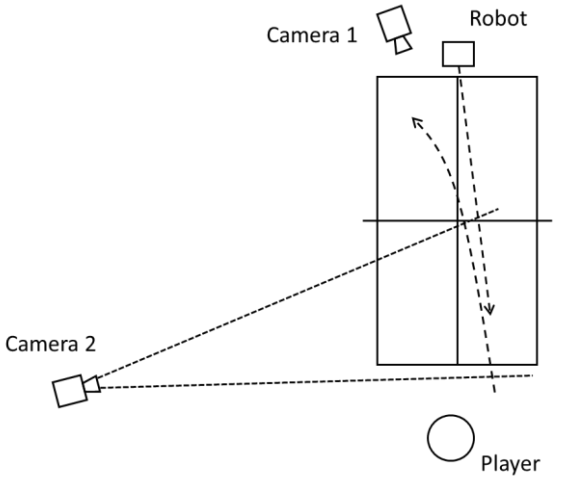

Fig. 1. Physical arrangement for data collection.

2.3. Training Design and Procedures

The eight-week training program was designed to improve participants' FLD spin rate, hitting speed, or both. Two practice sessions per week were conducted. Participants were asked to spend twenty minutes per occasion on practicing FLD against the robot or a partner who fed backspin balls to their forehand side. Similarly, to most amateur club settings, there were no personal coaching sessions, but participants could utilize self-regulated feedback, i.e., feedback from coaches or peer-participants whenever requested by the participant. In addition, participants studied instructional materials related to FLD such as journal articles or audio-visual sources.

2.4. Statistical Analysis

Group mean ± SD were calculated for SR, HS, and CL at each test measurement point. One-way repeated measures ANOVA was used to determine differences among mean scores ($p<0.05$). Following the one-way repeated measures ANOVA, pair-wise T-test comparisons were carried out to determine the changes on a bi-weekly basis ($p<0.05$). Correlations among SR, HS, and CL were calculated for each test ($p<0.05$).

3. RESULTS

Participants showed significant improvements throughout the training program in both SR and HS. By the end of the training program, SR was increased from 41.6 rs^{-1} to 60.7 rs^{-1}, which is a 45.9% improvement, and HS from 8.57 ms^{-1} to 9.71 ms^{-1}, constituting a 13.3% improvement (both $p<0.05$). While SR got increased consistently and gradually throughout the program, HS reached its peak after four weeks of training, then remained at that increased level. Table 1 summarizes SR and HS data at each bi-weekly measurement point.

Table 1. *Mean and SD of ball speed and spin rate of loop-drives at the five measurement points, and rate of improvement from week 0.*

	Spin Rate (rs^{-1})	Speed (ms^{-1})	Spin improvement relative to Week 0	Speed improvement relative to Week 0
Week 0	41.6 ± 30.5	8.57 ± 0.98	N/A	N/A
Week 2	52.1 ± 31.0$^{\alpha}$	9.09 ± 1.54	25.3%	6.0%
Week 4	53.6 ± 31.5$^{\alpha}$	9.84 ± 1.32$^{\alpha}$	28.9%	14.7%
Week 6	57.1 ± 31.1$^{\alpha}$	9.22 ± 1.35	37.4%	7.6%
Week 8	60.7 ± 31.6$^{\alpha\beta\gamma}$	9.71 ± 1.22$^{\alpha}$	45.9%	13.3%

α = significantly different from week 0 measurement ($p<0.05$)
β = significantly different from week 2 measurement ($p<0.05$)
γ = significantly different from week 4 measurement ($p<0.05$)

Average CL moved from 21 mm below the paddle's longitudinal axis (the paddle was usually in horizontal position at contact) to 35 mm below the axis by week 8 ($p<0.05$). See Figure 2.

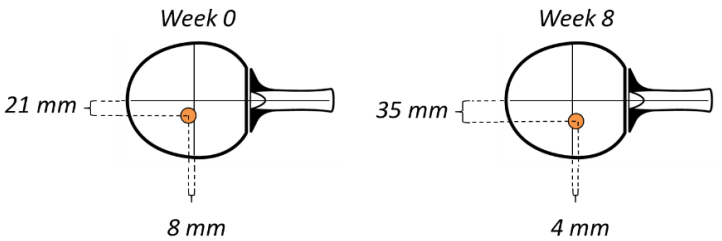

Fig. 2. Average contact location of the ball on the paddle.

Positive correlation was found between spin rate and ball speed on week 0 (r=0.640 p=0.018) and week 4 (r=0.633 p=0.020). At these two measurement points, participants who hit the ball with more spin also hit the ball with more speed. At other measurement points, this relationship was not observed.

4. DISCUSSION

The present study examined the effect of participating in a program that provided participants with the recommended amount of neuromotor exercise training via table tennis skill practice. The study had recreational, adult participants with limited competitive background in table tennis. The sport of table tennis is a highly contested and competitive recreational activity, where players seek technical and tactical improvements on a regular basis. By participating in table tennis practices, individuals meet and often exceed ACSM's recommendation for neuromotor exercise training. In addition to the health benefits, positive changes happen in skill development as well. The biomechanical feedback that was provided during this study increased participants' chances for success in the sport.

While our study effectively applied biomechanical methods to inform and motivate players for skill development, it also provided previously unpublished biomechanical data on recreational players' FLD. Since the participants of this study were amateur players, test results of both SR and HS remained below that of elite players' data at any bi-weekly measurement point. For example, based on Santos' (2017) categories of spin rates for advanced players, our participants remained in the "flat hitting" category until the last test on week 8, when they reached the "slow spin" category. A few participants, however, were able to reach spin rates over 100 rs^{-1}, which puts them in "medium spin" category based on elite table tennis players' spin categories. The measured HS data of 8.57-9.71 ms^{-1} also remained significantly under top players' corresponding data of 13.6 and 18.7 ms^{-1}. The rate of improvement, however, in both SR and HT were significant throughout the program. It was also observed that participants improved their SR at a higher rate than their HS in this eight-week training program. After reaching an already significantly higher level of both SR and HS by week 4, participants were able to further increase their SR to produce their "heaviest" hits, i.e. a combined effect of heavy spin and fast ball, by week 8 of the study.

An interesting finding of this study was a shift of the contact location of the ball on the paddle downward, along the transversal axis of the paddle. To the knowledge of the authors, there are no published data available on the contact locations during FLDs. Theoretically, regardless of the contact point on the paddle, a given tilt angle and a given velocity of the paddle would provide identical speed and spin to the ball. Further research is needed to discover if any correlation exists between CL and SR or CL and HS.

In summary, amateur, developing adult players were able to significantly improve spin rate and ball speed of their loop-drive in an eight-week training program. Similar training programs can contribute to recreational players' overall fitness and health by providing neuromotor exercise training.

REFERENCES

Amen, D. (2006). *Making a good brain great.* Harmony Publishing, New York: NY, p. 125-127.

Bańkosz, Z., & Winiarski, S. (2018). The evaluation of changes of angles in selected joints during topspin forehand in table tennis. *Motor Control, 22*(3)*,* 314-337.

Bootsma, R., & Van Wieringen, P. (1990). Timing an attacking forehand drive in table tennis. *Journal of Experimental Psychology-Human Perception and Performance, 16*(1)*,* 21-29.

Garber, C.E., Blissmer, B., Deschenes, M.R., Franklin, B.A., Lamonte, M.J., Lee, I., & Swain, D.P. (2011). Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine & Science in Sports & Exercise, 43*(7)*,* 1334-1359.

Iino, Y., & Kojima, T. (2009). Kinematics of table tennis topspin forehands: Effects of performance level and ball spin. *Journal of Sports Sciences, 27*(12)*,* 1311-1321.

Iizuka, S., Ushiyama, Y., Yoshida, K., Yang, F., Zhang Huan, Y., & Kamijima, K. (2010). The measuring ball spin at the service in table tennis by junior player. *ITTF Sports Science Congress Conference Proceedings*, 6, 123-126.

Malagoli Lanzoni, I., Di Michele, R., & Merni, F. (2014). A notational analysis of shot characteristics in top-level table tennis players. *European Journal of Sport Science, 14*(4)*,* 309-317.

McAfee, R. (2009). *Table tennis: Steps to success*. Champaign, IL: Human Kinetics. P. 53-58.

Munivrana, G., Petrinović, L.Z., & Kondrič, M. (2015). Structural analysis of technical-tactical elements in table tennis and their role in different playing zones. *Journal of Human Kinetics, 47*(1)*,* 197-214.

Pfeiffer, M., Hui, Z., & Hohmann A. (2006). A Markov chain model of elite table tennis competition. *International Journal of Sports Science & Coaching, 5*(2)*,* 205-222.

Santos D. R., Barbosa R. N., Vieira L. P., Santiago, P.P., Zagatto, A.M., & Gomes M.M. (2017). Training level does not affect auditory perception of the magnitude of ball spin in table tennis. *Journal of Human Kinetics, 55*(1)*,* 19-27.

Seemiller, D., & Holowchak, M. (1997). *Winning table tennis: skills, drills, and strategies.* Champaign, Ill.: Human Kinetics. p. 19-26.

Tamaki, S., Yoshida, K., & Yamada K. (2017). A shot number based approach to performance analysis in table tennis. *Journal of Human Kinetics, 55*(1)*,* 7-18.

Williams, J., & Krane, V. (2015). *Applied Sport Psychology.* Boston, MA: McGraw and Hill, p. 31-32.

Zhang, H., Liu, W., Hu, J., & Liu, R. (2014). Evaluation of elite table tennis players' technique effectiveness. *Journal of Sports Sciences. 32*(1)*,* 70-77.

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The study on the disabled table tennis player's journey – on the Paralympic Games process

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Abstract: *Purpose:* The journey of becoming an elite athlete is worthwhile to reflect and learn, that being said, for those elite disabled athletes, their process of becoming one is more noteworthy and remarkable. In this study, we expect the result to immensely inspire other disabled athletes. Therefore, this study is based on this disabled table tennis athlete with a wheelchair Cheng Ming-chih. He got a silver medal in men's singles- TT 5 in 2018 Asian Paralympic Games in India, got a gold medal in men's single in IWAS World Games in Sochi, Russia. He is the star of Taiwan, and we want to use his strenuous journey as the foundation of this study. *Method:* The qualitative research methodology will be utilized, at the same time, the semi-structured interviews will be given, then, we will analyse the content of the transcript. The approach above will tell the origin of the sport, wheelchair table tennis, the struggles and growth during the Para Games, and the story of from unforgettable tragic accident to being permanently disabled, then to a twist of physical and emotional transformation and acceptance, to becoming a true warrior, lastly to enjoying the victory. Each part of the story holds hand in hand to convey the main idea of this study. *Results:* Cheng Ming-chih used to be a table tennis athlete, however, a serious accident forced him to be amputated, which had challenged him massively physically and emotionally, at the point he almost gave up, his family was his silver linings that gave him strength and support. During his hellish journey, his family has always been his emotional outlet, whether it was positive or negative. And then, he reached his peak in his entire athletic career, he got a silver medal in men's group in 2015 Paralympics in Rio. Unfortunately, in 2017 he got injured again, which stalled his training. With the surgery and his family and friends, however, he once again walked out of the dark and began another pinnacle in his life. *Conclusion:* The victories that the athlete, Cheng Ming-chih has had are built by the discipline, the hard work in training; also, by learning from the strengths and weaknesses from the other athletes. After countless competitions, Cheng Ming-chih not only has a better mindset, a steel-like discipline but also the talent he has in tennis and the calmness from his character, all of this has finally led him to the best performance that brought the victory.

Keywords: wheelchair table tennis, Para Games, difficult journey, qualitative research, semi-structured interviews

1. INTRODUCTION

Paralympic Games, in short, Para. This name is explained that it derives from the Greek preposition, pará, meaning of "beside or alongside", which is a competition that is held in parallel with the Olympic Games. Thus, Paralympic was coined (Ye & Chen, 2013). In 1944, Paralympic was born in Stoke Mandeville Hospital where the spinal cord injury centre was located, in request of the British government. Dr. Ludwig Guttman had helped so many patients who had many mental and physical barriers, that he created a distinctive treatment, playing sports. It enhances the rehabilitations, at the same time, he hoped this could create great impact on many aspects of lives of the people with disabilities. In 1948, the early competitions were held, known as "Stoke Mandeville Games. »The first official Paralympic Games was held in Rome in 1960, another one was held in 1980 in Korea, the competition operation was just like Olympic Games. The numbers of the attendance in countries, individuals in female and males and sport events had significantly increased in Paralympic in Rio in 1960 (Xu, 2009). In 2010, Guangzhou, China hosted the first Asian Para Games, and Taiwan won 8 gold medals that year. Taiwan won 4 gold medals in the 2014 Asian Para Games in Incheon, South Korea. Three years ago, 2016, Taiwan only won 2 silver medals in the Para Games held in Rio de Janeiro, Brazil. From that, it is clear to see the number of the gold medals Taiwan has won has decreased (Liao and Hung, 2017).

To increase the number of wheelchair tennis attendance, the following strategies can help achieve the goal: 1. Promote adaptive sports. 2. Improve the quality of facilities. 3. Host more national tournaments. 4. Promotions supported by government policies. 5. Professional training. (Wang, 2012). The researchers found that there are three phases that those postnatal disabled individuals go through during their post-injured journey: first, they are lost in the adversity, next, they learn about themselves in opportunities, lastly find their true selves in victories. This research is based on the qualitative interview method, which is most widely used in social science research. It is a tool to collect information. The researchers focus on the emotions and feelings of the interviewee, also the person's life and experiences. Through the conversation with the interviewee, the researchers not only gain but truly can understand and explain how the interviewee views the fact of this society. The interviewee of this research is the wheelchair table tennis player from Taiwan, Cheng Ming-chih. His journey from how he got injured, how he fought through the adversity, until he competed in Paralympics, will be the studied in this research. The researchers are excited that the result of this research can be a reference of the development of wheelchair sports in Taiwan, as well as being a great example for those fellow wheelchair athletes.

2. METHODS

2.1. Subjects

The subject of this research is the glory of Taiwan, Cheng Ming-chih, a wheelchair table tennis player. The intention of this research and interview have been understood and agreed upon with a signed contact. With the agreement, the

researchers proceeded with the semi-structure deep interview. The following is the interviewees and their basic information.

Interviewee A	Cheng Ming-chih: Classes 5 male wheelchair table tennis athlete. The followings are the major achievements: - Men's singles, bronze medal in the 2018 World Para Table Tennis Championship - Men's singles, class 5, silver medal in the 2018 Asian Para Games in Jakarta, Indonesia. - Men's team, class 5, bronze medal in the 2018 Asian Para Games in Jakarta, Indonesia. - Men's team, Gold medal in the 2017 World Team Championship in Bratislava, Slovakia. - Men's team, silver medal in the 2016 Rio Paralympics Games. - Men's singles, in IWAS World Games in Sochi, Russia.
Interviewee B	Cheng Ming-Chih's wife
Interviewee C	Cheng Ming-Chih's father
IntervieweeD	Cheng Ming-Chih's coach

2.2. Research tool

After the interviewees agreed to our research, the researchers made sure that the participants/interviewees understood the procedures and the purpose of this study. The transcript of the interview will be made when the interview is over. Textual analysis method will be applied in the transcript to identify, number and categorize, so the researchers can present the useful information of the research. Hence, the researchers use opening coding, axial coding and selective coding in order to conceptualize the procedures, to code gradually, to conclude and analyse the collected data. Finally, the core and the theme of the study will be shown.

2.3. The outline of the interview

I. Starting to play specialized sport:

Please describe how table tennis was introduced to you.

II. Journey of hardship:

A serious accident disabled him, that he could only play wheelchair table tennis. He walked through the pain of the accident, the fact of the untreatable injuries, the physical and emotional acceptance, the transformation and the grind, to finally enjoy the worthwhile victory. Questions:

- Please describe how you felt when you were injured and the recovery.
- How can this process help you/him with your/his lives?
- Have you ever got hurt (physically and emotionally) when you were training for wheelchair table tennis?
- How was the process and how did it affect you/him?

- How did you prepare for the international competitions and how did you interact with other athletes? What kind of impact does table tennis give you in your life? How do you cope with stress?

III. The transformation from Paralympics:

What did the achievements in the Paralympics change you?

2.4. Data analysis

The data analysis done by qualitative interview method by Lin, Yan and Chen (2005) usually needs the researchers to use their theory to be the foundation and categorize the responses of the questions. In this research, the entire interview was voice recorded, the researchers processed the information by making a transcript out of the voice record, then analysed the collected data. After Wu and Li (1995) and her accompanies finished their qualitative interview, before they analysed the data, they had to make sure the transcript was ready and completed. To make a complete transcript, not only the words and sentences but also the emotional responses and the setting of the entire interview should be completely written and conveyed. With the completed transcript, the researchers then can start the process of the data analysis. This research will show the glory of Taiwan, Cheng Ming-Chih's Paralympics journey, and what it takes to be an elite and successful wheelchair table tennis athlete. In this research, Q01 represents "starting to play specialized sport", Q02 represents "journey of hardship", Q03 represents "the transformation from Paralympics". For instance, Q02-01-A-002, it means it's about "journey of hardship", question no.1, the second sentence of Chen, Ming-Chih's response.

The consistency rate of coding this research has three different results. The first time of coding, the consistency rate was 0.88; the second time was 0.92. After three courses of discussion, finally, the last consistency rate was 0.98. Clearly, the consistency in the encoders' results is very high. As of the validity, the researchers had the participants to review the concluded results, the participants considered the analysis has 98% of accuracy. It's obviously that the validity of this research is acknowledged.

3. FINDINGS AND DISCUSSION

3.1. Table 1 is the interview result of this study

Table 1. *The structure of the glory of Taiwan, Chen, Ming-Chih, the elite wheelchair table tennis athlete's Paralympics journey*

Discussion	Theme	Concept
Q1 Starting to play specialized sport	01 Starting to play specialized sport	Since he used to live near the table tennis training centre, plus, he got a lot of encouragement from the table tennis coach in elementary school, he joined the school team, began specializing in table tennis. Before he got injured, he was a national table tennis youth athlete.

(to be continued)

Discussion	Theme	Concept
	02 Injuries and the accident	(1) Due to a serious car accident, from an energetic athlete to being forced to be amputated. The hardship destroyed him. With his father, family and coach's encouragement, he became a wheelchair table tennis athlete. (2) After he got a silver medal in Paralympics in 2016, he had a surgery on his right wrist because of training and competitions.
Q2Journey of hardship	01 Experience he had undergone	The amputation destroyed his faith, table tennis is his last hope of his life that brings him purpose and direction.
	02 Support from special others	(1) When he was injured, his wife and his father gave him most of the support, they stayed and listened to him to walk through the darkest moment of his life. (2) The coach of the national team assisted him to become a wheelchair athlete. He trained his skills and taught him how to cope with his stress. (3) His training partners who he would study strategies by watching videos with.
	03 Important competition experience	There was a table tennis open in Taichung, where he beat at-the-time the best Chinese table tennis athlete in the world. This event gave him immense confidence of his future.
Q3 Paralympics	01 transformation on life	His victory in Paralympics gave him the confidence.
	02 expectations in the future	(1) Be consistent in training, overcome the manipulation of the wheelchair, excited to get good results in the future. (2) Stay calm for every competition in the future, as well as any difficulties in life.

3.2. The transformation from the beginning to the injury

Since Chen, Ming-Chih used to live near the table tennis training centre, plus, he got a lot of encouragement from the table tennis coach in elementary school, he joined the school team, began specializing in table tennis. Before he got injured, he was a national table tennis youth athlete.

"There was a table tennis training centre near my house when I was young. My dad and the coach are good friends, so it opened up the door of my table tennis journey. After all, besides the encouragement of the family, mostly it was because I performed pretty well, I kept training until now." (Q1-01-A-01)

Due to a serious car accident, from an energetic athlete to being forced to be amputated. The hardship destroyed him. With his father, family and coach's encouragement, he became a wheelchair table tennis athlete. After he got a silver medal in Paralympics in 2016, he had a surgery on his right wrist because of overtraining, and he went through another hardship.

"This car accident forced him to be amputated. The hope was gone. I can only stay by his side, walked through it with him…" (Q1-02-C-01)

"Chen, Ming Chih and I, when I was young, are table tennis athletes. A few years ago, he had a car accident, and he was hurt and in coma. When he woke up, the surgery was already done, he couldn't accept the fact of the amputation. He lost hope and wasn't like himself." (Q1-02-D-01)

"During the recovery days, all I can do was accompany. Talk to him, wait for the start of the rehabilitation." (Q1-02-B-04)

3.3. Journey of hardship (experience he had undergone, support from special others, important competition experience)

The amputation destroyed his faith, his father and his wife gave him the best support.

"When I go home, I talk to my wife. She is a table tennis athlete too. She encourages and supports me a lot. When I had setbacks, she was always there. I appreciate her so much. When I was so close to giving up, my father always gave me strength to keep going." (Q2-02-A-03)

"In the 2016 Rio Paralympics, I asked him what I can do before he left. He just wanted me to keep talking to him, listening to him. So that period of time, I didn't miss any calls from him, even with time difference, I wanted him to feel secured…" (Q2-02-B-01)

The coach of the national team assisted him to become a wheelchair athlete. He trained his skills and taught him how to cope with his stress.

"I told him that we have many exceptional standing athletes that supported by crutches. I told him not to lose faith. He used to be elite, and this is the advantage that others don't have. You can be a national disabled athlete, represent your country to compete." (Q2-02-D-02)

His family and friends supported him, they stayed and listened to him to walk through the darkest moment of his life; table tennis is his last hope of his life that brings him purpose and direction.

"I would watch some competition videos with my training partners, we talk about the pros and cons of athletes from different countries. I am glad that table tennis gives me a chance to compete around the world, gives me the meaning of life. At the same time, it encourages some disabled fellows to understand their true value again." (Q2-02-A-02)

"I am so lucky to specialize in table tennis, or else I could probably be a useless person." (Q2-03-A-01)

3.4. The transformation from Paralympics

As long you stay calm to face the future, you can conquer the upcoming challenges.

"When he is stressed, I always tell him that, only those people who don't want to win don't feel stressed. Every athlete can feel stressed. The stress is strength." (Q3-01-C-01)

"The key to win, can be the skill he built when he was young, but the main reason is how well he deals with stress." (Q3-01-C-01)

The victory in Paralympics gave him strength to fight the tough time in life, the consistency of training, overcoming the manipulation of the wheelchair, being excited to perform well in the future.

"You can't have a distracted mind when you play table tennis. He actually stays very calm and steady, he thinks about how to beat the opponent. This is his strength. When he improves on manipulating the wheelchair, strengthening his strength, he will reach to another level!" (Q3-02-CD-01)

4. CONCLUSION

Chen, Ming-Chih, a Taiwanese class 5 wheelchair table tennis athlete, he had an outstanding skill and foundation when he started specializing in table tennis when he was a kid. He used to be in the youth nation team. However, one car accident took his leg away, his life fell apart. With his father's encouragement, he asked his friend who she played table tennis with when he was young, a national table tennis coach for disabled athletes. With the coach's assistance, she trained Chen, Ming-Chih to compete from standing group to wheelchair group, he had his faith back to compete, and got a silver medal in men's team in 2016 Rio Paralympics. Unfortunately, due to overtraining and competitions, he overused his right wrist that he needed a surgery. The obstacle hit his life hard again. And this time, his wife, who is too a table tennis athlete inspired him a lot and gave him the security he needed. His wives accompany played an important part of his recovery journey, that he quickly got back to compete internationally, and earned a silver medal in class 5, men's single, in the 2018 Asian Paralympics in Indonesia.

Shi (2017) Disabled athletes have four potential qualities in life: develop the potential quality in life, recognize the quality of the morals in life, facilitate the excitement of life, realize the education for real human. Chen, Ming-Chi has a very valuable lesson for people to learn from. Although his life is full of hardship, he still fought through it with his levelheadedness to the path of competing in Paralympics.

REFERENCES

Jin-Ding, Lin, J.-D., Yen, C.-F., & Chen, M.H. (2005), Qualitative Research Method: Models and Steps of Interviewing, *Journal of Disability Research*, *3*(2), 122-136.

Liao, W.-R., & Hung, T.-C. (2017), Introduction to Strategy of Development of Wheelchair Tennis in Taiwan. *Sport Research Review*, *140*, 1-8.

Shi, S.-Q. (2017). The expletory role of disabled athletes in expression of life Education. *Journal of National Taiwan Sports University*, *6*(2), 35-46.

Wang, Y.-P. (2012). *Reversal of Victory - Case Study of Participation in Physical Exercises of the Acquired.* Taipei: National Taipei University of Education, Department of Physical Education.

Wu, Z.-Y., & Li, F.-G. (1995). *Quality evaluation and research.* Taipei City: Laurel Books.

Xu, Y.-Q. (2009), History of wheelchair sports, *100 National Games for the Disabled in Taichung.* Retrieved from http://www.tdpsf.org/myweb/2012/taichung_game/disabled_sport.htm

Ye, L.-F., & Chen, W.-C. (2013). A Study of the History of the Paralin Pic Games. *Journal of Sports Health and Leisure*, *9*, 41-53.

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The effects of a table tennis physical education course on the health and wellness profiles of female students

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Abstract: The study was conducted to determine the effects of a service physical education table tennis course on the health and wellness profile of female students even with a limited time. In the study, the participants (n = 16) were made to undergo one semester (34 hours) of an actual table tennis class which is the standard duration of Physical Education courses in the University of the Philippines System. The level of significance was at alpha=0.05. Using descriptive measures, the data revealed that their body fat percentage in the post-test mean = 24.9200 was significantly lower than in their pre-test mean = 26.0667. The pre-test and post-test body fat percentage had a mean difference of 1.1467 with p-value less than 0.05. Their resting metabolic rate had a post-test mean = 1027.6000 which was significantly lower than their pre-test mean = 1137.2000. Their resting metabolic rate mean difference = 109.6000 and p-value less than 0.05. Their body water percentage had a post-test mean = 55.9800 which was significantly higher than their pre-test mean 54.5100. Their body water percentage rate had a mean difference = -1.4700 with p-value less than 0.05. There were no significant differences in the pre-test and post-test mean in the students' visceral fat and physique rating.

Keywords: body fat percentage, body water percentage, resting metabolic rate

1. INTRODUCTION

1.1. Background of the Study

One of the main goals of Republic Act 14 Section 19 of the 1987 Philippine Constitution is to create a healthy citizenry that may eventually help alleviate hypokinetic diseases. Section 1 of the law states that: "The State shall promote physical education and encourage sports programs, league competitions, and amateur sports, including training for international competitions to foster self-discipline, teamwork, and excellence for the development of a healthy and alert citizenry". Republic Act 5708, the school's physical education and sports development act mandates taking Physical Education as a requirement for graduation. The main emphasis of this law is on sports and health development.

The service physical education program in the University of the Philippines System is a specialized program wherein students have a variety of courses to choose from in three major categories, namely sports, dance and recreation. Upon choosing a specific course the students would then undergo a total of thirty-four (34) hours which includes the orientation and lecture as well as the practical part of the course. The total number of hours could either be divided into a one hour twice a week or a two hour once a week class schedule.

There are studies on the health benefits of table tennis such as improving hand to eye coordination, developing mental activity, reflexes and the like (Becic, 2017) There are also studies on the benefits of table tennis on Alzheimer's disease (Zaretsky, 2011) of which further studies on such benefits on this disease are still being continued (Bat Foundation, 2015).

However, the subjects of these studies have spent countless hours of play as compared to the required number of hours of a service physical education course. A typical table tennis physical education course allots the first two hours for class orientation and lecture on the history of the sport, the types of grips, rubbers, dimensions of the table and the court. Thus, the actual number of plays is only thirty-two (32) hours spanning through one semester or the equivalent of four and a half months.

The premise of this study is since only thirty-two (32) hours of actual play is being allotted for one semester, notwithstanding students who even incur absences, there would be no significant effect on their health and wellness profiles. There are also four days interval in between weeks for a Tuesday and Thursday as well as a Wednesday and Friday class schedule.

Moreover, the purpose of the study is to lay the groundwork for physical educators to improvise with whatever limited resources are available such as limited tables and playing venues to achieve a well-rounded basic table tennis program. Students should have improvement not only in their basic skills but also in their health and wellness in a well-rounded basic table tennis course.

Statement of the problem

The study aimed to determine the health and wellness profiles of female students specifically in the following categories:

a. Body Fat Percentage
b. Resting Metabolic Rate
c. Body Water Percentage
d. Visceral Fat
e. Physique Rating

The following null hypotheses presented in this study were

H1 - Pre-test in Body Fat% is the same as the Post-test in Body Fat Percentage
H2 - Pre-test in Resting Metabolic Rate is the same as the Post-test in Resting Metabolic Rate
H3 - Pre-test in Body Water Percentage is the same as the Post-test in Body Water Percentage
H4 - Pre-test in Visceral Fat is the same as the Post-test in Visceral Fat
H5 - Pre-test in Physique Rating is the same as the Post-test in Physique Rating

1.2. Significance of the Study

Since one of the main goals of the law on physical education is also to create a healthy citizenry, it is important to determine that it is not only be the students'

skills that would have improved but also their health and wellness parameters. It is understood that students who enrolled in the sports courses shall have at least gained an acceptable degree of proficiency in terms of skills by the end of the semester. Studies have shown that students were able to gain skills even with less practice time of one (1) hour a day for a five (5) day period (Florendo, F. et al pg. 4, 2007) (Flores A. et. al 102, 2010).

This study aimed to determine the effects of a service physical education course on the health and wellness profiles of students in their (a). body fat percentage, (b). resting metabolic rate, (c). body water percentage, (d) visceral fat and (e)physique rating even with a limited time

1.3. Scope and Limitation of the Study

This study was confined to students enrolled in Physical Education 2 Basic Table Tennis Section E Women 7:30 – 8:30 am every Tuesdays and Thursdays. The reason for confining the subjects to female only is that several male students also indulge in other sporting activities such as playing basketball during their free time while others also avail of the fitness facilities in the school such as the weights and combative room. Male students who have vices such as smoking and drinking alcohol may also adversely affect the results of the study.

Definition of terms

a. Body fat percentage – The percentage of body weight that is composed of fat (Hayward, 1998)
b. Resting metabolic rate - The amount of energy or number of calories that the body carry out processes such as blood circulation, cell growth and repair, hormonal adjustment and breathing while the body is at rest (Plowman & Smith, 2001)
c. Body water percentage – The total amount of fluid in the human body. (Grodner, et al., 2012)
d. Visceral Fat – A type of fat stored within the abdominal cavity. It is located in several vital organs including the liver, stomach and intestines. (Shuster et. al., 2007)
e. Physique Rating – Assessment of muscle and fat levels. (Tanita Academy, 2015)

2. METHODOLOGY

2.1. Subjects

The subjects were female (n= 16) UP Baguio students enrolled through the University of the Philippines Computerized Registration System (CRS). Only female students were chosen since several male students indulge in other sporting or physical activities which may adversely affect the results of the study.

2.2. Instrument

The Tanita BC148 Scale was used as the instrument in the conduct of the study. The Tanita BC148 Scales's validity and reliability has been concluded to be a reliable method for assessing body composition (Kelly and Metcalf, 2012). It is a non-evasive

assessment instrument that requires minimal operator training. In the present study, the researcher availed of the expertise of a certified wellness coach who has an eight (8) year experience in using the Tanita scale. The wellness coach's service was enlisted so as to alleviate the margin of error in the procedure of conducting the test.

The BC Tanita 418 scale was used for assessing the students' health and wellness parameters in five categories namely: body fat percentage, resting metabolic rate, body water percentage, visceral fat and physique rating.

Fig. 1. Tanita scale

2.3. Procedure

The students were briefed on the purpose of the study. A review on the benefits of a healthy lifestyle through sound nutrition was also conducted. The students had already completed the required lecture type of physical education course (PE1 Foundations of Physical Fitness) during previous semesters prior to enrolling in the physical education table tennis course. A topic on nutrition and wellness are a major component of this lecture course. However, no interventions in the student's diet in whatsoever form was administered throughout the duration of the study. It was their sole discretion as to whether they were to live a healthy lifestyle or not.

The students stood bare foot on the Tanita scale for approximately three (3) minutes each until the reading of their data has been established. A computation was done based on the data gathered.

The following protocols (Hayward, 1998) were implemented during the pre-test and post-test phase of the study:

1. No eating or drinking within four (4) hours of the test
2. No exercise within twelve (12) hours of the test
3. Urinate within thirty (30) minutes of the test
4. No Alcohol consumption within forty eight (48) hours of the test.
5. No diuretic medications within seven (7) days of the test

*6. No testing of the female subjects who perceive they are retaining water during the stage of their menstrual cycle.

*There were no subjects who had their menstrual period at the time they were tested.

2.4. Class Sessions

Twenty (20) meetings of the class sessions were mostly derived from the International Table Tennis Federation's Level 1 Manual (Tepper, 2001). The objective

in adopting the ITTF's level 1 activities is for the students to have fun while learning the skills. A round robin type of tournament in singles and doubles was implemented for the remaining twelve (12) meetings towards the end of the semester. The standard forty-millimetre (40 mm) cell free ball was used for the singles part of the tournament. The students had no experienced playing with the old celluloid ball being novice players. Thus, there were no effects of the ball changes from celluloid to plastic in the laws of the game. A total of eight (8) meetings were allotted to singles play whilst four (4) meetings were utilized for doubles play.

The forty-four (44) millimetre ball was used in doubles play so as to increase the rallies since the objective at this stage of the semester was for the students to be fit rather than skilled. Being total beginners, the students had still to develop power and speed after only twenty (20) sessions of practice. Control was also the focal point rather than speed and power in the teaching methodology for beginners (Tepper, 2001). It could be observed that the rallies were longer in doubles play than in singles play which is the opposite for top level competitions.

A study on the use of the forty-four-millimetre ball has concluded that it is the optimal ball for television spectators due to its longer rally length. (University physics competition). Using the forty-four millimetre (44 mm) ball was both more strenuous and fun for the students.

The number of calories burned by using this type of ball has been presumed to be more due to more rallies in the game. A typical doubles pair burns approximately more than two (2) hundred calories as compared to using the standard forty-millimetre (40mm) cell free ball when using the Mio Drive Heart Rate watch. However, the mio heart rate watch has been concluded to accurately measure heart rates but not calories burned (Standford Medicine, 2017). Thus, only presumptions could be provided that novice players burned more calories in doubles play using the forty-four millimetre (44mm) ball.

2.5. Data Analysis

Data was analysed using one-tailed-t-test to determine significant changes in the post-test and retention-test in the five categories: body fat percentage, body water percentage, resting metabolic rate, visceral fat and physique rating. The level of significance was at P = .05.

3. RESULTS

Table 1. *Body fat percentage scores*

	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Value	P-value
Body fat %	26.0667 (5.9306)	24.9200 (5.9658)	1.1467	0.0007*

**The difference is significant at alpha = 0.05 level of significance*

Table 1 shows a significant difference in the mean scores between the pre-test and the post-test in the student's body fat percentage. The findings suggest that playing table tennis for one semester contributed to lowering their body fat

percentage. However, both mean in the pre-test and post-test were still within the average range for their age bracket (18- 20) according to the Jackson and Pollock body fat percentage chart. Playing for only two (2) hours twice a week was not sufficient as to conclude that the students became healthier even if they had improvements in their body fat percentage.

Table 2. *Resting Metabolic Rate percentage*

	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Value	P-value
RMR %	1137.2000 (110.2427)	1027.6000 (126.5463)	109.6000	0.0000*

**The difference is significant at alpha = 0.05 level of significance*

Table 2 shows a significant difference in the mean scores between pre-test and the post-test in the students resting metabolic rate. The lower resting metabolic rate may be due to the decrease in weight of the students and muscle mass. A lower resting metabolic rate means that the students burned less calories compared to when they started playing table tennis. They only played at an average of two (2) hours a week with a four (4) day interval between weeks. The subjects' hormones being females may also have adversely affected their resting metabolic rate. However, more concrete scientific based evidence is needed to validate this theory. Only four (4) of the sixteen (16) students had a complete attendance throughout the semester. Two (2) students almost incurred the maximum absences whilst the rest had an average of three (3) absences each.

Table 3. *Body Water Percentage*

	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Value	P-value
Body H_20 %	54.5100 (3.9506)	55.9800 (3.9263)	-1.4700	0.0001*

**The difference is significant at alpha = 0.05 level of significance*

Table 3 shows a significant difference in the mean scores between pre-test and the post-test in the student's body water percentage. The students had increased body water after the completion of the basic table tennis course. The increase body water was still within the healthy standards of fifty to sixty percent for adult women (Goodner et al., 2012). Their body water percentage is also within the optimal body water percentage range of fifty-eight (58) to fifty-two (52%) percent congruent to their body fat percentage of twenty-one (21) to twenty nine (29 %) percent (Wang, et al., 1999)

Table 4. *Visceral fat percentage*

	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Value	P-value
Visceral fat %	2.8667 (2.8251)	2.6000 (2.2928)	0.2667	0.0519

**The difference is significant at alpha = 0.05 level of significance*

Table 4 shows that there were no significant differences in the students' visceral fat percentage. Visceral fat response well to regular endurance exercises (Ross, R 1997) However, the two hours twice a week schedule is way below the recommended thirty (30) to sixty (60) minutes per day of exercise for effective results.

Table 5. *Physique rating percentage*

	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Value	P-value
Physique raiting %	4.4000 (1.4541)	4.7333 (1.7512)	-0.3333	0.1327

**The difference is significant at alpha = 0.05 level of significance*

Table 5 shows that there was no significant difference in the students' physique rating. The subjects were regular non-athletes who only played for duration of two (2) hours a week with a four-day interval between weekly sessions. The need for strength training for the same duration of two (2) hours a week is needed to alter their physique rating (American College of Sports Medicine, 2019).

4. DISCUSSION

The Philippine government created laws with the intent of creating a healthy citizenry. Students who have undergone the mandatory Physical Education requirements should have at least gained a notable proficiency in their chosen course whether it is in sports, dance or recreation. They should at least also have improvements in their health and wellness parameters should the overall objective of the law be considered.

The inclusion of a basic table tennis course as part of a physical education curriculum is in line with the main objectives of the mandatory law. Compared to other institutions; the University of the Philippines System implements a specialized physical education program wherein students who enrolled in their chosen course would undergo the course for one semester. Such as in the course table tennis, the student would take the course for one semester. Other institutions implement a different system such as dividing courses into groups. A typical physical education course then contains four (4) sports (badminton, table tennis, arnis and taekwondo) to be taken in one semester. There are no specializations in these schools and so far, no studies had been conducted to determine on how their students had fared in terms of skills as well as in their health and wellness parameters.

Thus, student transferees from other institution need to take the University of the Philippines System's Physical Education Proficiency Examination wherein they would choose a certain sport where they perceived they have excelled. For example, in table tennis, the transferee should need to pass both the written and practical examination in table tennis in order to be exempted from the taking the course again.

The study aimed to determine that there were no significant differences in the students' health and wellness profiles in five parameters given a limited time. The result shows that the students had improvements in their body fat percentage as

well as their body water percentage but had lower resting metabolic rate. There were no significant differences in their visceral fat percentage and physique rating.

Even with a limited time, the students were still able to have improvements in their body fat percentage. However, the findings were not sufficient as to conclude that they became healthier. Their pre-test body fat percentage (26. 0667) and their post-test body fat percentage (24. 9200) were still within the average body fat percentage for their age group category (18-20) according to the industry standard, Jackson and Pollock Body Fat Percentage Chart. The chart places an ideal body fat percentage of nineteen (19) to twenty-three (23%) percentage for their gender and age bracket.

The decrease in the students' resting metabolic rate shows that the limited time and the interval between weeks had an adverse effect on this parameter. They burned fewer calories when they started playing as compared to before they enrolled. The university policy on the number of absences incurred is twenty percent (20%) of their total number of hours or a total of six (6) absences before being dropped from the course. Only four (4) of the sixteen (16) subjects had a complete attendance. Two (2) students almost incurred the maximum number of absences for dropping having incurred five (5) absences each. These two (2) students also had an increased in body fat as well as decreased body water. The rest of those who participated in the study had an average of three (3) absences each.

Both the pre-test and post-test body water percentage of the students was within the forty-five to sixty percent (50% - 60%) range of health standards (Goodner et. al 2012). Thus, the data revealed that although there was a significant difference in between the post-test and the pre-test, both pre- and post-test were already in the recommended range of health standards.

There were no significant differences in their visceral fat percentage. The two (2) hours per week class schedule was not sufficient as to have any effect on the students' visceral fat (Ross, 1997). The nonintervention with regards to the students' diet had also contributed to the non-improvements on this health parameter (Ross et. al., 1999)

The need for strength training exercises for the same amount of time was evident in the study. (American College of Sports Medicine, 2019). There were no significant differences in their physique rating.

5. RECOMMENDATIONS

The leading world health organization's differ on the number of recommended duration of physical activity for health promotion and prevention per day (Fahey et. al., 2007). The World Health Organization (WHO) recommends sixty minutes of physical activity per day whilst the American Diabetes Association and the American Heart Association among others recommend at least thirty (30) minutes of moderate physical activity per day. Based on the recommendations of these leading health organizations, it is evident that the two (2) hours required number of physical educations per week is not sufficient to address the student's health and wellness parameters.

The University of the Philippines Baguio provides sufficient facilities for the student's physical education needs. Each pair of students had one (1) table to play and each student was provided with one standard racket. The improvements could also be attributed to these aspects. As for other institutions without sufficient facilities it is already evident that an increase in the number of required physical education hours would not be attainable since it would need another law to implement such. The need to modify even for schools with sufficient facilities is highly recommended to attain the goal of creating a healthy citizenry. The physical educators would then need to encourage students to indulge in lifestyle changes. No amount of exercise or playing could compensate for a well-rounded approach to health and wellness. In the present study, the students were still able to decrease their body fat percentage and increase their body water percentage even with a limited time. Playing table tennis as part of a healthy lifestyle that includes nutrition is most highly recommended. There were no interventions in the students' diet and still they were able to have improvements in their health and wellness parameters. This could also be due to the students' awareness on nutrition even before they enrolled. The lecture on a healthy lifestyle and nutrition was only a review at the start of the semester. Other institutions outside of the University of the Philippines system may also try to adapt the required physical course that includes nutrition and wellness as a major component. A variety of topics ranging from mental to physical health are also discussed in this course.

Further studies on how a limited playing time of only two (2) hours a week with four days a week interval should also be conducted. The results of this study showed that the lack of time as well as the four (4) day interval between weeks adversely affected their resting metabolic rate.

REFERENCES

American College of Sports Medicine (2019). Retrieved from *https://www.acsm.org/*

Bat Foundation (2019). Retrieved from https:*//vimeo.com/user46779258*

Besic, S. (2019). Top 10 Health Benefits of Ping Pong/Table Tennis. Retrieved from *http://www.healthfitnessrevolution.com/top-10-health-benefits-ping-pongtable-tennis/*

Fahey, T., Insel, P., & Roth, W. (2007). *Summary of Physical Activity Recommendations from Selected Leading Health Organization Fir and Well Core Concepts and Labs in Physical Fitness and Wellness.* New York: Mcgraw-Hill College

Florendo, P.F., & Bercades, T.D. (2007). The effectiveness of shadow practice in learning the standard forehand drive. In M. Kondrič, & G. Furjan Mandić (Eds.), *Proceedings book of The 10th Anniversary ITTF Sports Science Congress* (pp. 342 - 349). Zagreb: University of Zagreb, Faculty of kinesiology; Croatian Table Tennis Association; International Table Tennis Federation.

Flores, A., Bercades, D., & Florendo, F. (2010). The effectiveness of shadow practice in learning the table tennis standard backhand drive. *International Journal of Table Tennis Sciences, 6,* 105-110.

Grodner, M., & Stum, S. (2012). *Nutritional foundations and clinical Applications*. E

books.

Heyward, V.H. (1997). *Advanced Fitness Assessment and Exercise Prescription*. 3rd.ed. Champaign: Human Kinetics.

Jackson, A.S., & Pollock, M.L. (1985). Practical assessment of body composition. *Physician and Sports Medicine, 13*, 76-90.

Kelly, J., & Metcalfe, J. (2012). Validity and reliability of body composition analysis using the Tanita BC 418-MA' *Journal of Exercise Physiology, 15*(6), 74-83.

Plowman, S., & Smith, D. (2003). *Exercise Physiology for Health, Fitness and Performance. Body composition and weight control*. (pp. 244-254). Illinois: Pearson.

Ross, R. (1997). Effects of diet and exercise induced weight loss on visceral adipose tissue in men and women. *Sports Medicine, 24*(1), 55-64.

Ross, R., & Janssen, I. (1999). Is abdominal fat preferentially reduced to exercise induced weight loss. *Medicine and Science in Sports and Exercise, 31*(11), 568 - 572.

Stanford Medicine *https://med.stanford.edu/news/all-news/2017/05/fitness-trackers-accurately-measure-heart-rate-but-not-calories-burned.html*

Tepper, G. (Ed). 2003). ITTF Level 1 Manual. Lausanne: ITTF.

Wang, Z., & Duerenberg, P. (1999). Hydration of fat free body mass. *American Journal of Clinical Nutrition, 69*(5), 833-841.

Zatretsky, G. (2011). *Table Tennis Therapy*. Retrieved from *https://widerimage.reuters.com/story/table-tennis-therapy*

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Factors influencing learning outcome - application of decision tree algorithm

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Abstract: The purpose of this study is to address the important factors of learning outcome in table-tennis courses. Classification and regression tree (CART) were employed to evaluate the data. Decision trees are a non-parametric supervised learning method used for classification and as a predictive tool. It is to model a series of events and look at how it affects an outcome. It can also provide information for decision makers in the decision-making process. The following factors were identified: teaching attitude, teaching material, teaching method, grading scheme and class management. Participants were 196 Table Tennis course students (82 male, 114 female). The data obtained from the survey were then analysed by using SPSS Modeler which is statistical analysis software used for data analysis, data mining and forecasting. The findings of this study demonstrate that grading scheme was the most important factor that impact student learning outcomes.

Keywords: classification, table tennis, CART

1. INTRODUCTION

In the past two decades, the global education situation has undergone rapid changes, and the new competitive era of liberty, openness, transparency, rapid change, and complex and diverse values has taken shape (McMahon, 2018). This development trend has seriously affected the direction of domestic education reform. The principle of loosening is the biggest change in the education policy to adjust the school's mode of operation. Moreover, with the rapid changes in the social environment, the school faces the challenges of external environment, and the demands of the public for providing quality and excellent education to the school are increasing, and the pressure and challenges brought to the school are difficult (McEvoy, MacPhail, & Heikinaro-Johansson, 2015). In fact, the purpose of school education is not only to help students achieve academic achievement, but also to help students prepare for a fulfilling life (Forey & Cheung, 2019). Therefore, today's school physical education should have the learning about adding value to students, and enhance students' potential by enhancing students' thinking ability, knowledge, skills and socialized sports education process.

The purpose of physical education is to make students successful, rather than to cultivate an elite person. However, most of today's physical education is a teacher-cantered "traditional teaching method" (Dina & Dina, 2014). It advocates sports skills as the main axis, and focuses on the physical fitness of students, but ignores the importance of students' emotional experience, independent thinking and problem-solving ability. Innovation teaching method of physical education is not only the advocacy of the concept, but also the practice of action (Ganciu & Ganciu, 2014). It

must be guided by the correct concept and implemented in the actual physical environment of the school to make the school physical education more performance and characteristics. Therefore, it is necessary to develop high-quality school physical education curriculum, to create a positive physical education environment, to inspire the outstanding performance of physical education teachers, to apply methods and processes of evaluation, to analyse and explain teaching and learning results, and to achieve results that are consistent with performance.

The content of the physical education curriculum should be combined with the needs of the students' actual life (Kwon & Block, 2017). This is also the development of everyone's pursuit of the content of the physical education curriculum. This concept is very important; it is also an attempted trend. Since the emphasis on physical education curriculum, the goal should be to strengthen the students' ability to adapt to their own living environment, so that students can adapt to different environments as soon as possible. The arrangement of physical education curriculum should be strengthened on the basis of life and the learning content should emphasize the learning of the basic abilities, skills and life attitudes of students' daily life. This is the element of the physical education curriculum to enter the life, so it will be able to achieve the ideal goal of lifelong sports (Ganciu & Ganciu, 2014). In order to explore the effectiveness of physical education, this study analyses the evaluation of physical education curriculum. At present, the results of teacher assessment are generally calculated using descriptive statistics. However, this method can only obtain the total score and cannot be further analysed for individual items. Therefore, this study attempts to use the decision tree analysis method to find out the teacher teaching context that has an impact on the students' learning outcomes, so as to provide suggestions for follow-up teaching improvement programs.

2. METHODS

2.1. Participants

The sampling was conducted from 196 students who were taking the physical education of table tennis class in the university. 41.8% and 58.2% of participants were male and female, respectively. The ages were raging between 18-20 years old and most of the participants were 20 years old (47.1%). The participants studied in college of Living Technology, Management, Design, Arts and Tourism were 22.1%, 17.8%, 19.9%, 21.4% and 18.8%, respectively. The sampling number was roughly the same proportion in each college.

2.2. Measurements

The empirical research was specifically conducted on a table-tennis course of a university. The questionnaire was used to ask the students to evaluate the teaching content of teacher as the independent variables which included the dimension of "teaching attitude", " teaching material ", "teaching method", " grading scheme " and "class management". An individual self-evaluation of learning performance was as dependent variables which evaluated on the 5-point scale for the degree of consent of the questions (1 = very disagree; 5 = very agree).

2.3. Decision Tree Analysis

A decision tree usually consists of nodes and directed edges. The nodes include root nodes, internal nodes, and leaf nodes. The root nodes and internal nodes represent a feature or attribute, while the leaf nodes represent a specific classification (Chen & Hung, 2010; Tayefi et al., 2017).

3. RESULTS

This study uses the decision tree CART algorithm analysis (Figure 1) through the sample of 196 students in a table tennis course, with a total of five dimensions of "teaching attitude", "teaching material", "teaching method", "grading scheme" and "class management" as independent variables, and "student self-evaluation learning performance" as the target variable. The number of classification model nodes is 9, and the depth is 3. The mean score of students' self-evaluation of learning performance is 3.77. According to the mean score, learning performance of students' self-evaluation, which above the mean would be decided into "good" outcomes.

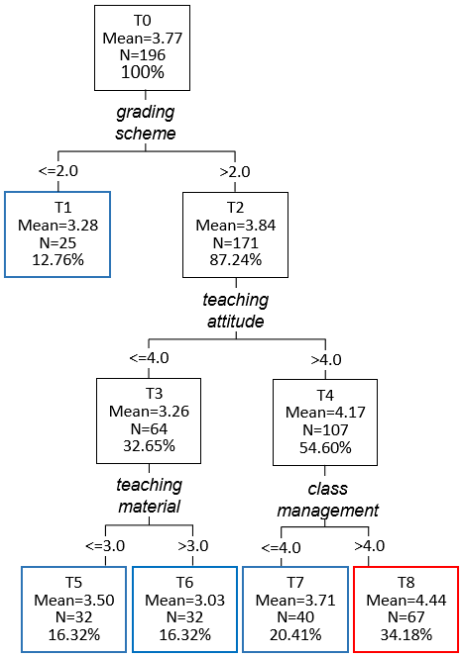

Fig. 1. Result of decision tree.

4. CONCLUSION

According to our research results, the present study provided an empirical evaluation to find the factors affecting students' self-evaluation which including "grading scheme", "teaching attitude", "teaching material", "class management" and "teaching method". The most important factor is "grading scheme". When the

students' recognition of this factor is low, the self-evaluation learning performance is poor. Students with better learning performance, however, "grading scheme", "teaching attitude", and "class management" would be the key attributions. Teachers who engaged in well teaching effective could pay more focus on these factors.

REFERENCES

Chen, Y.-J., & Hung, Y.-C. (2010). Using real-time acceleration data for exercise movement training with a decision tree approach. *Expert Systems with Applications, 37*(12), 7552-7556. doi:https://doi.org/10.1016/j.eswa.2010.04.089

Dina, G., & Dina, L. (2014). Direct Communication in Physical Education Classes. *Procedia - Social and Behavioral Sciences, 117*, 136-142. doi:https://doi.org/10.1016/j.sbspro.2014.02.191

Forey, G., & Cheung, L.M.E. (2019). The benefits of explicit teaching of language for curriculum learning in the physical education classroom. *English for Specific Purposes, 54*, 91-109. doi:https://doi.org/10.1016/j.esp.2019.01.001

Ganciu, M., & Ganciu, O.-M. (2014). Arguments on the Formative Function of Physical Education Deadlock Higher Education. *Procedia - Social and Behavioral Sciences, 163*, 115-119. doi:https://doi.org/10.1016/j.sbspro.2014.12.295

Kwon, E.H., & Block, M.E. (2017). Implementing the adapted physical education E-learning program into physical education teacher education program. *Research in Developmental Disabilities, 69*, 18-29. doi:https://doi.org/10.1016/j.ridd.2017.07.001

McEvoy, E., MacPhail, A., & Heikinaro-Johansson, P. (2015). Physical education teacher educators: A 25-year scoping review of literature. *Teaching and Teacher Education, 51*, 162-181. doi:https://doi.org/10.1016/j.tate.2015.07.005

McMahon, W.W. (2018). The total return to higher education: Is there underinvestment for economic growth and development? *The Quarterly Review of Economics and Finance, 70*, 90-111. doi:https://doi.org/10.1016/j.qref.2018.05.005

Tayefi, M., Esmaeili, H., Saberi Karimian, M., Amirabadi Zadeh, A., Ebrahimi, M., Safarian, M., . . . Ghayour-Mobarhan, M. (2017). The application of a decision tree to establish the parameters associated with hypertension. *Computer Methods and Programs in Biomedicine, 139*, 83-91. doi:https://doi.org/10.1016/j.cmpb.2016.10.020

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A study of the effect of table tennis ball change for the secondary school table tennis players in Kaohsiung City

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Abstract: The purpose of the study was to investigate the effect of changing table tennis ball material for the secondary school table tennis players in Kaohsiung City and the differences in sports training of different table tennis players' background variable. The survey was conducted personally by the researcher, and valid samples of the survey consisted of 197 secondary school table tennis players in Kaohsiung City in 2017.The researcher adopted survey method, and the data were analysed by descriptive statistics, one-way ANOVA, and Pearson correlation. The statistical result revealed that the effect of table tennis ball change: (1) the influence level of "Physical Fitness" was the highest; (2) "Skill", "Physical Fitness" and "Tactics" showed positive correlation. In conclusion, the researcher suggests that: (1) The table tennis coaches need to realize the characters of plastic 40+ table tennis ball and bring professional training model into practice; (2) The table tennis coaches need to consider the individual differences of table tennis players and strengthen the training of stamina and rally.

Keywords: plastic 40+ table tennis ball, table tennis training, table tennis skill, table tennis stamina, table tennis tactics

1. INTRODUCTION

Since the development of table tennis from 2005, equipment reform, rule innovation, and technological evolution has been the three major factors driving table tennis. The reform of table tennis rules has three major parts. One is the increase of sphere, another is the change of scoring methods, and the other is the limitation of no-hiding serve (Chen & Tseng, 2005).

In the change of material, because the material is Celluloid, which is flammable, so the International Table Tennis Federation (ITTF) formally changed the material from Celluloid to the plastic. The entire production, transportation, and storage become safer (Lee, 2015).

After changing to 40+ plastic ball, the ball size increased from 40mm to about 40.2mm. The ball is enlarged, the speed becomes slower and the spin becomes weaker, and the chance of let serve also slightly increases (Yao, 2014).

But for the players, it is easier to see the trajectory of the ball clearly, and the number of sustained rally balls in the game has also increased. The plastic ball loses more energy during the running process, and the less energy the player can borrow from the ball. Therefore, the 40+ plastic ball emphasizes the active energy from the player, otherwise it will be more likely to cause his own faults (Bang, 2015).

Due to the change of the table tennis "ball", the players will have obvious feeling change whether on the hitting or receiving either in the training or in the game compared to the past. How to adapt the impact of the reform is a main issue for both the players and coaches to arrange appropriate training plan in technics, fitness and tactics.

It can be seen from the above that the change of the table tennis "ball" has a significant impact on the overall technics, fitness and tactics training.

Therefore, it is necessary to understand the influences of the players' overall athletic performance on the table tennis "ball" change. Hence, we could understand how to improve the training system and promote the athletes' performance in the game.

2. RESEARCH PURPOSES

(1) To investigate the current situation of the impact after changing table tennis ball material for the secondary school table tennis players in Kaohsiung City in Skill, physical and tactical level.

(2) To explore the correlation of the impact of Skill, physical and tactical influences after changing table tennis ball material for the secondary school table tennis players in Kaohsiung City

3. RESEARCH METHODLOGY

3.1. Participants

The survey was conducted personally by the researcher, and valid samples of the survey consisted of 197 secondary school table tennis players in Kaohsiung City in 2017, including 128 male players (65%), and 69 female players (35%).

3. 2. Instrument

3.2.1. Questionnaire Scoring

In this study, the questionnaire was compiled based on the research topic. The researcher's used self-edited "The impact of 40+ plastic ball to secondary school table tennis players in Kaohsiung City questionnaire" to investigate the impact of 40+ plastic balls on training methods. The questionnaire contained three levels, including "Skill Training", "Physical Fitness Training" and "Tactics Training" at a total of 30 items. It applied Likert five points Scale for scoring which was "strongly disagree", "disagree", "neutral," "agree," and "strongly agree" and each option was given from 1 to 5 points. The participants circle the option which they agree or not. The whole questionnaire was positive scoring, the higher the score is, the higher the impact on the training is. Conversely, the lower the score is, the lower the impact on the training is.

3.2.2. Pre-test Analysis

After completing the first draft of the questionnaire, the researcher invited three experts in table tennis field to review and modify the questionnaire. Then the researcher integrated the views of experts as amended and established an expert validity of this study. The pre-test sample adopted 67 junior high school table tennis players from three different junior high schools in Tainan City. The pre-test

questionnaire samples will not be included in final research questionnaire. There are 4 background questions, and 10 items on each "Skill Training", "Physical Fitness Training" and "Tactics Training" level.

3.2.3. Item Analysis

In this study, the comparisons of extreme groups and correlation analysis method were used to analyse the pre-test questionnaire. The Comparisons of Extreme Groups Method is the evaluation indicator of the Likert scale. The main purpose was to calculate the critical value of the individual items of the questionnaire (critical ration, CR value). The researcher removed items which doesn't reach the significant level base on the item analysis. Researchers generally remain items which CR is greater than 3.0, remove items which CR less than 3.0.

The correlation analysis calculates the degree of correlation between each item and the whole scale. If the correlation coefficient is low, it means that the item cannot represent the participant's real response, so that the researcher will remove it. The correlation coefficient between each item and the total scale must be above 0.40, and the significant level must be 0.05. (Wu & Tu, 2005). The results of the pre-test item analysis are shown in Table 2. All of 30 items achieve significant level, except for item 7's CR and correlation coefficient doesn't. Other 29 items' CR achieved significant level ($p < .05$), and correlation coefficient all > 3.0, so the item 7 of Skill Training level should be deleted, and the other 29 items remained.

3.2.4. Factor Analysis

After the item analysis is completed, the researcher conducted the factor analysis of the questionnaire. The factor loading of item1, 2, 5, 6 of Skill Training Level, item 8 of Physical Fitness Training Level and item 7, 8 of Tactics Training Level were under .03, so that those should be deleted. After deleting unsuitable items and then the researcher obtained the KMO value = .816, indicating that the correlation is high, the factor analysis can be performed. Known from Table 3, there were 3 factors in the questionnaire. Factor 1 explained a variance of 22.410%, and factor loading was between .777 - .318, factor 2 explained a variance of 16.783%, and factor loading was between .803 - .603, and factor 3 explained a variance of 14.44%, and factor loading was between .712 - .348.

3.2.5. Reliability Analysis

When the ratio of the measurement error in the questionnaire decreases, the reliability increases. The common reliability coefficient value is mostly between 0 and 1. So when the reliability coefficient is closer to 1, the higher the reliability is. Conversely, the reliability coefficient is closer to 0, the lower the reliability is. Wu and Tu (2005) also suggested that the higher the Cronbach'α coefficient is, the more stable of the scale and the higher internal consistency is. In the reliability coefficient of the whole questionnaire, the Cronbach' α coefficient is suggested to be better than .07, acceptable at .06. In addition, the coefficient α of the whole questionnaire is preferred to be above .80, and even better to be over.90.

As shown in Table 4, the internal consistency α showed that the reliability of the whole questionnaire is .920, and the reliability of each level were Skill Training .761, Physical Fitness Training .907, and Tactics Training .823. It can be seen that the internal consistency of the whole questionnaire was good.

4. DATA PROCESSING AND ANALYSIS

4.1. Descriptive Statistics Analysis

This study used frequency distribution and percentages to understand the basic data of the participants and analysed mean score and standard deviation of the "Skill Training", "Physical Fitness Training" and "Tactics Training" levels.

4.2. Pearson Product-Moment Correlation Coefficient

This study used Pearson Product-Moment Correlation Coefficient to understand the correlation between "Skill Training", "Physical Fitness Training" and "Tactics Training" levels for the Secondary School Table Tennis Players in Kaohsiung City.

5. FINDINGS AND DISCUSSIONS

5.1. The 40+ Plastic Ball for the Secondary School Table Tennis Players in Kaohsiung City

Table 1 indicated that the mean score of the whole questionnaire was 3.97, and the standard deviation I was .82. This showed that the overall situation of the effect of changing table tennis ball material for the secondary school table tennis players in Kaohsiung City was close to "agree". This study was divided into three factors: "Skill Training Level", "Physical Fitness Training Level" and "Tactics Training Level".

At each level, the highest score was Physical Fitness Training Level at 3.99, the second was Tactics Training Level, and then was Skill Training Level.

On the average, three factors' score were close to the agree level, but the average of the Physical Fitness Training Level was 3.99, indicating that most participants were close to agree. It represented 40+. Plastic balls indeed caused an impact on Physical Fitness Training. Therefore, this study infers that after using 40+ plastic balls, the table tennis players pay more and more attention to the changes in sports training, so that they can adapt to the 40+ plastic balls.

The results of this study showed that the impact of ball changes on table tennis training average was 3.97, which was close to the level of agree. This means that the change of 40+ plastic balls was influential for most table tennis players on training.

This result was consistent with the results of several researchers (Gao, Zhu, & Shi, 2016; Liu, 2017; Liang, 2017). After using 40+ plastic balls, it had a considerable impact on Physical Fitness Training. Due to the score of Physical Fitness Training Level was high; it showed that the table tennis players were more concerned about the strengthening and changing on Physical Fitness Training. This result was corresponded with some studies (Zhang 2017; Gong, 2017; Yang, 2016)

In this study, the highest score was the item 14, "Must improve agility of lower limb." and the item 7, "Must improve power training of upper limb.", both were above 4 points. Hence, table tennis players deeply focus on the training on the agility of lower limb and the power of upper limb. This showed that there has to be a good physical fitness to improve the skill level.

In addition, the mean score of the item 4, "Must improve the sustained rally ball technique." and the item 20, "Must improve active attacking technique in rally." were also above 4 points. This means that the training of rally ball is also a very important part. The results of this study were consistent with the studies proposed

by past researchers (Huang, 2017). It can be seen that "Skill Training", "Physical Fitness Training" and "Tactics Training" are indispensable for today's table tennis training.

Table 1. *Impact of 40+ Plastic Ball on the Table Tennis Training Questionnaire Factor Mean Score and Standard Deviation Summary*

Item	MEAN	SD
Skill Training Level		
1. Must improve footwork agility.	3.86	.85
2. Must improve the spin when hitting the ball.	4.08	.77
3. Must improve moving speed.	3.89	.86
4. Must improve the sustained rally ball technique.	4.11	.80
5. Must advance the time of hitting point.	3.63	.87
	3.91	.83
Physical Fitness Training Level		
6. Must improve muscular endurance of waist.	3.88	.81
7. Must improve power training of upper limb.	4.07	.77
8. Must improve muscular endurance of upper limb.	3.98	.81
9. Must improve cardiovascular fitness training.	3.82	.85
10. Must improve power training of lower limb.	4.02	.80
11. Must improve muscular strength of upper limb.	4.02	.76
12. Must improve muscular endurance of lower limb.	4.02	.80
13. Must improve muscular strength of waist.	3.98	.78
14. Must improve agility of lower limb.	4.12	.76
	3.99	.79
Tactics Training Level		
15. Must improve top spin technique after receiving ball.	4.03	.84
16. Must improve middle long range rally loop technique after standing back the table.	3.86	.90
17. Must improve rally ball direction technique.	3.94	.79
18. Must improve early attacking technique after knuckle service.	3.95	.86
19. Must improve first attack technique after serving a long ball.	3.95	.77
20. Must improve active attacking technique in rally.	4.10	.82
21. Must improve first attacking technique after receiving service.	3.98	.87
22. Must improve rally ball attacking technique after the 5^{th} and 6^{th} ball.	4.01	.87
	3.98	.84
	3.97	.82

5.2. Correlation Analysis of 40+ Plastic Ball between Skill, Physical Fitness, and Tactics

The Correlation Analysis of 40+ Plastic Ball between Skill, Physical Fitness, and Tactics is shown in Table 2.

It is shown in Table 2 that "Skill Training", "Physical Fitness Training" and "Tactics Training" levels were positively correlated with each other and all reach significant level ($p<.05$). In the correlation Analysis, the correlation coefficient between .40 and .70 was moderately correlated, and the correlation coefficient higher than .70 was highly correlated (Wu & Tu, 2006).

This means that the Skill Training, Physical Fitness Training and Tactics Training Levels were moderately correlated.

According to the research results, the 40+ plastic ball had significant differences in Skill Training, Physical Fitness Training and Tactics Training levels, and presented a moderate correlation. It showed that the Skill Training, Physical Fitness Training and Tactics Training all were positively correlated. The correlation between Skill Training and Physical Fitness Training was greater than the correlation between Physical Fitness Training and Tactics Training. The results of this study were the same as those studies in the past (Qin, 2017; Yang, 2016; Zhang, 2017).

This can be inferred that the correlation between Skill Training and Physical Fitness Training was an important factor in table tennis training. This is in line with Gong (2017) has mentioned the players have to strengthen Skill Training and Physical Fitness Training. If you want to improve your performance in table tennis, especially when the ball material has changed, the Physical Fitness Training is more important than the past.

Table 2. *Impact of 40+ Plastic Ball on the Table Tennis Training Questionnaire*

	Skill Training	Physical Fitness Training	Tactics Training
Skill Training	1		
Physical Fitness Training	.676*	1	
Tactics Training	.584*	.635*	1

*$p<.05$

6. CONCLUSIONS AND SUGGESTIONS

6.1 Conclusions

6.1.1 Physical Fitness Training was the Major Effect of Table Tennis Ball Change for the Secondary School Table Tennis Players in Kaohsiung City

The mean score of Physical Fitness Training was the highest in the Effect of Table Tennis Ball Change for the Secondary School Table Tennis Players in Kaohsiung City. The reason should be that in the current 40+ plastic ball era, the ball sphere is larger, and the ball spin speed is slower, causing the rally ball increases in the game.

Hence, table tennis players must improve the physical fitness requirements, including the power of the hands and feet and the agility of movement, etc., so that

the table tennis players could adapt the current 40+ plastic ball. Therefore, the impact of 40+ plastic balls for players will be enhancing physical fitness training.

6.1.2 "Skill Training Level", "Physical Fitness Training Level" and "Tactics Training Level" were Mutually Positively Correlated for Table Tennis Ball Change for the Secondary School Table Tennis Players in Kaohsiung City

After using 40+ plastic balls for the Secondary School Table Tennis Players in Kaohsiung City, the correlation between Skill and Physical Fitness was greater than the correlation between Skill and Tactics, and the correlation between Physical Fitness and Tactics. It indicated that the table tennis training had to focus on Skill and Physical Fitness in the 40+ plastic table tennis ball era due to the characteristics of the ball change. Appropriately improve the stability of table tennis skill and the strength of physical fitness will improve the table tennis strength and strive for better achievement in the game.

6.2 Suggestions

Based on the above conclusions, the following suggestions were proposed as references for the secondary school table tennis team in training. Suggestions were as follows:

6.2.1 Understanding the Characteristics of 40+ Plastic Ball Table Tennis and Implement a Specialized Training Model

After the ball material was changed to 40+ plastic ball, reduced rotation, spin speed, and bounce were all different from the original material, Celluloid.

If the players can quickly adapt to the impact of 40+ plastic balls, he/ she will be able to improve the playing skill and technical level. Therefore, how the coach teaches the player to adapt to the 40+ plastic ball is definitely an important issue.

This study found that after the 40+ plastic ball was replaced, it was hugely influential on the players' training. Some players are vulnerable to the maladjustment of the new ball material, resulting in a decline in game performance, and even loss of confidence in table tennis. How can coaches use effective training methods to guide players to improve their skill, physical fitness and tactics to enhance their self-confidence and strength? It is a very crucial issue every coach needs to think about it.

6.2.2 Strengthening the Training of Special Physical Fitness and the Rally Ball

The study confirms that it is very important for the training of physical fitness and the rally ball of the 40+ plastic balls. The results of the questionnaire survey also showed that the mean score on the physical fitness level was the highest, especially the item 14 "Must improve agility of lower limb." and the item 7, "Must improve power training of upper limb.", was currently indispensable for two special physical functions. In the Tactics level, the item 4 " Must improve the sustained rally ball technique." and the item 20 " Must improve active attacking technique in rally." They all showed the importance of rally ball training. And the stability of rally ball is also the key to determining the strength of the table tennis players. Therefore, how

to use effective training to strengthen key skills is an important topic that players and coaches should consider together.

6.2.3 Suggestions for Future Research

This study only focused on the secondary school table tennis players in Kaohsiung City, so that it cannot extensively be compared to other cities. It is recommended that the future study can focus on the development of college players or even national secondary school players, so it can be more realistic to the overall situation of table tennis players in Taiwan. It can also provide more information for future players and coaches in training. In addition, this study only discussed the impact of table tennis material change on the table tennis players training. Today, 40+ plastic balls are constantly being researched and developed. The researcher recommends making correlation research to compare the differences in training between different 40+ plastic balls in the future. In this study, the questionnaire survey method was used to conduct a quantitative research. It is suggested that in the future study, qualitative analysis can be used to interview players and coaches, so that the research results can be more perfect.

REFERENCES

Bang, P. P. (2015). Dear, I Made the Ball Bigger: the Old Celluloid and the New Plastic Ball. *Sports Horizon.* Retrieved from https://www.sportsv.net/articles/14480

Chen, K. T., & Tseng, J. C. (2005). A preliminary study of 44mm table tennis ball. *Chinese Sports Quarterly Journal*, *19*(4), 92-99.

Gao, D. N., Zhu, X. Y., & Shi, L. (2016). Trend Analysis of the Specific Physical Fitness Training for Table Tennis Players. *New West*, *3*, 136.

Gong, T. (2017). Research on the Specific Physical Fitness Training of Table Tennis Players. *Sports Training Journal*, *7*(22), 41-42.

Huang, M. J. (2017). The Influence of Chinese Taipei National Team training toward table tennis ball change. In S. Matsuo (Ed.) *Programme and abstracts of Japan Table Tennis Association Sport Science and Medicine Committee International Meeting 2017*. Tokyo: JTTA SSMC.

Li, D. S. (2015). The Influence and Reaction to the Development of Table Tennis Equipment and Reformation of Rules. *Chung Yuan Physical Education Journal 6*, 41-49.

Liang, X. M. (2017). Preliminary Research on the Characteristics of the New Seamless Plastic Table Tennis Ball and its Influences on the Tactics Development. *Sports World*, 8, 15-16.

Liu, H. (2017). Impact Analysis of the New Seamless Plastic Table Tennis Ball on Table Tennis Technique. *Sports Vision*, 7 (9), 238-239.

Qin, Y. (2017). The Characteristics of New Material Table Tennis Ball and its Influence on Players' Skills and Tactics. *Sports vision*, *7*(18), 250-252.

Wu, M. L., & Tu, J. T. (2007). *Application of SPSS and statistical analysis*. Taipei, Taiwan: Wu-Nan.

Yang, M. Y. (2016). The Role of Core Strength Training of Table Tennis Players and its Specific Training Methods. *Sports Teacher Journal*, *39*(6), 35-37.

Yao, Y. (2014). The Two-Color Ball First Tear Note. *Ping Pong World*, *9*, 28-31.
Zhang, C. (2017). The Impact of Core Strength Training on Table Tennis Players. *Bulletin of Sport Science & Technology*, *25*(5), 78-81.

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Development of motion response training system for badminton applicable also to table tennis

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Abstract: This project is to implement the sports science professional to design and develop the badminton agility reaction training equipment with intelligent functions to assist players' training and monitoring. Product design with a Bluetooth wireless function of the LED lamp module, with the development of the APP system program, so that the operating interface simple and easy to understand. Products with functions to sub-timing, training mode, test and record, feedback and so on. Objective: First of all, design and develop a badminton visual action reaction training system based on cross-field design, which provided agility, assistance and monitoring of the badminton footwork. Second, the design can meet the needs of domestic training, and the product has the features of wisdom and the lower cost. Method: The design of product architecture is designed with LED lamps, infrared sensor modules, and programmable controllers to operate the interface by the touch panel. The product has functions such as segment timing, step training, game simulation mode, testing, recording, and feedback. Results: The visual action reaction training system with the characteristics of auxiliary training, monitoring, testing, recording and the lower cost. It can precisely record the sports time, reaction time, action time in all directions and the simulation game. What's more, do the analysis through the built-in formula to output the action time pattern. And in the next study we will apply to the training of table tennis and tennis.

Keywords: reaction time, action time, simulation

1. INTRODUCTION

Since January 1st in 2006, rules of badminton have been changed, total score is 21 points now. The game is at a higher tempo due to this change, hence, athletes must change and adjust their tactics to get rid of the physical performance because of the old rules while training or competing so that effectively develop speed, adopt to be more active and have steady hitting requirements, such as short serve, be an aggressive receiving side, and a quick tempo, these kinds of tactics. Therefore, it seems that from the current badminton competition, athletes intend to develop in the parts of comprehensive skills, outstanding specialty, active attack, the balance between offensive and defensive, having the rapid success, also emphasize on active, fast, and precise as the primary skills of badminton. (Lu & Lu, 2008; Su & Lee, 2009; Wang, 2017) In order to handle and perform the skills and the development of tactics what we mentioned above, athletes must have the ability of the faster footwork, direction changing, continuous start, quick stop, jumping, and other low body movement, all these elements are the main terms for the best skill

performance and a key to get points. (Hong, Wang, Lam, & Cheung, 2014) In the past, the ability for processing of visual information had less attention during training or doing research. However, the general sport performances are related to vision. For instance, the tennis serving speed is 200 kilometres per hour, before player hit the ball it only takes 430 milliseconds; the baseball pitching speed is 160 kilometres per hour, players only get 415 milliseconds to judge swing or not (Wu et. al, 2014; Chang, Liu, & Liu, 2013). Badminton has the quickest initial speed smash in all sports, it means that players have the shorter reaction time than other games. It can be seen that athletes with racket or bat are only have less than 1 second to determine the speed, direction and rotation of ball, also do the reaction properly. Therefore, the ability of visual cognition decides who will be a winner in the competition. Lu and Chang (2007) pointed out that the 5 basic footwork consist of sidestep, lunge, stride, pace, and jump. What's more, combine all this footwork can benefit of the initiative on the court. Players need to pay attention to opponent's movement and ball to master different ball directions to determine what kind of footwork is suitable for the condition; all performance must be integrated in 6-point footwork. (Jiang, Liao, & Chen, 2016; Kao, Hsiao, & Jang, 2010; Tseng & Chang, 2010). Applying the non-stop step of starting, quick stopping, direction changing, and faster speed to against opponent. Fabulous visual reaction and footwork are the main reasons to show better performance of agility, quick movement, and hit the shuttlecock (Sekulic, Spasic, Mirkov, Cavar, & Sattler, 2013).

2. METHODS

The elements of the system include 6 LED lamps (3 colours), 7 photoelectric sensors, the programmable controller, human interface, tripod and different kinds of connecting lines. Figure 1 use the programmable controller crystal to be a processing core written in the SFC programming language and transmit the data through the human-machine interface which send the page to the computer for instant display, training mode, detection and data storage (Figure 2). In order to combine the measurement of the overall reaction time with sport visual action reaction showing up because of the random number. There are 2 types of mode included. First, depends on a random or fixed direction mode according to the six-point footwork. The other one is simulation game training with the real scoring, numbers of rally, and the break time. Moreover, the training rules can be set by the user, including direction, time, and interval. To do an evaluation test, there are totally 5 participants recruited (average height is 166.4 ± 6.5 cm, average weight is 59.7 ± 5.8 kg, average age is 21 ± 2 years) who with more than 5 years experience of badminton (Table 1). Using simulation game mode to examine, set a score of 6 hits per point, totally are 30 points, 10 seconds break time between each point and record the reaction time, action time and game time during this test.

Fig. 1. Badminton visual action reaction training system

Fig. 2. Operation interface and feedbacks

Table 1. *The functions of Badminton visual action reaction training system*

Function	Explanation	Direction for use
Fixed direction footwork training	The turns of lighting are set according to the original setting process position	1. Move to the corresponding position according to the lighting instruction 2. Wave hands to block the infrared sensor 3. Return to the start, and record a point for completion.
Random direction footwork training	The turns of lighting are set randomly and six times lighting as a cycle.	1. Move to the corresponding position according to the lighting instruction 2. Wave hands to block the infrared sensor 3. Return to the start, and record a point for completion.
Simulation game training	1.Random lighting 2. Do simulation settings according to the actual points 3. The position participants have to reach for each point 4.The break time between each point 5. Ask for the settings is available	1. Move to the corresponding position according to the lighting instruction 2. Wave hands to block the infrared sensor 3. Return to the start, and record a point for completion.

3. RESULTS

The system is actually tested by badminton players through the simulation game. There are totally 30 points, 6 hitting for each point, and 10 seconds break time between each point in the game, this design for this research did meet the actual competition mode. After examined by 5 players, the system is able to provide data and pattern feedback precisely during the training process, and can keep operating for more than 3 hours. The actual data from performances shows that the average time is between 16 to 21 seconds per 6 hits, the average visual reaction time is between 0.742 to 0.884 second, the total running time is between 481 to 646 seconds, and the total game time is between 771 to 936 seconds. It means that this training system are able to record and give feedback exactly, offer each finds of data for coach and athlete after completing training that to arrange and refer to the future training plan (Table 2).

Table 2. *Simulation game training (Second)*

Participants / Time	A	B	C	D	E
6-hit average time	16.019	17.529	18.920	17.026	21.522
Average reaction time	0.742	0.827	0.851	0.738	0.884
Total running time	481	526	568	511	646
Total game time	771	816	858	801	936

4. DISCUSSION

The results of research are similar with Cabello-Manrique and Gonzalez-Badillo (2003), approximately there are 9 hits for each round, time is between 14.57 to 18.86 seconds. Also, Phomsoupha and Laffaye (2015) pointed out that the structure of the badminton game, women's singles matches are completed in 1,365 seconds. After each round, there are short preparation and 14 seconds break time, and the hit frequency is 0.89 second per hit.

In the terms of functions of the training system, every test for each function in operating test process is able to keep working for more than 3 hours and non-stop. Core controller and optical sensing components did not face the high temperature problem or crash condition. In other words, all related components can take when do the training. In the side of training functions, through different kinds of 6-point footwork, system can accurately give feedback and data for players about their movement time, visual reaction time, and total training time. As for the random mode, system also exactly control for random lighting, let players cannot predict the direction to offer the higher level of visual reaction training. The most successful and recommended part is the system can simulate a mode just like players in real games, let them carry out the real running in the match through the visual lighting. Coach can depend on the player's condition to set the strength, and players need to accomplish what system shows. The testing results also achieve the expectation including reaction time, action time and total game time. Moreover, system also gives immediate feedbacks as reference and evaluation for coach and player.

5. CONCLUSION

Research team keeps doing for the further science experiment with more reliable and effective output parameters; make this training system more scientific and competitive after commercialization. The research team also plans to give an advance design for the training system, in the future, to upgrade the product, design the wireless module, and provide a cloud database. So that, the training parameters from players can through big data analysis and AI intelligence improve the training system, also better the results greatly to expand the strength for basic level of badminton in Taiwan. What's more, do the analysis through the built-in formula to output the action time pattern. And in the next study we will apply to the training of table tennis and tennis.

REFERENCES

Cabello-Manrique, D.C., & Gonzalez-Badillo, J.J. (2003). Analysis of the characteristics of competitive badminton. *British journal of sports medicine, 37*(1), 62-66.

Chang, S.-T., Liu, Y.-C., & Liu, Y-H. (2013). A Comparison Study of Sports Vision in Soft Tennis Players of Different Skill Levels. *Physical Education Journal, 46*(3), 231 – 239. DOI: 10.6222/pej.4602.201309.0905.

Hong, Y., Wang, S. J., Lam, W. K., & Cheung, J. T. M. (2014). Kinetics of badminton lunges in four directions. *Journal of applied biomechanics, 30*(1), 113-118.

Jiang, P.-X., Liao, H.-F., & Chen, C.-Y. (2016). Analysis of Matched Statistics of Women's Singles Badminton Tournament in Malaysia Open 2013. *NTU Journal of Physical Education, 30,* 1-9. DOI: 10.6569/NTUJPE.2016.30.01

Kao, S.-L., Hsiao, P.-R., & Jang, J.-T. (2010). Two Weeks of Different Training in Female High School Badminton Players' Specific Moving Speed. *Sports Coaching Science, 19*, 69-82. doi:10.6194/SCS.2010.19.06

Lu, C.-C., & Chang, Y-F. (2007). An Analysis of Time Structure on Badminton Singles in the Thomas and Uber Cup 2006. *College Sports Academic Special Issue*. 2007 / 05 / 01, 410 – 415. DOI: 10.6695/AUES.200705_96.0066

Lu, Z.-C., & Lu, F.-Y. (2008). Analysis of the structure information of badminton singles competition. *Sports Research Review, 97*, 42-46. doi:10.6162/SRR.2008.97.07.

Phomsoupha, M., & Laffaye, G. (2015). The science of badminton: game characteristics, anthropometry, physiology, visual fitness and biomechanics. *Sports medicine, 45*(4), 473-495.

Sekulic, D., Spasic, M., Mirkov, D., Cavar, M., & Sattler, T. (2013). Gender-specific influences of balance, speed, and power on agility performance. *The Journal of Strength & Conditioning Research, 27*(3), 802-811.

Su, S.-b., & Lee, H.-r. (2009). The effect of vibration stimulation on the agility of badminton special footwork. *Sports Research Review, 101*, 139-145. doi:10.6162/SRR.2009.101.20

Tseng, M.-H., & Chang, C.-M. (2010). An Analysis of Time Structure and Strokes on Badminton Men's Single in the 2009 First National Tournament. *Journal of Sports Knowledge, 7*, 101-110.

Wang, C.-C. (2017). An Outcome Analysis of 21-Point Score Structure and Winning Factors on Badminton Competitions -- A Case Study of 2014 Total World Championships. *Sports Coaching Science, 45*, 35-44. DOI:10.6194/SCS.2017.45.04.

Wu, S.-H. et. al (2014). Assessment of Visual Information Processing Ability in Elite Racket Sport Players. *Sports & Exercise Research, 16*(2), 226-233.DOI:10.5297/ser.1602.009.

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Comparison and analysis of the techniques and tactics of Zhang Jike using new plastic ball and celluloid ball in the match

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Abstract: As a result of rapidly changing the ball material in table tennis competition. It has brought great challenge to the table tennis players' technique and tactics. It is necessary to understand the impact of material changes in the ball on players' technique and tactics. This paper based on the methods of video observation and mathematical statistics, this paper makes a systematic technical and tactical analysis of Zhang Jike's six games in London 2012 which used the celluloid balls, and 2016 Rio Olympics which use the new plastic balls. It is in order to find out the impact on Zhang Jike's technique and tactics by using the celluloid balls and the new plastic balls. The results shown that after using the new plastic table tennis, Zhang Jike's technique and tactics had little change, but the technical quality was decreased, and the continuous attack ability was obviously decreased.

Keywords: table tennis, technique and tactics, ball material

1. INTRODUCTION AND AIMS

With the emergence of new plastic balls, adapt to the new balls becomes imminent. It is urgent to establish a new training system in order to master the winning rule of table tennis, and apply scientific training methods and measures to the daily training, therefore, players can constantly update the existing techniques and tactics.

2. METHODOLOGY AND DATABASE

2.1. Object

Zhang Jike, born in February 16, 1988 in Shandong, Qingdao Province, is a Chinese men's table tennis team player. He is the history of the seventh grand slam tennis players, but also following the third Grand Slam player after Liu Guoliang, Kong Linghui.

2.2. Methodology

This paper adopted the three-phase method, video-observation method and mathematical statistics method.

2.3. Database

This study conducted a profound and extensive analysis in a sample of Zhang's six games at the London and Rio Olympics.

Table 1. *Zhang Jike's six matches in Olympics*

Event	opponent	round	result
London Olympic (celluloid)	Wang Hao	Final	4:2 (10, 7, -6, -9, 5, 12)
London Olympic (celluloid)	Ovtcharov Dimitrij	Semi-final	4:1 (-7, 5, 3, 3, 9)
London Olympic (celluloid)	Jiang Tianyi	Quarter-final	4:2 (9, -7, -8, 9, 6, 7)
Rio Olympic (New plastic Ball)	Ma Long	Final	0:4 (-9, -10, -10, -5)
Rio Olympic (New plastic Ball)	Vladimir Samsonov	Semi-final	4:2 (10, -3, 5, -10, 9, 10)
Rio Olympic (New plastic Ball)	Niwa Koki	Quarter-final	4:2 (10, -3, 5, -10, 9, 10)

3. RESULTS

3.1. Zhang with left - handed players

From the data in Table 2 can be seen that Zhang Jike scored a lot on the serve and the third receive. It can be shown that Zhang Jike's serve has a great threat to left-handed players which has strong rotation, multiple changes and good concealment, thus making the third attack more flexible. Zhang Jike in the first and third stroke scoring rate is respectively 63% and 78%, the scoring rate is higher. So it can be shown that whether the old ball or the new ball is used, the treatment of the first and third stroke is very effective to the left-handed players.

It can be found from the data (Table 2) that Zhang Jike scored a lot of direct points on the receiving service, which were 10 respectively, indicating that Zhang Jike had been relatively stable and lethal in receiving the left-handed service. But in the fourth stroke, Zhang Jike lost more points than he scored. The scoring rates of the second and fourth stroke are 56% and 55% respectively. It can be seen that whether the old ball is used or the new ball is used, it has little influence on Zhang Jike and the left hand athletes when they are playing with each other and relatively stable. But the connection of Zhang Jike's receiving and fourth stroke is not quite coherent. Also, the usage rate of receive and assault stage is decline since use the new plastic ball.

In the stalemate segment (Table 2), the match which Zhang Jike against Jiang Tianyi the scoring rate is 62%, usage rate 27%, in the use of new ball scoring rate is 44%, usage rate 32%. Therefore, after Zhang Jike used the new ball, the number of balls in the stalemate stage increased obviously, because the ball is spinning less. The strengths of Zhang Jike are that he has a strong ability of active manufacturing rotation in the stalemate. However, with the new ball, the rotation is weak, which has greatly restricted his ability of active manufacturing rotation. So that Zhang's pressure on his opponents in the stalemate against left-handed players gradually decreased, and even turned from strength to weakness.

Table 2. *The stage of service and attack with left-handed players*

stage	Technique	Jiang Tianyi(old ball)		NIWA Koki(new ball)	
		win	lose	win	lose
the stages of serve and assault	Service	8	1	6	0
	Third stroke	11	10	16	6
	Scoring rate	63%		78%	
	usage rate	34%		34%	
the stages of receive and assault	Receive	10	4	10	4
	Fourth stroke	8	10	5	8
	Scoring rate	56%		55%	
	usage rate	37%		32%	
the stages of stalemate	Stalemate	15	9	12	15
	Scoring rate	62%		44%	
	usage rate	44%		32%	

3.2. Zhang with European players

According to the data in Table 3, Zhang Jike used the old ball to serve against Ovtcharov Dimitrij and scored 6 points. Using the new ball scored two points against Vladimir Samsonov, indicating that the material change had an impact on Zhang's serve when against Europe's top table tennis players. His third stroke is still very powerful. These data show that after changing the ball, there is not much influence on Zhang Jike's third stroke, because the European players generally focus on the attack after receiving. But after changing the ball, the scoring rate and the usage rate of the segment have declined, but it does not affect the advantage of Zhang Jike.

In the stages of receive and assault, Zhang Jike had a certain influence on the receiving. Compared to against Ovtcharov Dimitrij, Zhang dropped nearly half number of his reception when he against Vladimir Samsonov, indicating that he was no longer a threat in receive and assault due to the restriction of the rotation.

In the stalemate, Zhang Jike's scoring rateis 36 percent against Ovtcharov and 42 percent against Samsonov. Zhang Jike's usage rate is 28 percent against Ovtcharov and 52 percent against Samsonov. Whether Zhang Jike used the old ball or the new ball, the scoring rate of the stalemate segment was low, because the European athletes have strong stalemate ability. The usage rate of the new ball has been greatly improved. It shows that the ball material changing has a great impact on Zhang Jike, because the rotation is weakened, the speed becomes slow, and also he has injury.

Table 3. *The stage of service and attack with European players*

stage	technique	Ovtcharov Dimitrij (old ball)		Vladimir Samsonov (new ball)	
		win	lose	win	lose
the stages of serve and assault	service	6	0	2	0
	Third stroke	14	7	11	8
	Scoring rate	74%		61%	
	usage rate	30%		20%	
the stages of receive and assault	receive	15	9	7	2
	Fourth stroke	5	7	10	9
	Scoring rate	55%		60%	
	usage rate	40%		27%	
the stages of stalemate	Stalemate	9	16	23	31
	Scoring rate	36%		28%	
	usage rate	42%		52%	

3.3 Zhang with Chinese players

Zhang Jike against Wang Hao serves 7 points, and when he against Ma Lone had only 1 point, suggesting that it's easy to receive Zhang's serve. Once that happens, his advantage on the third stroke is greatly reduced. Zhang Jike scored 15 points and lost 11 in the third stroke against Wang Hao, when he against Ma Lone, his third stroke scored one and lost 11 points. From the point of view of scoring rate and usage rate, Zhang Jike against Wang Hao scoring rate is 67%, usage rate is 29%, against Ma Long scoring rate is 15%, usage rate is 18%, It can be seen that the influence of the new ball was more obvious when Zhang Jike played against Chinese players.

It can be found that Zhang Jike still has some advantages in this aspect (the stages of receive and assault). He received 14 points against Wang Hao, nine points allowed, and scored seven points against Ma Long, three points allowed. The scoring rate of against Wang Hao is 53%, usage rate is 34%, and against Ma Long, scoring rate is 54, usage rate is30%. According to the data, Zhang Jike is relatively stable in this aspect when facing Chinese players.

In the stalemate segment, Zhang Jike's scoring rate was 48% and usage rate was 36% in the match which used the old ball, and in the use of the new ball scoring rate was 29% and usage rate was 51%. It can be seen that the scoring rate was significantly reduced, while the usage rate was obviously improved. It can be concluded that besides the improvement of the opponent's strength and the decline of his own ability, the change of ball material has a great impact on Zhang Jike's techniques and tactics in the stalemate stage of the competition.

Table 4. *The stage of service and attack with Chinese players*

stage	technique	Wang Hao(old ball)		Ma Long(new ball)	
		win	lose	win	lose
the stages of serve and assault	service	7	0	1	0
	Third stroke	15	11	1	11
	Scoring rate	67%		15%	
	usage rate	29%		18%	
the stages of receive and assault	receive	14	9	7	9
	Fourth stroke	7	3	5	7
	Scoring rate	53%		54%	
	usage rate	34%		30%	
the stages of stalemate	Stalemate	20	21	11	26
	Scoring rate	48%		29%	
	usage rate	36%		51%	

4. FINDINGS

After using new plastic ball, Zhang Jike's technique and tactics haven't changed much, but technical quality drops somewhat, this can see from the scoring rate of each stage. Through the observation of the video, it is obvious that the shot speed slower, the rotation weakens, and Less pressure on your opponent, so that resulting in the relative decline of Zhang Jike's scoring rate in each stage compared with that in the period of using celluloid balls.

After using the new plastic table tennis, the usage rate of the stages of receive and assault and stalemate increased slightly. It shows that the centre of gravity of the competition has shifted to the stages which after the stages of serve and assault, and the competition will be fiercer in the stalemate stage in the future, which is relatively unfavourable for Zhang Jike. With his growth of age and the increase of injuries, the physical quality is difficult to return to the peak period.

REFERENCES

Liu, J., & Zhao, J. (2012). Technical and tactical analysis of men's singles final of the 51st world table tennis championships Zhang Jike. *Journal of Guangzhou Physical Education Institute, 23*(3), 75-112.

Wang, F. (2014). Discussion on the tactical application ability of table tennis player Zhang Jike. *Sport, 81,* 11-12.

Yan, J. (2013). *Comparative study on the technical and tactical characteristics of the world's outstanding table tennis players Zhang Jike and Tim Boll*. Beijing: Beijing sports university.

Zheng, L.H. (2014). Research on the application of backhand pull-table inner ball receiving technique in modern table tennis competition. *Journal of Shandong physical education institute, 30*(1), 98-101.

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The role of affects in predicting the success of expert table tennis players

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Abstract: The relationship between psychological variables and skill performance has been a key matter for sports psychologists for many years. For example, in the multidimensional anxiety theory (Martens et al., 1990), it is assumed that cognitive anxiety has a negative linear relationship, somatic anxiety has an Inverted-U shape relationship, and self-confidence has a positive linear relationship with the performance. Therefore, the purpose of the present study was to predict the success (Winner or loser) of table tennis athletes based on arousal, self-confidence, cognitive and somatic anxiety. The participants were 56 expert table tennis players (28 men and 28 women, mean age of 25.36 ± 2.70 years) who participated in Iran Super League competitions. Self-confidence and somatic anxiety were measured by two items of the Mental Readiness Form (MRF-3; Krane, 1994), and cognitive anxiety and arousal levels were assessed by "sport grid-revised" (Ward & Cox, 2004), 15 minutes before the start of the first match in the morning. Logistic regression was used for prediction. Results revealed that one model with two factors was significant. Cognitive anxiety, and Self-confidence have been able to significantly predict winning in the match. This model supports the part of the multidimensional anxiety theory. Also, these findings established the important effects of psychological variables on the final success of the champions.

Keywords: table tennis, arousal, anxiety, self-confidence, prediction

1. INTRODUCTION

Researchers have made many efforts to clarify the relationship between emotions and performance by presenting several theories and models. These models include the multidimensional anxiety theory (Martens, Burton, Vealey, Bump, & Smith, 1990), catastrophe models (Hardy, 1990), the reversal theory (Apter, 1982; Kerr, 1990) and zones of optimal functioning models (Hanin, 1980; 1986). For example, in the multidimensional anxiety theory (Martens et al., 1990), it is assumed that cognitive anxiety has a negative linear relationship, somatic anxiety has an Inverted-U shape relationship, and self-confidence has a positive linear relationship with the performance. Many studies have shown that high levels of cognitive anxiety can have a detrimental effect on the performance of tasks (Hardy, Beattie, and Woodman, 2007). The anxiety reduction effect on performance is shown in several researches including rock climbing in the hall (Pijpers, Oudejans, & Bakker, 2005), and basketball throwing (Hardy and Parfitt, 1991). But the positive effects of anxiety are also recorded in some studies, including anagram-solving tasks (Blankstein,

Toner, & Flett, 1989), and rebounds, and basketball free-throwing (Parfitt and Hardy, 1993). Another model that tries to give at least some explanation for these contradictions is the catastrophe model (Hardy, 1990). The catastrophe theory predicts the interactive effects of cognitive anxiety and physiological arousal on performance in a three-dimensional model (Hardy et al., 2007). This theory believes that when cognitive anxiety is high, the increase in physiological arousal reduces the performance catastrophically from a higher level to a lower level. Then a further decrease in physiological arousal is needed to return to the higher level. In addition to verifying this model by some studies, some researchers also criticized, for example, Gill (1994) criticized that testing this model is difficult due to its complex appearance. Therefore, as indicated, the Martens multidimensional model (1990) emphasizes on the relationship between the three variables (cognitive and somatic anxiety, and self-confidence) with performance and the catastrophe model (Hardy, 1990) on the relationship between the two variables (cognitive anxiety, and arousal) with performance. The question is, do these theories apply to all sports? Which of these psychological variables affects the performance of each particular sporting skill?

Some researchers have shown that Self-confidence is a moderating variable between performance and exercise hours in table tennis players (Lin, Li, Lin, Lu, 2011). On the other hand, another study showed that there is no significant difference between the winner and loser of table tennis athletes in self-confidence, cognitive, and somatic anxiety variables (Iizuka et al., 2005). Covassin and Pero (2004) indicated that winner tennis players had significantly lower cognitive and somatic anxiety, and higher self-confidence levels than loser players. We know that athletes in individual sports, experience higher levels and more variation in pre-competition anxiety than team sports (Martens et al., 1990; Woodman & Hardy, 2001). Therefore, the purpose of the present study was to predict the role of four psychological variables (arousal, self-confidence, cognitive and somatic anxiety) on performance with table tennis (an individual sport) athletes based on two mentioned theories.

2. METHODS

We have randomly selected 56 expert table tennis players (28 men and 28 women) who participated in the Iran Super League competitions (mean age of 25.36 ± 2.70 years). All participants provided informed consent. All participants completed the Sport Grid-Revised (Ward and Cox, 2004) to measure the levels of arousal and cognitive anxiety and MRF-3 (Krane, 1994) to measure the somatic anxiety and self-confidence, 15 minutes prior to start of their 1st match in 1/16 stage. The result of that match (Winner or loser) for each participant was recorded as performance score. The Logistic regression was used for analysing of the data.

3. RESULTS

The participants were separated into two groups, considering their results in their first game in 1/16 stage: 28 players were 'losers', 28 players were 'winners'. Each group was made out of 14 women, and 14 men. The data were analysed by logistic regression (Forward LR Method) to predict the winning or losing of players based on four psychological variables (arousal, self-confidence, cognitive and somatic anxiety). The means of these psychological variables are shown in Table 1.

Table 1. *Means, and Standard Deviations of four psychological variables*

Win Lose		Anxiety	Self Confidence	Arousal	Somatic
lose	Mean	6.89	5.46	5.57	4.71
	N	28	28	28	28
	Std. Deviation	1.853	1.319	1.168	1.718
win	Mean	3.07	8.54	5.86	4.68
	N	28	28	28	28
	Std. Deviation	1.152	1.453	1.484	1.722

The results of logistic regression test were shown two models with two variables were significant (Table 2).

Table 2. *Omnibus tests of model coefficients*

		Chi-square	df	Sig.
Step 1	Model	46.349	1	.0001
Step2	Model	58.045	2	.0001

Table 3 showed that model 2 specified % 64 to % 86 of variance of successful factor (win or lose).

Table 3. *Model summary of logistic regression*

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	31.283[a]	.563	.751
2	19.588[b]	.645	.860

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

b. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Also, the results showed that 89/3% of the losers and 92/9 of winners are classified correctly, therefore 91/1 of predictions are correct (Table 4).

Table 4. *Classification of athletes in winner or loser groups*

Steps	Observed		Predicted Success loser	Predicted Success winner	Percentage Correct
1	Win Lose	loser	26	2	92.9
		winner	2	26	92.9
	Overall Percentage				92.9
2	Win Lose	loser	25	3	89.3
		winner	2	26	92.9
	Overall Percentage				91.1

Step 2 showed that cognitive anxiety and self-confidence can significantly predict the athletes' success (winning or losing), but the arousal and somatic anxiety have not significant effect on athletes' successful in a table tennis match. Finally, Table 5 showed that cognitive anxiety has a negative, and self-confidence has a positive effect on success factor of athletes.

Table 5. *The predictor variables of athletes' successful factor (winning or losing) in the Equation*

		B	S.E.	Wald	df	Sig.	Exp. (B)
Step 1[a]	Cognitive Anxiety	-1.363	.353	14.929	1	.0001	.256
	Constant	6.610	1.718	14.811	1	.0001	742.497
Step 2[b]	Cognitive Anxiety	-1.116	.376	8.820	1	.003	.328
	Self-confidence	1.311	.521	6.329	1	.012	3.709
	Constant	-3.776	3.364	1.260	1	.262	.023

a. Variable(s) entered on step 1: Anxiety.
b. Variable(s) entered on step 2: Self Confidence.

3. DISCUSSION

The results of the present study revealed that one model with two factors was significant. Cognitive anxiety, and Self-confidence have been able to significantly predict winning the match, but the arousal and somatic anxiety have not significant effect on athletes' success in a table tennis match. The results showed that cognitive anxiety has a negative, and self-confidence has a positive effect on success factor of athletes, in another world, as the self-confidence increases, the likelihood of winning the math increases. In other hand, as the cognitive anxiety increases, the likelihood of winning the math decreases. This model supported the part of the multidimensional anxiety theory. These findings established effects of some psychological variables in the final success of table tennis match. Present results were consistent with studies of Pijpers, et al., 2005; Hardy and Parfitt, 1991; Lin, et al., 2011; Covassin and Pero, 2004; Pierpaolo & Antonia, 2018. Also, current results were varying from outcomes of Blankstein et al., 1989; Parfitt and Hardy, 1993; Iizuka et al., 2005. Woodman and Hardy (2003) in a meta-analysis have revealed that

both cognitive anxiety and self-confidence are significantly related to competitive sport performance. Those were also greater for high-standard athletes than for low-standard athletes. Also, Silva et al., (2019) showed that swimming athletes who take part in higher ranking competitions are more self-confident than those of lower competitive level, and that swimming players had higher self-confidence scores than cognitive and somatic anxiety, which suggests a larger ability to interpret the competitive context as a challenge to be overcome.

Total conclusion of present results demonstrated that the anxiety experienced by athletes before a competition and its effects on cognitive and physical functioning are intrinsic elements of the race. This study showed how these components have become the effectors on the race successful. Present fruitful results identified the role of psychological factors in sports performance that allow the coaches to find a best strategy to help the athletes achieves the best performance and to recognize and support the psychological needs that hinder or benefit performance.

REFERENCES

Apter, M. J. (1982). *The experience of motivation: The theory of psychological reversals*. London: Academic Press.

Blankstein, K. R., Toner, B. B., & Flett, G. L. (1989). Test anxiety and the contents of consciousness: Thought-listing and endorsement measures. *Journal of research in Personality*, *23*(3), 269-286.

Covassin, T., & Pero, S., (2004). The relationship between self-confidence, mood state, and anxiety among collegiate tennis players. *Journal of Sport Behavior*, *27*(3), 230-242.

Gill, D. L. (1994). A sport and exercise psychology perspective on stress. *Quest*, *46*(1), 20-27.

Hanin, Y.L. (1980). A study of anxiety in sports. In W.E Straub (Ed.), *Sport psychology: An analysis of athlete behaviour*. (pp. 236-249). Ithaca, NY Movement.

Hanin, Y.L. (1986). State-trait anxiety research on sports in the USSR. In C.D. Spielberger & R. Diaz-Guerrero (Eds.), *Cross-cultural anxiety*. (pp. 45-54). New York: Hemisphere.

Hardy, L. (1990). A catastrophe model of performance in sport. In J. G. Jones & L. Hardy (Eds.), *Wiley series in human performance and cognition. Stress and performance in sport* (pp. 81-106). Oxford, England: John Wiley & Sons.

Hardy, L., & Parfitt, G. (1991). A catastrophe model of anxiety and performance. *British Journal of Psychology*, *82*,163-178.

Hardy, L., Beattie, S., & Woodman, T. (2007). Anxiety-induced performance catastrophes: Investigating effort required as an asymmetry factor. *British Journal of Psychology*, *98*(1), 15-31.

Iizuka, C. A., Marinovic, W. and Machado, A. A. (2005). Anxiety and performance in young table tennis players. *Sports Science Research*, *26*, 73-75.

Kerr, J.H. (1990). Stress in sport: reversal theory. In J. G. Jones & L. Hardy (Eds.), *Stress and Performance in Sport*, (pp. 107–131). Chi Chester, England: Wiley.

Krane, V. (1994). The Mental Readiness Form as a measure of competitive state anxiety. *The Sport Psychologist*, *7*, 113-126.

Lin, C.J., Li, Y.Y., Lin, C.Y., & Lu, C.J. (2011). Young table tennis players' involvement in the practice: a test of Eysenck and Calvo processing efficiency theory. *International Journal of Table Tennis Sciences, 7,* 47-51.

Pierpaolo, L., & Antonia, T. G. (2018). The psychological constructs and dimensions applied to sports performance: a change of theoretical paradigms. *Journal of Physical Education and Sport*, *18*, 2034.

Pijpers, J. R., Oudejans, R. R., & Bakker, F. C. (2005). Anxiety-induced changes in movement behavior during the execution of a complex whole-body task. *The Quarterly Journal of Experimental Psychology,* Section A, *58*(3), 421-445.

Silva, G. C. B., Cortez, A. C. L., do Nascimento Júnior, J. R. A., Granja, C. T. L., Conde, E. F. Q., & de Melo, G. F. (2019). Analysis of pre-competitive anxiety of Brazilian young swimmers. *Acta Scientiarum. Health Sciences*, *41*, e45475-e45475.

Ward, D. G., & Cox, R. H. (2004). The sport grid-revised as a measure of felt arousal and cognitive anxiety. *Journal of Sport Behavior*, *27*(1), 93-107.

Woodman, T., & Hardy, L. (2001). Stress and anxiety. In R.N. Singer, H.A. Hausenblas & CM. Janelle (Eds.), *Handbook of sport psychology*, 2nd ed., (pp. 290-318). New York: Wiley.

Woodman, T. I. M., & Hardy, L. E. W. (2003). The relative impact of cognitive anxiety and self-confidence upon sport performance: A meta-analysis. *Journal of sports sciences*, *21*(6), 443-457.

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Affective experiences and benefits of participation in table tennis for youth and adults: A review of literature

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Abstract: Mental health issues have led to an increased attention to the affective benefits of participation in sport. The question that concerns the present study was 'can table tennis contribute to the affective development for health?' The purpose of the study was to explore how the empirical research has reported on their affective experiences and benefits in both competitive and recreational settings. A literature search was conducted through EBSCO databases with the search term 'table tennis'. Peer-reviewed studies published in English until December 2018 that examined concepts and achievements related to the affective domain in table tennis will be included. A total of 10 studies were identified that satisfied the inclusion criteria. The review found that three main themes of the affective experiences and benefits could be recognised: motivation, stress coping, and emotional process during competition. In addition, this review highlighted that motivation is associated with recovering from stress and negative emotions among table tennis players. This review concludes by suggesting that the empirical research shows evidence that table tennis participation can be beneficial to the affective domain. Nevertheless, little has been reported on the interaction of teaching and outcomes in order to understand how and why the affective development occurs.

Keywords: mental health, motivation, stress coping, emotional response, emotional process

1. INTRODUCTION

The affective development of young people and adults is an urgent topic since mental health has been identified as a serious issue across the world over the decade. For instance, it is estimated that over a billion people worldwide struggled with mental health disorders in 2017, such as depression and anxiety (Ritchie and Roser, 2018). Mental health-related issues among young people such as poor body image, bullying victimization, depression, and low self-esteem have been highlighted recently (Inchley et al., 2016). The prevalence of mental health disorders among youth and adults has led to increased attention to the affective domain.

It is widely acknowledged that participation in sport is beneficial to the affective components, not just only physical aspects of health. A number of previous research showed that participation in sport is associated with improved psychological health including higher self-esteem, higher confidence, and fewer depressive symptoms (Eime et al., 2013). In addition, there are reports that participation in team sports can be longitudinally associated with enhanced positive mental health, compared to individual sports (Eime et al., 2013; Doré et al., 2018). Although there is a growing

awareness of affective benefits of participation in sport, previous research has not extended any specific sport.

Table tennis is an individual sport that could be effective to enhance health benefits. There is a number of research that reported the physical development for health in table tennis, but researchers and coaches may have still limited resources to address the affective outcomes. The question in the present study was 'can table tennis contribute to the affective development for health?' Reviewing table tennis research in the affective domain is important because evidence for the enhancement of the affective outcomes in table tennis might produce positive benefits to people's mental health, as well as a positive justification of table tennis participation. Therefore, the purpose of the present study was to review how the empirical research has reported on the affective experiences and benefits of table tennis in both competitive and recreational settings.

2. METHOD

2.1. Search strategy

A literature search was carried out in EBSCO databases. The search period covered from January 2009 to December 2018. The term 'table tennis' was used as a search term to capture relevant research on the affective domain in table tennis.

2.2. Eligibility criteria

After the literature search, studies were excluded if they were (a) not available in full-text, (b) review articles, (c) advocacy or protocol studies, (d) conference abstracts. The criteria for inclusion in this review were studies were (a) available in English, (b) peer-reviewed, (c) addressed table tennis participation, rather than involving in multi-activities included table tennis, (d) addressed participants' affective outcomes, which cover psychological and emotional aspects that include feelings, beliefs, and aspirations.

2.3. Study selection

A total of 51 studies was identified through database searching. 51 studies were screened based on title and abstract. Following the screening process, 28 full-text articles were assessed for eligibility. As a result, a total of 10 studies were included in this review.

3. RESULTS

3.1. Geographic location

The included studies were conducted in France (*n*=5; Briki et al., 2012; Martinent et al., 2012, 2014, 2018; Martinent & Decret, 2015), Croatia (*n*=1; Sindik et al., 2013), Czech Republic (*n*=1; Francová, 2014), and the United State (*n*=1; Kurimay et al., 2017). Two studies had a survey of table tennis participants in multi-country (Chu et al., 2018; Laborde et al., 2012).

3.2. Competition level

The number of studies in national level was five (Kurimay et al., 2017; Laborde et al., 2012; Martinent et al., 2012, 2014; Martinent & Decret, 2015). Two studies were conducted in both international and national level (Briki et al., 2012; Martinent et al., 2018). Two studies took place in recreational settings (Francová, 2014; Sindik et al., 2013). One study included all competition levels (Chu et al., 2018).

3.3. Study design and methodology

Eight studies adapted quantitative measures (Chu et al., 2018; Francová, 2014; Kurimay et al., 2017; Laborde et al., 2012; Martinent et al., 2014, 2018; Martinent & Decret, 2015; Sindik et al., 2013), whereas there were two studies with qualitative methods (Briki et al., 2012; Martinent et al., 2012). There were six cross-sectional studies (Briki et al., 2012; Chu et al., 2018; Kurimay et al., 2017; Martinent et al., 2012, 2018; Sindik et al., 2013) and three longitudinal studies (Laborde et al., 2012; Martinent et al., 2014; Martinent & Decret, 2015). One study used a pre-post study design (Francová, 2014).

3.4. Main themes

Motivation: Motivation refers to the autonomous forms of motivation (i.e., intrinsic motivation and identified motivation), the controlling forms of motivation (i.e., external motivation), and amotivation, which stemmed from self-determination theory (SDT; Deci & Ryan, 1985). There were five studies related to motivation (Chu et al., 2018; Martinent et al., 2014, 2018; Martinent & Decret, 2015; Sindik et al., 2013). More specifically, the studies investigated the relationship between motivation and stress coping (Martinent & Decret, 2015), burnout (Martinent et al., 2014, 2018), and psychological well-being (Chu et al., 2018; Sindik et al., 2013).

Coping skills: Coping skills consist of three different types of strategies. The task-oriented coping strategy aims to remove the cause of the stressor (e.g., problem-solving, time management, and social support), whereas the emotion-focused coping strategy involves trying to reduce the negative emotional responses associated in stress (Kariv & Heiman, 2005). Avoidance coping strategy refers to behavioural disengagement (Kurimay et al., 2017). There were three studies of coping skills in this review (Francová, 2014; Kurimay et al., 2017; Laborde et al., 2012). The studies explored the characteristics of table tennis players' coping skills.

Emotional response: Emotional response refers to psychological and emotional components, such as burnout, confidence, anxiety, worry, and vitality. There were two studies related to the theme of emotional response (Chu et al., 2018; Sindik et al., 2013). Both studies had a significant relationship with the theme of motivation.

Emotional process: There were two studies that investigated how table tennis players felt during a game (Briki et al., 2012; Martinent et al., 2012). They found that table tennis players perceived positive (e.g., getting self-confidence) and negative (e.g., worries about being defeated) psychological momentum during a game. Additionally, Briki et al. (2012) reported that negative emotions among table tennis players were triggered by a fear of winning.

4. DISCUSSION

The findings of the included studies showed that table tennis participation generally has an impact on their affective experiences and benefits such as motivation, stress coping skills, emotional response, and emotional process during a game. However, this review did not reveal that table tennis participation has a positive effect on the affective development since most of the included studies were cross-sectional study and studies of intervention effectiveness were rarely reported. Also, we came across a small number of the included studies as they should be written in English only. We will discuss that there is the potential to influence the affective outcomes through table tennis. Furthermore, the result of this review reveals the importance of an optimal teaching and coaching style for table tennis players.

The present results suggests that autonomous motivation is key as it is significantly associated with lifelong participation, psychological well-being, and reducing stress. The self-determined profile had a higher levels of sport-specific stress recovery (Martinent and Decret, 2015), whereas the controlled motivational profile had higher level of somatic anxiety, worry, and concentration disruption than the self-determined profile (Chu et al., 2018). Also, lifelong table tennis participants reported lower amotivation and lower levels of burnout symptoms than those who dropped out (Martinent et al., 2018). In further consideration, this review of literature suggests that we need to consider how to motivate athletes in an autonomous way to participate in table tennis. One optimal strategy to enhance autonomous motivation and encourage lifelong participation is an autonomy-supportive coaching style, that is outlined by SDT. An autonomy-supportive coaching style involves adopting supportive motivating behaviours such as offering positive feedback and athlete-centred approaches (Haerens et al., 2018). Even though a player felt negative emotions during a competition, an autonomy-supportive coach would be helpful to recover from disappointment and other emotional problems (Briki et al., 2012). Future research might be needed to explore table tennis interventions programme adopting an autonomy-supportive coaching style.

Coping skills also can be considered as important affective and social skills for table tennis players. Kurimay et al. (2017) revealed that the highly competitive anxiety group used more avoidance coping and emotion-focused coping strategies compared to those who were in the low competitive anxiety group. Likewise, Laborde et al. (2012) found that high trait emotional intelligence had positively associated with task-oriented coping. From a practical point of view, it is important for coaches to assess athletes' emotional status in terms of the development of stress coping skills. As well as studies of motivation, it suggests that some interventions are needed to develop task-oriented coping skills and less the use of avoidance coping and emotion-focused coping strategies. Furthermore, Francová (2014)'s study would be a good justification of table tennis, in which showed that a 10-month table tennis training had a positive effect on coping skills including self-care, communication, friendship, and responsibility.

This review remains difficult to claim that table tennis participation has a positive effect on the affective outcomes because the included studies did not show how and

why the affective experience and benefits occurred. This information would be necessary to discuss on practical implications at a deeper and more critical level. There is a need for further investigations on the interactions between coaching/teaching and the affective outcomes.

5. CONCLUSIONS

This study presented current evidence of affective experience and benefits of participating in table tennis. Table tennis participation might be beneficial to the affective development for health, but the process of this development is less clear. Intervention research to investigate the effectiveness of table tennis on the affective development will need to be attempted.

REFERENCES

Briki, W., Den Hartigh, R. J., Hauw, D., & Gernigon, C. (2012). A qualitative exploration of the psychological contents and dynamics of momentum in sport. *International Journal of Sport Psychology*, *43*(5), 365-384.

Chu, T. L., Zhang, T., & Hung, T. M. (2018). Motivational profiles in table tennis players: Relations with performance anxiety and subjective vitality. *Journal of sports sciences*, *36*(23), 2738-2750.

Deci, E. L., & Ryan, R. M. (1985). Intrinsic motivation and self-determination in human behavior. New York: Plenum Press.

Doré, I., O'loughlin, J. L., Schnitzer, M. E., Datta, G. D., & Fournier, L. (2018). The longitudinal association between the context of physical activity and mental health in early adulthood. *Mental Health and Physical Activity*, *14*, 121-130.

Eime, R. M., Young, J. A., Harvey, J. T., Charity, M. J., & Payne, W. R. (2013). A systematic review of the psychological and social benefits of participation in sport for children and adolescents: informing development of a conceptual model of health through sport. *International journal of behavioral nutrition and physical activity*, *10*(1), 98.

Francová, L. (2014). The level of physical and social skills after completion of the training program for children aged 9-11. *Acta Gymnica*, *44*(1), 33-45.

Haerens, L., Vansteenkiste, M., De Meester, A., Delrue, J., Tallir, I., Vande Broek, G., ... & Aelterman, N. (2018). Different combinations of perceived autonomy support and control: identifying the most optimal motivating style. *Physical Education and Sport Pedagogy*, *23*(1), 16-36.

Inchley, J., Currie, D., Young, T., Samdal, O., Torsheim, T., Auguston, L., Mathison, F., Aleman-Diaz, A., Molcho, M., Weber, M., & Barnekow, V. (2016). Growing up unequal: gender and socioeconomic differences in young people's and well-being. Health Behaviour in School-aged Children (HBSC) study: international report from the 2013/2014 survey. WHO Regional Office for Europe.

Kariv, D., & Heiman, T. (2005). Task-oriented versus emotion-oriented coping strategies: The case of college students. *College student journal*, *39*(1), 72-85.

Kurimay, D., Pope-Rhodius, A., & Kondric, M. (2017). The relationship between stress and coping in table tennis. *Journal of human kinetics*, *55*(1), 75-81.

Laborde, S., You, M., Dosseville, F., & Salinas, A. (2012). Culture, individual differences, and situation: Influence on coping in French and Chinese table tennis players. *European Journal of Sport Science*, *12*(3), 255-261.

Martinent, G., Campo, M., & Ferrand, C. (2012). A descriptive study of emotional process during competition: Nature, frequency, direction, duration and co-occurrence of discrete emotions. *Psychology of Sport and Exercise*, *13*(2), 142-151.

Martinent, G., Cece, V., Elferink-Gemser, M. T., Faber, I. R., & Decret, J. C. (2018). The prognostic relevance of psychological factors with regard to participation and success in table-tennis. *Journal of sports sciences*, 1-8.

Martinent, G., & Decret, J. C. (2015). Motivational profiles among young table-tennis players in intensive training settings: A latent profile transition analysis. *Journal of Applied Sport Psychology*, *27*(3), 268-287.

Martinent, G., Decret, J. C., Guillet-Descas, E., & Isoard-Gautheur, S. (2014). A reciprocal effects model of the temporal ordering of motivation and burnout among youth table tennis players in intensive training settings. *Journal of Sports Sciences*, *32*(17), 1648-1658.

Ritchie, H., & Roser, M. (2018). Mental Health. *Our World in Data.* https://ourworldindata.org/mental-health (accessed 1 March 2019).

Sindik, J., Novokmet, N., & Havaš-Auguštin, D. (2013). The application of Psychological Skills Inventory for Sports at Croatian coaches and recreational table tennis players. *Sport Science*, *1*, 54-60.

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Evaluation of frictional properties and consequences on table ball interaction for different ITTF approved plastic balls

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***Abstract**:* The purpose of this study is to evaluate influence of table/ball combination on bounce in table tennis. From 2014, a variety of non-celluloid plastic balls have been approved by the ITTF to replace highly flammable celluloid as base material for table tennis balls. Currently, different manufacturers use different type of plastic material and manufacturing process for these new balls. An entire study was performed to compare the interaction between the different types of balls in combination with a selection of table tops. Therefore, hitting experiments have been executed under realistic conditions. Results are used to show the differences in bounce behaviour, but also to check whether the Brody/Durey impact model may be applied for the bounce. This model allows calculation of dynamic parameters Coefficient of Friction (CoF) and Coefficient of Restitution (CoR) from special bounces, which then allows to describe bounce behaviour and thus the consequences on table tennis game. Further to that, there was a check whether it is possible to measure a meaningful CoF from a sliding experiment. At the end, a recommendation was given for a measurement method to classify frictional properties of table/ball combinations in a meaningful way, which could be used for approval purposes.

Keywords: table tennis, plastic balls, table ball interaction, frictional properties, impact model

1. INTRODUCTION

To take care of the quality of the game ITTF approves equipment used in competition. For ball approval, criteria are summarised in Technical Leaflet T3. These criteria have been developed to standardise balls, which in the past all have been made of more or less same material (celluloid). The criteria covered roundness, perpendicular bounce, hardness, weight and other properties. Direct playing properties have not been in focus of T3 criteria in the past (before appearance of plastic balls), but due to the use of always the same material celluloid, T3 worked to keep playing properties under control.

ITTF encouraged manufacturers over decades to develop new balls for table tennis not consisting of highly flammable celluloid as base material. From 2014, finally non-celluloid plastic balls have been approved by the ITTF to be used in high level competition. Currently, different manufacturers use different type of plastic material and manufacturing process for these new balls. But when different plastic materials are used, play-behaviour might get out of control since important properties are not included in T3, that might differ a lot for different plastic material.

Frictional properties are supposed to have big influence on bounce on table and need to be examined.

Thus, the purpose of this study was to investigate frictional properties on the bounce. There is an impact model of Brody/Durey that builds up a connection of Coefficient of Friction (CoF) and the transformation of spin, speed and angle due to bounce. This model can be used both ways: When CoF is known as well as incoming velocity and spin, outgoing velocity and spin may be predicted. On the other hand is is possible to calculate CoF when velocity and spin before and after impact are known.

The study contained three experimental parts: A) Measurement in real table tennis of incoming velocity (speed and angle) for 4 typical strokes. B) Measurement of CoF by use of a quasi static sliding test for several ball/table combinations. C) Determination of CoF for the strokes from B) transferred to a lab set-up (same spin, speed and angles as measured under B). D) Transfer of the tests performed under C) to a spin-drop-test using equivalence principle.

2.THEORETICAL BACKGROUND

To model impact effect, velocities are separated into two components: Normal and tangential (Figure 1). According to different physical effects, each component then can be modelled separately (superposition principle) applying Newton laws.

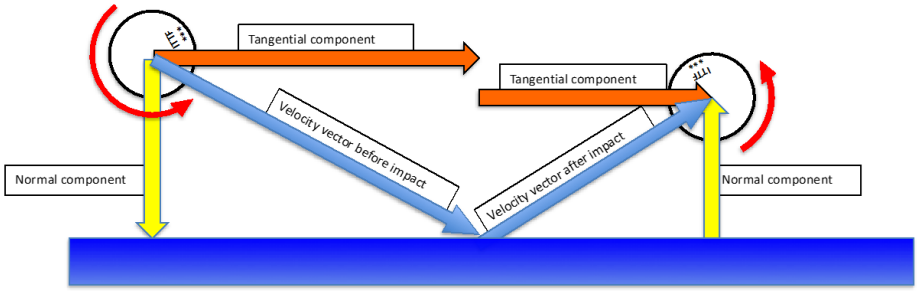


Fig. 1. Explanation of components and scheme of backspin bounce

2A) *Normal component*

Historically, a rough proportionality of outgoing to incoming perpendicular (normal) rebound speed was found.

Thus, for normal component impact is modelled by "Coefficient of Restitution" (CoR)

$$CoR = -\frac{v_{n1}}{v_{n0}} \qquad (1)$$

while index n means normal component, 0 before and 1 after bounce. Popularly

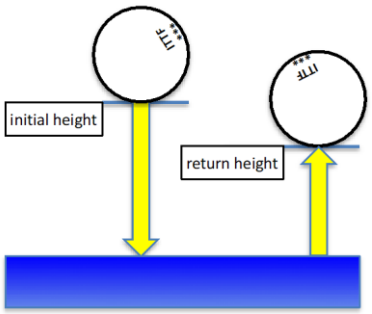


Fig. 2. CoR Explanation

speaking CoR is ratio of rebound height and initial height h in drop test as shown in Figure 2. But to be exact:

$$CoR = \sqrt{\frac{h_1}{h_0}} \qquad (2)$$

To consider CoR as a constant is a simplification, but it works rather good as model equation as long as speed is not passing large ranges.

2B) *Tangential component*

A classic way to take friction into theoretical consideration is the postulation of a proportionality of tangential and normal force between two bodies sliding on each other (Coulomb friction) which then motivates the introduction of a proportionality constant CoF (Coefficient of Friction) (Figure 3):

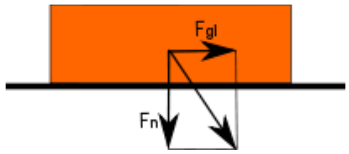


Fig. 3. Sliding force

$$CoF = \left|\frac{F_t}{F_n}\right| \qquad (3)$$

CoF is not a parameter to classify a material alone. It is always related to a material-combination. Using Newton laws and CoF definition, it is possible to postulate a correlation between tangential and normal momentum p with CoF as proportionality constant:

$$|\Delta p_t| = \left|\int_{t=0}^{T} F_t\, dt\right| \overset{\text{def}}{=} \left|\int_{t=0}^{T} CoF\, F_n\, dt\right| = CoF \left|\int_{t=0}^{T} F_n\, dt\right| = CoF|\Delta p_n|$$

(4)

This equation is only true, when the ball slides through during the whole duration of contact. Other cases are also possible which is outlined in the Brody/Durey impact model, but would be too far reaching to outline here. But then it means that, if CoF is double, the ball loses double momentum as well as spin. Thus, we have a model equation to describe the behaviour in the tangential component by use of one parameter.

3. MEASURING REAL TABLE TENNIS STROKES

3a) *Setup*

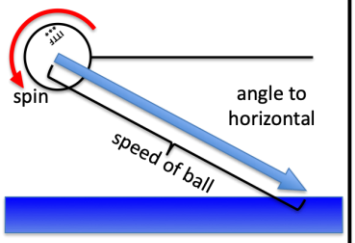
A German third league player served as subject. Four striking techniques were defined to be measured: A) Backspin serve, second bounce, B) long push return on a short backspin serve, C) Forehand topspin against block and D) Forehand topspin against push. Marked balls have been used to allow determination of spin. For each stroke, the contact area has been filmed by a 300f/s high speed camera

perpendicular to the stroke direction as well as by a full HD 50 frames/s camera for the total view to allow to identify outlayers/untypical strokes. For each bounce has been analysed by digitising the balls high speed video frame by frame 5 pictures before and after impact.

Each condition has been measured at least 20 times and mean values have been calculated.

3b) *Results*

Figure 4 shows incoming spin, velocities and angles. This values are used for the rest of the study. Spin direction is important for the two last given values: "Surface velocity caused by spin" means speed of the surface caused only by spin. The total "Resulting tangential surface speed" then is the sum of tangential ball velocity and surface velocity. For backspin strokes, this speed sums up in total value, since the movement direction is the same. For topspin strokes, it is different, since tangential ball velocity and the surface speed caused by spin show in opposite directions.



	Values of Striking Technique						
	Ball Speed	Angle to Horizontal	Tangential Ball Velocity	Normal Ball Velocity	Spin	Surface velocity caused by Spin	Resulting tangential surface speed
Striking Technique	[m/s]	[°]	[m/s]	[m/s]	[Rev/s]	[m/s]	[m/s]
Short Backspin Serve	3,5	32,2	-2,9	**-1,8**	-39,5	-5,0	**-7,9**
Push vs. Serve	5,6	16,8	-5,3	**-1,6**	-50,1	-6,3	**-11,7**
Topspin vs. Block	11,4	18,4	-10,8	**-3,6**	118,3	14,9	**4,1**
Topspin vs. Topspin Halfdistance	11,0	22,1	-10,2	**-4,1**	121,9	15,4	**5,2**

Fig. 4. Explanations and results for real table tennis stroke

4) SPECIMEN FOR OTHER TESTS

4a) *Table-Tops:*

ITTF provided 12 different types of anonymised tiles of competition table tops, supposed to cover the whole range of available friction difference on the market (Figure 5a)

Fig. 5a. Table tiles

4b) *Table Tennis Balls:*

One typical competition table tennis ball based on celluloid. Six different types of approved plastic balls from several manufacturers made of different plastic material and produced with different processes (Figure 5b)

Fig. 5b. Tested balls

5) SLIDING TEST

5a) *Setup*

A simple way to measure CoF is to put a defined weight on three interconnected balls, to pull them over the surface and to measure the pull force (Figure 6). A setup was chosen with a weight of 429 g and a pull speed of 100 mm/min. A typical result then is a zigzag curve (Figure 7) which is quite reproducible. CoF is calculated on a defined distance. For each ball/table combination experiment was repeated 3 times to scrutinize significance.

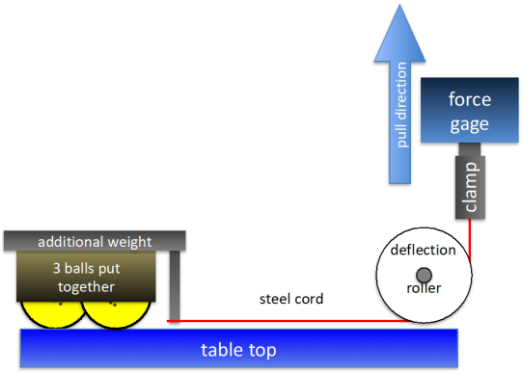


Fig. 6. Sliding test setup

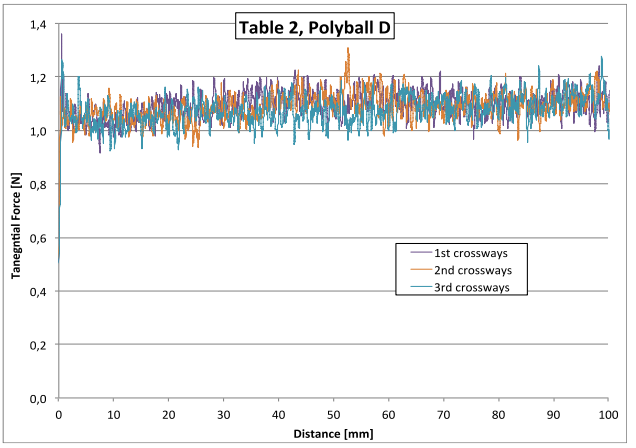


Fig. 7. Force curves for 3 repeated tests

5b) *Results*

Figure 8 shows CoF results of sliding tests for all Ball (lines) Table (columns) combinations.

CoF was found in a range of 0.14 … 0.32, but results look sometime complex (no simple superposition). Generally, Celluoid balls show least friction and the range of difference covered by the balls may be 0.12 dependent on table type, which is quite a lot. In this test, No. 3, 1, 5 and 7 generally showed lowest friction, and No. 6, 10 and 9 show highest friction. But picture not consistent for all types of balls.

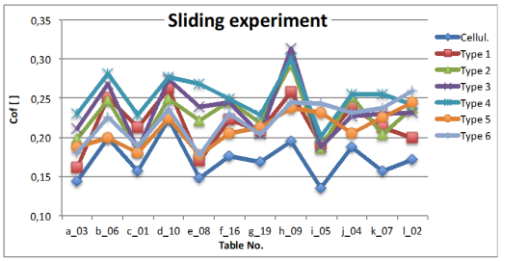


Fig. 8. Results of sliding test

6) Impact experiments

6a) *Backgrund*

Sliding experiment runs at only 100 mm/min. Only in simple linear theory, CoF and CoR are constant parameters. But reality is non linear, thus CoR and CoF are dependent on intensity (directed relative speed) of experiment. Relative tangential impact speed in table tennis is in the range of 10 m/s, which is 6.000 times faster than sliding experiment. Use of model equation (4) allows to calculate "dynamic" CoF out of impacts results:

$$CoF = \left|\frac{(v_{t1}-v_{t0})}{(v_{n1}-v_{n0})}\right| \qquad (5)$$

6b) *Experimental Setup*

To exclude human factor, impacts have been produced/measured with special test device to determine CoF and CoR, consisting of: High performance cannon allowing pre-defined speed (±0.1 m/s) and spin (± 0.5Hz). Shooting angle precisely adjustable (± 0.1°) and high high performance velocity measurement (± 0.03 m/s). The above described results for the four striking techniques have been used to define four conditions for lab tests. All 12 x 7 table top and ball types have been measured. Each table/ball combination has been tested for each striking technique 36 times to generate mean values. In total more than 12.000 impacts have been analysed.

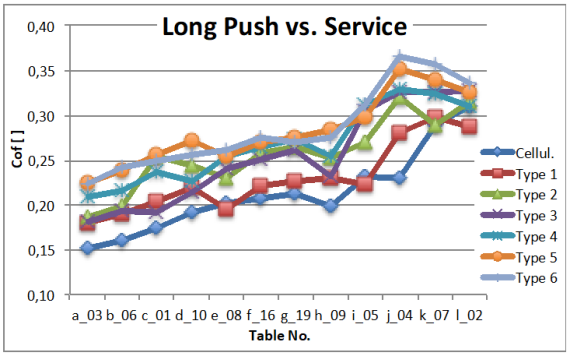


Fig. 9. CoF for Long push vs. Service

6c) *Results*

Figure 9 shows CoF for "Long Push vs. Serve" for all table ball combinations: Highest CoF 0.37 for Table #4 and Poly-Ball Type 6. Lowest CoF 0.15 for Table #3 and Celluloid-Ball. For Poly-Balls lowest CoF 0.17 is found for Ball Type 1 also on Table #3. CoF for each table may vary about 0.07 dependent on ball. CoF range for each ball is about 0.15 dependent on table.

Figure 10 shows CoF mean values for "Backspin serve" drawn against "Long Push vs. Serve" for all the 12 x 7 table ball combinations. We find a very good correlation between the results of CoF measured from two completely different incident conditions. This is not the case if CoF results of sliding experiment is compared with "Backspin serve", Figure 11.

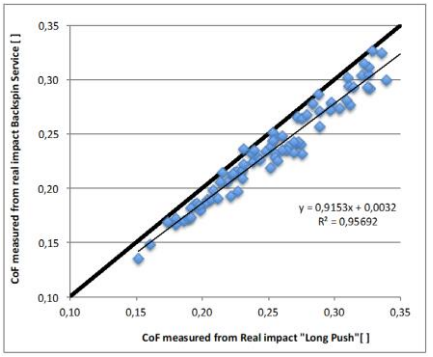


Fig. 10. Correlation of CoF measured from two strokes

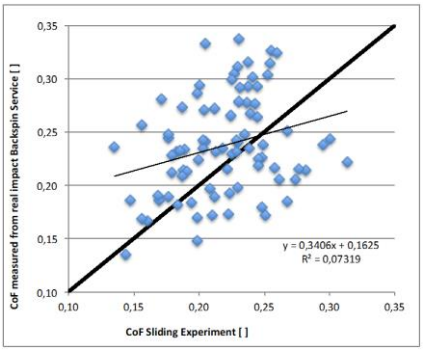


Fig. 11. Correlation between CoF measured for 2 strokes and sliding

Spin bounce test

7a) Background of development

Conclusions of results so far are: There really is a big difference in frictional properties and the difference has become bigger due to introduction of plastic balls with unregulated material. With some plastic balls, we find 70% higher CoF which means directly 70% more loss of tangential momentum and spin during bounce. Players reported a lot, that with plastic balls, they produce less spin but in fact, the spin is lost at bounce on table due to higher friction. Difference in bounce due to friction demands adaption of players each time they change type of ball. Thus, there is the necessity to introduce tests to record frictional properties. Second conclusion is: A sliding test does not give meaningful results. While measuring, relative surface speeds need to be in a realistic range (as Figure 4). The task then was to design a method to analyse impacts with a simpler setup as used under 6).

7b) Design of device

Using equivalence principle, it is possible to transfer conditions from real strokes from Figure 4 and 1 to perpendicular spindrop experiments: Tangential surface velocity then has to be completely produced by spin, while normal incident velocity is defined by the drop height. The ball is rotated on predefined rate attaching it to a

motorized axis (Figure 12). Then the ball is released and dropped on the table and displaces sidewise because of spin (Figure 13). A fundamental calculation shows, that measurands to determine CoF and CoR then can either be velocity components (before and after bounce) or displacement and time shift between two bounces:

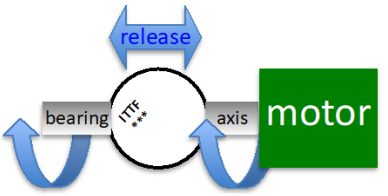


Fig. 12. Spinning mechanism

$$CoF = \left| \frac{\Delta x}{\Delta t \left(\frac{1}{2} g \, \Delta t + \sqrt{2gh} \right)} \right| \quad (6)$$

$$CoR = \Delta t \sqrt{2gh} \quad (7)$$

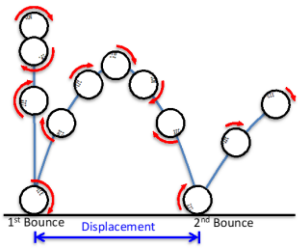


Fig. 13. Spinning mechanism

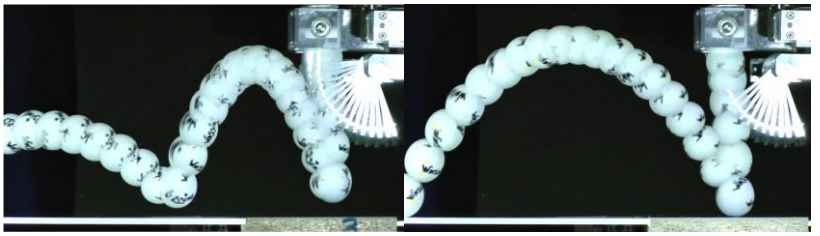


Fig. 14. Stroboscopic picture of spin bounce on low (left) and high friction table top (right)

Figure 14 shows stroboskopic pictures from such spinbounce tests with same plastic balls released from the same height and with the same spin but on the two most different table surfaces. On the one hand, we see that the test works. On the other hand it visualises how different table surfaces currently behave with plastic balls and how much influence this might have on the game.

REFERENCES

Durey, A. (1987). Vers des activités didactique de mise au point des modèles: trajectoires, frappés, rebonds de balles en rotation [Towards didactic activities for the development of models: trajectories, hits, bounces of rotating balls]. (Thesis). France, Paris.

Technical Leaflet T3 (2018). *The Ball (Version for 40mm Balls) BoD Approval*. Retrieved from http://www.ittf.com/wp-content/uploads/2018/07/T3_Ball_BoD2018.pdf

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Estimation of table tennis ball drop position using a high-speed camera

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Abstract: In order to develop a system capable of analysing table tennis matches in real time, we propose a method for estimating the ball dropped position. Previously, when the drop position of a hit ball was estimated using a regular commercially available camera, the error between the actual and estimated drop position was 140 mm on average with a maximum of ~300 mm. When predicting the drop position of a hit ball, the average error was 280 mm and the maximum was ~600 mm. In this study, we investigated a method for more precisely estimating the drop position of a ball that overcomes the effects of lighting. We photographed table tennis balls using a single high-speed camera and estimated their drop position by combining a background difference method and a particle filter. As a result, the errors between the actual and estimated drop positions of balls was an average of 40 mm to 60 mm, and the estimation precision was improved because the incorrect estimates were significantly reduced.

Keywords: table tennis ball, drop position, particle filter, estimating

1. INTRODUCTION

Video is currently being used to perform objective analysis in many ball sports. If an analysis system that utilizes video and can be used at competitions were developed, both the competitiveness and audience ratings for table tennis games can be improved.

Herein, the authors was proposed a method for analysing the after-images of a table tennis ball captured by a single video camera to estimate and predict the position where a ball drop. To estimate the drop position, the drop position of the ball is calculated from the change in path of the ball after-images formed by the ball bouncing on the table-tennis table. To predict the drop position, the drop position of the ball is calculated from the trajectory of the ball after-images prior to bouncing on the table-tennis table. In previous research, the authors have estimated and predicted the drop positions of balls hitting in a single direction, resulting in an average estimation error of 140mm, with a maximum of approximately 300mm. The average prediction error was 280 mm, with a maximum of approximately 600 mm. It

was also shown that, when estimating the drop position of the ball during a rally, the drop position could be estimated at a degree of accuracy equal to or greater than that of the previous research. Although this method can be used to calculate the drop position of a ball using a single store-bought video camera with a degree of accuracy acceptable for actual tactic analysis, calculating the drop position of a ball when capturing video under lighting that uses normal fluorescent lamps or mercury proved to be difficult. To detect the after-images of a ball more easily, a table-tennis table covered with a blackout curtain had to be placed next to the table-tennis table being used, such that the pattern of the floor did not interfere.

In this research, the authors propose a method using a high-speed camera to relax these restrictions. A high-speed camera can more clearly capture the shape of a ball than a general camera and should enable a robust system to be built while unaffected by lighting or floor pattern.

2. METHODS

2.1. Method for estimating drop position

In this research, two methods were used to track the ball to estimate the position at which the ball dropped. The first method involves utilizing background differences to extract the regions of the ball in each frame continuously. This is the same method used in the previous research ('method using background differencing' hereinafter). The second method involves extracting the regions of the ball continuously using a colour histogram and particle filter to identify similar images after extracting the regions of the ball using background differencing ('method combining background differencing with a particle filter' hereinafter). Using a particle filter is ideal for tracking objects in real time, as the amount to calculate is small.

2.1.1. Method using background differencing

The method using background differencing processes images based on the following five steps.

I. Extract the ball region
II. Remove noise outside of the ball region
III. Segment the extracted ball region
IV. Estimate the drop position of the ball in the image
V. Convert to coordinates on the table-tennis table

The overview of this process is described below.

When capturing video using a high-speed camera, the ball once hit can be captured without any blurring, and the ball region can be extracted continuously if the frame rate is increased to a sufficiently high number. This enables the drop position of the ball to be captured. Figure 1 shows the change in the ball's trajectory according to the shutter speed. During Process I, background differences and a threshold are used to binarize the image in each frame, and the region of the table tennis ball is extracted from the captured image.

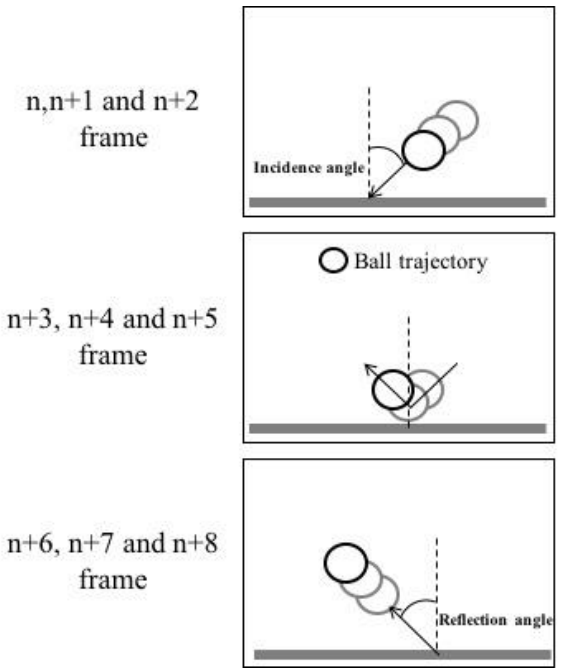

Fig. 1. Change in trajectory according to shutter speed

Depending on the lighting, the frame brightness may change at a slightly different cycle than the frame rate; therefore, multiple frames in which the ball is not present were used to update the background image sequentially. During Process II, erosion and dilation processing (typical methods to remove noise in binarized images; they are jointly referred to as morphological processing) are used to remove noise outside of the table tennis ball region. Erosion processing will replace a pixel being observed with a white pixel if even a single white pixel (background pixel) is located near the pixel thereof. Dilation processing will replace a pixel being observed with a black pixel even if a single black pixel (table tennis ball region pixel) is located near the pixel thereof. Because excessive noise is found in small isolated regions not included in the extracted trajectory, erosion processing is first performed twice; subsequently, dilation processing is performed two times. Noise removal is performed in a three-by-three region cantered on the pixel being observed.

The regions of the ball extracted during Processes I and II will be individual pixels; therefore, segmenting must be performed to aggregate the pixels into a single region. During Process III, region clustering that utilizes an improved nearest neighbour algorithm is used to segment the extracted ball region. Figure 2 shows clustering based on an improved nearest neighbour algorithm. The improved nearest neighbour algorithm adds class merging and elimination processes to the standard nearest neighbour algorithm. This prevents segmentation of a section wider than the original extracted region and eliminates segments composed of only noise, thus enabling the detection of only the ball region used for estimation. During Process IV,

the change in the vertical direction of the ball region detected in the image is used to estimate the position at which the ball drops (Figure 1). It is noteworthy that, in this research, the ball is estimated only in a single direction (when the ball is hit from one side to the opposite side). During Process V, a planar projection matrix is used to convert the drop position estimated in the image into coordinates on the table-tennis table. For these coordinates, the upper left corner of the table-tennis table was set as the origin, while the horizontal direction moving to the right was set as the x_w-axis, and the vertical direction moving upward was set as the y_w-axis (Figure 3).

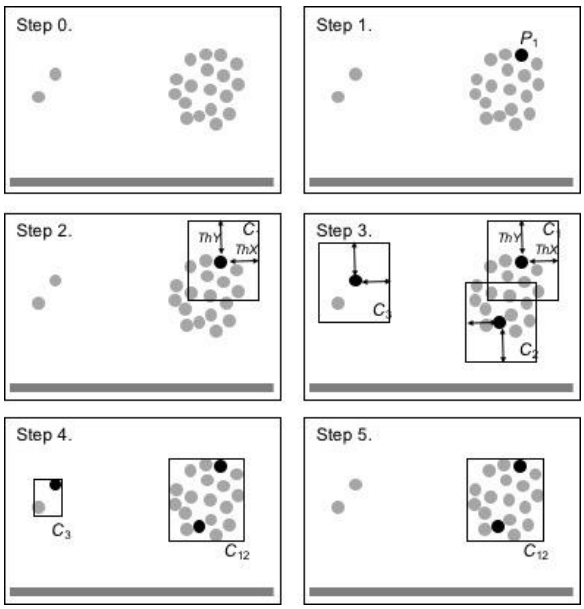

Fig. 2. Clustering based on improved nearest neighbour algorithm

Improved nearest neighbour algorithm:

Step 0. Points within the image are possible points for the ball regions extracted through background differencing. These possible ball region points are set as P1 to PN.

Step 1. The point being observed P1 is assigned to class C1. When P1 is regarded as the representative point of class C1, the process moves to the next possible point (i=2).

Step 2. The distance in the X and Y directions between point Pi and the representative point of each class Cj is determined. With the distance in the X direction to class Cj set to DXij and the distance in the Y direction set to DYij,

A) If $DX_{ij} < ThX$ & $DY_{ij} < ThY$, point P_i is assigned to class C_j.

B) If it is not assigned to any class, point P_i is registered as a new class.

Step 3. The results immediately after searching for all possible points are shown and clustered into three regions.

If i = N, the process continues to Step 4; otherwise,
the process returns to Step 1.

Step 4. If the rectangular regions of classes touch, they are merged into a single class.

Step 5. If the horizontal width, vertical width, pixel count, or area ratio of a class is at or below the threshold, that class is eliminated as a noise region. In Figure 2, noise region C3 has been eliminated. Finally, the possible ball region points in the ball region class C12 are registered as region points.

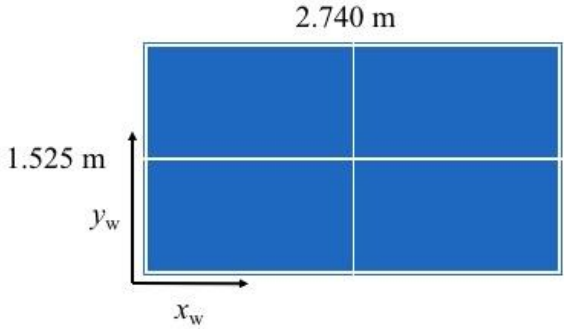

Fig. 3. Coordinates set on table-tennis table

2.1.2. Method combining background differencing with particle filter

This method processes images using the following four steps:

I. Extract the initial ball region
II. Use a particle filter to track the ball
III. Estimate the drop position in the image
IV. Convert to coordinates on the table-tennis table

The overview of this process is described below.

In this method, the object to detect (the initial rectangular region of the table tennis ball) must first be specified. Therefore, during Process I, Processes I through III from Section 2.1.1 are used to extract the initial rectangular region of the ball that has passed over the net. Figure 4 shows an image where background differences were used to detect the initial rectangular region of the table tennis ball. In the image, 'frame' in the upper left indicates the frame number.

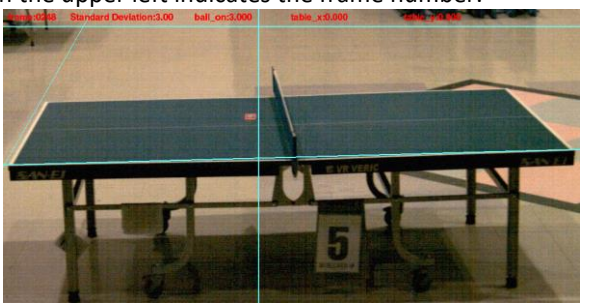

Fig. 4. Initial rectangular region of table tennis ball

During Process II, a condensation algorithm is used to track the ball. This algorithm repeats four operations (prediction, observation, target estimation, and selection) per time unit to track the target object. The following ① to ⑤ conditions are set for the particle filter and calculated during each operation. Figures 5 and 6 show the images of the ball being tracked.

① State vector: Centre of gravity of rectangular region
② Particle state transition model: Uniform linear motion + normal random number
③ Likelihood calculation: Degree of similarity of colour histogram for rectangular region
④ Estimation of target object: Weighted average considering the state quantity of each particle
⑤ Particle selection: Extraction based on weight of each particle

Fig. 5. Tracking using a particle filter (1)

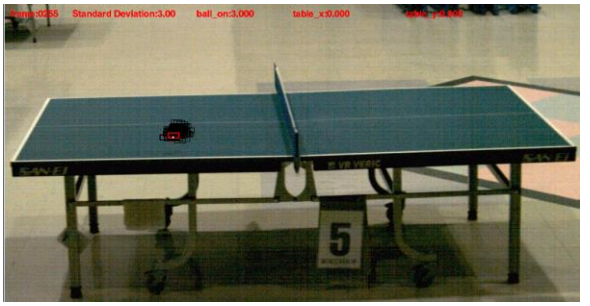

Fig. 6. Tracking using a particle filter (2)

Processes III and IV are the same as Processes IV and V in Section 2.1.1, respectively. Figure 7 shows the estimated drop position of the ball in the image. In the image, 'table_x' and 'table_y' on the upper right indicate the estimated drop position of the ball on the table-tennis table.

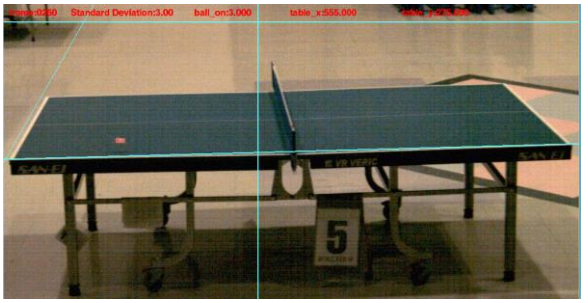

Fig. 7. Example of image results for method combining background differencing with a particle filter (Drop position estimated area in image)

2.2. Experiment method

A table-tennis table (SAN-EI IF-VERIC) and official balls (40-mm plastic white balls) were used during the experiment. A high-speed camera (HAS-EF digital high-speed camera from DITECT) was placed 6.70 m from the edge of the table-tennis table, at a height of 2.40 m. Figure 8 shows the layout of the experiment. The frame rate was set to 200 fps and the shutter speed to 1/300 s when capturing the footage. Video data was imported into a computer in JPEG format (1024 – 768 pixels). Processing 2 was used to create the program that performed the processes described in the previous section.

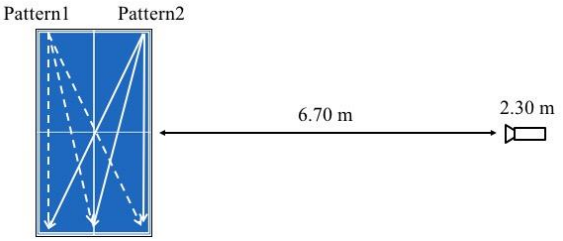

Fig. 8. Experiment layout

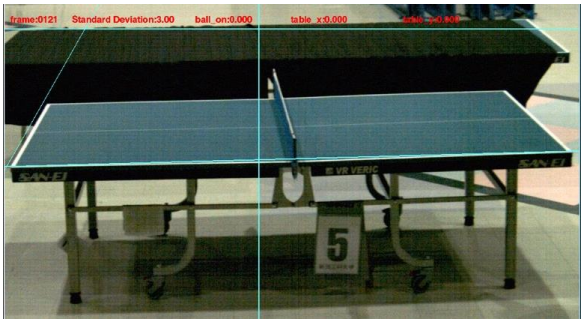

Fig. 9. Background condition A

As shown in Figure 8, two patterns were used to hit the ball during the practice throw. In Pattern 1, the player was positioned at the upper left and hit five balls each

straight, to the centre and crossing the table. In Pattern 2, the player was positioned on the upper right and hit five balls each in the same regions as in Pattern 1. The experiment was captured indoors using a mercury lamp under two conditions. In condition A (Figure 9), a table-tennis table covered in a blackout curtain was placed next to the table-tennis table to prevent the floor pattern being shown in the video. In condition B (Figures 4 to 7), this table-tennis table covered in a blackout curtain was not used. The region surrounded by the light blue frame in Figure 4 was used as the region to detect the ball, and the drop position was estimated for 60 balls.

3. RESULTS AND DISUCUSSION

3.1. Using background differences to estimate background condition A

Background differences (described in Section 2.1.1) were used to estimate the drop positions of the balls for Patterns 1 and 2 under background condition A. This was estimated for 30 balls. Figure 10 shows two scatter diagrams depicting the coordinates for the actual positions where the balls dropped and the estimated positions x_w and y_w for each pattern. It is noteworthy that, for the actual positions where the balls had dropped, the bouncing position on the image was confirmed visually; subsequently, the position was calculated from the relationship between the coordinates in the image and those on the table-tennis table.

◆: Dropped points ■: Estimated points ▲: Table frame

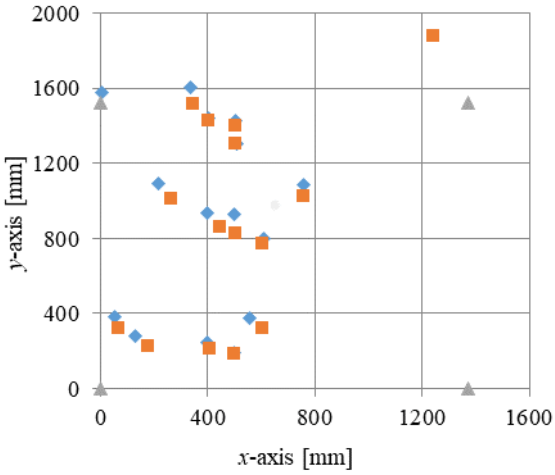

Fig. 10-1. Scatter diagram indicating actual and estimated ball drop positions under background condition A (pattern 1)

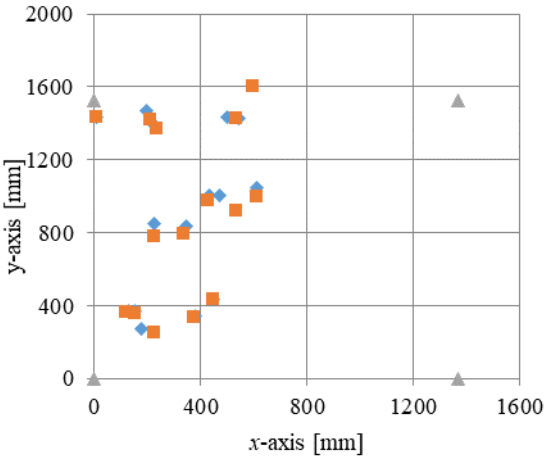

Fig. 10-2. Scatter diagram indicating actual and estimated ball drop positions under background condition A (pattern 2)

Table 1 shows two tables including the distance errors for the coordinates of the actual positions where the balls had dropped and the estimated positions, $\boldsymbol{x_w}$ and $\boldsymbol{y_w}$. The average estimation difference for Pattern 1 was 135.8 mm, with a maximum of 1272.6 mm. The average estimation difference for Pattern 2 was 135.8 mm, with a maximum of 194.4 mm. The highest distance error in Table 1-1 was for ball number 14, in which the estimation was clearly different from the actual distance. This large estimation error was likely due to the ball touching the net and subsequently dropping to the end of the table-tennis table. The position where the ball touched the net was therefore estimated incorrectly as the drop position. This could likely be improved by adding a new judgement condition to the simple judgement used currently. For ball number 13 in Table 1-2, the white line on the inside of the table-tennis table was the same colour as that of the ball and affected the processing. This will likely result in an incorrect estimation of the drop position, i.e. slightly ahead of the position at which the ball had actually dropped. If these two cases are excluded, the average estimation error would be 60 mm for Pattern 1 and 40 mm for Pattern 2, which represents a clear improvement in estimation accuracy compared to using a store-bought camera.

Table 1-1. *Distance error between actual and estimated ball drop positions under background condition A (pattern 1)*

Ball number	Drop *x*w	Drop *y*w	Estimate *x*w	Estimate *y*w	Error
1	129	278	177	224	72.2
2	498	188	500	187	2.2
3	56	383	69	320	64.3
4	558	373	604	318	71.7
5	400	246	408	209	37.9
6	501	927	503	827	100.0
7	217	1095	265	1014	94.2
8	756	1084	757	1024	60.0
9	400	939	448	862	90.7
10	609	800	604	772	28.4
11	502	1431	503	1398	33.0
12	509	1302	502	1302	7.0
13	405	1444	402	1428	16.3
14	6	1581	1243	1880	1272.6
15	337	1603	346	1517	86.5
Average					135.8 [mm]

Table 1-2. *Distance error between actual and estimated ball drop positions under background condition A (pattern 2)*

Ball number	Drop *x*w	Drop *y*w	Estimate *x*w	Estimate *y*w	Error
1	381	345	373	333	14.4
2	153	372	121	363	33.2
3	129	375	154	359	29.7
4	447	436	449	436	2.0
5	175	272	225	254	53.1
6	343	833	336	792	41.6
7	471	1003	535	922	103.2
8	612	1044	613	999	45.0
9	433	1008	428	979	29.4
10	227	848	227	778	70.0
11	542	1426	535	1426	7.0
12	215	1405	209	1421	17.1
13	502	1431	598	1600	194.4
14	9	1433	9	1432	1.0
15	195	1472	234	1370	109.2
Average					50.0[mm]

3.2. Estimation of background condition B using background differencing

Next, background differencing (described in Section 2.1.1) is used to estimate the drop positions of the balls under background condition B. The positions for 30 balls were estimated for Patterns 1 and 2 combined. Figure 11 shows two scatter diagrams depicting the coordinates for the actual positions where the balls had dropped and the estimated positions, x_w and y_w for each pattern. Table 2 shows two tables including the distance errors for the coordinates of the actual positions where the balls had dropped and the estimated positions, x_w and y_w. The estimation results indicated average errors of 187.6 and 422.3 mm for Patterns 1 and 2, respectively. Meanwhile, the maximum errors were 971.2 and 1618.0 mm, respectively. Six balls in Pattern 1 (balls number 6, 10, 11, 13, 14, and 15 in Table 2-1) and ten balls in Pattern 2 (balls number 1, 2, 6, 7, and 9 through 14 in Table 2-2) were incorrectly estimated in positions that were clearly different from their actual drop positions. The increased estimation error is likely due to the white line shown on the table-tennis table toward the inside of the image. If the target ball region overlaps with the white line, the detection region of the ball for estimation will become extremely small even if processed using background differencing, thus complicating its differentiation from noise. This can be verified in Figure 11 that shows a white line on the end or side of the table-tennis table that tends to be used for estimation rather than the actual drop position.

◆: Dropped points ■: Estimated points ▲: Table frame

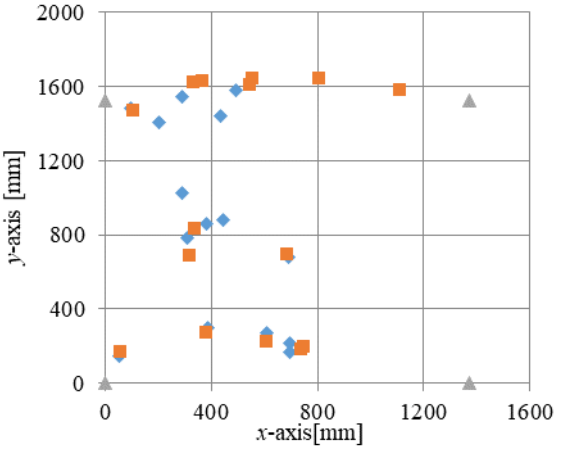

Fig. 11-1. Scatter diagram showing actual and estimated ball drop positions under background condition B (pattern 1)

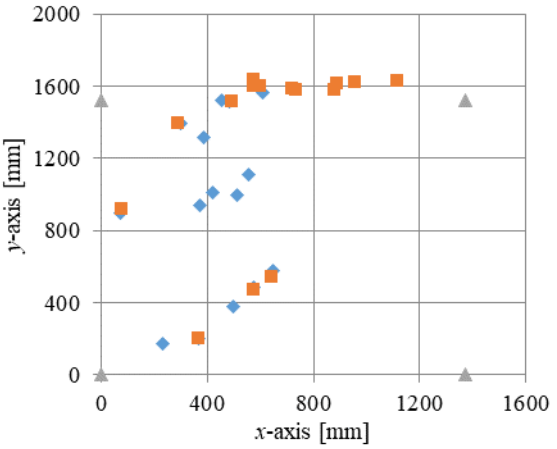

Fig. 11-2. Scatter diagram showing actual and estimated ball drop positions under background condition B (pattern 2)

Table 2-1. *Distance error between actual and estimated ball drop positions under background condition B (pattern 1)*

Ball number	Drop *x*w	Drop *y*w	Estimate *x*w	Estimate *y*w	Error
1	610	270	609	221	49.0
2	385	296	383	271	25.1
3	51	146	56	168	22.6
4	696	165	737	183	44.8
5	695	212	748	193	56.3
6	442	877	1111	1581	971.2
7	690	680	683	694	15.7
8	310	782	317	685	97.3
9	380	859	336	834	50.6
10	289	1026	805	1640	802.0
11	201	1407	331	1620	249.5
12	97	1486	105	1468	19.7
13	494	1581	543	1608	55.9
14	432	1441	555	1640	233.9
15	287	1543	368	1632	120.3
Average					187.6 [mm]

Table 2-2. *Distance error between actual and estimated ball drop positions under background condition B (pattern 2)*

Ball number	Drop *x*w	Drop *y*w	Estimate *x*w	Estimate *y*w	Error
1	497	380	1115	1631	1395.3
2	231	172	955	1619	1618.0
3	646	579	644	540	39.1
4	369	202	369	202	0.0
5	576	484	576	471	13.0
6	420	1009	734	1582	653.4
7	513	998	877	1579	685.6
8	73	901	79	922	21.8
9	558	1110	888	1613	601.6
10	372	943	721	1583	729.0
11	387	1318	574	1604	341.7
12	454	1520	494	1514	40.4
13	484	1516	576	1638	152.8
14	607	1566	598	1600	35.2
15	299	1394	291	1394	8.0
Average					422.3[mm]

3.3. Estimation of background condition B using background differences and a particle filter

Estimation using simple background differencing results in many erroneous estimations; therefore, a method combining background differencing with a particle filter (described in 2.1.2) is used next for estimation. Although the same data from 2.1.1 were used when estimating the hit balls, processing using a particle filter estimates the drop positions stochastically; therefore, the estimated position will not necessarily be the same at each time. In this method, the position was estimated thrice for each hit ball, and the average value was used as the estimated position. Figure 12 contains two scatter diagrams showing the coordinates for the actual positions where the balls had dropped and the estimated positions, x_w and y_w for each pattern.

◆: Dropped points ■: Estimated points ▲: Table frame

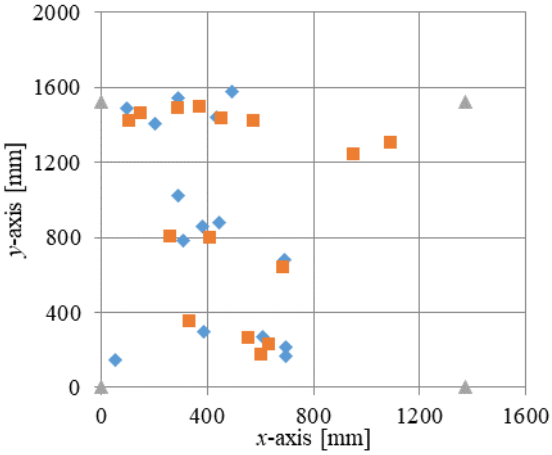

Fig. 12-1. Scatter diagram showing actual and estimated ball drop positions under background condition B using background differences and a particle filter (pattern 1)

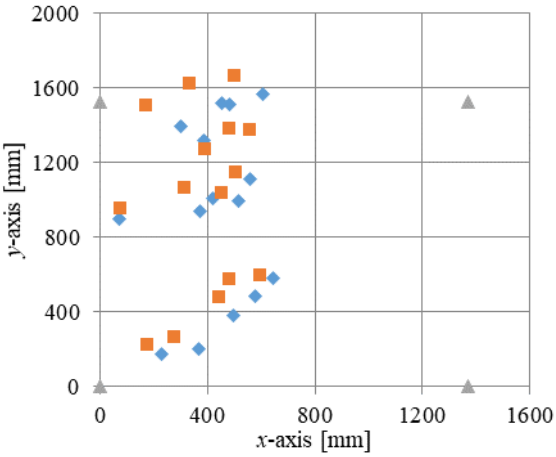

Fig. 12-2. Scatter diagram showing actual and estimated ball drop positions under background condition B using background differences and a particle filter (pattern 2)

Table 3-1. *Distance error between actual and estimated ball drop positions under background condition B using background differences and a particle filter (pattern 1)*

Ball number	Drop *x*w	Drop *y*w	Estimate *x*w	Estimate *y*w	Estimate *x*w	Estimate yw	Estimate *x*w	Estimate *y*w	Error
1	610	270	555	263	555	263	555	263	55.4
2	385	296	334	350	328	351	335	338	72.9
3	51	146	951	1242	944	1243	908	1295	1421.7
4	696	165	634	230	634	218	634	218	84.2
5	695	212	605	175	644	194	655	204	63.9
6	442	877	409	797	409	797	407	783	91.1
7	690	680	685	640	685	640	685	640	40.3
8	310	782	258	802	258	802	258	802	55.7
9	380	859	1092	1303	1092	1303	1095	1286	837.0
10	289	1026	575	1421	582	1420	451	1503	489.0
11	201	1407	149	1462	136	1464	152	1461	78.3
12	97	1486	103	1419	118	1401	102	1403	79.1
13	494	1581	451	1437	465	1436	448	1438	149.3
14	432	1441	370	1498	367	1498	374	1497	83.7
15	287	1543	287	1492	287	1492	280	1493	50.7
Average									243.5 [mm]

Table 3-2. *Distance error between actual and estimated ball drop positions under background condition B using background differences and a particle filter (pattern 2)*

Ball number	Drop *x*w	Drop *y*w	Estimate *x*w	Estimate *y*w	Estimate *x*w	Estimate yw	Estimate *x*w	Estimate *y*w	Error
1	497	380	444	474	447	474	448	461	103.0
2	231	172	177	224	659	1393	178	212	450.6
3	646	579	597	598	597	598	593	611	55.5
4	369	202	276	260	276	260	274	248	108.1
5	576	484	482	573	479	573	479	573	130.9
6	420	1009	314	1067	314	1067	311	1067	121.7
7	513	998	453	1034	450	1034	449	1049	74.6
8	73	901	76	951	76	951	85	1503	234.1
9	558	1110	504	1147	151	1544	507	1147	240.4
10	372	943	557	1374	557	1374	553	1391	473.7
11	387	1318	389	1270	379	1271	386	1270	47.7
12	454	1520	335	1620	331	1620	488	1368	71.2
13	484	1516	484	1384	487	1400	488	1368	132.0
14	607	1566	499	1665	552	1573	499	1665	113.3
15	299	1394	172	1508	173	1524	177	1524	176.5
Average									168.9 [mm]

Table 3 shows two tables including the distance errors for the coordinates of the actual positions where the balls had dropped and the estimated positions, x_w and y_w. The results of estimation indicated average errors of 243.5 and 168.9 mm for Patterns 1 and 2, respectively. Meanwhile, the maximum errors were 1421.7 and 473.7 mm, respectively.

Table 3 shows that, although some erroneous estimations occurred, using a color histogram and particle filter clearly and significantly reduced the number of such errors compared to the previous method. In background condition B, it is extremely difficult to detect the white ball because the floor is overall white. However, a colour histogram and particle filter can be used to build a system capable of estimating at a better accuracy even under such conditions, by placing a mat used in official games on the floor.

4. CONCLUSION

In this research, we proposed two methods of using a single high-speed camera to estimate the drop position of a table tennis ball, and subsequently assessed the accuracy of estimations performed using these methods quantitatively. The two methods proposed herein were a method using background differencing and a method combining background differencing with a particle filter. This research revealed the following:

1. The method using background differencing could estimate with a high accuracy level (with an estimation error of approximately 40 to 60 mm) under conditions where no white floors were shown in the images, even if a mercury lamp was used for lighting.
2. However, it was difficult to estimate the drop position of a ball using background differencing under conditions where a white floor was shown in images.
3. Using a particle filter together with background differences could improve the estimation accuracy under conditions where a white floor was shown in the images, and this could be applied to systems used at competition sites.

In the future, we will investigate the method to capture and process images under conditions more suited to actual competition sites.

REFERENCES

Fujiyosi, H., (2009). *Moving image processing technology and its application.* Triceps seminar text.

Kamijima, K., Ito, K., Ushiyama, Y., Shioiri, A., & Gao, P. (2017). Estimation and Prediction of Table Tennis Ball Fall Position from Monocular Image using After-image. *Niigata Physical Education Research*, *35*, 17-28 (in Japanese).

Kobatake, H., (1996). *Morphological*. Tokyo.: Corona Publishing CO., LTD. Processing.org. (n.d.). Processing, Retrieved April, 15, 2019, from https://processing.org/

Seki, Y., Ushiyama, Y., Kamijima, K., Iizuka, S., Guang, X., et al. (2011). The Table Tennis Game Analysis Method by Relationship between Falling Points and Flight Time of the Ball. *Niigata Physical Education Research*, *29*, 91-99 (in Japanese).

Tanaka, K., Ito, K., & Kamijima K. (2017). Estimation of Ball Falling Position during Table Tennis Rally by Monocular Image using After-image. *Proceedings of the 2017 IEICE Shin-Etsu Conference.* 150. MACHINE PERCEPTION AND ROBOTICS GROUP(MPRG). (2019). Retrieved April 15, 2019, fromhttp://www.vision.cs.chubu.ac.jp/VU/html/index. html

Yang, F., Ushiyama, Y., Huanyu, Z., Iizuka, S., & Kamijima, K. (2010). The analysis of the ball fall point in table tennis game. *International Journal of Table Tennis*, 6, 131-138.

Yang, F., Ushiyama, Y., Ooba, M., Huanyu, Z., Mizoi, et al. (2010). About the Attack Pattern Up to the Third Ball of the Table Tennis Player of University. *Niigata Physical Education Research*, *28*, 51-56 (in Japanese).

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Psychological characteristics of the national Hungarian table tennis team

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Abstract: *Aim:* The aim of the study was to investigate the relationship between age category, assertiveness, temperament and character dimensions and the playing styles of the players. *Method:* A total of 32 table tennis players from the Hungarian national team were tested (average age 19,31, male=7, female=25). Three questionnaires were used. (1) Competitive State Anxiety Inventory-2 (CSAI-2) with 3 subscales (cognitive and somatic anxiety, and self-confidence); (2) Assertiveness Questionnaire (AST) with 2 subscales (offensive, defensive); (3) Temperament and Character Inventory (TCI) with 7 subscales, out of these 4 temperament subscales (novelty seeking, harm avoidance, reward dependence, persistence) and 3 character subscales (self-directedness, cooperativeness, self-transcendence). *Results:* We used SPSS 22 and found positive relationship between assertiveness and attacking playing style (p=0,02). Significant difference were found between gender in cognitive (p=0,01) and somatic anxiety (p=0,01). Among age categories (cadet, junior, adult) the only positive relationship were found between the offensive subscale of assertiveness and junior category (p=0,02). There were no significant difference between the temperament and character dimensions and age categories, playing styles and assertiveness. *Conclusion:* Results showed that assertiveness can be a core element of the attacking style.

Keywords: table tennis, anxiety, assertiveness, personality temperament

1. INTRODUCTION

Sport psychology deals with sports and the psychological characteristics of the athlete. It explores the factors that affect sports performance.

Assertiveness behavior is characterized by self-confidence and accomplishment of will, which is important in sport. In Hungary the introduction of assertivity in sport attaches to Nagykáldi (2002, quoted Morvay-Sey, 2015). He says that assertiveness in sport is an initiative, confident attitude. A player, who is assertive, uses an offensive playing style, but not aggressive (Nagykáldi, 2002). Németh et al. (1999) in their study resulted, that there were positive correlation between assertiveness and confidence and with the effectiveness of an action on the playing court.

Psychologists have long been attributing successful athletic performance to their personality characteristics (Matystsin, 1994). The TCI questionnaire (Cloninger, 1987) has not been applied on table tennis players, so our research is a novelty in this regard. The Temperament and Character Inventory (TCI) developed by Cloninger (1987) provides broad information on personality characteristics. It is a biopsychosocial model of the personality. It is focusing on seven dimensions of

personality, which are vary wildly in general population. The four temperament factors are genetically independent from one another, moderately heritable, and stable across time (Cloninger et al., 1991). Sensation seeking is the far most studied personality factor in the literature (Monasterio et al., 2014) especially among high risk taking sports (e.g.: mountain climbing, BASE jumping, etc). Sport psychology literature principally uses TCI to investigate novelty seeking among high risk physical athletes and to compare the results of the athlete group with the non-athlete group (Han et. al, 2006). Furthermore, they found that endurance sports showed highest Novelty Seeking, and lowest Persistence score among 4 types of sports (endurance, power/combat, power/individual, and team sports). Specifically, taekwondo players were lowest and throwers were highest in Novelty seeking. Long distance runners were lowest and cerium players were highest for Persistence. Golfers were lowest and swimmers were highest in Harm avoidance (Han et. al, 2006).

In this study we wanted to examine all the factors of the personality, because we assume, that there is a relationship between temperament, character dimensions, assertiveness and playing style (e.g.: positive correlation between harm avoidance and defensive playing style).

Anxiety is one of the most common problems among athletes. (Gyömbér, 2017). The Competitive State Anxiety Inventory-2 developed by Martens et al. (1990) measures very good state anxiety and self confidence before competition. We can see in the sport psychology literature, that anxiety negatively correlates with self-confidence (Hajdúné, 2003). Kurimay et al. (2017) examined gender differences in table tennis players and they found that women rated their cognitive anxiety higher than their male counterparts.

Tactics, especially in team sports seems to be an important factor that affects the performance (Charmichael-Thomas, 1995; Skandalis et al., 2017). Gkagkanas et al. (2018) found gender differences (not significant) in defense and attacking tactical options among beach handball players. In table tennis sport there are some easily definable playing styles that are used by athletes. It can be divided in two main categories, attacking and defensive style. Within the attacking style more styles can be distinguished: (Friedrich, Fürste, 2012).

(1) Attacking from both side. This playing style make great efforts to achieve the point as soon as possible, use roughly equal proportions of back and forehead sides

(2) Forehand-oriented, aggressive attacking style: It strives to gain points with forehand spin. Even from the backhand sides turning out with forehand and try to beat with forehand.

(3) Backhand-oriented, aggressive attacking style: It means that the athlete strives to use the backhand to gain points even from the middle of the table.

(4) Blocking-oriented player gives the opponent the initiative, then drops and flips over the table, speed up the game and makes the opponent make a mistake. The player wants to make the point less him or herself, but builds on the opponent's mistakes (Wolfgang-Frank, 2012).

The aim of the study was to investigate the relationship between age category, assertiveness, temperament and character dimensions and the playing styles of the

players. The novelty of the research is, that we took the playing style into consideration. We examine the listed playing styles on the basis of subjective judgment.

2. METHODOLOGY AND DATABASE

A total of 32 table tennis players from the Hungarian national team were tested (ethical approval number:15117-9/2018EÜIG) (average age 19.31, male=7, female=25). The test package was filled out online by the athletes after a competition. The test was completed anonymously and took about 20 minutes. The sample separated by 3 ages categories: 10 person were in cadet (14-15 years), 11 person were in junior (16-18 years) and 11 person were in adult category (over 18 years). Three questionnaires were used:

(1) Competitive State Anxiety Inventory-2 (CSAI-2) (Martens et al., 1990) with 3 subscales (cognitive and somatic anxiety, and self-confidence). The cognitive state anxiety is considered the immediate conscious awareness of unpleasant feelings (worry) about oneself. The person is concerned about his ability and future consequences. The somatic state anxiety is the immediate awareness of body symptoms of the nervous system (e.g. heart rate, tense muscles, clammy hands). State confidence is the degree of certainly that the athletes feel about their ability to be successful. The test consist of 27 item. The items rated on 4 points scale where the 1 means „not et all and 4 means „extremely". CSAI-2 was validated in Hungarian by Sipos et al. (1999).

(2) Assertiveness Questionnaire (AST) with 2 subscales (offensive, defensive). The Assertiveness Measurement Questionnaire developed by the Nagykáldi (1999).

The test consists of 30 item and measures the athletes' s assertiveness degrees. Half of the test contains offensive and defensive items. The total score and the two subscales show the degree of assertiveness. (Nagykáldi, 1999)

(3) Temperament and Character Inventory (TCI, Cloninger (1987) has 7 subscales, out of these 4 temperament subscales (novelty seeking, harm avoidance, reward dependence, persistence) and 3 character subscales (self-directedness, cooperativeness, self-transcendence). TCI is currently one of the most modern personality measurement. The temperament dimensions are the response to the emotional stimulus and the character dimensions are based on the concepts of ourselves, others and the world; person's intentions, goals, attitudes. The test consists of 55 item and there are two types of answer for each statement: "true" or "not true" The questionnaire was validated in Hungarian by Szabó et al. (2016).

In the demographic data we asked them about their gender, age, educational attainment, marital status, sport age, and their subjective playing styles. They had to declare themselves as attacking or defensive players. Within the attacking style there were four categories specified: (1) Attacking from both side, (2) Forehand-oriented, (3) Backhand-oriented, (4) Blocking-oriented.

We used SPSS 22. software for statistical analysis.

3. RESULTS

The tested players have been the member of the national team for an average of 6.19 (±5.71) years now. All tested athletes said about their playing styles that they have attacking playing style, within 40.6% stated themselves aggressive (attacking from both sides) 21.9% forehand oriented, 31.3% backhand oriented and 6,2% blocking oriented players. We used Chi-square test and found positive relationship between assertiveness and playing style (Chi-square value=9.475; p=0.024). Attacking from both sides players achieved the highest score in assertiveness, after that the forehand oriented players came, then the backhand oriented players, and the blocking oriented players achieved the lowest score (Figure 1).

According to the descriptive statistics in the total score of Assertiveness Questionnaire the athletes achieved an average 98.59 points (±11.71). In the offensive subscale they achieved an average 52.18 points (±9.93) and in the defensive subscale an average 46.40 points (±8.79).

With Chi-square test, positive relationship were found between the offensive subscale of assertiveness and the age categories (Chi-square value: 7.086; p=0.029). The junior category achieved the highest score in this subscale, after that the adult category came, and finally the cadet category (Figure 2).

With Mann Whitney U test, significant difference were found between gender in cognitive (Z=-3.230; p<0.001) and somatic anxiety (Z=-2.361; p=0.018). The women achieved higher score in somatic anxiety (17.6±4.21) and cognitive anxiety (21.6±4.26) than men (13.57±3.15 and 15.57±3.26) (Figure 3).

We used Kruskal-Wallis test and there were no significant difference between the temperament and character dimensions and age categories. (Novelty seeking: Chi-square value=1.763; p=0.414) (Harm avoidance: Chi-square value=1.846; p=0.397) (Reward dependence: Chi-square value=4.631; p=0.099) (Persistence: Chi-square value=1.331; p=0.514) (Self-directedness: Chi-square value=3.518; p=0.172) (Cooperativeness: Chi-square value=0.748; p=0.688) (Self-transcendence: Chi-square value=0.338; p=0.845).

According to the descriptive statistics in the Novelty seeking subscale the junior category achieved the highest score (19.45) after that adult category came (15.18) and finally the cadet category (14.70). Within temperament scale in the Harm avoidance subscale the adult category achieved 19.27 score, the cadet category 16.3 and the junior category 13.91 score. In the Reward dependence the cadet category achieved the highest score (20.30), after the junior category (17.59) then the adult category (11.95). In the Persistence subscale the cadet category achieved 18.85 score, the adult category 15.77 and the junior category 15.09. Within character scale in the Self-directedness subscale the adult category achieved the highest score (19.95), after the junior category (16.77) then the cadet category (12.40). In the Cooperativeness subscale the cadet category achieved 18.55 score, the adult category 15.82 and the junior category 15.32. In the Transcendence subscale the junior category achieved the highest score (17.77) after the adult category (15.95) then the cadet category.

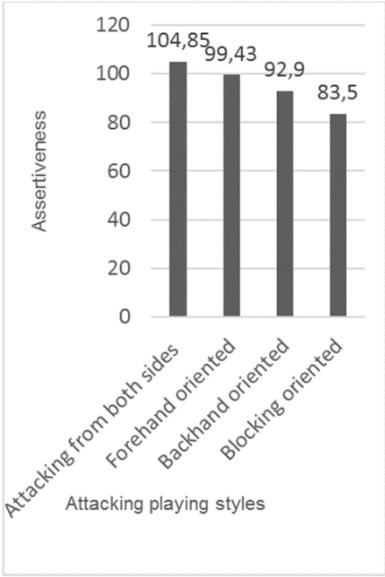

Fig. 1. Total scores of assertiveness of the attacking playing styles

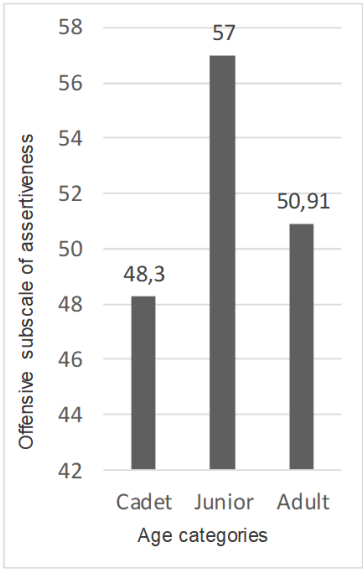

Fig. 2. Total scores of offensive subscale of assertiveness in age categories

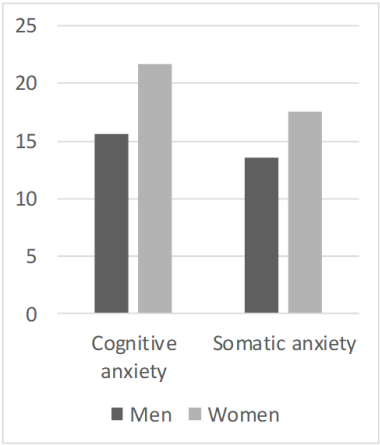

Fig. 3. Gender differences in anxiety scores

4. DISCUSSION AND CONCLUSIONS

All tested athletes said about their playing styles that they have attacking playing style.

We found positive relationship between assertiveness and attacking playing style. In our research in the total score of assertiveness were higher points, compared to other sports. In the study of Morvay-Sey (2015) the athletes reached lower assertiveness level. These athletes were not members of the national team.

These results can be explained by that assertiveness is higher among athletes who play on a higher level. There is a strong positive relationship between assertiveness and self-confidence, and competitive behaviour. (Jack, 1934). These factors are very important in elit sports.

In the offensive subscale in our research the table tennis players achieved an average 52.18 points (±9.93) and in the defensive subscale an average 46.40 points (±8.79). It seems that the game of table tennis players the offensive playing style is more typical than defensive playing style.

Among age categories (cadet, junior, adult) the only positive relationship were found between the offensive subscale of assertiveness and age categories. Junior category achieved the highest score on this subscale. The junior category (16-18 years) include the adolescence. This result may be explained by the characteristics of adolescence. The offensive part of assertiveness can be considered an age-specific feature of adolescence. Adolescence is a developmental stage during which a person transitions from childhood to adulthood. This period is characterized by physical, emotional, and social changes, which can bring about tumultuous emotions resulting in stress and conflict. At this stage one can take risk more often, than in adulthood or in the childhood. Youth can behave unconsidering or unreflective which on the court means that the young player will undertake an ambiguous situation in an offensive manner (Jack, 1934).

Significant difference were found between gender in cognitive and somatic anxiety as well. The level of anxiety is not a sport-specific feature. Women are generally more anxious than men (Hosseini & Khazali, 2013). Nevertheless our results confirm Gyömbér's (2017) results. She also found gender differences: cognitive anxiety were higher among women and self-confidence were higher among men. This difference is also reflected in sports (Kurimay et al. 2017). In spite of this, we did not found gender differences in connection with self-confidence. The anxiety show sensitivity to people's approval and worry about what others think of them. They lack self-confidence and tend to get defensive when they are criticized. In contrast to an important attribute of an elite athlete which is to be calm and relaxed (Lopez & Santelices, 2012). The female table tennis athletes of our study showed high scores in anxiety. They though belonging to the elite group still worry about what other people think of them and about their skills. This calls for a psychological skills training program to be included in their training regimen.

There were no significant difference between the temperament and character dimensions and age categories and the playing styles.

The main result in our study was the relationship between assertiveness and the playing styles. Results showed that assertiveness can be a core element of the attacking style and it seems this style is more effective than defensive style. The skill of assertiveness can be learned so in sport more emphasis should be placed on skill development, because it is an important factor of the sport performance.

REFERENCES

Carmichael, F., & Thomas, D. (1995) Production and efficiency in team sports: an investigation of rugby league football. *Applied Economics, 27*(9), 859-869.

Cloninger, C.R., Przybeck T.R., & Svrakicz, D.M. (1991). The tridimensional Personality Questionnaire. *Psychological Reports, 69*, 1047-1057.

Cloninger, C.R (1987). A Systematic Method for Clinical Description and Classification of Personality Variants. *Arch Gen Psychiatry, 44*, 573-588.

Friedrich, W., & Fürste, F. (2012). *Tischtennis. Verstehen, Lernen, Spielen*. Münster:Philippka Verlag.

Gyömbér, N. (2017). The role of sport psychological preparation in the shaping of the athletic personality. [A sportpszichológiai felkészítés szerepe a sportolói személyiség formál(ód)ásában]. (Doctoral dissertation). University of Physical Education, Doctoral School of Sport Sciences. Retrieved from http://real-phd.mtak.hu/690/1/gyombernoemi.d.pdf

Gkagkanas, D., Hatzimanouil, K., & Skandalis, V. (2018). Gender differentiation in tactical options in defense and attack on beach handball. *EQOL, Journal of Science in Sport, 10*(2), 23-30.

Hajduné László, Z. (2003). Investigation of competitive anxiety in medium and long distance athletes. [A közép- és hosszútávfutó atléták versenyszorongás vizsgálata]. *Magyar Sporttudományi Szemle, 4*, 12.

Han, H.D., Kim, H.J., Lee, S.Y,. Soo Joeng Bae, J.S., Bae, J.S., Kim, J.H., Sim, Y.M., Sung, H.Y., & Lyoo, K.I. (2006). Influence of temperament and anxiety on athletic performance. *Journal of Sports Science and Medicine, 5*, 381-389.

Hosseini, L., & Khazali, H. (2013). Comparing the level of anxiety in male & female school students. *Procedia - Social and Behavioral Sciences, 84,* 41-46.

Jack, L. M. (1934). An experimental study of ascendant behavior in preschool children. *University of Iowa Studies: Child Welfare, 9 3,* 7–65.

Kurimay, D., Pope-Rhodius, A. & Kondric, M. (2017). The Relationship Between Stress and Coping in Table Tennis. Journal of Human Kinetics, 55, 75-81.

Lopez, A., & Santelices, O. (2012). Personality characteristics of elite table tennis athletes of the Philippines: basis for a proposed recruitment program. *International Journal of Table Tennis Sciences, 7*, 1-4.

Martens, R., Burton, D., Vealey, R.S., Bump, L.A., & Smith, D.E. (1990). Development and Validation of the Competitive State Anxiety Inventory-2 (CSAI-2). In Martens, R., Vealey, R.S. & Burton, D. (Eds.), *Competitive Anxiety in sport*, (pp. 117-190). Champaign: Human Kinetics.

Matytsin, O. V. The role of personal characteristics of the table tennis player in providing efficiency and stability during competitions, *International Journal of Table Tennis Sciences*, 2, 55-60, 1994.

Monasterio, E., Alamri, A.Y., & Mei-Dan, O. (2014). Personality Characteristics in a Population of Mountain Climbers. *Wilderness and Enviromental Medicine, 25*(2), 214-219.

Morvay-Sey, K. (2015). *Possible Application of Budo Martial Arts to Deal with Aggression at Schools*. (Doctoral Dissertation). University of Pécs. "Education and Society" Doctoral School of Education.

Available: https://pea.lib.pte.hu/bitstream/handle/pea/14121/morvay_sey_kata_doktori_ertekezes_2014_pdf.pdf?sequence=1

Nagykáldi, C., & Mocsai, L. (1999). Comparative study of the assertiveness of combat athletes and sports players. [Küzdősportolók és sportjátékosok asszertivitásának összehasonlító vizsgálata] In Mónus, T. (Ed.), *III. National Sports Science Congress, March 5-6, 1999*. (pp. 284-288). Budapest: Hungarian University of Physica-Education.

Nagykáldi, Cs. (2002): Küzdősportok elmélete. Computer Arts Kft., Budapest.

Németh, E., Nagykáldi, C., & Barna, T. (1999). Action efficiency in combat sports and its relationship with assertiveness and psychic stability. [Az akcióhatékonyság a küzdősportokban és kapcsolata az asszertivitással és pszichés stabilitással.] In Mónus, T. (Ed.), *III. National Sports Science Congress, March 5-6, 1999*. (pp. 288-292). Budapest: Hungarian University of Physica-Education.

Sipos, K., Kudar, K., Bejek, K., & Tóth, L. (1999). Standardisation and validation of the Hungarian Competitive State Anxiety Inventory-2 (CSAI-2). Abstract Book of *20th International Conference of the Stress and Anxiety Research Society*. (pp. 131). Cracow, Poland, July 12-14.

Skandalis, V., Hatzimanouil, D., Papanikolaou, F., Kanioglou, A., & Yiannakos, A. (2017). Effectiveness analysis in shooting in European Beach Handball Tournament (EBT) 2016. Physical Tarining. *EJMAS,* http://ejmas.com/pt/2017/September (Electronical Journal)

Szabó, G., Szántó, Z., Susánszky, É., & Martos, T. (2016). Psychometric characteristics of the abbreviated Hungarian version of Cloninger's temperament and character questionnaire (TCI55) on a domestic sample. [A Cloninger-féle temperamentum és karakter kérdőív rövidített magyar változatának (TCI55) pszichometriai jellemzői hazai mintán]. *Psychiatria Hungarica, 31*(4), 348-358.

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Receive analyses in elite European table tennis matches

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Abstract: The purpose of this study was to analyse serve receive activities in elite European players. Twenty matches (78 games, 1466 points) of semifinal and final German League and Europe TOP 16 in men's (in the top 30 of ETTU Rank list) were analysed. Differences in serving activities (type, stroke type, outcome and placement) were analysed according results outcome of match, game, point, phase of the game and result outcome.

Results showed that forehand and the backhand stroke ratio in receiving was 59/41%) and the ratio between active and passive receive (strokes) were 43.8/56.2%. The most used forehand backspin strokes (42.1%) mostly placed in the middle of the table on the opponent's forehand side. Percentage of point won directly with receive was (24.5%), then follow point won in rallies after receiving (23.6%), lost point after received were noted in 40.6% while receive errors were 11.7%. In the 2nd phase of the game were noted the most of active receive, while in 3rd phase the most of receive was with passive strokes. Results of Pearson´s chi-squared test showed an association between match outcomes and receive stroke type, outcome and placement zone, and the relation between use of active and passive receive and phase of the game.

Keywords: serve, tactic, notational analysis, match analysis

1. INTRODUCTION

Both the serve and serve receive in table tennis affect the whole rally and point outcome. In professional sport, one skill that sets the winner apart from the loser is the capacity to more efficiently anticipate, react, and move in response to game situations (Cañal-Bruland & Mann, 2015).

The serve receive has gained the same importance as a serve in table tennis, especially with changing game regulations (ball visibility to opponent, playing with new rubbers and enrolment of plastic balls) (Djokic, Munivrana, & Levajac, 2017; Djokic et al., 2019), and become as Muster (1999) predicted "the most important shot in table tennis".

The receiving player has several possibilities of how to return the opponent`s serve: basically he can perform passive or with an active type of stroke, placing on a different zone of the table on the opponent's side and continue the rally.

The serve receive is essential, for gaining the position in coming rally or taking initiative, which will determine the whole rally, so collecting data of strategy and tactics is important (O'Donoghue, 2004; Padulo et al., 2016).

Many performance analysts pointed the importance of receiving activities as important indicators of performance in elite table tennis (Djokic, 2002a; 2002b; 2003; Katsikadelis, Pilianidis, & Mantzouranis, 2013; Zhang et al., 2013; Zhang, Zhou, & Yang, 2018; Malagoli Lanzoni, Di Michele & Merni, 2014; Fuchs et al., 2018). In the last major world and continental competitions were noted significant differences in efficacy of receiving activities - percentage of winning points on opponent serve (Djokic, Munivrana, & Levajac, 2016a; 2016b; 2017).

Since there are continuous changes in table tennis performance activities (Djokic et al., 2019) which impact on the game, there is a need for permanent monitoring of activities such as serve receive.

Therefore, the aim of this study was match analyses considering the serve receive activities in elite European table tennis.

2. METHODS

2.1 Sample

Twenty matches (78 games, 1435 points) of semifinal and final German League (season 2018/19 and Europe TOP 16 (2018) in men's were analysed. All players were in the top 30 of ETTU Rank list.

2.2 Performance indicators

Performance indicators measured to provide information about the receive activities were:

Receive type:

1) ACTREC – Active receive of serve (flick or topspin stroke)
2) PASREC – Passive receive (backspin stroke)

Receive stroke type:

3) FHBCSR - Forehand backspin receive
4) FHFLCR - Forehand flick receive
5) FHTSPR - Forehand topspin
6) BHBCSR - Backhand backspin receive
7) BHFLCR - Backhand flick receive
8) BHTSPR - Backhand topspin

Receive outcome:

9) RDIRPO - Receive direct point
10) RWONPO - Receive won point
11) RLOSPO - Receive lost point
12) RERROR - Receive error

Receive stroke placement:

13) ROUTFH - Outside forehand zone
14) RMIDFH - Middle forehand zone
15) RMIDBH - Middle backhand zone
16) ROUTBH - Outside backhand zone

Differences in receiving activities (type, stroke type, outcome and placement) were analysed according final results outcome of a match, game, point and instead phase of the game (Phase 1: 1-4 point; Phase 2: 5-8 point; Phase 3: 8-11 point).

2.3. Procedure

Data were collected by videos of matches available on the official DTTB and ITTF website. The video material allowed the observers during the video analysis to clearly see the players, the table, and the playing area, which allowed a reliable verification of all events during the match. The recordings were analysed in real speed, but in case of certain inconsistencies, they were re-winded and seen in slow motion (0.2 X). All the data were registered in the specially prepared templates for the analysis of every match, in which all the analysed variables were coded and after that, the data were inputted into a Microsoft Excel spreadsheet.

2.4. Reliability

In order to ensure a quality of reliability (O'Donoghue & Mayes, 2013), the matches were evaluated by means of intra-observers and inter-observers. For this research, two table tennis experts with adequate competition and coaching experience were engaged for the role of observers. The reliability of intra-observers is based on the concept of reanalysis of 20 random games. The intra and inter-observers' reliability has been evaluated by Krippendorff's Alpha. The reliability of the inter-observers was secured by reanalysis of all the matches by a second analyst. The intra-observers' reliability analysis showed an Alpha value of 0.993.

2.5 Statistical analyses

Descriptive statistical parameters (frequencies and percentages) were calculated for all analysed players and considering result outcome (winners/losers). A Pearson´s chi-square test of independence was performed to examine the relation between receiving activities and winning matches, with a level of significance of (α = 0.05). All the data were analysed using SPSS 20.0 (IBM Corporation, USA).

3. RESULTS

Results of analyses on all samples showed that the ratio between active and passive receive were 43.8/56.2%, more with forehand than backhand strokes (59/41%). Mostly used strokes were forehand backspin (42.1%) and backhand flick stroke (14.2%). Complete results of analyses of receiving type and receive stroke type are shown in Table 1.

Table 1. *Results of analysis of receive type and receive stroke type of all analysed sample and according result outcome (winners/losers)*

	ALL SAMPLE		WINNERS		LOSERS	
	Frequency	%	Frequency	%	Frequency	%
ACTREC	629	43.8	304	42.3	325	45.3
PASREC	806	56.2	414	57.7	392	54.7
FHBCSR	604	42.1	296	41.2	308	43.0
FHFLCR	86	6.0	32	4.5	54	7.5
FHTSPR	149	10.4	90	12.5	59	8.2
BHBCSR	204	14.2	120	16.7	84	11.7
BHFLCR	306	21.3	136	18.9	170	23.7
BHTSPIR	86	6.0	44	6.1	42	5.9

Based on the results of chi-square test of independence, which was performed to examine the relation between receiving activities and winning matches, we can state that since the p-value was greater than our chosen significance level, there was not enough evidence to suggest an association between active/passive serve receive and winning in match, $X^2(2, N=1435) = 1.301$, $p = 0.254$), but there was noted a significant association between winning the match and receive stroke type, $X^2(2, N=1435) = 22.493$, $p < .000$).

Considering, receive outcome, in general, in analysed matches percentage of point won and lost points receiving serve was 48.1/51.9. Most points were won directly to receive was high, then at the continuation point after receiving, while receiving errors were 11.3%. Results of analyses of receiving outcome are shown in Table 2.

Table 2. *Results of analysis of receive outcome of all analysed sample and according result outcome (winners/losers)*

	ALL SAMPLE		WINNERS		LOSERS	
	Frequency	%	Frequency	%	Frequency	%
RDIRPO	346	24.5	178	24.9	168	23.4
RWONPO	338	23.6	204	28.5	134	18.7
RLOSPO	582	40.6	258	36.0	324	45.2
RERROR	167	11.3	76	10.6	91	12.7
Won points	690	48.1	382	53.4	302	42.1
Lost points	745	51.9	334	46.6	415	57.9

Based on the results of chi-square test we can state the that there was a significant association between winning the match and receive outcome, $X^2(2, N=1435) = 23.617$, $p < .000$).

Tactically, the most used zone on the opponent's side of the table where return strokes were placed was middle of the table, more in forehand than backhand. Results of analyses of receiving stroke placement are shown in Table 3.

Table 3. *Results of analysis of receive stroke placement of all analysed sample and according result outcome (winners/losers)*

	ALL SAMPLE		WINNERS		LOSERS	
	Frequency	%	Frequency	%	Frequency	%
ROUTFH	346	24.5	152	21.2	194	27.8
RMIDFH	442	31.2	222	31.0	220	31.5
RMIDBH	260	18.4	160	22.3	100	14.3
ROUTBH	234	16.5	122	17.0	112	16.0

There was a significant association between winning the match and receive stroke placement, $X^2(2, N=1435) = 22.103$, $p < .001$).

In Table 4 are shown efficacy of receiving stroke type.

Table 4. *Results of analysis of receive stroke type efficacy of all analysed sample and according result outcome (winners/losers)*

	ALL SAMPLE		WINNERS		LOSERS	
	% WP	% LP	% WP	% LP	% WP	% LP
FHBCSR	44.7	55.3	63.6	36.4	46.6	53.4
FHFLCR	53.5	46.5	59.3	40.7	25.0	75.0
FHTSPR	43.0	57.0	55.9	44.1	42.2	57.8
BHBCSR	51.0	49.0	47.6	52.4	50.0	50.0
BHFLCR	51.6	48.4	52.9	47.1	42.6	57.4
BHTSPIR	55.8	44.2	57.1	42.9	31.8	68.2

% WP – Percentage of won points
% LP – Percentage of lost points

Analysing receive the type and outcome instead the phase of the game, it is noted that in the 2nd phase (5-8 point) players use most of active receive with more risk which have as consequence high percentage of made errors, while in last phase players chose less risk on receive with passive strokes (Table 5).

Table 5. *Results of analysis of receive type and outcome in different phases of the match of all analysed sample*

	1st PHASE	2nd PHASE	3rd PHASE
RDIRPO	26.5	23.0	22.9
RWONPO	25.7	25.7	18.7
RLOSPO	36.9	37.9	48.1
RERROR	11.0	13.4	10.3
ACTREC	43.5	47.9	39.3
PASREC	56.5	52.1	60.7

There was a significant association between phase of the match and use of active and passive receive, X^2 (2, N=1435) = 7,163, p <.028).

The analyses of all won and lost points were done from the aspects of receiving stroke type, outcome, placement, rally number and frequency in different phases of the match. Results of analyses of receiving stroke placement are shown in Table 6.

Table 6. *Results of analysis of receive won/lost points*

	WON POINTS		LOST POINTS	
	Frequency	%	Frequency	%
FHBCSR	270	39.1	334	44.8
FHFLCR	46	6.7	40	5.4
FHTSPR	64	9.3	85	11.4
BHBCSR	104	15.1	100	13.4
BHFLCR	158	22.9	148	19.9
BHTSPIR	48	7.0	38	5.1
RDIRPO	346	50.1		
RWONPO	338	49.0		
RLOSPO			576	77.5
RERROR			167	22.5
ROUTFH	198	28.7	148	20.4
RMIDFH	216	31.3	226	31.2
RMIDBH	140	20.3	120	16.6
ROUTBH	132	19.1	102	14.1

Won points are mostly in 2nd rally (38.8%) and 4th rally (25.2%), while lost in 4th (32.2%), 2nd (22.7%), 6th (13.4%) and 3rd (11.5%) ball.

Based on the results of chi-square test we can state the that there was no significant association between game result outcome and receive type and outcome.

Considering phase of match, most points on receiving were won in 1st phase (37.1%), 2nd phase (36.8%) and less in 3rd phase (26.1%), while in case of lost points most of them were noted in 2nd phase (36.0%) than 3rd phase (33.3%) and less in 1st phase (30.7%).

4. DISCUSSION

The objective of the research was to study a serve receive activities of elite European table tennis players.

There was no significant relation between winning the match and active/passive receive, but from analyses it is more likely that losers use more active receive (probably to reach point deficit in game).

Most frequently used stroke with a high proportion of serving returns has been a forehand backspin stroke (Malagoli Lanzoni et al., 2014). This stroke is characterized as neutral stroke (enable continuation of the rally), but with precise placement it could be a winning stroke or stroke, which can give advantage to receive. This type

of stroke also was dominant in receiving in match analyses of best Chinese and European players (Djokic, Munivrana, & Levajac, 2016a).

A significant association between winning the match and receive stroke type, indicate that the winners were more use offensive forehand receive with topspin and less offensive receive stroke from the backhand (flick) than the losers, which is also noted in the match outcome of best Asian and European players (Djokic, Munivrana, & Levajac, 2016a; 2016b).

Winners were more likely successful in winning points after receive (but not directly), and they lost less points and with less errors instead losers. Probably, decreasing of serving efficacy is related to the high percentage of points won directly to receive, and winning point after opponent serve.

Like in study of Djokic, Munivrana and Levajac (2017), higher percentage of successful receive is contributing winning outcome. In this study average percentage of winners in receive were 53.4%, like in analyses of final of European Championships 2014 (Djokic, Munivrana, & Levajac, 2016b) and at European Games 2016 (Djokic, Munivrana, & Levajac, 2017), while in study of best Chinese players receive winning percentage were more than 65% (Djokic, Munivrana, & Levajac, 2016a) and that is pointing in difference between European and World elite table tennis. The same conclusion made Tamaki, Yoshida and Yamada (2017), that the only chance for players from other countries to win against Chinese players are to minimize the difference in receiving rallies.

Tactically, winners were more use a middle backhand zone for receiving stroke placement, and less outside forehand zone of an opponent than losers. Frequent use of the middle zone is confirmed and by Huang and Zhang (2013).

There is a significant association between phase of the match and use of active and passive receive. Probably players adapt to opponent serve and play with more risk, and in this part of the game (5^{th} – 8^{th} point) practically mostly they decide who will win or lose the game. In the 3^{rd} phase of the game dominate passive receive.

Considering phase of match most points on receive were won in 1^{st} and 2^{nd} phase, which implicate that is necessary to start match with full concentration, because this could be possible to take advantage in the game.

Points played after receive are mostly short and finished in 2^{nd}, 4^{th} and 6^{th} rally. 2^{nd} and 4^{th} ball is most important for winning point.

Generally, results showed reduced the advantage of the server and greater opportunity for receiver to win points. With the optimal selection of stroke type and precise placement in short rallies there is a good chance of winning the point.

5. CONCLUSSION

The findings of this study implicate that the winning outcome in table tennis matches is related to successful serve receive activities. Since, nearly the half played points are won or lost in receive, so these activities should be monitored as a valuable performance indicators, in competitions and be useful for performance analysts and coaches in designing specific training sessions related to serve receive and for monitoring of players progress.

REFERENCES

Cañal-Bruland, R., & Mann, D. L. (2015). Time to broaden the scope of research on anticipatory behavior: a case for the role of probabilistic information. *Front. Psychol, 6,* 15-18.

Djokic, Z. (2002a). Differences caused with new 40 mm ball in structure of competitors' activities of top table tennis players. *International Journal of Table Tennis Sciences*, *5*, 220–232.

Djokic, Z. (2002b). Structure of competitors' activities of top table tennis players. *International Journal of Table Tennis Sciences*, *5*, 74–90.

Djokic, Z. (2003). Service and service return in modern top table tennis. In Kahn et al (Eds.), *Book of abstracts of the 8th International Table Tennis Federation Sports Science Congress – The 3rd World Congress of Science and Racket Sports*, (pp.21). Paris: ITTF.

Djokic, Z., Munivrana, G., & Levajac, D. (2016a). Match analyses of the final game of Men's World Championship 2014 - China vs. Germany. In M. Kondrič, X. Zhang & D. Xiao (Eds.), *Science and Racket Sports V.* (pp. 242-250). Suzhou University Press, China: Soochow University & International Table Tennis Federation.

Djokic, Z., Munivrana, G., & Levajac, D. (2016b). Match analyses of final game of Men's Team European Championships 2014 - Portugal vs. Germany. In M. Kondrič, X. Zhang & D. Xiao (Eds.), *Science and Racket Sports V.* (pp. 113-121). Suzhou University Press, China: Soochow University & International Table Tennis Federation.

Djokic, Z., Munivrana, G., & Levajac, D. (2017). Role of serve and return of serve at European Games 2015 table tennis tournament. In M. Kondrič, M. Fuchs & T. Matjašič (Eds.), *Proceedings book of the 15th ITTF Sports Science Congress*. (pp. 242-246). Lausanne: International Table Tennis Federation.

Djokic, Z., Straub, G., Malagoli Lanzoni, I., Katsikadelis, M., & Munivrana, G. (2019). Effects of rule changes on performance efficacy: Differences between winners and losers table tennis players. *Facta universitatis - series: Physical Education and Sport, 17*(1), 149-163.

Fuchs, M., Liu, R., Malagoli Lanzoni, I., Munivrana, G., Straub, G., Tamaki, S., Yoshida, K., Zhang, H., & Lames, M. (2018). Table tennis match analysis: a review. *J Sports Sci, 36*(23), 2653-2662.

Huang W., & Zhang H. (2013). The effect analysis of Zhang Jike's return serve with backhand side-twisted at the 2/3 court right - 2012 London Olympic table tennis singles. *Int J Table Tennis Sci, 8*, 72–76.

Katsikadelis, M., Pilianidis, T., & Mantzouranis, N. (2013). The interaction between serves and match winning in table tennis players in the London 2012 Olympic Games. In Kahn (Ed.). *Book of abstracts of the* 13th ITTF Sports Science Congress, (pp. 28). Paris, France: ITTF.

Malagoli Lanzoni, I., Di Michele, R., & Merni, F. (2014). A notational analysis of shot characteristics in top-level table tennis players. *European Journal of Sport Science*, *14*(4), 309-317.

Muster, M. (1999). *Zur Bedeutung des "situativen Trainings" im Hochleistungstischtennis – empirische Untersuchung zur Identifikation von*

"Spielsituationen" [The significance of "situational training" in high-performance table tennis – an empirical study for the identification of "game-play situations"]. (Doctoral dissertation). Technical University of Munich, Germany: Munich.

O'Donoghue, P. (2004). Match analysis in racket sports. In A. Lees, J. F. Kahn & I. W. Maynard (Eds.), *Science and Racket Sports III.* (pp. 155 - 162). London: Routledge.

O'Donoghue, P., & Mayes, A. (2013), Performance analysis, feedback and communication in coaching. In McGarry,T., O' Donoghue, P. & Sampaio, J. (Eds.) *Routledge Handbook of Sport Performance Analysis*. (pp. 155 - 164). Routledge.

Padulo, J., Pizzolato, F., Tosi Rodrigues, S., Migliaccio, G.M., Attene, G., Curcio, R., & Zagatto, A.M. (2016). Task complexity reveals expertise of table tennis players. *J Sports Med Phys Fitness, 56*(1-2), 149-156.

Tamaki, S., Yoshida, K., & Yamada, K. (2017). A Shot Number Based Approach to Performance Analysis in Table Tennis. *J Hum Kinet, 55*, 7-18.

Zhang, H., Liu, W., Hu, J.J., & Liu, R.Z. (2013). Evaluation of Elite Table Tennis Players' Technique Effectiveness. *J Sports Sci, 32*(1), 70-77.

Zhang, H., Zhou, Z., & Yang Q. (2018). Match analyses of table tennis in China: a systematic review. *J Sports Sci, 36*(23), 2663-2674.

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Net height impact to table tennis game

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Abstract: We investigated the impact of the net height to the table tennis game by statistically observing 7 parameters across the 5 net heights within the 6 sets played at each net height. Additionally, we observed 2 parameters within the three rally parts (the service, the return, the rest of the rally) using about 100 rallies played at each of the 5 net heights in order to determine which part of the rally is affected the most. We used the descriptive and the inferential statistics and in both cases only the impact on the ball height and speed above the net at the service was observed. No significant differences either at the set-level or at the rally-level in any of the other measured parameters across the five net heights were determined.

Keywords: table tennis, net height, statistics

1. INTRODUCTION

All four major racket sports (table tennis, tennis, badminton and also squash) belong to the most popular sports in the world. Players range from youth, recreational players to the world-class elite players. Correspondingly, scientific studies on racket sports are increasing (Lees, 2003, 2019; Kondrič, Matković, Furjan-Mandić, Hadžić, & Dervišević, 2011; Cece, Guillet-Descas, & Martinent, 2020; Chen, Chien, & Chiang, 2019). Research in every field of interest has been conducted in separate and individual areas such as physical training, biomechanics, physiology, psychology, medicine, dietetics, physics, and engineering (Cece, Guillet-Descas, & Martinent, 2020; Chen, Chien, & Chiang, 2019; Fullen, 2010, etc.). Lately a lot of focus is set to the speed of the three racket sports where we have in the middle the net (Kashiwag, Okamura, Murakami, & Takahashi, 2019; Takahashi, Kashiwagi, Okamura, & Murakami, 2019; Kondrič et al., 2019). According to the speed of the ball (shuttle), the fastest is badminton shuttle which can reach speed up to 421 km/h (executed by Tan Boon Heong from Malaysia); followed by tennis where the fastest serve rates to 263 km/h (executed by Australian Sam Groth); and at the end there is table tennis with ball speed at 120 km/h (Fullen, 2010). One would say that badminton is the fastest racket sport followed by tennis. But when we turn average speed of the rallies and the player's reaction time into classification of racket sports, it turns out that table tennis is the fastest one.

Consequently the rallies are short and the viewing pleasure for the live and also for the TV spectators is reduced. In the last decades the ITTF introduced several changes into the table tennis game to supress this. The ball size was increased from

38 to 40 mm in 2000, a 21-point scoring system was changed to an 11-point in 2001. The rules of service were changed in 2002 to reduce the server's advantage. In 2014 a new 40+ mm plastic ball was introduced to further slow down the game and to decrease the gap among the best players. Each change caused the adaptation of the material producers especially rubber producers and the players who adapted their training exercises and the way of playing. In the last few years a discussion was brought up in the table tennis community regarding a new change which should be implemented in the next years. It is a change on the net height. At the ITTF Annual General Meeting held in Kuala Lumpur on March 23rd 2016, Suisse Table Tennis Federation proposed tests on the height of the net. We followed this initiative and investigated the impact of the net height to the table tennis game by statistically observing 7 characteristic parameters across the 5 net heights within the 6 sets played at each net height. Additionally, we observed 2 parameters within the three rally parts (the service, the return, the rest of the rally) using about 100 rallies played at each of the 5 net heights in order to determine which part of the rally is affected the most.

2. MATERIALS AND METHODS

2.1 Laboratory setup

The laboratory setup consisted of:

- a high speed camera system recording at 1000 frames per second (Mikrotron MotionBlitz LTR),
- two powerful Fresnel light sources,
- a full HD camera recording at 50 frames per second from above the table,
- a table tennis table,
- a black textile shield for filtering out the background and to intensify the ball contrast,
- a calibration chessboard,
- custom made net height gauges,
- two HD cameras recording at 30 frames from each side of the table,
- in-house image/video processing software.

This camera setup enables capturing the table tennis ball position even at its highest speed (Yamamoto et al., 2010). Initial calculations showed that if the camera is recording 1000 frames per second the ball moving with the speed of 40 m/s is captured within the distance of at most 2 cm away from the net which means that at least ball edge is positioned just above the net.

The high speed camera was positions away from the net with optical axis aligned with the net top. Only the area around the net was illuminated with powerful light sources and recorded with frame resolution 720 x 646 pixels at 1000 fps. This way only the net and the ball passing it were recorded without disturbing factors. We used another camera positioned above the table to record the whole scene to be able later to reconstruct the game synchronising it with the high speed camera. The two additional cameras positioned from each table side were used for the same purpose and for the backup as well.

The net height was adjusted using custom made Plexiglass gauges at five different heights: 15.25 cm, 15.75 cm, 16.25 cm, 16.75 cm and 17.25 cm. The standard net holder was used. Decision made to go till 17.25 cm was due to the first height of the table tennis net in history.

2.2 Calibration

The high speed camera needs to be calibrated in order to obtain accurate measurements. The calibration procedure based on a pinhole camera model (Sturm, 2014) in general requires the determination of the 5 intrinsic parameters and the 6 extrinsic parameters (3 angles and 3 translations) describing position and orientation (pose). Using these parameters we can transform an object point from the outside (world) coordinate system into the image coordinate system as depicted in Figure 1, where the world coordinate system is centred at the top end of a table tennis net and which the measurements are to be made in. The camera frame is centred in the focal point on the optical axis and the image coordinates have the origin in the top left corner of the image.

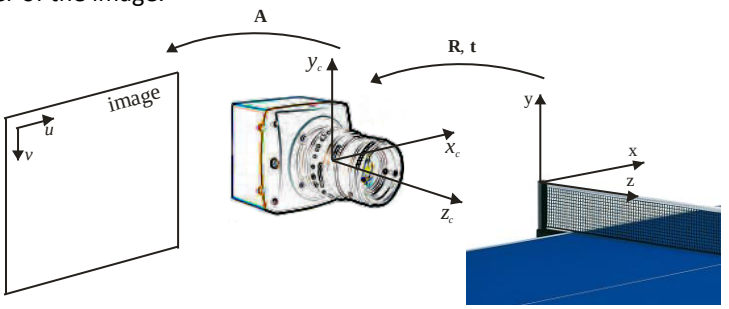

Fig. 1. Three different coordinate systems which are mapped with camera calibration.

The image plane in Figure 2 is positioned between the focal point O and the object and not on the other side as is in reality. This way the vertical image orientation is in accordance with scene orientation and the geometrical relations are not changed.

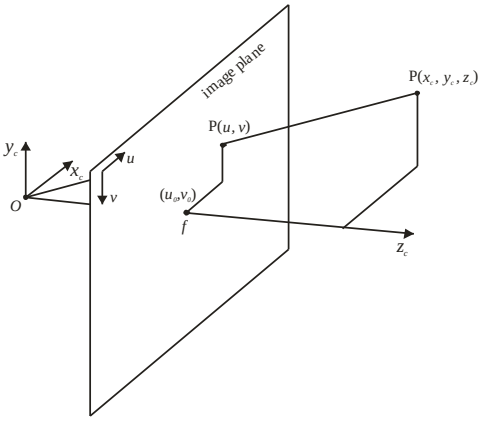

Fig. 2. Pinhole camera model.

During the camera calibration we must consider also the image radial and tangential distortion caused by imperfect lenses which results in the determination of the 5 parameters used in image correction.

We used the well-known Zhang procedure (Zhang, 2000) to solve the camera calibration and the lens distortion problem using the planar pattern with known square sizes (Figure 3) using the computer vision OpenCV library (Bradski, 2000). The A2-sized chessboard pattern was placed in the middle of the table and was slowly rotating while recording with camera. This was done before any table tennis game took place. The recording was used later in the offline phase as input to the calibration algorithm.

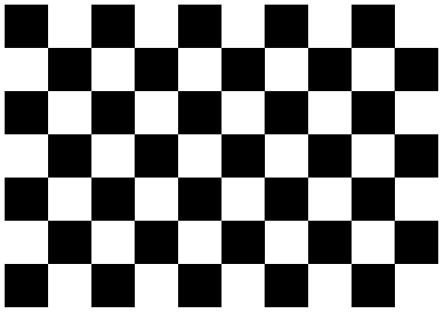

Fig. 3. A calibration pattern.

2.3 Set-level analysis

In this experiment we invited 3 advanced players (1 top European, 2 top national) to play 2 sets between each other at each of 5 net heights which gave us 6 sets at each height and 30 sets all together. We measured 7 parameters:

- ball-to-net distance,
- ball speed above the net,
- net errors,
- net balls,
- set duration,
- net serve errors, and
- lets.

The ball-to-net distance and the ball speed were determined automatically with the in-house image processing software. The other five parameters were extracted by manual processing of the video recordings. The comparison of parameters was done by:

- the descriptive statistics for each measured parameter, and
- the inferential statistics comparison with ANOVA test if data was normally distributed or Friedman test if data was not normally distributed. The level of significance 0.05 was considered.

2.4 Rally-level analysis

Following the initiative of the Suisse table tennis association we extracted the rally based data from our video recordings. The rallies were then manually

segmented into service points, return points and the remaining points of the rally. The term point is used here for the ball appearance above the net. For example, service point means the event when the ball regularly (without touching) passed the net at a service action of the player. The numbers are summarized in Table 1. Each of these three categories, together with the whole rallies, were observed separately in terms of statistics. Again, we used the descriptive and the inferential statistics.

Table 1. *Number of extracted sets, rallies, services, returns and remaining points of the rallies.*

net	sets	rallies	services	returns	remaining
15.25	6	102	102	99	226
15.75	6	106	106	97	237
16.25	6	106	106	102	237
16.75	6	108	108	108	310
17.25	6	98	98	97	258

3. RESULTS

3.1 Set-level

Descriptive statistics

We compared the results in terms of mean values (Table 2), standard deviations (Table 3) and medians (Table 4) for five heights (h1=15.25 cm, h2=15.75 cm, h3=16.25 cm, h4=16.75 cm, and h5=17.25 cm). The statistics was calculated at set level, using counted values for 5 parameters (net errors, net balls, lets, net serve errors and set duration) and average values for ball height above the net and ball speed calculated from measurements of every ball passing the net.

Table 2. *Mean values for 7 parameters.*

	h1	h2	h3	h4	h5
net errors [#]	5.00	6.67	7.33	7.33	6.00
net balls [#]	0.67	1.67	0.83	1.33	0.50
lets [#]	2.83	2.50	2.50	2.33	3.67
net serve errors [#]	1.00	1.17	1.67	1.17	0.67
average set duration	224.00	243.00	236.67	246.67	226.83
average ball height	113.69	108.80	106.87	103.01	101.66
average speed [m/s]	4.17	4.67	5.12	5.25	5.15

Table3. *Standard deviations for 7 parameters.*

	h1	h2	h3	h4	h5
net errors [#]	2.28	3.01	2.34	2.25	1.79
net balls [#]	0.52	1.37	0.98	1.97	0.55
lets [#]	1.83	2.07	1.64	1.51	2.25
net serve errors [#]	0.89	0.98	1.86	1.47	1.03
average time [s]	75.46	50.72	34.55	52.86	38.19
average ball height	12.95	12.89	6.95	6.75	13.39
average speed [m/s]	0.98	0.62	0.43	0.42	0.45

Table 4. *Medians of 7 parameters.*

	h1	h2	h3	h4	h5
net errors [#]	4.50	6.50	7.00	6.50	5.50
net balls [#]	1.00	1.50	0.50	0.50	0.55
lets [#]	3.00	2.50	3.00	2.00	3.00
net serve errors [#]	1.00	1.50	1.50	0.50	0.00
average time [s]	237.50	268.50	226.00	254.50	226.50
average ball height [mm]	114.46	110.17	106.82	104.09	98.66
average speed [m/s]	4.35	4.63	5.08	5.05	5.12

As shown in Table 2 and Figure 4 the mean values of each particular parameter do not differ much for different net heights. The average number of net errors per set first increases with increased net height (15.75 and 16.25) but then remains equal (16.75) and even decreases (17.25). Similar happens with net balls and net serve errors. The decrease at the top net height might indicate the players' adaptation to new conditions. The number of lets increases only at 17.25 while before slightly decreases. Average ball height above the net slightly decreases with higher net which is expected. Average set duration which indicates also average duration of rallies (not measured in this experiment) does not change much. At highest height is approximately the same as at initial height. Average ball height increases with net height and drops a little at the top height. The speed surprisingly first increases with net height and drops a little only at the top height.

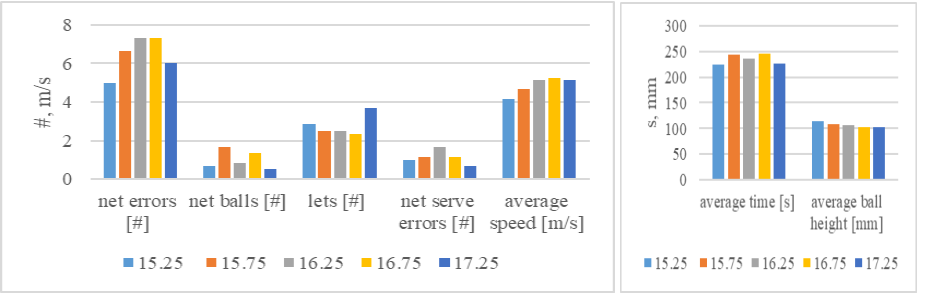

Fig. 4. Comparison of mean values of 7 parameters across 5 net heights.

In Table 3 and Figure 5 standard deviations are compared. We can see almost no correlation between the net height and the standard deviation of a particular parameter. Maybe we can say that the ball speed is less dispersed with higher net height. The dispersion of other parameters seems not to be related to the net height.

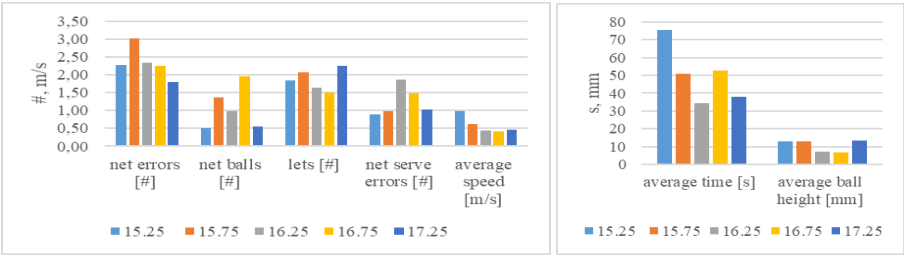

Fig. 5. Comparison of standard deviations of 7 parameters across 5 net heights.

In Table 4 and Figure 6 the median values of parameters are presented which we may interpret as typical values. Here we see that the typical ball height over the net is decreasing with increasing net height, which is expected. Surprisingly the median speed increases with higher net. The average set duration seems unaffected by net height, so as net balls and lets. Net serve error even decreases at highest net height which again might be a consequence of players' adaptation and carefulness when serving.

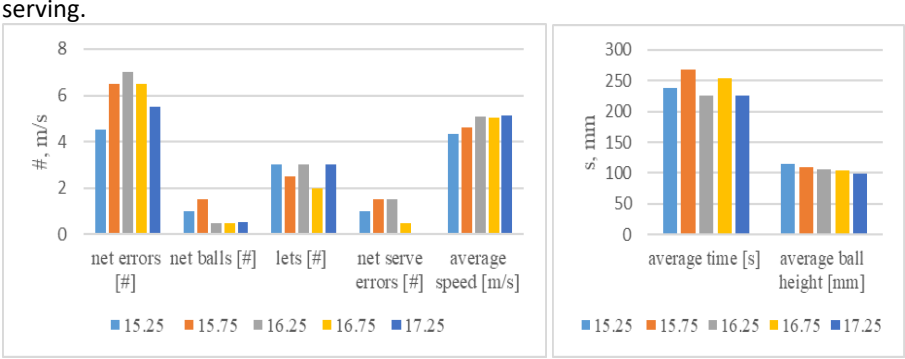

Fig. 6. Comparison of medians of 7 parameters across 5 net heights.

Inferential statistics

The use of set level inferential statistics on our collected data is questionable due to a small sample size. The number of sets per each height (6) is rather small and therefore the results are not conclusive although in line with the descriptive statistics conclusions.

Table 5. *Results of statistical comparison of 7 parameters over 5 net heights for the level of significance 0.05.*

	test	p-value	post hoc	difference
net errors	ANOVA	0,3930		no
net balls	Friedman	0,5747		no
lets	Friedman	0,7358		no
net serve errors	Friedman	0,8726		no
average time	Friedman	0,6387		no
average ball height	ANOVA	**0,0352**	Bonferroni	no
average ball speed	ANOVA	**0,0030**	Bonferroni	no

The results of statistical tests are presented in Table 5. In the case of five parameters (net errors, net balls, lets, net serve errors and average time) the initial tests with p-values strongly above the significance level showed no significant statistical difference among net heights.

In the case the two parameters (average ball height and average ball speed) the p-values were close to the level of significance therefore we used Bonferroni post hoc test which also revealed no significant difference between the five heights.

We can conclude that inferential statistics tests show no significant differences in any of the measured parameters across the five net heights.

3.2 Rally-level

Descriptive statistics

We calculated the mean values, standard deviations and medians for the whole rallies and their parts (service, return, remaining). For the whole rallies, first the mean value of each rally was calculated and then the mean, standard deviation and median of these mean values for each category were computed (Table 6, Table 8, Table 10). For the rally parts ((Table 7, Table 9, Table 11) all the points in the category were used. For example, to calculate the mean value of service points, all service points (of all rallies) at each net height were used. For the mean of remaining points, all remaining points of all rallies at certain net height were used together (not their rally means).

Table 6. *Mean values of ball height and speed for whole rallies.*

	rallies		
net height	n [#]	ball height [mm]	speed [m/s]
15.25	102	98,65	4,41
15.75	106	96,83	4,65
16.25	106	99,39	5,26
16.75	108	99,25	5,28
17.25	98	95,33	5,16

Table 7. *Mean values of ball height and speed at different net heights. Number of samples n is also included*

	services			returns			remaining		
net height	n [#]	ball height [mm]	speed [m/s]	n [#]	ball height [mm]	speed [m/s]	n [#]	ball height [mm]	speed [m/s]
15.25	102	54,90	3,00	99	122,68	4,06	226	124,67	6,20
15.75	106	47,80	3,17	97	108,90	4,27	237	131,24	6,39
16.25	106	48,46	3,58	102	124,20	5,13	237	121,94	6,93
16.75	108	43,82	3,37	108	123,56	4,81	310	121,68	6,82
17.25	98	40,60	3,34	97	106,76	4,88	258	119,43	6,53

Table 8. *Standard deviations of ball height and speed for the whole rallies at different net heights.*

	rallies		
net height [cm]	n [#]	ball height [mm]	speed [m/s]
15.25	102	47,70	1,54
15.75	106	45,93	1,72
16.25	106	45,09	1,58
16.75	108	47,39	1,53
17.25	98	42,23	1,73

Table 9. *Standard deviations of ball height and speed above the net for rally segments at different net heights.*

	services			returns			remaining		
net height	n [#]	ball height [mm]	speed [m/s]	n [#]	ball height [mm]	speed [m/s]	n [#]	ball height [mm]	speed [m/s]
15.25	102	54,69	1,08	99	102,84	2,07	226	124,46	4,13
15.75	106	40,56	1,17	97	94,71	2,04	237	144,84	4,49
16.25	106	28,22	1,09	102	115,87	2,85	237	123,30	4,38
16.75	108	36,78	1,37	108	125,32	2,43	310	122,38	4,39
17.25	98	31,63	1,32	97	100,16	2,52	258	133,21	4,57

Table 10. *Median values of ball height and speed for the whole rallies at different net heights.*

	rallies		
net height	n [#]	ball height [mm]	speed [m/s]
15.25	102	90,37	4,47
15.75	106	92,20	4,42
16.25	106	93,75	5,58
16.75	108	93,68	5,12
17.25	98	88,93	5,35

Table 11. *Median values of ball height and speed above the net for rally segments at different net heights.*

	services			returns			remaining		
net height	n [#]	ball height [mm]	speed [m/s]	n [#]	ball height [mm]	speed [m/s]	n [#]	ball height [mm]	speed [m/s]
15.25	102	33,12	2,78	99	112,89	3,78	226	112,28	6,40
15.75	106	38,89	2,96	97	94,59	3,84	237	95,28	6,44
16.25	106	40,46	3,26	102	105,95	4,47	237	97,40	6,89
16.75	108	31,98	3,12	108	93,00	4,33	310	100,83	6,93
17.25	98	32,85	3,09	97	89,54	4,61	258	97,75	6,60

In Figure 7 one can visually compare mean values of the ball height of the rallies and their segments played at each height while in Figure 8 the same is possible for the mean values of the ball speed.

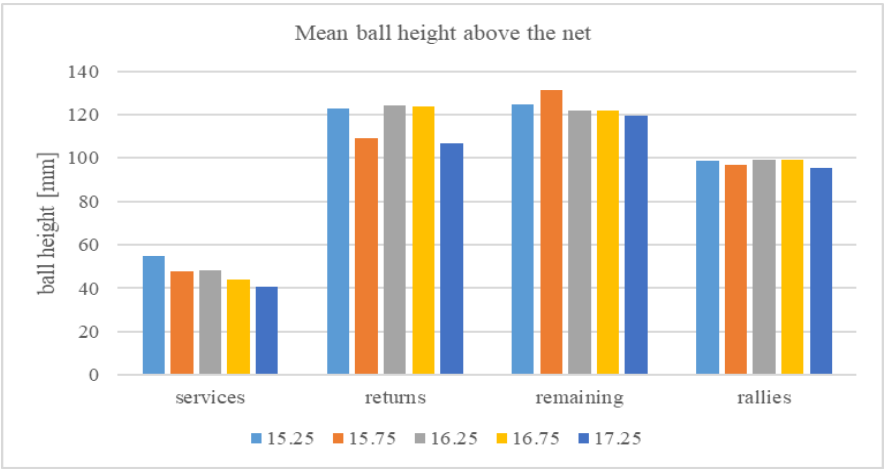

Fig.7. Mean ball height at services, returns, the remaining of the rallies and the whole rallies.

As seen in Figure 7, the mean ball height of the services is slightly reduced with each net height. They are inversely correlated with Pearson's correlation coefficient r=-0.96. For instance, the reduction is 7.3% at net height 17.25 cm with regard to 16.75 cm and 26% with regard to 15.25 cm.

The mean ball height of the returns oscillates in the range of 16% between the maximal and minimal value and does not depend on net height (r=-0.32)

The mean ball height of the remaining points of the rallies varies only a little bit (10%) and is not correlated with the increase of the net height (r=-037).

The mean ball height of the whole rallies is even more stable (within 4%) and exhibits almost no correlation (r=-037) with the increase of the net height.

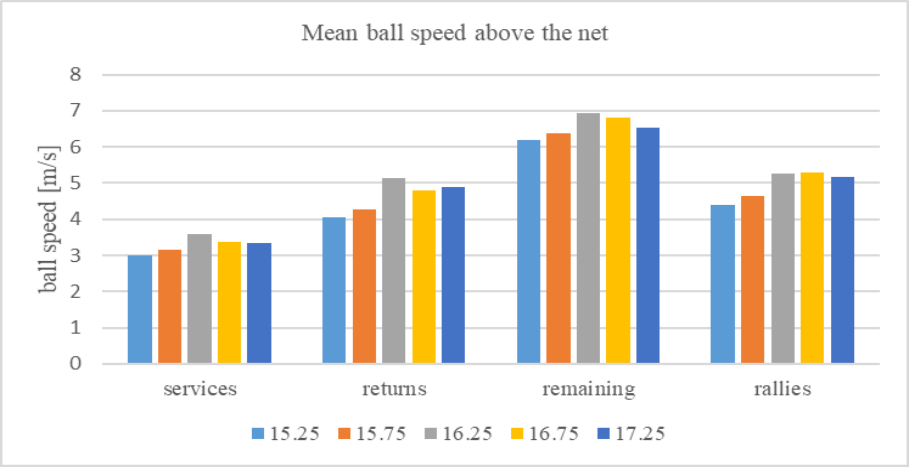

Fig. 8. Mean ball speed at services, returns, the remaining of the rallies and the whole rallies.

In Figure 8, one can see that the correlation of the mean ball speed with the net height is not very strong. Pearson coefficient for services is 0,62, for returns 0,77, for remaining points 0,57 and for the whole rallies 0,84. Interesting observation is that the mean rally speed first increases with increased net height, only at 17.25 cm then slightly decreases but is still higher then at 15.25 cm.

Inferential statistics

We tested how our rally based data groups differ among each other using inferential statistics. The available data after segmentation of video recordings were classified into 8 categories. Four of them consisted of mean values (rally ball heights, rally ball speeds, remaining rally ball heights and remaining rally ball speeds). The other four consisted of the raw measurements.

In each category there were 5 groups (one for each net height) with different number of samples (Table 12).

Table 12. *Categories and number of samples in each category group.*

	number of samples				
category	15.25	15.75	16.25	16.75	17.25
rally mean ball heights	102	106	106	108	98
rally mean ball speeds	102	106	106	108	98
service ball heights	102	106	106	108	98
service ball speeds	102	106	106	108	98
return ball heights	99	97	102	108	97
return ball speeds	99	97	102	109	97
remaining rally mean ball heights	71	78	75	83	81
remaining rally mean ball speeds	71	78	75	83	81

Firstly, we tested each group's distribution for normality. In case of normal distribution we used repeated measures ANOVA test and in the case of not normal distribution we used Friedman test. If the calculated *p-value* was of the same magnitude as the preselected threshold value $\alpha = 0.05$ then the post hoc test was applied to verify the previous test. The results of initial comparison among groups are presented in Table 13.

Table 13. *Significance test results of ball heights and speeds at different net heights.*

	test	p-value	post hoc	difference
rally mean ball heights	Friedman	0,9926		no
rally mean ball speeds	ANOVA	0,0200	Bonferroni	yes
service ball heights	Friedman	0,0056		yes
return ball heights	Friedman	0,8240		no
service ball speeds	Friedman	0,0038		yes
return ball speeds	Friedman	0,0667	Bonferroni	no
remaining rally mean ball	Friedman	0,9878		no
remaining rally mean ball	Friedman	0,3736		no

These results show that there are statistically significant differences only in rally mean ball speed, service ball height and service ball speed among different net heights. The differences for other 5 measured parameters are not significant.

Then, for the three categories exhibiting significant differences we wanted to know at which net heights they are different. Therefore we repeated the tests from Table 13 in a pairwise manner. We compared measurements at each increased net height (15.75, 16.25, 16.75 and 17.25) to basic net height (15.25 cm). Comparisons among other net heights are less interesting and were not performed. The results are summarized in Table 14.

Table 14. *Significance test results of pairwise comparison of three categories at different net heights.*

	15.25 : 15.75	15.25 : 16.25	15.25 : 16.75	15.25 : 17.25
rally mean ball speeds	no	no	no	no
service ball heights	no	no	no	yes
service ball speeds	no	yes	no	no

In the case of rally mean ball speeds, there was no significant difference which means that the difference exists between the net heights that were not tested here. In the case of service ball heights the difference is only at the highest net height (17.25 cm) and in the case of the service ball speed the difference is at 16.25 cm net height.

4. CONCLUSIONS

The net height was varied within 2 cm (13.1%) which is afforded by current net holders. The performed experiments in laboratory conditions with limited data

collection did show only minor overall influence of the net height to the table tennis game. Even the impression of the players was in accordance with this.

At the set level there is no significant influence to a single parameter out of seven although the results show that the ball speed and the ball height above the net are slightly affected.

At the rally-level the results show that increasing the net height statistically significantly affects only the service ball speed and the service ball height above the net while the remaining of the rallies and the whole rallies themselves are not affected.

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REFERENCES

Bradski, G. (2000). The OpenCV Library. *Dr. Dobb's Journal of Software Tools,* 120, 122-125.

Cece, V., Guillet-Descas, E., & Martinent, G. (2020). Mental training program in racket sports: A systematic review. *International Journal of Racket Sports Science, 2*(1), 55-71.

Chen, M.-K., Chien, J.-C., & Chiang, H.-H. (2019). A research of health-related fitness of university students: The case study of NCHU students join racket sports courses in 2017. In M. Kondrič, D. Cabello-Manrique, M. Pinthong (Eds.), *Science and Racket Sports VI.* (pp. 98-109). Bangkok: Mahidol University, BWF, ITTF.

Fullen, R. (2010). *Table Tennis: Fastest Ball Sport?* http://protabletennis.net/content/table-tennis-fastest-ball-sport

Kashiwag, R., Okamura, S., Murakami, S., & Takahashi, H. (2019). The ball speed and the ball spin created by ground strokes during the rallies in an actual tennis match. In M. Kondrič, D. Cabello-Manrique, & M. Pinthong (Eds.), *Science and Racket Sports VI*. (pp. 65-69). Bangkok: Mahidol University, BWF, ITTF.

Kondrič, M., Matković, B., Furjan-Mandić, G., Hadžić, V., & Dervišević, E. (2011). Injuries in racket sports among Slovenian players. *Collegium Antropologicum, 35*(2), 413-417.

Kondrič, M., Torkar, D., Supej, M., Ogrin, J., Ochiana, N., & Matjašič, T. (2019). Measuring ball speed and height above the net in table tennis. In M. Kondrič, D. Cabello-Manrique, & M. Pinthong (Eds.), *Science and Racket Sports VI*. (pp. 167-172). Bangkok: Mahidol University, BWF, ITTF.

Lees, A. (2003). Science and the major racket sports: a review. *Journal of Sports Sciences, 21*(9), 707-732.

Lees, A. (2019). Science and racket Sports: past, present and future. In M. Kondrič, D. Cabello-Manrique, & M. Pinthong (Eds.), *Science and Racket Sports VI*. (pp. 9-16). Bangkok: Mahidol University, BWF, ITTF.

Sturm, P. (2014). Pinhole Camera Model. In Ikeuchi K. (Ed.), *Computer Vision*. Springer, Boston, MA.

Takahashi, H., Kashiwagi, R., Okamura, S., & Murakami, S. (2019). The relationship between the ball speed and the ball spin rate of serves in collegiate male tennis players. In M. Kondrič, D. Cabello-Manrique, & M. Pinthong (Eds.), *Science and Racket Sports VI*. (pp. 110-115). Bangkok: Mahidol University, BWF, ITTF.

Yamamoto, F., Kasai, J., Hirakawa, H., Someya, S., & Okamoto, K. (2010). High-Speed Video Image Analysis of Air Flow around a Table Tennis Ball. *International Journal of Table Tennis Sciences*, *6*, 149-150.

Zhang, Z. (2000). A flexible new technique for camera calibration. *IEEE Trans. Pattern Analysis and Machine Intelligence*, *22*(11), 1330–1334.

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Multiball training: A review

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Abstract: The structure of table tennis training is governed by the training rules that outline all organized sports and divides into two categories; general and specific training. General training refers to the development of physical abilities while specific training refers to the improvement and development of technical and regular skills. This review aims to collect and analyse the studies that refer to table tennis training with the Multiball method. Even though this method has been extensively used for years, the volume, frequency and duration of the training stimulus have not been clearly defined yet. The literature review shows that modification in the parameters of this training method makes it possible to simulate competition conditions and improve technical and regular skills. Therefore, it is crucial for table tennis coaches to be familiar with the application methodology of Multiball training in order to provide the training stimuli that reinforce the training process depending on the athletes' needs and requirements. This study presents researches that refer to Multiball training and provides highlights for the organization of the training process.

Keywords: table tennis training, multiball, technical skills

1. INTRODUCTION

The contemporary training process should include the main factors of athletic performance, a general concept which can be defined as physical abilities (Ferrauti, Bergeron, Pluim, & Weber, 2001) and technical skills. Moreover, it should aim at combining all the main and supporting factors in relation to the specific requirements of each sport. Table tennis is considered as a complex sports activity which demands intense physical activity and the application of special technique to a high degree (Kondric, Mandic, Kondric, & Gabaglio, 2010; Willmore & Costill, 2004). The combination of physical abilities with technique can result in performance improvement (Zhang, 2013). However, even though the improvement of physical abilities has been adequately researched, the improvement of technical skills is a result of good empirical approaches. One of the most common table tennis training forms is the interval training which is called *Multiball Training* in the relevant literature (Tepper, 2003; Turina, 2002).

1.1 Forms of Training and Training Adaptations

Racket sports, due to their energy and match requirements, are considered as athletic activities in which both the aerobic and the anaerobic mechanisms of energy participate (Kasai et al., 2010; Zagatto et al., 2010; JTTA, 1994). In practice, this means that the training process should be designed in such a way so that both energy systems are activated. Racket sports are complex in nature, since they are influenced by numerous competition factors. The cycle 'effort-interval-effort', which is repeated in a unit of time, simulates interval training. Therefore, the requirements of racket sports, in which short breaks succeed high-intensity short efforts, are similar to interval training. This type of training may meet sports requirements more substantially, with the adaptation of athletes' physiological parameters, since it consists of continuous switching between charge and restoration, as is the case in the match conditions of this sport.

1.2 Interval Training

Interval training is a widely used training method. At a research level, it has been used either as a method of long-term training intervention in order to explore the possibility of adapting the aerobic system, or as a comparison with other methods in order to explore its effect on the acute response of various physiological parameters during exercise (Midgley & Naughton, 2006; Billat, 2001; Tabata et al., 1997). Interval training consists of repetitive charges which are interrupted by short breaks. Breaks are taken either by lower-intensity exercise (actively) or by pause (passively). Interval training can be done in a wide variety of combinations, depending on the intensity and duration of the charging periods and their proportion to the intensity and duration of the restoration periods (Daniels & Scardina, 1984).

2. MULTIBAL TRAINING

2.1 Description of the Process

Multiball training is a form of training in which a coach continuously supplies a trainee with balls in a unit of time. The kind, duration, direction and frequency of the supply and the returns depend on the design of the training process. This type of training has been systematically used for over three decades and is internationally known as Multiball training (Tepper, 2003; Turina, 2002; Leach,1971). This type of training aims at making athletes adapt to a continuous pace of stroke exchange and improve their stamina and technique. It is clear that several combinations may exist in Multiball training, in order to cause various physiological reactions in an athlete's body, as well as cover a wide range of training stimuli. Therefore, the training goal changes if the break time between exercise sets, the ball feed pace or the frequency are modified. Moreover, Multiball training enables the application of all regular exercises and the teaching of technique, regardless of the trainees' level (Seemiller, Holowchak, 1997; Bruecker, 1995; Leach, 1971). Finally, the trainees' response time is directly influenced by the coach's position in relation to the net. (Molodzoff, 2008). According to the training manual of the International Table Tennis Federation, Multiball training can be used: i) to develop and improve the technical adequacy of strokes, ii) to improve the quality and increase the intensity of the training, iii) to

simulate match conditions, and iv) to improve speed, flexibility and stamina (Tepper, 2003). In training terminology, Multiball training refers to ball toss by a natural person and not by a machine.

2.2 Adaptations

Even though Multiball training can be adapted in many ways, and although it has been widely used over the past decades, it has not been systematically researched up to now. International literature does not contain references which could guide coaches and adequately indicate if a specific training stimulus serves the purposes for which it is used. Furthermore, it has not been analysed whether the modification of training factors, such as the time, frequency, volume and duration, influences the physiological responses of the body. Therefore, although the benefits of Multiball training are considered to be self-evident, they are not scientifically supported. Nevertheless, the use of this method has been studied with the aim of evaluating the physical competition parameters of the sport as well as athletes' technical ability.

As early as 1988 an effort was made to evaluate different training methods, including Multiball training; it was shown that the use of this type of training results in increased concentration of lactic acid in the blood (4.3±1.9mmol/l), compared to the lactic acid level during resting state (1.1±0.2mmol/l), in relation to other forms of training (1.1±0.1mmol/l) and match conditions (Preub, 1988). Fayt et al., (2003) used Multiball training and modified the ball feed pace with the aim of evaluating the results in relation to the trainees' performance and heart rate. The study showed that the more the intensity of exercises increases, the more the athletes' performance decreases. Moreover, Kasai et al (1994) report that Multiball training should be used because it can help to lower the level of cardio-respiratory requirements during a match. This result was obtained with the use of a multi-ball stimulus (60 balls/min) by combining technical strokes with and without movement. Additionally, Jospin & Fayt (2004) used this method to determine whether there are changes in performance under the same charges in relation to the athletes' training age. Thus, they modified the difficulty of the exercises by altering their technical requirements with the use of a combination of strokes as well as free strokes.

Considering that the heart rate appears to increase during a table tennis match (Durand, 1992), care should be taken to ensure that athletes exercise with training stimuli similar to those of the competition. For this purpose, attempts have been made to record the results after applying specific training stimuli (Fayt, 2003; Grosser & Starischka, 2000) with increasing intensity. Exercises of the Multiball type have been used for the precision of measurements. The above facts show that the use of these exercises allows for precise control over both the performance of the exercises and the provoked training stimulus, since the performance parameters are controlled. Relatively recent studies have shown that using Multiball exercises there may be improvements in adolescent table tennis technique as well as in their physical abilities (Katsikadelis et al., 2017; Katsikadelis, Pilianidis, Mantzouranis, & Aggelousis, 2015).

Furthermore, it seems that regardless of the duration of the stimulus, short duration of high intensity Multiball exercises affects in cardiorespiratory capacity of

youth table tennis player (Katsikadelis, Pilianidis, Mantzouranis, & Berberidou, 2018). However, the data we have in relation to the widespread use of the method is very limited.

3. CONCLUSION

The purpose of the literature review was to record and analyse the publications that refer to Mutliball training. This method has been used for more than 30 years as a controlled and figurable training method that adapts to training planning. This review demonstrated that by modifying the training protocol, various adjustments are brought about to both the physical abilities and the technique of Table Tennis. Nevertheless, in order to arrive at more solid conclusions, the training protocols should be further investigated, new ones should be tested, and their application needs to be checked at different ages and levels of athletes.

REFERENCES

Billat, V. (2001). Interval Training for Performance: A Scientific and Empirical Practice Special Recommendations for Middle and Long Distance Running. Part I: Aerobic Interval Training. *Sports Medicine, 31*(1), 13-31.

Bruecker, S. (1995). *Table Tennis Educational Program.* USA: Harvard Sports.

Daniels, J., & Scardina, N. (1984). Interval training and performance. *Sports Medicine, 1*, 327-334.

Durand, M. (1992). The optimization of performance. A study of tasks constituted by a non-optimal solicitation. *Revue Staps*, *28*, 41-57.

Fayt, V., Quignon, G., & Lazzani, S. (2003). Influence of exercises intensity on physiological parameters and on the drive execution in table tennis. In A. Lees, J.F. Kahn & W. Maynard (Eds.), *Science and Racket Sports III. Proceedings of the Eight International Table Tennis Federation Sport Science Congress and The Third World Congress of Science and Racket Sports*. London and New York: Routledge.

Ferrauti, A., Bergeron, M.F., Pluim, B.M., & Weber, K. (2001) Physiological responses in tennis and Running with similar oxygen uptake. *European Journal of Applied Physiology, 85*, 27–33.

Grosser, M., & Starischka, S. (2000). *Προπόνηση Φυσικής Κατάστασης σε όλα τα αθλήματα και τις ηλικίες* [*Fitness workout in all sports and ages].* Thessaloniki: Salto Editions.

Japan Table Tennis Association, Sport Science Committee (1994). *Q & A format, the Handbook of Table Tennis Sport Science.* Japan: JTTA.

Jospin, L., & Fayt, V. (2004). Monitoring effort during increasing levels of training exercises in table tennis. In A. Lees, J.F. Kahn & W. Maynard (Eds.), *Science and Racket Sports III. Proceedings of the Eight International Table Tennis Federation Sport Science Congress and The Third World Congress of Science and Racket Sports* (p. 21-22). London and New York: Routledge.

Katsikadelis, M., Pilianidis, Th., Mantzouranis, N., & Berberidou (2018). Comparison of effect of two interval Multiball training protocols on VO_{2max} and lactate concentration. *Journal of Biology of Exercise, 14*(2), 53-64.

Katsikadelis, M., Pilianidis, Th., Mantzouranis, N., Berberidou, F., Fatouros, I., & Aggelousis. N. (2017). The influence of 10 weeks high-intensity interval Multiball training on aerobic fitness in adolescent table tennis players. *Journal of Biology of Exercise*, *13*(1), 1-13.

Katsikadelis, M., Pilianidis, Th., Mantzouranis, N., Fatouros, I., & Aggelousis. N. (2017). The effect of detraining on cardiovascular responses in young table tennis players. (p. 203-208). In M. Kondrič, M. Fuchs & T. Matjašič (Eds.), *Proceedings book of the 15th ITTF Sports Science Congress*. Lausanne, Switzerland: International Table Tennis Federation

Kasai, J., Akira, O., Eung, T. J., & Mori, T. (2010). Research on table tennis cardio – respiratory endurance. *International Journal of Table Tennis Sciences*, *6*, 6-8.

Kasai, J., Dal Monte, A., Faccini, P., & Rossi, D. (1994). Oxygen consumption during practice and game in table tennis. *International Journal of Table Tennis Sciences, 2*, 120-121.

Kondric, M., Furjan-Mandic, G., Kondric, L., & Gabaglio, A. (2010). Physiological demands and testing in table tennis. *International Journal of Table Tennis Sciences*, *6*, 165-170.

Leach, J. (1971). *Table Tennis for the seventies*. New Jersey: Barnes & Co.

Midgley, A., & Naughton, L. (2006) Time at or near VO2 max during continuous and intermittent running. *Journal of Sports Medicine and Physical Fitness*, *46*, 1-14.

Molodzoff, P. (2008). *ITTF advanced coaching manual*. Lausanne: International Table Tennis Federation.

Preub, A. (1988). *Supply of Energy at Table Tennis during Competition Loads and during Different Training Loads*. (Diplomarbeit), Köln: Deutsche Sporthochschule Köln.

Seemiller, D., & Holowchak, M. (1997). *Winning table tennis*. Champaigh, IL: Human Kinetics.

Tabata, I. Nishimura, K. Kouzaki, M. Hirai, Y. Ogita, F. Miyachi, M., & Yamamoto, K. (1997). Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and V˙O2max. *Med. Sci. Sports Exer, 28*, 1327–1330.

Tepper, G. (2003). *Table Tennis Coaching Manual Level One*. Lausanne: International Table Tennis Federation.

Turina, B. (2002). *Some advice concerning Multiball training*. Saarbrücken: Tibhar.

Willmore, J.H., & Costill, D.L. (2004). *Physiology of sport and exercise*. Champaign, II: Human Kinetics.

Zagatto, A.M., Morel, E.A., & Gobatto, C.A. (2010). Physiological responses and characteristics of table tennis matches determined in official tournaments. *Journal of Strength and Conditioning Research*, *24*(4), 942–949.

Zhang, H. (2013). Evaluation of elite table tennis players' technique effectiveness. *Journal of Sport Sciences, 31*, (14), 1526-1534.

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The development of table tennis cognitive test for college students - A preliminary research

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Abstract: In the PE, cognitive learning is an important indicator for assessing learning accomplishment. The purpose of this study was to develop a written table tennis cognitive test for college students. The participants were 93 students (aged 19-20) selected from 2 basic table tennis class. Item analysis was used to choose the items that fit acceptable difficulty index and discrimination index, and split-half reliability was applied to analyse reliability of the test. 25 items that met acceptable item difficulty index and item discrimination index were chosen from 35 items to be included in the final test. Regarding reliability, the Cronbach's α coefficients and split-half coefficients of all items were .60 and .56. Content validity was established according to the goals and contents of teaching and approved by table tennis instructors and sport pedagogy researcher. 25 items of table tennis cognitive test that fit item analysis index were developed for college students. But due to the moderate reliability of this test, further research is needed for revision and verification.

Keywords: table tennis, cognitive learning, sport rules, physical education, college students

1. INTRODUCTION

In recent years, the concept of physical literacy (PL) have been adopted by Canada, the United States, the United Kingdom, Australia, the Netherlands, New Zealand, Northern Ireland, Wales, and many other countries, as a national curriculum goal and assessment indicator, and has been regarded as the ultimate goal of physical education (PE). (Aspen Institute, 2015; Chan, Keh, & Chang, 2017; *Society of Health and Physical Educators*, 2014). Physical literacy is the motivation, confidence, physical competence, knowledge, and understanding to value and take responsibility for engagement in physical activities for life. (International Physical Literacy Association, 2015), and a lifelong journey (Whitehead, 2010). The trend of selective PE courses has cast its impact on PE teachers in recognizing the importance and significance of PE (Kuo & Lin, 2006; Wang, 2000). Therefore, in addition to improving motor competence, cognitive and affective learning effect of fields such as sport rules, motivation, and learning attitude also plays a very important role in terms of improving PE-related research. With the rise of pedagogy practice research in recent years, teachers and researchers in various fields are beginning to pay more attention to the change of students' learning process and the implementation of multiple evaluation approaches. Among them, the quantitative evaluation method

often adopts the pre- and post-learning tests as the basis for formative and summative evaluation, in which the precision of measurements and the ability in reflecting students' learning performance are the key elements in determining the teaching efficacy and the representativeness of research.

In the case of Taiwan's current conditions, the evaluation criteria of PE performance in the university stage are stipulated by each university or college respectively. Based on the curriculum goal, the majority of PE instructors tend to allocate their score ratio across three major goals: cognition, affection, and motor skill. Although motor skill plays the dominant evaluation element of PE, sports knowledge still remains an important reference to evaluating students' learning performance, and with paper and pen test sheet as the most adopted format. Hence, it is necessary to compile a set of test questions with good reliability and validity (Kuo & Lin, 2006). The current college PE courses are interest-based, providing students with the choices of their own interest. Moreover, they allow teachers to present teaching subjects in a broader and richer manner since the courses each only contains one sport in an entire semester (Kuo & Lin, 2006). In order to determine whether the students have acquired an in-depth learning result, and to provide college teachers a measure for evaluating students' cognition learning effect, this study attempts to devise a table tennis cognitive test instrument with good reliability and validity.

2. RESEARCH METHOD

2.1 Compilation of the test sheet

Targeting college students of the basic table tennis course, the test sheet comprises both multiple choice and true-false items. With the two-way specification table as the guideline, the purpose of the test is to establish the foci and the scope of the test, as well as to integrate teaching objectives and contents, to ensure the validity of the contents, and to reflect the teaching objectives (Chang, 1986; Kuo & Lin, 2006). In compiling the two-way specification table, several references were used to categorized the cognitive dimensions: Ichiro Ogimura (1989), *Basic Table Tennis Course*; National Education Information Center (2007), *Teaching Methods, Materials, and Assessment in Physical Education – Table Tennis* (Chinese Taipei Table Tennis Association, 2015), and Anderson et al. (2001), *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. Specifically, this study referred to the six cognitive process dimensions that Tsao (2012) divided in his compiled edition of the "*Revision of Bloom's Framework of Cognitive Process Dimension of the Recognition Education Object*," which are detailed as follows:

(1) Remember: To retrieve relevant knowledge from long-term memory, e.g., (a) recognizing, identifying; and (b) recalling, retrieving.

(2) Understand: To determine the meaning of instructional messages (including oral, written, and graphic communication), e.g., (a) interpreting, clarifying, paraphrasing, representing, translating; (b) exemplifying-illustrating, instantiating; (c) classifying-categorizing, subsuming; (d). summarizing-abstracting, generalizing;

(e) inferring-extrapolating, interpolating, predicting; (f) comparing-contrasting, mapping, matching; and (g) explaining-constructing, models.

(3) Apply: To carry out or use a procedure in a given situation, e.g., (a) carrying out; and (b) implementing-using.

(4) Analyse: To decompose material into several components, and determine the connections between the components, component and the entire structure, and purpose, e.g., (a) differentiating-discriminating, distinguishing, focusing, selecting; (b) organizing-finding, coherence, integrating, outlining, parsing, structuring; and (c) attributing-deconstructing.

(5) Evaluate: To make judgement according to rules or criteria, e.g., (a) checking-coordinating, detecting, monitoring, testing; and (b) critiquing-judging.

(6) Create: To compose elements into an orderly or functional unity, or recompose them into an original mode or structure, e.g., (a) generating-hypothesizing; (b) planning-designing; and (c) producing-constructing.

The test took the students of the basic table tennis selective course as the objects. Since the objective of the test is to enable students to acquire basic rules, skills, and knowledge of table tennis, more items were selected from the cognitive dimensions of Remember, Understand and Apply, than those at the Analyse, Evaluate and Create categories. The two-way specification table is shown in Table 1.

Table 1. *Two-way specification table of Table Tennis Cognitive Test*

Cognitive Domain / Content	Remember	Understand	Apply	Analyse	Evaluate	Create
Rule	C5,C10	C4,C25,T1,T2,T4,T8,T10	C6,C7,T5,T9	T3	C11,T6	C18
Skill			C8,C12,C14,C15,C20	C9,C17	C16,C19	
Sense	C1,C23,T7	C2,C3,C24				
Tactical				C21		C22

C: multiple choice item; T: true-false item

2.2 Implementation of pre-test

Among the 50 test questions initially compiled by referring to Ichiro Ogimura (1989) *Basic Table Tennis Course*; Chinese Taipei Table Tennis Association (2015), *Table Tennis rules in ROC*; and National Education Information Center (2007), *Teaching Methods, Materials, and Assessment in Physical Education – Table Tennis*, 35 were selected to include in the 2nd pre-test after a pre-test taken by 150 examinees. Then, following a revision made by two table tennis instructors, those of the similar nature and those with discrimination and difficulty level considered unfit for the indicators were deleted.

The objects of the test were 93 students of a certain national university in eastern Taiwan who took the basic table tennis courses in the first semester of 2018 academic year. The test was administered during the courses in December 20-31. A

total of 93 valid test sheets were immediately collected upon the expiration of the 30-minute test time limit.

2.3 Item analysis

After the pre-test, the item analysis on the 35 test questions done by 93 students was proceeded as follows:

(1) First, all test sheets were arranged in sequence of order (from the highest to the lowest score).

(2) The collected test sheets were then split into high and low score groups of the top and bottom 27%. Among the multiple-choice items, a total of 28 respondents belong to the low score group (0-42 points), 25 belong to the high score group (53-75 points); while in the true-false items, a total of 41 respondents belong to the low score group (0-17.5 points), and 30 belong to the high score group (22.5-25 points).

(3) Difficulty: The proportion of respondents who gave the correct answer to each item. The higher the index, the simpler it is. The purpose is to test whether the students have acquired the basic competence taught in the courses. The mean difficulty of all items fell around 0.8, and items with ≦ 0.10 difficulty index (too difficult) and those with ≧ 0.90 difficulty index (too simple) were either modified or discard.

(4) Discrimination: It is intended to determine whether the items have the ability to distinguish between high and low scores. In this study, the difference between the number of respondents in both the high and the low group is divided by the number of respondents in the high group or the low group respectively, to compute the discrimination level. Items with ≦ 0.20 discrimination index were deleted.

3. RESULTS

3.1 Item analysis

Generally speaking, those with ±0.50 difficulty index are considered as the most fit, and those fell within 0.30~0.70 are regarded as acceptable; and those with a discrimination index of ≧ 0.40 are the best fit, and 0.30~0.39 are considered as acceptable (Chang, Z. M., 1986). Among all the 35 pre-test questions, a total of 19 items, including those with difficulty index between 0.30~0.70, and with ≧ 3.0 discrimination index, were No. 1, 2, 5, 7, 8, 9, 10, 13, 14, 15, 16, 17, 19, 20, 22, and 23 of the multiple-choice section, as well as No. 3, 8, and 9 of the true-false section. In addition, a total of 6 items, including those with difficulty index between 0.30~0.70, and ≧ 0.30 discrimination index, were No. 4, 11, 18, and 21 of the multiple-choice section, as well as No. 6, and 7 of the true-false section. Combining the resultant items together, a total of 25 items were compiled as the final college table tennis cognitive test sheet. The difficulty and the discrimination indices are summarized in Table 2.

Table 2. *Difficulty and discrimination index of Table Tennis Test*

Item	Difficulty Index	Discrimination Index	Item	Difficulty Index	Discrimination Index
C1	0.80	0.33	C 19	0.52	0.57
C 2	0.56	0.57	C 20	0.67	0.51
~~C 3~~	~~0.98~~	~~0.19~~	C 21	0.54	0.20
C 4	0.89	0.22	C 22	0.67	0.57
C 5	0.61	0.40	C 23	0.61	0.41
~~C 6~~	~~0.97~~	~~0.19~~	C 24	0.09	0.01
C 7	0.80	0.45	C 25	0.18	0.28
C 8	0.68	0.34	~~T1~~	~~0.68~~	~~0.08~~
C 9	0.81	0.38	~~T 2~~	~~0.67~~	~~0.00~~
C 10	0.68	0.54	T 3	0.66	0.61
C 11	0.42	0.21	~~T 4~~	~~0.66~~	~~0.15~~
~~C 12~~	~~0.34~~	~~-0.05~~	~~T 5~~	~~0.65~~	~~0.00~~
C 13	0.89	0.55	T 6	0.65	0.21
C 14	0.82	0.45	T 7	0.66	0.23
C 15	0.30	0.38	T 8	0.68	0.55
C 16	0.75	0.61	T 9	0.66	0.39
C 17	0.67	0.57	~~T 10~~	~~0.65~~	~~0.10~~
C 18	0.78	0.25			

C: multiple choice item; T: true-false item

3.2 Reliability and validity analysis

In terms of reliability, the stability of the test instrument was initially confirmed by the Cronbach's α value of .60, and .56 split-half reliability. On the other hand, all the items of the study were focused on the basic rules, skills, and common sense of the table tennis, based on the course objectives and teaching contents, and have been checked by senior scholars and sports education researchers for content validity of the measurement tool.

4. CONCLUSION AND SUGGESTIONS

4.1 Conclusion

Based on the table tennis cognitive test compiled from the revised cognition process dimensional structure of Bloom's education objectives in the cognition domain, the final college student table tennis cognitive test of this study met the difficulty index and the discrimination index fit, and with a 0.56 split-half reliability. In addition, the content validity of the measurement tool checked by the sport education researchers and table tennis scholars has also been confirmed. The final version contains 25 items.

In view of the emphasis placed on the physical literacy as an ultimate goal, and the PE by college teachers and researchers in recent years, research in the improvement on pedagogy practice and the PE curriculum has become a subject of great concern. Motivated by the attempt to enhance sports learning effect of college

students, this study initially complied a basic table tennis cognitive test sheet to be served as a measurement tool for PE teachers in assessing students' learning effects. Through reviewing relevant literature and books, compilation of two-way specification table and test questions, as well as administration of pre-tests, item analysis and reliability and validity checking, etc., the initial college basic table tennis recognitive test that met the difficulty and discrimination indices and with a moderate reliability and validity, was finally produced.

4.2 Suggestions

(1) Targeting college students as the research objects, this table tennis cognitive test was compiled according to the basic rules, skills, and common sense of table tennis sport. It is recommended that future researchers in the related academic fields compile spot cognitive test instruments at different levels, so as to add more depth and breadth to the relevant research.

(2) Since the cognitive test of this study is applicable to college students of the selective table tennis courses, it can be used as an assessment for students' learning effect, and comprehension competence of the table tennis-related knowledge.

(3) Due to the constraints of time and manpower, the split-half reliability was used in this study. It is suggested that the test-retest method should be adopted by future researchers to verify the stability of measurement tools. In addition, the skill test score of the college students can be used as an indicator to criterion-related validity for testing the validity of the measurement tool.

REFERENCES

Anderson, L.W., Krathwohl, D.R., Airasin, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., & Wittrock, M. (Eds.) (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* New York: Addison Wesley Longman.

Aspen Institute. (2015). P*hysical literacy: A global environmental scan*. Retrieved from https://www. shapeamerica.org//events/upload/GlobalScan_FINAL.pdf

Chan, E.H., Keh, N.C., & Chang, C.W. (2017). Analysis of Literacy-Oriented PE Curriculum: Taking the UK, Canada, USA and Australia as Examples. *Sports Research Review, 143*, 1-13. doi: 10.6162/SRR.2017.143.01

Chang, Z.M. (1986). *Measuring and Evaluation in PE.* Taipei, Taiwan: Buffalo Book Co.

Chinese Taipei Table Tennis Association. (2015). *Table Tennis rules in ROC.* Taipei, Taiwan: author.

International Physical Literacy Association. (2015). International physical literacy association homepage. Retrieved from http://www.physical-literacy.org.uk

Kuo, Y.C., & Lin, C.P. (2006). The Development of Table Tennis Cognitive Test for College Students. *PE Journal, 39*(3), 119-129. doi:10.6222/pej.3903.200609.1110

National Education Information Center. (2007). *School PE Teaching Materials and Assessment - Table Tennis*. Taipei, Taiwan: author.

Ogimura, I. (1989). *Basic Tennis Course*. Taipei, Taiwan: Lianguang Book Company.

Society of Health and Physical Educators. (2014). *National standards & grade-level outcomes for K-12 PE*. Champaign, IL: Human Kinetics.

Tsao, P.S. (2012). Examples of Applying the Revision of Bloom's Taxonomy of Educational Objectives to Mathematics Assessment Items. *Secondary Education, 63*(4), 38-65. doi:10.6249/SE.2012.63.4.03

Wang, Z.C. (2000). Construct an effective sports cognitive testing. *Taiwan PE, 107*, 9-13.

Whitehead, M.E. (2010). *Physical literacy: Throughout the life course*. New York, NY: Routledge.

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Relationship between postural abnormalities and functional movement assessments in table tennis players

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Abstract: Table tennis is one of the popular sports that many people playing this sport. During matches and exercises, especially in young athletes, the body adapts to postural deviations that are suitable for table tennis and affect movement efficiency. *Aim and theoretical framework:* Athletes need to spend a lot of time in the dominant physical habit of the sport, so the posture in athletes may be affected and lead to changes in functional movements. Therefore, our aim in this study is to determine the Relationship between postural abnormalities and Functional Movement Assessments in table tennis players. *Method:* 51 male table tennis players with age (13.68±2.83) were selected randomly. For evaluation of movement efficiency, three functional movements including double limb squat, double limb squat with heel lift, and single limb squat were conducted for assessing movement dysfunctions and scored using Fusionetics algorithms. For assessing postural abnormalities, New York test and plumb line were used. *Results:* The results shown that table tennis players had poor (47.32±.8%), moderate(64.67±6.63%), and good (84.11±5.75%) movement efficiency in single leg squat, double limb squat, and double limb squat with heel lift, respectively. Similarly, there is a positive and significant correlation between the total movement efficiency scores and New York test scores ($p<0.05$). *Discussion and conclusion:* Table tennis players had movement dysfunctions during functional movement patterns. There were correlations between functional movement errors and postural abnormalities. Based on the results it is recommended to coaches to concern about their athlete's postures.

Keywords: movement dysfunctions, fusionetics, postural abnormalities

1. INTRODUCTION

Postural abnormalities are unfortunate changes that interfere with the structure of the skeletal body. These abnormalities are generally due to environmental reasons, inappropriate function of muscles and joints and improper motor habits (Vakili et al., 2016). High rates of musculoskeletal problems are reported in the community as a result of muscular imbalance. This inconsistency is usually due to weakness of the muscles on the one hand, and shortness and stiffness of the muscle on the other, which leads to a natural disorientation in the individual. The occurrence of these problems is more prevalent in people who do their daily work in a specific pattern and do not have a good physical activity. It should be noted that

although the abnormalities of the situation act as separate parts, but usually different abnormalities and changes in the body are related. One of the most controversial areas of musculoskeletal rehabilitation is identification of the weakest link between parts of the body, as this weakness leads to motor defects while performing functional movements in other parts of the body and increases the risk of injury and successful modification. This bond has a great impact on the proper function of the body during functional exercises such as jumping, landing, squat, etc. (Clark & Lucett, 2010; Terada, Pietrosimone, & Gribble, 2014; Webster, Pietrosimone, & Gribble, 2016)

Athletes in various sports need to perform regular exercises and strengthen certain muscles of the body to achieve high levels of performance, and they have to spend a lot of time in the prevailing physical state of that sport, so depending on the prevailing status of each field of physical fitness and the amount of spinal arches in athletes may be affected. It is also said that during certain exercises, especially in young athletes, the body adapts to mild postural deviations that are suitable for exercise; in other words, the body adapts to the posture required for that activity. Therefore, athletes alternatively take a podium that is typically related to sports. That is why it is stated that athletes are more susceptible to negative postural adaptations than non-athletes (Marfell-Jones & Reilly, 2005; Rajabi, Doherty, Goodarzi, & Hemayattalab, 2008; Stošić, Milenković, & Živković, 2011). Table tennis is one of the popular sports that many people playing this sport. In this sport as well as other sports, athletes take on the sport in their practice and sporting competitions. Unfortunately, no study has been found to examine the movement efficiency of athletes in this sport, but other studies have looked at the posture of athletes of other disciplines and examined the effects of these exercises on the posture of the body. So the purpose of this study is to investigate the relationship between postural abnormalities and Functional Movement Assessments in table tennis players.

2. METHODS

The present study was a descriptive-correlational study in which the relationship between motor defects and musculoskeletal abnormalities of the table tennis players was evaluated. 51 male table tennis players with age (13.68±2.83) were selected randomly.

The Fusionetics Scoring System (Fusionetics®, Milton, GA) was used to calculate functional movement scores based on the company's proprietary scoring algorithms. Number of errors, type of error, and body region within which the error occurred are considered within the proprietary scoring algorithm (Bagherian, Rahnama, & Wikstrom, 2017). Three lower extremity tasks were completed to assess movement efficiency. The double-limb squat (DLS) and double-limb squat with heel lift (DLS-HL) had participants stand barefoot with their feet shoulder-width apart and their arms raised straight up over the head. Participants then performed a squat before returning to the starting position with both the descent and the ascent lasting 2 seconds. The only difference between the movements was the 5.1-cm (2-in) plate placed under the participant's heels for the DLS-HL. A total of 15 DLS and DLS-HL

were completed so that the research team could evaluate movement proficiency from the anterior, lateral, and posterior perspectives. The single-limb squat (SLS) required hands to be kept on hips while squatting to between 45 and 60 degrees of knee flexion while barefoot. A total of 5 SLS were performed while scored from the anterior view. Errors during the tasks were recorded in a binary fashion: "yes" (i.e., this error was made) or "no" (i.e., this error was not made). Movement efficiency assessments during the DLS, DLS-HL, and SLS were shown to have moderate to high interrater reliability in previous studies (Frank, Stanley, & Padua, 2016; Stanley, Frank, & Padua, 2016). Before the initiation of this research, the research team conducted both online training and repeatedly scored 10 pilot participants until an acceptable level of reliability was achieved.

In addition to tracking individual movement errors, errors were submitted to the Fusionetics Platform for an overall score. Scores are calculated based on proprietary software but are based on the number of errors and type of error made. Overall scores for the DLS and DLS-HL were interpreted as poor (0%-49.99%), moderate (50%-74.99%), and good movement efficiency (75% 100%) based on Fusionetics platform recommendations.

For assessing postural abnormalities, New York Posture Rating Scale (NYPR) and plumb line were used. The NYPR was originally published in 1958 (The New York Physical Fitness Test) and later published in a modified form by Howley and Franks (1992). The NYPR applies a quantitative approach to assess proper and improper alignment of various body segments for an individual in the anatomical position. The NYPR published in 1958 includes a set of three figure drawings for each of 13 body alignment segments contributing to overall postural alignment. The 13 body alignment segments include posterior views of the head, shoulders, spine, hip, feet, and arches, and lateral (left side) views of the neck, chest, shoulders, upper back, trunk, abdomen, and lower back. Short verbal descriptions are provided to indicate the visual cues to use as criteria in deciding the score. In this original version, each body segment was scored 5 (correct Posture), 3 (slight deviation), or 1 (pronounced deviation) (McRoberts, Cloud, & Black, 2013).

Arnold et al. (2000) concluded that the NYPR was a practical tool with a moderate intrarater correlation coefficient (Arnold, 2000).

Regarding the collected data were qualitative type, descriptive statistics and chi square and Pearson correlation were used for data analysis with using SPSS version 16 software.

3. RESULTS

Totally 235 postural abnormalities were observed in 51 participants. According to the results of Table 1. The most prevalence disorder was uneven shoulder (98%) and then hyper kyphosis (96.1%). Also as shown in Table 2. , table tennis athletes had had poor (47.32±.8%), moderate(64.67±6.63%), and good (84.11±5.75%) movement efficiency in single leg squat, double limb squat, and double limb squat with heel lift, respectively. The results of the study shown that there was a positive correlation between total movement efficiency scores and New York Posture Rating Scale (r=.47, p=0.00).

Table 1. *Observed postural abnormalities in table tennis players*

Type of disorder	Number of disorder	Percentage
Hyper kyphosis	49	96.1
torticollis	2	3.9
Uneven shoulder	50	98
Forward head	27	52.9
Flat back	2	3.9
Hyper lordosis	28	54.9
Uneven pelvic	6	11.8
scoliosis	5	9.8
Winging scapula	3	5.9
Genu valgus	23	45.1
Genu varus	21	41.2
Flat foot	15	29.4
Hallux valgus	4	7.8

Table 2. *Mean and S.D of Fusionetics Scores for movement efficiency*

Test	Poor	Moderate	Good
Double leg squat	39.9±4.9	55.96±12.94	79.53±14
Double leg squat with heels lift	59.25±23.3	76.94±10.57	92.35±12.33
Single leg squat	66.6±16.6	61.57±12.57	78.91±11.29
Total ME scores	47.32±.8	64.67±6.63	84.11±5.75

4. DISCUSSION

The results showed that all players who were evaluated had at least one postural abnormality. This research is consistent with the results of Honary (1993), Silva (2018) and Samakoush and Noraseth (2017) researches that athletes have abnormality.

It can be concluded that table tennis players are also subject to certain abnormalities due to their specific physical condition during training and games. The most abnormalities that table tennis players had were: hyper kyphosis and uneven shoulder. It seems that because of special situation behind the table during training and matches, and they also use one part of their body (superior hands) more than the other, it seems that this situation in the long term Causes abnormalities due to distortion of muscular balance.

Although sport activities make an imbalance in strength and even postural abnormalities in body building, should not overlook the important role of body building and corrective exercises beside main sports such as table tennis in preventing and correcting abnormalities.

Also the results showed that table tennis players had poor (47.32±.8%), moderate (64.67±6.63%) and good (84.11±5.75%) movement efficiency in single leg squat, double limb squat, and double limb squat with heel lift, respectively. Evaluation of functional movements is interesting for researchers in identifying

susceptible individuals and assessing movement to physicians allow to observe movement deficits, muscle imbalances, and exercise strategies.

Detected modified muscles and provide corrective remedies to correct these problems (Clark & Lucett, 2010). Kinesiopathology approach indicates that movement postural abnormalities can lead to injury. So with simple tools like squat and other functional assessments that have validity and reliability, can identify this deficits and prevent injuries.

It can be concluded that in the double leg squat with lifting of the heels, few motor defects were observed that the main reason for reducing motor defects is to raise the heel. Most of the movement defects occurred during the single leg squat. These results are consistent with Bagherian et al. (2017).

Similarly, there is a positive and significant correlation between the total movement efficiency scores and New York test scores (p=0). This means that with increasing New York test scores, ME scores also increased. This can be explained by the fact that if muscles and joints are in balance, fewer abnormalities are exist, movement efficiency increases, The consequences of skeletal abnormalities are general fatigue, joint changes, shortness and weakness of the ligaments, abnormal pressure on meniscus and discs, muscle weakness, disruption of biomechanical equilibrium, decreased agility and muscle strength, postural abnormalities Cardiovascular, reduction of respiratory volume, absence of the individual in the social works (Connolly, Drubach, Connolly, & Treves, 2004). Postural abnormalities lead to negative changes in alignment and movement, if a person has good posture, can perform functional movements with less energy and better quality.

Unfortunately, most of the researches that have examined the motor function during performance of motion in people have been using motion analyser cameras to evaluate movement defects. While they are expensive and unavailable to the general public and there is no scale for their assessments. Double leg squat, double leg squat with heel lift and single leg squat can be used at medical centres or athletes' assessments in sports fields with the aim of screening and identifying movement defects with aim of reducing the risk of injury. These tests are simple screening tools with high validity and reliability that can be used to identify people with motor defects and susceptible to injury by therapists and athletic trainers and Corrective exercise experts (Frank et al., 2016; Stanley et al., 2016).

REFERENCES

Arnold, C. (2000). The reliability of five clinical postural alignment measures for women with osteoporosis. *Physiother Can, 52*, 286-294.

Bagherian, S., Rahnam, N., Wikstrom, E. A., & Clark, M. A. (2017). Relationships between Functional Movement Assessments and Elements of Sensorimotor Function in Collegiate Athletes with Chronic Ankle Instability. *J Rehab Med, 7*(2), 138-147.

Bagherian, S., Rahnama, N., & Wikstrom, E. A. (2017). Corrective Exercises Improve Movement Efficiency and Sensorimotor Function but Not Fatigue Sensitivity in Chronic Ankle Instability Patients: A Randomized Controlled Trial. *Clinical journal of sport medicine: official journal of the Canadian Academy of Sport Medicine*.

Clark, M., & Lucett, S. (2010). *NASM essentials of corrective exercise training*: Lippincott Williams & Wilkins.

Connolly, L. P., Drubach, L. A., Connolly, S. A., & Treves, S. T. (2004). Young athletes with low back pain: skeletal scintigraphy of conditions other than pars interarticularis stress. *Clinical nuclear medicine, 29*(11), 689-693.

Frank, B., Stanley, L., & Padua, D. (2016). Inter-rater reliability of a lower extremity movement efficiency screening tool. *J Athl Train, 51*(6), 361.

Honary, H. (1993). *Assessment of postural anomalies male athlete students across the country.* MA thesis]. Tarbiat Modarres University.

Marfell-Jones, M., & Reilly, T. (2005). The investigation of thoracic kyphosis in cyclists and non-cyclists *Kinanthropometry VIII* (pp. 251-259): Routledge.

McRoberts, L. B., Cloud, R. M., & Black, C. M. (2013). Evaluation of the New York Posture Rating Chart for assessing changes in postural alignment in a garment study. *Clothing and Textiles Research Journal, 31*(2), 81-96.

Rajabi, R., Doherty, P., Goodarzi, M., & Hemayattalab, R. (2008). Comparison of thoracic kyphosis in two groups of elite Greco-Roman and freestyle wrestlers and a group of non-athletic participants. *British journal of sports medicine, 42*(3), 229-232.

Samakoush, H. B., & Norasteh, A. (2017). Prevalence of Postural Abnormalities of Spine and Shoulder Girdle in Sanda Professionals. *Annals of Applied Sport Science, 5*(4), 31-38.

Silva, N. A. V. d. (2018). *Postural and anthropometric changes in canoe sprint athletes: The impact of two different active recovery methods.*

Stanley, L., Frank, B., & Padua, D. (2016). Between-day reliability of lower extremity movement quality during double and single leg squatting tasks. *J Athl Train, 51*(6), 360.

Stošić, D., Milenković, S., & Živković, D. (2011). The influence of sport on the development of postural postural abnormalities in athletes. *Facta universitatis-series: Physical Education and Sport, 9*(4), 375-384.

Terada, M., Pietrosimone, B., & Gribble, P. A. (2014). Individuals with chronic ankle instability exhibit altered landing knee kinematics: potential link with the mechanism of loading for the anterior cruciate ligament. *Clinical biomechanics, 29*(10), 1125-1130.

Vakili, L., Halabchi, F., Mansournia, M. A., Khami, M. R., Irandoost, S., & Alizadeh, Z. (2016). Prevalence of common postural postural abnormalities among academic dental staff. *Asian journal of sports medicine, 7*(2).

Webster, K. A., Pietrosimone, B. G., & Gribble, P. A. (2016). Muscle activation during landing before and after fatigue in individuals with or without chronic ankle instability. *Journal of athletic training, 51*(8), 629-636.

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Analysis and predictive classification model of athletes' brainwave based on machine learning – A case study of table tennis athletes

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Abstract: The psychological states of athletes will influence the performance of competition. Different levels of concentration and mental representations of each sport will reflect on brainwaves. The related brainwave researches of sports' field are applying scientific analysis to provide quantitative data, which provide researchers, coaches, and players to understand the psychological states of athletes during sports. Obviously, the performance of certain sports is related to the α frequency of brainwave, the psychological states of players in different sports can be analysed with other frequencies. The proposed method in this study can be used as a prototype of high potential players' selection system in the future or can be used as adjusting the mental state for active athletes to improve training efficiency and performance.

This study aims to establish classification model of sports by analysing electroencephalogram (EEG) of athletes with data mining techniques. In data collection, collects the EEG with pressure of the athletes with filling out the questionnaires in limited time. In data analysis, applies the Butterworth low-pass filter to remove noise before converts the EEG to power spectral density by Fast Fourier Transform, then extracts 24 features according to frequency bands and statistical methods as the basis of the classification model. Last but not least, constructs the classification model by machine learning algorithms such as C4.5 and CART and compares the accuracy of different classifiers.

By means of proposed sports classification model coordinated with other biotechnologies such as electrocardiogram and electromyogram, which can help athletes and prospective athletes to well understand psychological conditions and choose more appropriate sports.

Keywords: players' selection system, electroencephalogram, Butterworth low-pass filter, Fast Fourier Transform, C4.5

1. INTRODUCTION

Sports are inherently competitive, and athletes continuously seek any edge or advantage that can bring victory. The rapid development of modern sports science has greatly improved the efficiency of athletes physical training, and the technical

gap between athletes is gradually narrowing, raising the importance of psychological factors in the pursuit of victor. Excellent athletic performance is closely related to the quality of the athlete's mental state (Weinberg, 1988; Grosu, 2018). The difference between winning and losing in many sports can be measured in milliseconds, and this extreme competitiveness can produce stress which can cause anxiety in athletes, which will negatively impact performance. Poor adjustment to psychological pressure prior to athletic performance can result in errors which can make the difference between victory and defeat (Barnes, 1986; Nicholls, 2016).

Different people react differently to stress, and different sports are associated with different levels of psychological pressure. Previous studies have largely relied on questionnaires, scales and experimental measurements, which are all subject to error due to the inherent subjectivity of personal experience.

Electroencephalography (EEG) directly measures physiological response in the brain and thus can objectively reflect a person's mental and physical state. In recent years, EEG has been used in research related to the detection of stress as a means of simplifying measurement and data collection. It has been shown to be an efficient and objective means of assessment (Goodman, 2013). This study uses EEG measurements to assess the stress impact levels of different sports, and to develop a classification model for sports using techniques including time domain and frequency domain analysis and deep learning. The results may allow athletes to better understand their psychological condition, and to participate in more suitable sports.

2. RELATED WORK

2.1 Brain waves and stress

Stress results from the impact of external stimuli which threaten to disrupt an individual's sense of internal balance. Physiological and psychological states may respond to various stimuli to re-establish an equilibrium, but excessively large and persistent external stimuli may negatively impact the body's structure or function (Gaetano, 2015). Although stress cannot be directly measured, an individual's physiological response can be measured as a proxy. Certain physiological parameters (such as EEG, ECG and EMG) have been found to be very sensitive to the regulation of external stimuli (Li, 2011).

EEG records the changes in electrical current produced by brain cell activity using electrodes attached to the scalp. Stress can cause emotional instability which can manifest as anger, anxiety, sadness, etc. and is reflected in brainwaves (Davidson, 1984) which can be recorded by EEG based on energy changes in the various brain wave bands. The relationship between human physiological response and stress, and the varying degrees of stress change also affect the intensity of brain wave band activity. The International Union of Clinical Psychology classifies brain wave frequencies into four bands from low to high: delta (0.5~4Hz), theta (4~7Hz), alpha (8~13Hz), beta (14~30Hz) and gamma (30~100Hz). Alpha waves represent an alert, quiet, stable and focused psychological state, while beta waves represent a state of tension, anxiety or excitement. Theta and delta waves respectively represent deep sleep and unconsciousness, and rarely appear in awake adults.

2.2 Machine learning

2.2.1 GainRatio

GainRatio considers the information carried by the candidate attribute itself to be converted to the decision tree, and finds the most suitable branching attribute by calculating the ratio of the information gain to the information amount of the branching attribute (Quinlan, 1986):

$$Gain_{ratio(D,a)} = \frac{Gain(D,a)}{Split\ Info(a)}$$

Split Info(a) is a measure of the discrete or cluttered value of the data, so the larger the Split Info(a), the less significant the branch, thus an attribute with a smaller Split Info(a) value is usually chosen for branching variables.

2.2.2 Decision tree

The decision tree is decision-making technique based on artificial intelligence (Lu, 2018). This study mainly uses the C4.5 decision tree technique to construct a classification model and to compare it with other classifiers.

The C4.5 decision tree improves the multi-branch ID3, and selects the attribute with the largest gain ratio as the branching attribute (Quinlan, 2014).

3. METHODS

Research data was sourced from six table tennis players at the National Taiwan Sports University (NTSU) and four from National Chung Hsing University (NCHU), along with ten tennis players from NCHU. Each participant was tested by EEG while completing a questionnaire.

Figure 1 illustrates the experimental process, which is divided into two parts: Signal processing and construction of the classification model. The experiment was conducted using Python 3, WEKA 3.6, and R 3.4.4 running on Windows 7.

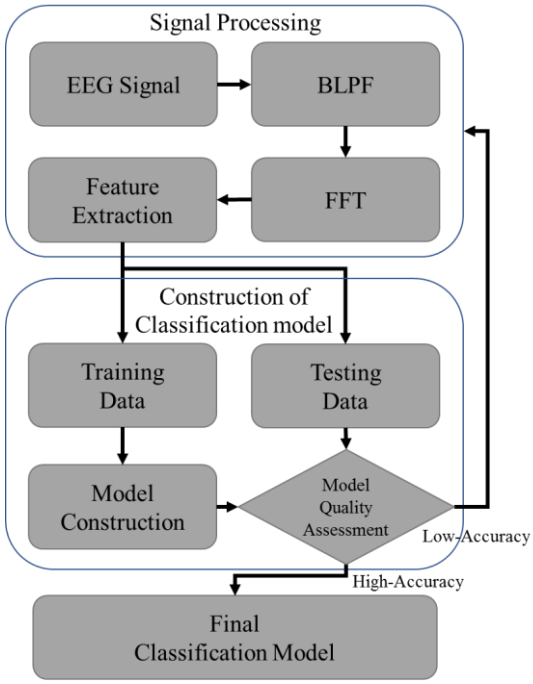

Fig. 1. Experimental process

3.1 Butterworth Low Pass Filter(BLPF)

The main purpose of BLPF is to remove unwanted frequencies from the desired frequency bands, and to eliminate noise from external interference (e.g., sweating, blinking, eye motion, head movement, etc.) and to shift the amplitude of high and low oscillations in the average amplitude (Alsté, 1986; Jung, 2012).

3.2 Power Spectral Density (PSD)

Signal processing provides two methods of analysis: time domain and frequency domain. Most studies involving EEG records use frequency domain analysis, using PSD at different frequencies in the EEG to reflect physiological changes resulting from external stimuli. This study uses FFT to convert time domain signals into the amplitude in multiple frequency bands to form PSD (Cooley, 1965), (Figure 2).

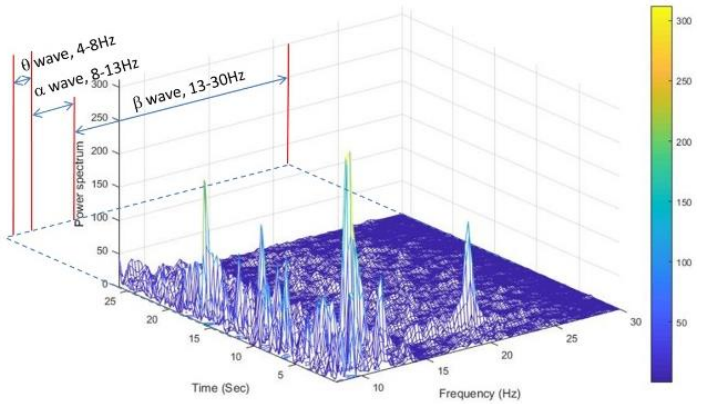

Fig. 2. Power Spectral Density (PSD)

3.3 Brain wave pressure feature extraction

The converted power spectral density is extracted from the average energy carried in the δ (0.5-4Hz), θ (4-8Hz), Low α (8-9Hz), Mid α (9-12Hz), High β (12-13Hz), Low β (13-16Hz), Mid β (16-20Hz) and High β (20-30Hz) bands to derive 24 attributes such as maximum energy carried and the standard deviation of the energy carried. Gain Ratio is used for feature filtering (Figure 3), removing the less relevant attributes and highlight their eigenvalues.

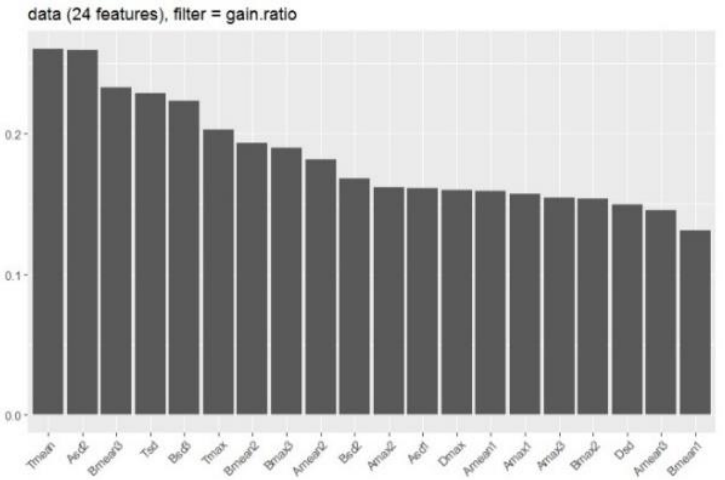

Fig. 3. GainRatio

3.4 Classification model construction

To compare the C4.5 decision tree classifier against other classifiers, the Gain Ratio-filtered features are used as the input values, with data divided into training and testing sets to construct the classification model. Ten-fold cross-validation is used to measure model accuracy.

4. RESULTS

Three classifier models (C4.5, BayesNet, and SVM) were assessed and compared using Gain Ratio, Table 1.

Table 1. *Comparison of classifier accuracy before and after feature selection*

	Before Feature Selection	After Feature Selection
C4.5	82.86%	83.27%
BayesNet	80.40%	80.45%
SVM	72.24%	72.45%

After removing the attribute of average energy carried in the δ (0.5-4Hz) band, the accuracy of the C4.5 classifier improved significantly from 82.86% to 83.27%.

5. CONCLUSION

The results of the brain wave assessment of the athletes studied indicate a significant difference in the accuracy of the various methods, with C4.5 providing the highest accuracy at 82.27%.

Based on the athlete classification model presented here, future work can focus on extending this approach to other assessment techniques including ECG and EMG, providing athletes and their trainers with greater insight into their psychological suitability for various types of sports.

REFERENCES

Alsté, J.A., Eck, W., & Herrmann, O.E. (1986). ECG Baseline Wander Reduction Using Linear Phase Filters. *Computers And Biomedical Research, 19*, 417-427.

Barnes, M. W., Sime, W., Dienstbier, R., & Plake, B. (1986). A test of construct validity of the CSAI-2 questionnaire on male elite college swimmers. *International Journal of Sport Psychology*, *17*(5)*,* 364–374.

Cooley, J.W., & Tukey, J.W. (1965). An algorithm for the machine calculation of complex Fourier series. *Mathematics of computation*, *19*(90), 297-301.

Davidson, R.J., (1984). Affect, cognition and hemispheric specialization. In C.E. Izard, J. Kagan & R. Zajonc (Eds.), *Emotions, Cognition, & Behavior.* (pp. 320-365). Cambridge: University Press.

Gaetano, R., Paloma, F.G., & Gaetano, A. (2015). Anxiety in the Youth Physical and Sport Activity. *Mediterranean Journal of Social Sciences*, *6*(3), 227-230.

Goodman, R. N., Rietschel, J. C., Lo, L. C., Costanzo, M. E., & Hatfield, B. D. (2013). Stress, emotion regulation and cognitive performance: The predictive contributions of trait and state relative frontal EEG alpha asymmetry. *International Journal of Psychophysiology*, *87*(2), 115-123.

Grosu, E.F., Motică, F.C., Ordean, M.N., & Grosu, V.T. (2018). Increase Performances in Ski-Biathlon by Reducing Anxiety Stress Using Mental Training Techniques. *The International Scientific Conference eLearning and Software for Education*, 268-273.

Jung, W.H., & Lee, S.G. (2012). An R-peak detection method that uses an SVD filter and a search back system. *Computer Methods and Programs in Biomedicine 108(3)*, 1121-1132.

Li, Y., Li, X., Ratcliffe, M., Liu, L., Qi, Y., & Liu, Q., (2011). A real-time EEG-based BCI system for attention recognition in ubiquitous environment. *Proceedings of 2011 international workshop on Ubiquitous affective awareness and intelligent interaction*, 33-40.

Lu, H., Li, Y., Chen, M., Kim, H., & Serikawa, S. (2018). Brain intelligence: go beyond artificial intelligence. *Mobile Networks and Applications 23*(2), 368-375.

Nicholls, A.R., Levy, A.R., Carson, F., Thompson, M.A., & Perry, J.L. (2016). The applicability of self-regulation theories in sport: Goal adjustment capacities, stress appraisals, coping, and well-being among athletes. *Psychology of Sport and Exercise*, *27,* 47-55.

Quinlan, J.R. (1986). Induction of decision trees. *Machine Learning, 1*(1), 81-106.

Quinlan, J.R. (2014). *C4.5: programs for machine learning*. Elsevier.

Weinberg, R.S. (1988). *The mental advantage: Developing your psychological skill in tennis.* Champaigne, IL: Human Kinetics.

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Detecting ball distribution patterns in table tennis by using autocorrelation method

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Abstract: The purpose of this research is to verify whether there is regularity in the player's ball distribution pattern by collecting coordinate data of the ball fall position during the game. The coordinate data was measured by an analysis system of a ball distribution characteristic using an ultrasonic sensor. For the analysis of the distribution pattern, autocorrelation was used to verify the presence or absence of regularity. As a result, the rally and distribution patterns that showed a strong correlation were all negative. By autocorrelation analysis of coordinate data in the time series, it became clear that it is possible to judge whether there is regularity in rally or distribution pattern. By knowing regular rally and distribution patterns, it was thought that it might be a clue to judge the distribution tendency of the player or an effective distribution pattern or an invalid distribution pattern.

Keywords: ultrasonic sensor, pattern of course distribution, autocorrelation

1. INTRODUCTION

At the scene of table tennis, little advice, or data presentation using objective data has been conducted. The reason for this is considered that game analysis software has not been developed and spread compared to other sports. So far, most of the research on game analysis in table tennis has been focused on how to use a style of batting and techniques (Hui et al., 2013; Munivrana et al., 2015). In recent years, several proposals have been made such as the analysis of a table tennis game by using a camera installed on the gymnasium ceiling by Takeuchi and Yoshida (2017) the performance analysis software of table tennis by Tamaki (2012).

In table tennis, Nonaka et al. (2017) researched usage techniques and attack patterns in a chopper. However, there are no studies that analyse and evaluate distribution patterns from serve to final stroke. In addition, according to Yang (2013), it is said that by analysing the distribution pattern at the time of score and lost points in a game of table tennis, appropriate advice regarding the distribution can be performed.

So, in this research, the ball falling position is connected during the game using the ball distribution characteristic analysis system using the ultrasonic sensor, and it

will be verified whether there is regularity in the player's distribution pattern in the match.

2. METHOD

2.1 Subject

The subjects were five male from Niigata University Table Tennis Club (height 172.2 cm ± 3.8, weight 62.2 kg ± 4.4, competition history 14.2 years ± 2.5). Due to the different characteristics of the distribution depending on the playing style, The researches have limited the game to the most frequent right-handed offensive players.

2.2 Matches to be analysis

The practice match was played by 5 games match 3 game pre-fetching (Table 1). The researches have collected data for a total of 11 games in 3 matches, and the number of the rally was 205. In the third game of the match of A-B one rally was not recorded, so the number of the analysed rally was 204.

Table 1. *Subject matches result*

	A vs. B			C vs. D			C vs. E		
Score	1	9–11 11–9 9–11 8–11	3	1	9–11 13–11 5–11 5–11	3	0	8–11 6–11 3–11	3

2.3 Outline of ball distribution characteristic analysis system

We used the ball distribution characteristic analysis system in this research. It arranges the ultrasonic sensor on the top of the table-tennis table and calculates the coordinate of the falling position from the time difference until the falling sound of the ball reaches the ultrasonic sensor. The trilateration theorem is mainly used to calculate coordinates. As for the coordinates, the intersection of the centre line and the net is set as the origin (0, 0), the horizontal axis is the x-axis, and the vertical axis is the y axis. We developed a program that displays the calculated coordinates on the computer screen using C #, a programming language, in Visual Studio Community 2015 of the development environment. Also, coordinate data of the calculated drop position can be stored in a file.

The average error of the ultrasonic sensor is 20.8 cm in the x-axis direction and 22.5 cm in the y-axis direction. In verifying the error, the coordinate data of the ball drop position was compared with the actual ball drop position obtained from digital video camera shooting. It was assumed that the actual ball falling position was replaced with an area divided into 20 areas on one side of the table tennis table, and all bounded to the centre of the area. Therefore, it is considered that there were some errors, and the advice on distribution was possible.

2.4 Data collection

Using a ball distribution characteristic analysis system using an ultrasonic sensor, the subject had performed a practice game and collected coordinate data of the ball falling position. When collecting coordinate data, noise may be included, and it may be difficult to distinguish between the coordinate data and the noise. Therefore, to identify only the coordinate data from the obtained data, the game was photographed by a digital video camera, and the coordinate data were identified by comparing the game image with the data.

2.5 Distribution analysis

The coordinate data of the ball falling position obtained by the ball distribution characteristic analysis system is used to analyse whether there is regularity in the rally or player's distribution pattern. At the time of analysis, analysis is performed separately for each of the x-axis coordinate and the y-axis coordinate. In the x-axis coordinate, it is analysed whether regularity exists in the left and right arrangements regardless of the depth, and in the y-axis coordinate, whether regularity exists in the arrangement of the depth regardless of left and right.

The game contents (score, service right, point loss, drop position area) were recorded on a self-made recording sheet because it is difficult to grasp the contents of the game only by the coordinate data of the ball drop position (Figure 1). The ball drop position area is obtained by converting the coordinate data into areas divided into 20 (5 × 4) on one side of the table tennis table (Figure 2). Each area is numbered 1 to 20. However, it was set to 0 if the coordinate data obtained due to the sensor problem was outside the table tennis table. Also, rally and items that contained 0 were excluded from the analysis.

score	service	win/loss	bound															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0–0	S	×	10	18	16	14	10	12	12									
0–1	S	○	7	14	10	8												
1–1		×	8	13	9	12	7	0	0	8	0	3						
1–2		×	8	13	15	8	7	6										
1–3	S	○	9	8	13	8												
2–3	S	×	10	14	11	13	7											
2–4		○	9	9	9	14	14	12										
3–4		○	8	0	0													
4–4	S	×	8	8	14	9	14											
4–5	S	○	15	13	8	9												
5–5		○	8	18	13													
6–5		×	8	12	6	10												
6–6	S	×	8	14	14													
6–7	S	○	8	15	9	9												
7–7		×	8	11														
7–8		×	8	13	9	10												
7–9	S	○	15	9	0	13	12	0										
8–9	S	○	9	15	7	15												
9–9		×	8	9	7	7												
9–10		×	8	12	15	13	9	9	9	5								

Fig. 1. Self-made recording paper

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16
17	18	19	20
20	19	18	17
16	15	14	13
12	11	10	9
8	7	6	5
4	3	2	1

Fig. 2. Ball drop position area

2.6 Analysis items

The analysis items of this study are as follows. Each analysis item analyses every x-axis coordinate and y-axis coordinate. However, the rally regularity of the y-axis coordinate was excluded because the analysis results were biased.

- About the regularity of the rally focusing on the left and right distribution
- About the regularity of the distribution of each player focusing on the left and right distribution
- About the regularity of the distribution of each player focusing on the distribution of length
- About regularity of service course focusing on left and right distribution
- About regularity of service course focusing on the distribution of length
- About the regularity of the receive course focusing on the left and right distribution
- About the regularity of the receive course focusing on the distribution of length

2.7 Autocorrelation analysis

In this study, to analysis, whether there is regularity in the player's ball distribution pattern in the practice match, we examined by autocorrelation analysis. Autocorrelation is to clarify the correlation between certain time-series data and data shifted by several time steps and indicates how much the data correlates with the history. If it is close to 1, there is a strong positive correlation, if it is close to -1, there is a strong negative correlation, and if it is close to 0, there is no correlation. In this research, to analysis, whether there is a correlation between a certain bound and a previous bound, we calculated the autocorrelation coefficient with data that is all shifted by a one-time step. In addition, Excel was used to calculate the autocorrelation coefficient. The following is the autocorrelation equation (1).

$$r = \frac{\sum_{i=1}^{N-h}(x_i - \bar{x})(x_{i+h} - \bar{x})}{\sum_{i=1}^{N}(x_i - \bar{x})^2} \quad (1)$$

3. RESULT AND CONSIDERATION

The ball drop position coordinate data obtained by the ball distribution characteristic analysis system was subjected to autocorrelation analysis to analyse whether there was regularity in the rally of each game and the ball distribution pattern of the players. The following are the results obtained by autocorrelation analysis.

When a positive correlation is found in the regularity of the rally focusing on the left and right distribution, it can be seen that the rally has much straight distribution regardless of the length. In other words, a ball returned to a straight course tends to be returned to a straight course. When a negative correlation is found, it can be seen

that a cross rally is taking place regardless of the length. In other words, the ball returned to the course of the cross tends to return the ball to the course of the cross.

When a positive correlation is found in the regularity of the distribution/service course/receive course of each player focusing on the left and right distribution, it can be seen that after arranging in a course of one course continuously as “fore side, fore side, fore side” it is arranged in the other course continuously as “back side, back side, back side”. When a negative correlation is recognized, it can be seen that the left and right are arranged alternately regardless of the length.

When a positive correlation is recognized in the regularity of the distribution, service course, and receive course of each player focusing on the distribution of length, It can be seen that after arranging in a course of one length continuously as “long, long, long” it is arranged in a course of the other length continuously as “short, short, short”. When a negative correlation is recognized, it can be understood that a course of length is alternately arranged regardless of right and left.

Figure 3 shows the records of the A-B match and the results of the autocorrelation analysis of each rally and distribution. All rallies and distribution that were strongly correlated were negatively correlated. In the distribution of A, it can be seen that after the second game, a regular distribution such as “back, middle, back” or “back, fore, back” is made and points are lost. In the distribution of B, it can be seen that, in the second half of the third game, points are scored with a regular distribution such as “long, short, long”.

Table 2 shows the results of the autocorrelation analysis of the service-received distribution of each game of the A-B match. In A's Serve's distribution, regularity is seen in the distribution like “short → very short” in the second game, and A won the game.

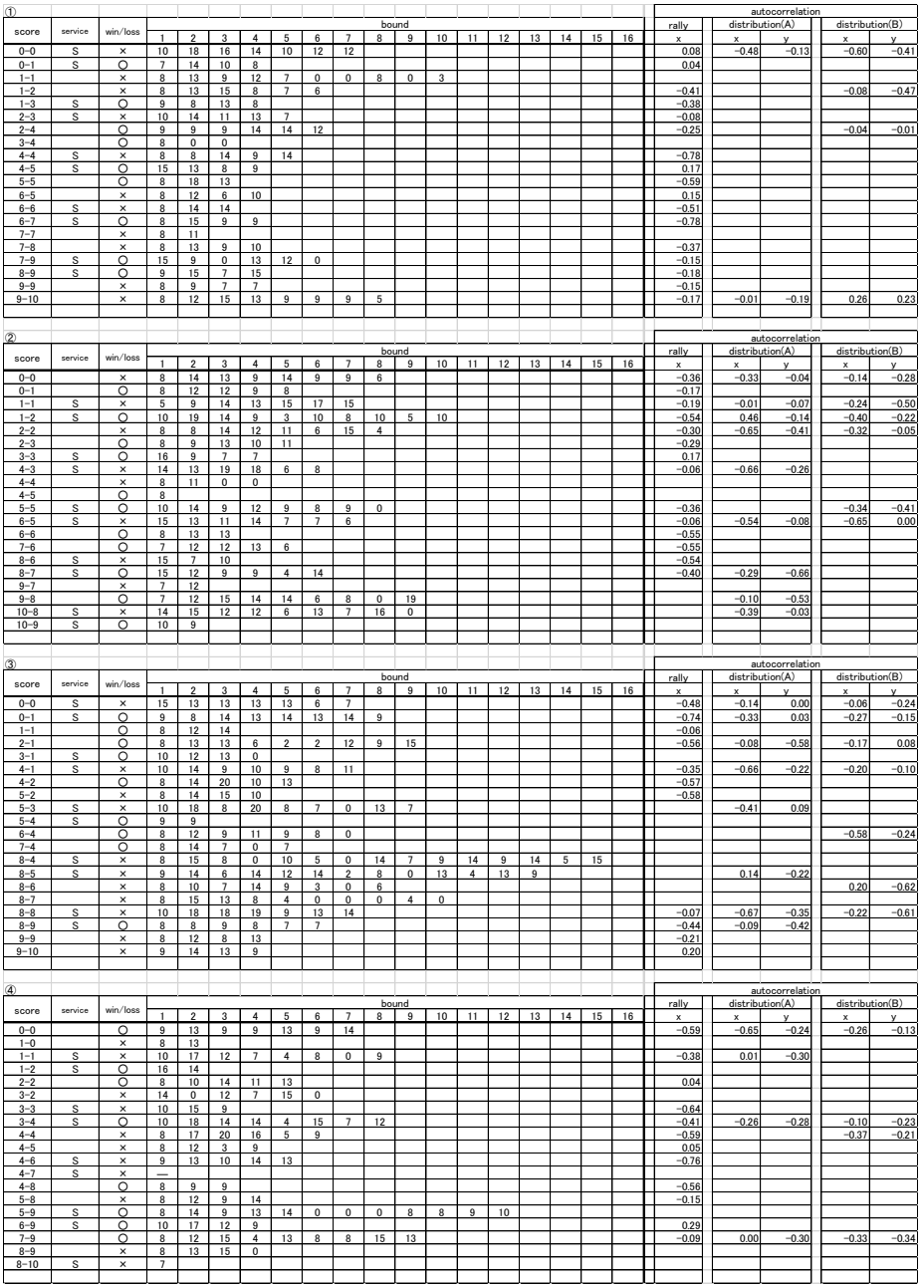
Figure 4 shows the records of the C-D match and the results of the autocorrelation analysis of each rally and distribution. All rallies and pitches that were strongly correlated were negatively correlated. Among the rally that was negatively correlated, the pattern that D scored was the “back side vs. back side” rally. In the distribution of each player, the number of the rally was low, and the items for which autocorrelation analysis could be performed were few.

Table 3 shows the results of the autocorrelation analysis of the service-received distribution of each game of the C-D match. In D's receive distribution, regularity is seen in the length distribution in the first game, and D won the game.

Figure 5 shows the records of the C-E match and the results of autocorrelation analysis of each rally and distribution. All rallies and pitches that were strongly correlated were negatively correlated. In the distribution of each player, the number of the rally was low, and the items for which autocorrelation analysis could be performed were few. It is possible that the number of bounces was small throughout the game and the difference in real ability was large.

Table 4 shows the result of the autocorrelation analysis of the service-received distribution of each game of the C-E match. In the third game, in E’s service

distribution, a regular distribution like a “long serve or a half-long serve” is seen after the short serve in front of the fore, and E on the game.



①

score	service	win/loss	bound 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	autocorrelation rally x	distribution(A) x	distribution(A) y	distribution(B) x	distribution(B) y
0–0	S	×	10	18	16	14	10	12	12										0.08	−0.48	−0.13	−0.60	−0.41
0–1	S	○	7	14	10	8													0.04				
1–1		×	8	13	9	12	7	0	0	8	0	3											
1–2		×	8	13	15	8	7	6											−0.41			−0.08	−0.47
1–3	S	○	9	8	13	8													−0.38				
2–3	S	×	10	14	11	13	7												−0.08				
2–4		○	9	9	9	14	14	12											−0.25			−0.04	−0.01
3–4		○	8	0	0																		
4–4	S	×	8	8	14	9	14												−0.78				
4–5	S	○	15	13	8	9													0.17				
5–5		○	8	18	13														−0.59				
6–5		×	8	12	6	10													0.15				
6–6	S	×	8	14	14														−0.51				
6–7	S	○	8	15	9	9													−0.78				
7–7		×	8	11																			
7–8		×	8	13	9	10													−0.37				
7–9	S	○	15	9	0	13	12	0											−0.15				
8–9	S	○	9	15	7	15													−0.18				
9–9		×	8	9	7	7													−0.15				
9–10		×	8	12	15	13	9	9	9	5									−0.17	−0.01	−0.19	0.26	0.23

②

score	service	win/loss	bound 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	autocorrelation rally x	distribution(A) x	distribution(A) y	distribution(B) x	distribution(B) y
0–0		×	8	14	13	9	14	9	9	6									−0.36	−0.33	−0.04	−0.14	−0.28
0–1		○	8	12	12	9	8												−0.17				
1–1	S	×	5	9	14	13	15	17	15										−0.19	−0.01	−0.07	−0.24	−0.50
1–2	S	○	10	19	14	9	3	10	8	10	5	10							−0.54	0.46	−0.14	−0.40	−0.22
2–2		×	8	8	14	12	11	6	15	4									−0.30	−0.65	−0.41	−0.32	−0.05
2–3		○	8	9	13	10	11												−0.29				
3–3	S	○	16	9	7	7													0.17				
4–3	S	×	14	13	19	18	6	8											−0.06	−0.66	−0.26		
4–4		×	8	11	0	0																	
4–5		○	8																				
5–5	S	○	10	14	9	12	9	8	9	0									−0.36			−0.34	−0.41
6–5	S	×	15	13	11	14	7	7	6										−0.06	−0.54	−0.08	−0.65	0.00
6–6		○	8	13	13														−0.55				
7–6		○	7	12	12	13	6												−0.55				
8–6	S	×	15	7	10														−0.54				
8–7	S	○	15	12	9	9	4	14											−0.40	−0.29	−0.66		
9–7		×	7	12																			
9–8		○	7	12	15	14	14	6	8	0	19									−0.10	−0.53		
10–8	S	×	14	15	12	12	6	13	7	16	0									−0.39	−0.03		
10–9	S	○	10	9																			

③

score	service	win/loss	bound 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	autocorrelation rally x	distribution(A) x	distribution(A) y	distribution(B) x	distribution(B) y
0–0	S	×	15	13	13	13	13	6	7										−0.48	−0.14	0.00	−0.06	−0.24
0–1	S	○	9	8	14	13	14	13	14	9									−0.74	−0.33	0.03	−0.27	−0.15
1–1		○	8	12	14														−0.06				
2–1		○	8	13	13	6	2	2	12	9	15								−0.56	−0.08	−0.58	−0.17	0.08
3–1	S	○	10	12	13	0																	
4–1	S	×	10	14	9	10	9	8	11										−0.35	−0.66	−0.22	−0.20	−0.10
4–2		○	8	14	20	10	13												−0.57				
5–2		×	8	14	15	10													−0.58				
5–3	S	×	10	18	8	20	8	7	0	13	7									−0.41	0.09		
5–4	S	○	9	9																			
6–4		○	8	12	9	11	9	8	0													−0.58	−0.24
7–4		○	8	14	7	0	7																
8–4	S	×	8	15	8	0	10	5	0	14	7	9	14	9	14	5	15						
8–5	S	×	9	14	6	14	12	14	2	8	0	13	4	13	9					0.14	−0.22		
8–6		×	8	10	7	14	9	3	0	6												0.20	−0.62
8–7		×	8	15	13	8	4	0	0	0	4	0											
8–8	S	×	10	18	18	19	9	13	14										−0.07	−0.67	−0.35	−0.22	−0.61
8–9	S	○	8	8	9	8	7	7											−0.44	−0.09	−0.42		
9–9		×	8	12	8	13													−0.21				
9–10		×	9	14	13	9													0.20				

④

score	service	win/loss	bound 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	autocorrelation rally x	distribution(A) x	distribution(A) y	distribution(B) x	distribution(B) y
0–0		○	9	13	9	9	13	9	14										−0.59	−0.65	−0.24	−0.26	−0.13
1–0		×	8	13																			
1–1	S	×	10	17	12	7	4	8	0	9									−0.38	0.01	−0.30		
1–2	S	○	16	14																			
2–2		○	8	10	14	11	13												0.04				
3–2		×	14	0	12	7	15	0															
3–3	S	×	10	15	9														−0.64				
3–4	S	○	10	18	14	14	4	15	7	12									−0.41	−0.26	−0.28	−0.10	−0.23
4–4		×	8	17	20	16	5	9											−0.59			−0.37	−0.21
4–5		×	8	12	3	9													0.05				
4–6	S	×	9	13	10	14	13												−0.76				
4–7	S	×	—																				
4–8		○	8	9	9														−0.56				
5–8		×	8	12	9	14													−0.15				
5–9	S	○	8	14	9	13	14	0	0	0	8	8	9	10									
6–9	S	○	10	17	12	9													0.29				
7–9		○	8	12	15	4	13	8	8	15	13								−0.09	0.00	−0.30	−0.33	−0.34
8–9		×	8	13	15	0																	
8–10	S	×	7																				

Fig. 3. Record of A vs. B

Table 2. *A vs. B service / receive allocation*

A		service		receive
①	x	0.15	x	—
	y	−0.26	y	—
②	x	0.23	x	—
	y	−0.65	y	—
③	x	0.24	x	0.32
	y	−0.25	y	0.31
④	x	−0.14	x	—
	y	−0.34	y	—

B		service		receive
①	x	—	x	—
	y	—	y	—
②	x	−0.39	x	−0.44
	y	0.27	y	−0.47
③	x	0.16	x	0.26
	y	−0.32	y	−0.12
④	x	—	x	—
	y	—	y	—

①

score	service	win/loss	bound												autocorrelation				
			1	2	3	4	5	6	7	8	9	10	11	12	rally	distribution(C)		distribution(D)	
															x	x	y	x	y
0–0		○	8	15	14	9	0												
1–0		×	7	14	7	0													
1–1	S	×	0	17	14	14	8	13	6	2	0	7	0			−0.21	0.26		
1–2	S	×	16	9	9										−0.05				
1–3		×	8	9															
1–4		×	8	18	13	14	9	9							−0.67			−0.57	0.00
1–5	S	○	9	19	11	9	6	6							−0.11	−0.15	−0.16		
2–5	S	○	15	17															
3–5		○	8	12	14										−0.18				
4–5		×	8	0	15	15													
4–6	S	○	4	9															
5–6	S	○	9	9															
6–6		○	8	4	14	11	12								−0.29				
7–6		×	8	13	13	9									−0.12				
7–7	S	×	11																
7–8	S	×	8																
7–9		○	7	12	16										−0.60				
8–9		○	8	14	8										−0.66				
9–9	S	×	3																
9–10	S	×	7	15	9										−0.31				

②

score	service	win/loss	bound												autocorrelation				
			1	2	3	4	5	6	7	8	9	10	11	12	rally	distribution(C)		distribution(D)	
															x	x	y	x	y
0–0	S	○	12	14															
1–0	S	○	13	12	12	13									−0.58				
2–0		×	19	15															
2–1		○	8	8	15										−0.35				
3–1	S	○	8	7															
4–1	S	×	7	8															
4–2		×	9	7	20	15									−0.43				
4–3		×	8	13	13	8									−0.70				
4–4	S	×	13	13	6	7	8	7	14	8	8				−0.40	−0.17	0.07	0.04	0.08
4–5	S	×	12																
4–6		×	8	12	10	4									−0.40				
4–7		×	8	4	13	7									−0.18				
4–8	S	○	15	14	14	8									−0.61				
5–8	S	○	8	14															
6–8		○	8	12	10	16	10	19	14	14	7	0	8			0.28	−0.09		
7–8		○	7	13	11	16	13	10	11						−0.11	−0.67	−0.52	−0.50	−0.63
8–8	S	×	7	17	19	8	9	14	1						0.15	0.00	−0.60	−0.04	0.00
8–9	S	○	13	12	12	6									−0.65				
9–9		×	16	5															
9–10		○	8	14	17										−0.26				
10–10	S	○	14	13	6	8									−0.07				
11–10		×	8	14															
11–11	S	○	12	19	8	9									−0.53				
12–11		○	8	12	14	9	4	7	3						−0.33	−0.15	−0.13	−0.61	−0.13

③

score	serviow	win/loss	bound												autocorrelation				
			1	2	3	4	5	6	7	8	9	10	11	12	rally	distribution(C)		distribution(D)	
															x	x	y	x	y
0–0		×	0	9															
0–1		○	8	7	5										−0.01				
1–1	S	×	14	6	0														
1–2	S	×	15	10	15										−0.66				
1–3		×	7	0	8	8													
1–4		×	8	6	9	13									−0.24				
1–5	S	×	12	14	8										−0.36				
1–6	S	○	13	13	9	7									−0.18				
2–6		×	15	13	9	10									−0.28				
2–7		×	8	20	14	11									0.12				
2–8	S	○	0	14	13	15													
3–8	S	×	19																
3–9		○	8	14	9										−0.58				
4–9		○	8	16	6										−0.46				
5–9	S	×	13	12	16	12	11	2	9	13	0	1	0			−0.67	−0.52		
5–10	S	×	14	15	14	7	2								−0.58				

④

score	service	win/loss	bound												autocorrelation				
			1	2	3	4	5	6	7	8	9	10	11	12	rally	distribution(C)		distribution(D)	
															x	x	y	x	y
0–0	S	×	8	0	0														
0–1	S	○	8	4	10	13									−0.38				
1–1		×	8	13	18	14									−0.29				
1–2		×	8	15	7	0													
1–3	S	○	8	12															
2–3	S	×	13	12	17										−0.26				
2–4		×	9	8	13	10									0.08				
2–5		×	8	8															
2–6	S	×	10	20	7	1	15	14	4						−0.11	−0.54	−0.64	−0.35	−0.32
2–7	S	○	0	14	6	8													
3–7		○	8	0	14														
4–7		×	8	12															
4–8	S	○	9	13	7	6	10	8	0	3						−0.26	−0.14		
5–8	S	×	9	15	14										−0.67				
5–9		×	8	19	9	8	8	9							−0.48			−0.64	−0.21
5–10		×	8	10	14	8									−0.40				

Fig. 4. Record of C vs. D

Table 3. *C vs. D service / receive allocation*

C		service		receive
①	x	−0.28	x	0.24
	y	−0.37	y	−0.10
②	x	0.09	x	−0.14
	y	0.01	y	−0.16
③	x	−0.36	x	−0.06
	y	0.04	y	−0.07
④	x	—	x	0.28
	y	—	y	−0.18

D		service		receive
①	x	—	x	−0.51
	y	—	y	−0.68
②	x	0.11	x	−0.03
	y	−0.15	y	0.09
③	x	—	x	—
	y	—	y	—
④	x	—	x	—
	y	—	y	—

①

score	service	win/loss	bound									rally	autocorrelation distribution(C)		distribution(E)	
			1	2	3	4	5	6	7	8	9	x	x	y	x	y
0–0	S	○	10	17	8	18						0.27				
1–0	S	○	5	10												
2–0		×	8	12	13	8						−0.55				
2–1		×	8	12	8	6	12	12				−0.76			−0.64	−0.65
2–2	S	×	0	12	4	8	9									
2–3	S	○	13	12	8	11						−0.47				
3–3		×	0	14	8											
3–4		×	8	9	3	9	14	13				−0.45			−0.18	−0.18
3–5	S	×	12													
3–6	S	○	14	13												
4–6		×	8	5												
4–7		×	9	17	14	6						−0.33				
4–8	S	○	15	12	11	11						−0.30				
5–8	S	×	9	13	9							−0.67				
5–9		○	8	8	14							−0.16				
6–9		×	8	11	7	10						0.03				
6–10	S	○	10	13												
7–10	S	○	9	1												
8–10		×	8	9												

②

score	service	win/loss	bound									rally	autocorrelation distribution(C)		distribution(E)	
			1	2	3	4	5	6	7	8	9	x	x	y	x	y
0–0		×	8	8												
0–1		○	8	12	12	6	13					−0.81				
1–1	S	○	10	11	10	8	7	8				0.45	−0.20	−0.35		
2–1	S	×	5	12	9							−0.43				
2–2		○	14	12	9							−0.11				
3–2		×	9	9	10	11						−0.20				
3–3	S	○	13	20												
4–3	S	○	13	12	10	7						0.15				
5–3		×	8	14	13	8	14	7	7	7		−0.29	−0.46	−0.06	0.23	0.10
5–4		×	9	14												
5–5	S	×	10	17	13							−0.04				
5–6	S	○	16	4												
6–6		×	8	18	7	8						−0.22				
6–7		×	8	9												
6–8	S	×	10	12	0											
6–9	S	×	15	15	8							−0.49				
6–10		×	9	9												

③

score	service	win/loss	bound									rally	autocorrelation distribution(C)		distribution(E)	
			1	2	3	4	5	6	7	8	9	x	x	y	x	y
0–0	S	×	7	8	8	4	10	19	7			−0.51	−0.57	−0.40	−0.54	−0.26
0–1	S	○	9	12	7	15	14	0								
1–1		×	8	12	14	15						−0.15				
1–2		×	8	9	15	7						−0.13				
1–3	S	×	16	9	3							−0.05				
1–4	S	×	15	12	13							−0.01				
1–5		×	9	13												
1–6		×	9	4												
1–7	S	×	3													
1–8	S	○	13	15												
2–8		×	14	12												
2–9		○	8	6	7							−0.57				
3–9	S	×	19	20	11	1	12	12	9			−0.10	−0.34	−0.55	−0.02	0.00
3–10	S	×	13	12	10	9	7					0.11				

Fig. 5. Record of C vs. E

Table 4. *C vs. E service / receive allocation*

C	service		receive	
①	x	−0.56	x	−0.15
	y	−0.41	y	−0.48
②	x	−0.39	x	0.02
	y	−0.26	y	−0.33
③	x	−0.23	x	−0.30
	y	0.29	y	−0.33

E	service		receive	
①	x	−0.17	x	−0.28
	y	−0.29	y	0.17
②	x	0.51	x	—
	y	−0.10	y	—
③	x	0.17	x	−0.50
	y	−0.85	y	−0.22

The rally and distribution patterns that showed a strong correlation were all negative. There is no rally or distribution that is positively correlated. It is thought that it is hard to come out because it is not a rally with much straight distribution like “fore straight, fore straight, fore straight” or “back straight, back straight, back straight”. In this study, the researches recorded the number of bounces, not the number of the rally, but when the number of bounces was small, it was thought that a positive correlation would be difficult to appear when autocorrelation analysis is performed.

As described above, it has become clear that it is possible to judge whether there is regularity in a rally or a distribution pattern by autocorrelation analysis of time-series coordinate data. By knowing regular rally and distribution patterns, it can be considered as a clue to judge the distribution tendency of players, effective distribution patterns, or invalid distribution patterns.

In this research, the analysis was only for 11 games in a total of 3 matches of right-handed offensive type’s male university students. It is possible that new results can be obtained by increasing the number of data, for example, players who have more real ability, female players with a relatively large number of rally times, or choppers.

4. SUMMARY

The purpose of this research is to collect ball fall position coordinate data during the match using a ball distribution characteristic analysis system using an ultrasonic sensor and to verify whether there is regularity in the player's ball distribution pattern. For the analysis of the ball distribution pattern, autocorrelation was used to verify the presence or absence of regularity.

As a result, the rally and distribution patterns that showed a strong correlation were all negative. By autocorrelation analysis of time series coordinate data, it became clear that it is possible to judge whether there is regularity in rally or distribution pattern. By knowing regular rally and distribution patterns, it was thought that it might be a clue to judge whether it is a player's distribution tendency or an effective distribution pattern, or an invalid distribution pattern. Furthermore, This method helps the coach to advise the player.

REFERENCES

Hui, Z., Wei, L., Jun, H., & Rui, L. (2013). Evaluation of elite table tennis players’ technique effectiveness. *Journal of sports sciences 31*(14), 1526-1534.

Munivrana, G., Petrinović, L.Z., & Kondrič, M. (2015). Structural Analysis of Technical-Tactical Elements in Table Tennis and their Role in Different Playing Zones. *Journal of Human Kinetics, 47*, 197-214.

Nonaka, Y., (2017). Characteristic of the games of the world top-level women choppers in the table tennis: Focusing on the using technique. *Japan Journal of Physical Education, Health and Sport Sciences, 62*(1), 241-262.

Takeuchi, Y., & Yoshida, K., (2017). Table Tennis Game Analysis Based on a Single Camera Placed on Gymnasium Ceiling. *Journal of Japan Society of Sports Industry, 27*(3), 267-275.

Tamaki, S., (2012). *A Performance Analysis of Table Tennis with Vision Technology*. ViEW2012.

Yang, F. (2010). *Analysis of distribution pattern in table tennis competition* (Master's thesis). Niigata University Graduate School of Modern Society and Culture: Niigata.

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Anthropometric characteristics and motor abilities of young female players in relation to competitive success

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Abstract: The aim of this research is to establish the correlation between anthropometric characteristics, motor and specific abilities and competitive success. The study included 40 young female table tennis players at the age 11±0.33 with training experience a 3.01±0.91 years. The predictive variables were 15 anthropometric measures, 24 motor tests and 6 specific table tennis tasks. The criterion variable – the competitive success was verified on points won and registered on the Croatian Table Tennis Association ranking lists for categories (cadets and young cadets). The correlation between the predictive variables and competitive successfulness was analysed with the Pearson correlation coefficient. The results show that height, arm length, leg length and biacromial range has a statistical positive correlation with the competitive success. The positive correlation with the competitive success was obtained with 4 agility tests in which the intensive body movement or some parts of the body on a relatively small, limited space has been highlighted, and where the outcome has been connected with fast changes of the movement direction, the explosive power of the leg and the arm, the repetitive strength of the arms and the body, and cardiorespiratory endurance. Significant positive correlation was obtained with all 6 specific table tennis tests. This information can help trainers with talent identification, precise selection of players and planning of the training process. Programmes at this age should be targeted towards those abilities which demonstrate the biggest influence on the competitive success.

Keywords: young female table tennis players, anthropometric characteristics, motor abilities, specific table tennis tasks, success

1. INTRODUCTION

The structure of motor space in table tennis children and adults indicates that coordination, agility, movement frequency speed, explosive repetitive strength, and flexibility are important factors of success in table tennis. Since table tennis belongs into the category of the technically most complex sports and fastest playing games, the learning of table tennis technique requires good knowledge of the methodical approach when working with children and teenagers. The development of a table tennis player is a multidimensional process during which, except for monitoring and accepting the biological development, it is also required to know the anthropological characteristics of children, which are the predisposition for learning table tennis

technique and tactics. Kondrič et al. (2003) claimed that the development of technical skills depends on motor skills such as speed, coordination, agility, precision, balance and strength.

There is a small number of research on table tennis that concerns the determination of factors affecting table tennis performance. Research in other sports also show that it is difficult to predict long-term success because the younger players who had the best ranked positions did not manage to retain in the older categories, and vice versa, those who later achieved success were not necessarily among the best in the younger categories. Success in competition depends on many factors. It depends on a player (rate of learning, training and maturation of anthropometric, physiological, technical, tactical and psychological factors) as also the environment (opportunities created by parents, trainers, coaches, talent development programme and the competition structure) along with a component of chance (Elferink-Gemser & Visscher, 2012).

The aim of this research was to establish the correlations between anthropometric characteristics, motor and specific abilities and competitive success.

2. METHODS

The study included 40 young female table tennis players at the age 11±0.33 with training experience a 3.01 ± 0.91 years. The set of variables for assessing morphological characteristics encompassed 15 standard anthropometric variables that were measured according to the International Biological Programme (IBP) which represents a unique measuring methodology. All of the anthropometric measurements were taken by a single measurer. A set of standard motor measuring instruments was chosen to assess the subjects' basic motor abilities. Twenty-four motor tests were used and 6 specific tests to assess basic table tennis elements (Kondrič, 1995). After two years of measurement, competitive success (criterion variable) was verified by points won and registered on the Croatian Table Tennis Association ranking lists for specific categories (female cadets and young cadets). The correlation between the predictive variables and competitive successfulness was analysed with the Pearson correlation coefficient.

3. RESULTS AND DISCUSSION

Table 1 shows that there is no significant correlation between competitive success and training experience, which suggests that the length of training does not have any impact on competitive success, but probably other factors. From a total of 15 anthropometric measures, significant positive correlation with competitive success is with height, arm length, biacromial range and wrist diameter.

Table 1. *Correlation coefficients (r) between competitive success, training experience and anthropometric characteristics*

Test	Competitive success	p
Training experience	.189	.244
Height	.383*	.015
Arm length	.392*	.012
Leg length	.453**	.003
Biacromial range	.507**	.001
Wrist diameter	.352*	.026

**p<0.05; **p<0.01*

The results can be explained by the differences between young players in growth and maturity, so we assume that female players who are biologically more mature will achieve greater competitive success at this age. Research in other sports have shown that differences in maturity can be extensive, as a result, older and more mature players often have the advantage of being higher, stronger and faster, might therefore be more successful, which results in greater motivation and commitment (Helsen, Starkes, & van Winckel, 1998). Also, Malina et al. (2005) claimed that this advantage is only temporary because when adolescence nears termination, height differences among athletes of contrasting maturity status are negligible.

Previous studies in table tennis that determined the somatotype of young players have shown predominant mesomorph somatotype for males and mesomorph-endomorph for females (Pradas et al. 2007; De la Torre et al., 2017) and that there was no relation between performance somatotype as a factor that directly influences the competitive success (Munivrana, Paušić, & Kondrič, 2011). In the study of young top level table tennis players (Carrasco, Pradas, & Martinez, 2010), a higher body fat mass was determined in female players than in male players. These differences may be the consequence of a normal growth because the age of the players correspond to the prepubertal phase in which muscles are underdeveloped and fat content can be prominent. Research on top table tennis players have shown there are no statistical significant relationship between height, weight, and body mass index and the top 32 world rankings of women table tennis players (Limoochi, 2007), as also there was no statistical significant differences in anthropometric characteristics according performance level of top 100 ITTF Rank male table tennis players (Djokić, Munivrana, & Levajac, 2017). An interesting research that compared skinfold thickness among different sports indicated that table tennis was among those sports with greater fat mass (Garrido-Chamorro et al., 2012).

In line with those studies, it seems that the influence of anthropometric characteristics on competitive performance is not significant, but anthropometric tracing of younger players provides useful information for talent identification and development for the assessment of training progression.

Table 2. *Correlation coefficients (r) between competitive success and motor abilities*

Test	Competitive success	p
Juggle with matches	.414**	.008
Medicine ball throw	.432**	.005
Sit ups	.409**	.009
Push ups	.365**	.021
Triple jump	.567**	.000
5m sprint	-.523**	.001
Lateral agility test	.490**	.001
Standing long jump	.540**	.000
Standing jump backwards	.385**	.014
Lateral steps	-.600**	.000
Run with direction change	-.401**	.010
Slalom run	-.506**	.001
Beep test	.394*	.012

**p<0.05; **p<0.01*

Of the total of 24 motor tests, only 13 are shown that are significantly related with competitive success.

The positive correlation with the competitive success was obtained with agility and coordination tests (juggle with matches, lateral agility test, lateral steps, run with direction change, 5m sprint and slalom run), in which the intensive body movement or some parts of the body on a relatively small, limited space has been highlighted, and where the outcome has been connected with fast changes of the movement direction. It is worth to mention that significant correlations of lateral agility are noticed only in short relation tests, e.g. up to 1.5 meters. Also, the lower extremities explosive strength that is significantly correlated with success, manifests in the fast changes in direction of movement from a stable position, but also the ability to repeatedly change movement direction in certain agile movements (jump to the side, return to the original position, etc.). In table tennis, agility means a type of footwork which enables a player to rapidly position their body for a particular stroke. Movements around the tennis table are even more complex and consist of five types (Malagoli-Lanzoni et al., 2007) based on the technique executed: the most common step is one step, while the chasse step, then slide step, crossover step and pivot and thus preparing for changes in direction, speed and agility must involve highly specific training that recognises the specific demands of the sport, especially in pre-puberty, because speed tasks (e.g. running speed and agility) attain maximal gain before the peak height velocity is reached (Beunen & Malina, 1998). As well as in previous studies, it seems to be eye-hand coordination an essential ability for high performance in table tennis and also demonstrated to be a valuable instruments for identifying talents and tracking young players' development (Faber et al., 2014; Nikolić et al., 2014). Repetitive strength of the trunk and arms comes to the fore in tasks longer duration, particularly in females who play slower and longer- rallied game. The study of the influence of motor abilities on competitive performance (Ivanek et al., 2015) on the sample of table tennis players 17-36 years showed

statistically significant predictor variables of speed frequency hand movements, explosive strength of upper and lower extremities and agility. On the other hand, Picabea, Camara and Yanci (2017) determined that there was no significant correlation between physical fitness tests and the sport performance in competition in 17 years male and female players.

The obtained results in this research can help trainers with talent identification, precise selection of players and planning of the training process. Programmes at this age should be targeted towards those abilities which demonstrate the significant relation with the competitive success.

Table 3. *Correlation coefficients (r) between competitive success and specific table tennis tasks*

Test	Competitive success	p
Ball balance on the racquet	-.404**	.010
Alternate shots using FH and BH	.345*	.029
Dribbling the ball	-.350*	.027
Shooting target on the ground	.338*	.033
Hitting balls with a racquet	.465**	.003
Shooting target on the table	.433**	.005

**p<0.05; **p<0.01*

Significant positive correlation was obtained with all 6 specific table tennis tests. The highest correlation coefficient between competitive success and specific table tennis tasks were hitting balls with a racket, shooting target on the table and ball balance on the racquet. Obtained results in shooting target on the ground with a racquet and ball is in accordance with the research of Faber et al. (2016) where the precision test was proved to be a significant predictor of competitive result and can be used to follow young players' development.

The importance of specific knowledge is also confirmed by research that states that their sport-specific tests rebounding tennis ball with racquet and racquet ball handling, in which eye–hand coordination is an essential feature, have significant relation with competition outcomes in adolescent tennis players (Filipčič & Filipčič, 2005; Panjan et al., 2010). The obtained results indicate that specific table tennis skills are important in the sensitive phase of the development of young female players and that the tests can be used to follow young players' development. With table tennis exercises of manipulation with racket and ball without table, motor abilities are developing, particularly coordination, agility, balance and precision. Games and playing with different balls and rackets in variable conditions are the basic methods of learning table tennis. According to these arguments, research (Cote & Hay, 2002) shows that early specialization is not conducive to the development of elite players, but it is more important there participation in diverse sports before adolescence.

4. CONCLUSION

The obtained results will enable trainers to be more objective when directing the long term development of young female players, especially the development of specific motor skills in sensitive phases. Based on this data, a more successful planning, evaluating the training process will be possible, as well as understanding important factors for successfulness in table tennis, next to establishing the effects of the training process on abilities.

REFERENCES

Beunen, G., & Malina, R.M. (1988). Growth and physical performance relative to the timing of the adolescent spurt. *Exercise and Sport Sciences Reviews, 16*, 503-540.

Carrasco, L., Pradas, F., & Martinez, A. (2010). Somatotype and Body Composition of Young Top-level Table tennis Players. *International Journal of Table Tennis Sciences, 6*, 175-177.

Cote, J., & Hay, J. (2002). Children's involvement in sport: A developmental perspective. In J. M. Silva & D. Stevens (Eds.), *Psychological foundations of sport* (pp. 484-502). Boston: Merrill.

De la Torre, A. I., Pradas, F., Salva, P., Castellar, C., & Gonzales-Jurado, J.A. (2017). Analysis of Anthropometric Characteristics in Young Table Tennis Players. In M. Kondrič, M., Fuchs & T. Matjašić (Eds.), *Proceedings Book of the 15th ITTF Sports Science Congress*. (pp. 74-79). Düsseldorf: International Table Tennis Federation, Lausanne.

Djokić, Z., Munivrana, G., & Levajac, D. (2017). Anthropometric Characteristics of Top-Class World and European Male Table Tennis Players. In M. Kondrič, M., Fuchs & T. Matjašić (Eds.), *Proceedings Book of the 15th ITTF Sports Science Congress*. (pp. 170-174). Düsseldorf: International Table Tennis Federation, Lausanne.

Elferink-Gemser, M.T., & Visscher, C. (2012). Who are the superstars of tomorrow? Talent development in Dutch soccer. In J. Baker, J. Schorer & S. Cobley, (Eds.), *Talent identification and development in sport*. *International perspectives*. London: Routledge

Faber, I.R., Oosterveld, F.G.J., & Nijhuis-Van Der Sanden, M.W.G. (2014). Does an eye-hand coordination test have added value as part of talent identification in table tennis? A validity and reproducibility study. *PloS One, 9*(1), e85657.

Faber, I.R., Elferink-Gemser, M.T., Faber, N.R., Oosterveld, F.G.J., & Nijhuis-Van der Sanden, M.W.G. (2016). Can Perceptuo-Motor Skills Assessment Outcomes in Young Table Tennis Players (7–11 years) Predict Future Competition Participation and Performance? An Observational Prospective Study. *PLoS ONE 11*(2), e0149037. doi:10.1371/journal. pone.0149037

Filipčič, A., & Filipčič, T. (2005). The relationship of tennis specific motor abilities and the competition efficiency of young female tennis players. *Kinesiology*, *37*(2), 164–172.

Helsen, W.F., Starkes, J.L., & van Winckel, J. (1998). The influence of relative age on success and dropout in male soccer players. *American Journal of Human Biology*, *10*(6), 791-798.

Ivanek, V., Mikić, B., Ćorluka, M., Brekao, M. & Čerkez, I. (2015). Influence of motor abilities on competitive efficacy in table tennis. *Sports Science and Health, 5*(1), 55-63.

Kondrič, M. (1995). *A Test Bank for Basic and Specialized Table Tennis Motorics and Morphology*. Ljubljana: Faculty of Sport.

Limoochi, S. (2007). The effects of some anthropometrics elements on the world ranking of 32 top women table tennis players in Athens 2004 Olympic Games. In M. Kondrič & G. Furjan-Mandić (Eds.), *Proceedings Book of the 10th Anniversary ITTF Sports Science Congress*. (pp.190-193). Zagreb: Faculty of Kinesiology University of Zagreb. Croatian Table Tennis Association. International Table Tennis Association Zagreb.

Munivrana, G., Paušić, J., & Kondrič, M. (2011). The influence of somatotype on young table tennis players' competitive success. *Kinesiologia Slovenica*, *17*(1), 42-51.

Nikolić, I., Furjan-Mandić, G., & Kondrič, M. (2014). The Relationship of Morphology and Motor Abilities to Specific Table Tennis Tasks in Youngsters. *Collegium Antropologicum, 38*, 241-247.

Panjan, A., Šarabon, N., & Filipčič, A. (2010). Prediction of the successfulness of tennis players with machine learning methods. *Kinesiology*, *42*(1), 98–106.

Picabea, J. M., Cámara, J., & Yanci, J. (2017). Physical fitness analysis in male and female table tennis players and their relationship to competition performance. *Revista Internacional de Ciencias del Deporte, 47*, 39-51.

Pradas, F., Carrasco, L., Martínez, E., & Herrero, R. (2007). Anthropometric profile, somatotype, and body composition of young table tennis players. *Revista Internacional de Ciencias del Deporte, 3*(7), 11-23.

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Development of tactical analysis method using Markov model in table tennis competition

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Abstract: Tactical coaching in table tennis makes a difference in improving performance of the competition, however study based on objective statistical data is not progressing compared with other competitions. The current situation is that different advice is given by each advisor. Creating a table tennis Markov model from the transition probability of table tennis strokes, courses, and spins, and analysing it, we obtain data on the ball delivery rate and score rate of the players and aim to use it at the coaching. In the experiment, simulation was carried out by obtaining the transition probability of hit balls and scores from data of a total of six matches, targeting four drive main types using the most mainstream double-sided pimples in. As a result, the actual match and the simulation had a very strong positive correlation. Furthermore, when comparing them, the items of the distribution rate, the score rate, and the average number of rallies were approximately equal. From the above, the Markov model of the table tennis could reproduce the actual match. Since objective statistical data can lead to improvement points of play and effective tactics for opponents, this study is useful for improving the competitiveness of the athletes and the leadership of the coaches.

Keywords: table tennis, Markov model, tactical analysis, simulation

1. INTRODUCTION

In competitive sports, as much as improving your skill, it is important to identify tactics and build up tactics accordingly to win opponents. Moreover, it is necessary to analyse the match data of opponents and to construct plays or strategies to prevent the opponent's features.

In order to enhance athletic performance in table tennis, it is necessary that tactical advice. However, study based on objective statistical data has not progressed as compared to other major sports. The main content of the advice is mental and tactical, however, no advice based on data has been provided. Therefore, when giving coaching, subjective advice is in common use, in addition, different coaches may give different advice. This study considers the tactics side.

The tactical elements in table tennis competition are classified into three categories: "flight characteristics", "allocation characteristics", and "rotation characteristics". In this study, focusing on the distribution patterns in "allocation characteristics", the axis of rotation in "rotation characteristics", we used the three elements of batting method, course, and rotation. Therefore, the purpose of this study is to make a Markov model of table tennis from the transition probability of hitting methods, and to simulate the match based on the distribution rate and the scoring rate, to enable advice using data as competition sports, besides, to create tactical analysis software that is cheap and easy to handle by anyone will contribute to the improvement of the skill level of table tennis.

2. METHODS

2.1 Subject characteristics and Target matches

In this study, subjects are 4 men who belong to the Niigata University table tennis team which shakehand drive main type that use the most "pimples in" on both sides. Subjects characteristics appear in Table 1. The target match is a total of 6 matches of the 4 subjects. Table 2 shows the result of 6 matches.

Table 1. *Subject Characteristics*

Subjects	Sex	Height	Weight	Age	Competition Age	Playing Style
Sub.A	M	171	65	20	7	Right Shakehand Drive
Sub.B	M	170	65	20	13	Right Shakehand Drive
Sub.C	M	170	61	21	8	Left Shakehand Drive
Sub.D	M	167	56	19	10	Left Shakehand Drive
Mean ± S.D		169.5 ± 1.5	61.8 ± 3.7	20.0 ± 0.7	9.5 ± 2.3	

Table 2. *Target matches*

	Sub.A	Sub.B	Sub.C	Sub.D	W / L
Sub.A		○	○	○	3 / 0
Sub.B	9 - 11 0 9 - 11 3 8 - 11		○	11 - 8 11 - 6 2 6 - 11 3 7 - 11 5 - 11	1 / 2
Sub.C	9 - 11 0 9 - 11 3 3 - 11	5 - 11 9 - 11 1 11 - 6 3 8 - 11		9 - 11 11 - 8 2 11 - 7 3 8 - 11 8 - 11	0 / 3
Sub.D	6 - 11 0 5 - 11 3 5 - 11	○	○		2 / 1

2.2 Definition of hitting methods

We explain the hitting methods used in this study. “Stop” is how to hit which bounces more than 2 bounces to opponent coat with backspin. "Push" is how to hit which returns backspin with backspin. "Flick" is how to hit that flicks a ball on the tabletop, in addition, "Chiquita" is how to hit which gives strong side-to-side rotation on the tabletop with the backhand. "Drive" is how to hit which gives a strong forward rotation, furthermore, "Smash" is how to hit that strikes strongly to opponent coat. "Counter" is how to hit which returns the bang of the opponent with the bang, moreover, "Block" is how to hit which defends against the bang. In play, no hitting methods included in the above classified into closest.

In the scene of practice, it is often the case to talk using words such as “Fore,” “Fore short”, etc. Therefore, we can be classified by long and short in a name of hitting methods like "Stop" is short ball and "Push" is long ball. This study used 3 courses: “Fore”, “Middle” and “Back”.

2.3 Definition of state

The hitting method and the course when a player returns a ball is defined as a state. The first and second balls are separated for convenience of the simulation process. States 0 to 5 shown in Table 3 are divided into 6 items by the spin and the course at the player's service. State 0 to state 23 shown in Table 4 are divided into 24 items according to the hitting method of the player and the course. State 24 is the score of player1, and state 25 is the score of player2. A total of 30 hitting methods will be used in this study.

Table 3. *State (At the time of serve)*

State	0	1	2	3	4	5
Spin	Topspin	Topspin	Topspin	Backspin	Backspin	Backspin
Course	Fore	Middle	Back	Fore	Middle	Back

Table 4. *State (After the second ball)*

State	0	1	2	3	4	5	6	7	8	9	10	11	12
Technique	Stop	Stop	Stop	Push	Push	Push	Flick	Flick	Flick	Chiquita	Chiquita	Chiquita	Drive
Course	Fore	Middle	Back	Fore	Middle	Back	Fore	Middle	Back	Fore	Middle	Back	Fore
State	13	14	15	16	17	18	19	20	21	22	23	24	25
Technique	Drive	Drive	Smash	Smash	Smash	Counter	Counter	Counter	Block	Block	Block	Player 1 Point	Player 2 Point
Course	Middle	Back	Fore	Middle	Back	Fore	Middle	Back	Fore	Middle	Back		

2.4 Flow of simulation

In the beginning, we divide the actual playing into each hitting ball, thereafter, the transition probability is calculated from the count result of the number of hitting balls which changes from state *i* to state *j (=i+1)*. Table 5 shows the transition probability matrices of Sub.C in Sub.C vs Sub.D used in this experiment. Rows are the states before transition, columns are the states of transition destinations, and the numbers correspond to the state numbers. States *0* to *23* represent the player's

hitting methods, moreover, States *24* and *25* represent points. "D_{ij}" represented the element, each element "P_{ij}" of the row sum "SUM_i" of row "i" is calculated by Eq. (1).

$$P_{ij} = \begin{cases} \frac{D_{ij}}{SUM_i} & (0 \le i \le 23, 0 \le j \le 25) \\ 1 & (24 \le i \le 25, 0 \le j \le 25, i = j) \\ 0 & (24 \le i \le 25, 0 \le j \le 25, i \ne j) \end{cases} \quad (1)$$

Table 5. *Transition probability matrix of Sub. C in Sub. C vs. Sub. D (1 match)*

			Stop			Push			Flick			Chiquita			Drive			Smash			Counter			Block			Point
Sub. C			Fore	Middle	Back	Fore	Middle	Back	Fore	Middle	Back	Fore	Middle	Back	Fore	Middle	Back	Fore	Middle	Back	Fore	Middle	Back	Fore	Middle	Back	C
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Top	Fore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**100.0%**	0	0
Spin	Middle	1	0	0	0	**8.3%**	0	0	**16.7%**	**25.0%**	**8.3%**	0	0	0	0	0	0	0	0	0	0	**8.3%**	**8.3%**	0	**8.3%**	0	**16.7%**
Srv	Back	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**9.1%**	**18.2%**	0	**9.1%**	**36.4%**	**27.3%**
Back	Fore	3	0	0	0	**25.0%**	0	**75.0%**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spin	Middle	4	0	0	**7.7%**	**15.4%**	**15.4%**	**38.5%**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**23.1%**
Srv	Back	5	**20.0%**	0	0	0	0	**20.0%**	**20.0%**	0	0	0	0	**20.0%**	0	0	0	0	0	0	0	0	0	0	0	0	**20.0%**
	Fore	0	0	0	0	0	0	**75.0%**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25.0%**
Stop	Middle	1	0	0	0	0	0	**100.0%**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Back	2	0	0	0	0	0	**50.0%**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**50.0%**
	Fore	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Push	Middle	4	0	0	0	0	0	**33.3%**	0	0	0	0	0	0	0	**33.3%**	**33.3%**	0	0	0	0	0	0	0	0	0	0
	Back	5	0	0	0	0	0	**28.6%**	0	0	0	0	0	0	**14.3%**	0	**28.6%**	0	0	0	0	0	0	0	0	0	**28.6%**
	Fore	6	0	0	0	0	0	0	0	0	0	0	0	0	**25.0%**	**25.0%**	0	0	0	0	0	0	0	0	0	**25.0%**	**25.0%**
Flick	Middle	7	0	0	0	0	0	0	0	0	0	0	0	0	0	**20.0%**	0	0	0	0	**20.0%**	**40.0%**	0	0	0	0	**20.0%**
	Back	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fore	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiquita	Middle	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Back	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**100.0%**	0	0	0	0
	Fore	12	0	0	0	0	0	0	0	0	0	0	0	0	**11.8%**	**5.9%**	0	0	0	0	**5.9%**	0	0	**5.9%**	**17.6%**	**52.9%**	
Drive	Middle	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**8.3%**	**8.3%**	**16.7%**	**41.7%**	0	**25.0%**	
	Back	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**44.4%**	**22.2%**	**33.3%**	
	Fore	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Smash	Middle	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**50.0%**	0	0	**50.0%**	
	Back	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Fore	18	0	0	0	0	0	0	0	0	0	0	0	0	**37.5%**	0	0	0	0	0	0	0	0	**12.5%**	0	**50.0%**	
Counter	Middle	19	0	0	0	0	0	0	0	0	0	0	0	0	0	**10.0%**	**10.0%**	0	0	0	**20.0%**	**10.0%**	0	**10.0%**	0	**40.0%**	
	Back	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15.4%**	**23.1%**	0	0	**15.4%**	0	**46.2%**
	Fore	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**33.3%**	0	0	0	0	0	0	0	0	0	**66.7%**
Block	Middle	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**14.3%**	**14.3%**	**28.6%**	0	**28.6%**	**14.3%**	0
	Back	23	0	0	0	0	0	0	0	0	0	0	0	0	0	**25.0%**	**25.0%**	0	0	0	0	**25.0%**	0	0	0	0	**25.0%**
Point	C	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**100%**

A Markov model of table tennis is created from the transition probability shown above. Using a Markov model of table tennis simulated the match. In considering the tactics, advisers do not consider the service mistake of the opponent, thus we omit the service mistake in this study.

The detailed rules are as follows:

- The first player to gain 300 games wins the match.
- When one player has 11 points or more and the score difference is 2 points or more, the match ends.
- The service right changes in twice and after 10-10, it changes in once.
- Do not consider service mistakes.
- Do not consider expedite system or foul play.

The transition between each state when the simulation executed is determined by the probability, hence use uniform random numbers between 1 and 100. The transition probability matrix P is expressed by Eq. (2).

$$\sum_{j=1}^{N} pij = 1 \quad (2)$$

In order to process transitions between states by programming, the matrix with "C_{ij}" is expressed by Eq. (3).

$$C_{ij} = \sum_{k=1}^{j} pik \quad (0 \leq i, j \leq 25) \qquad (3)$$

When transition to the score (state *24*, state *25*), the transition of the Markov model is cancelled. After finishing the score processing, restart the simulation from the initial state of the service (state *0*).

2.5 Simulation software

This simulation software can be used by inputting three items: transition probability of hitting methods, transition probability of serve, and the number of running games. Simulation results are output on tactical analysis software and saved as a CSV file. In this study, the CSV file was output to Excel of spreadsheet software to analyse the data. If the first player to gain 100 games wins, the result can be output in about 30 seconds. Figure 1 shows the screen of the created simulation software.

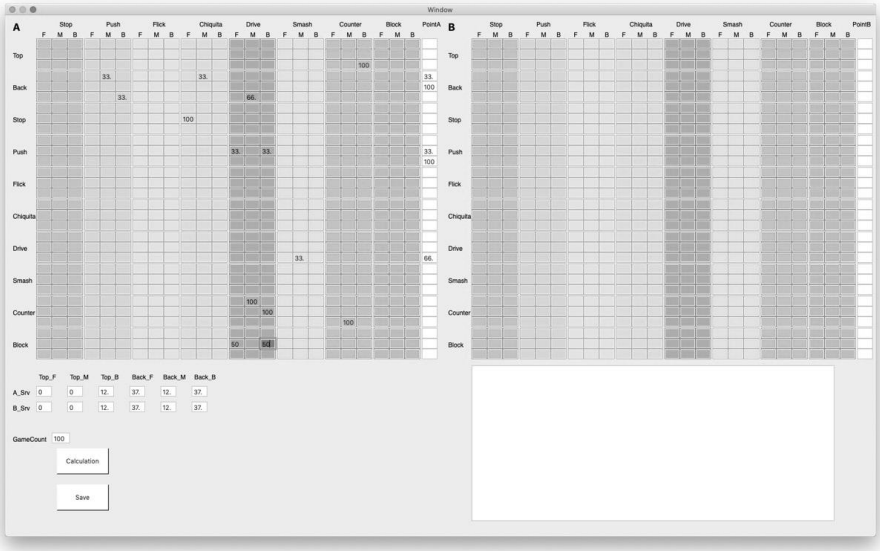

Fig. 1. The screen of the simulation software

3. RESULTS

3.1 Simulation accuracy

In this study, regression analysis was performed to confirm the precision of the simulation. Statistically, it is difficult to prove that the actual match and the simulation are equal. In this analysis, based on the score rate and usage rate of each hitting method obtained in both the actual match and the simulation, the difference in data is judged in a pseudo manner from the correlation coefficient. Figure 2 shows the relationship between the actual match and the simulation. The horizontal axis is transition probability of the actual match, and the vertical axis is transition

probability the simulation. The correlation coefficient is 0.99 and represents an extremely strong correlation. And also, the slope on a graph is 0.9913 and the intercept is 0.0007, therefore, the simulation created this time is considered to account for the actual match. From the above results, it is possible to analyse the match using the data obtained from the simulation.

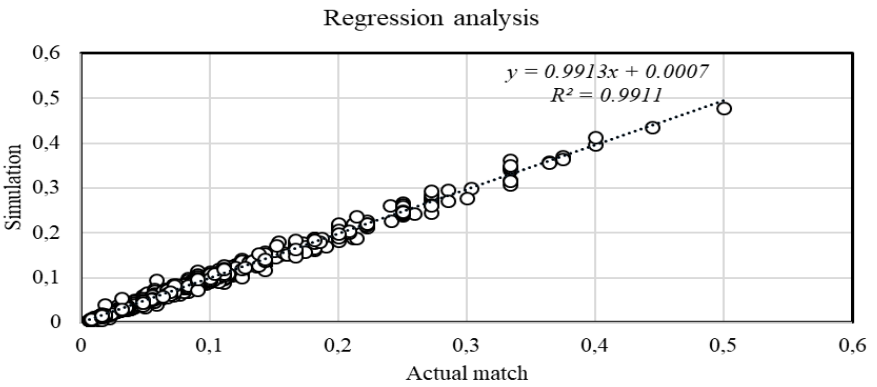

Fig. 2. Regression analysis

3.2 Game analysis

Sub.A scored 100% using "Stop" and "Smash". "Drive" to middle course has a score rate of around 25%, while "Drive" to fore course and back course has a score rate of 50% or more. In comparison with "Flick" which are attacks on the tabletop, "Chiquita" which gives strong rotation scored a lot. Services in "Back" course are many than in "Fore" course.

Sub.B scored 100% with "Smash" however, does not use "Chiquita" and does not score by hitting methods on the tabletop. In comparison with Sub.A, Sub.B scored a lot with "Push" and "Block". "Backspin" serve is distributed to all courses.

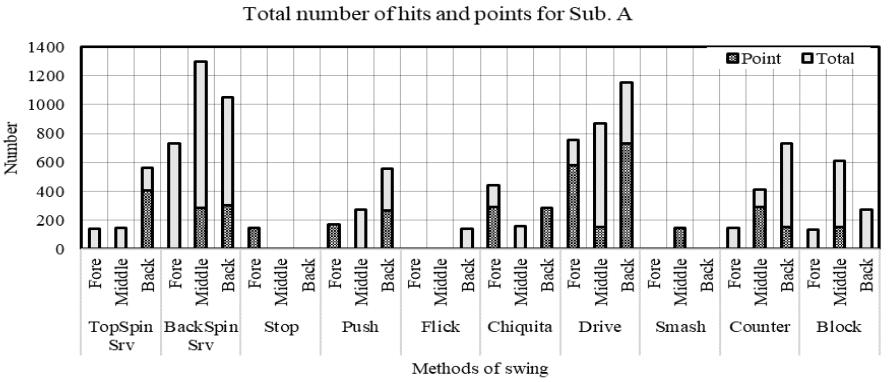

Fig. 3. Total number of hits and points for Sub. A in Sub. A vs Sub. B

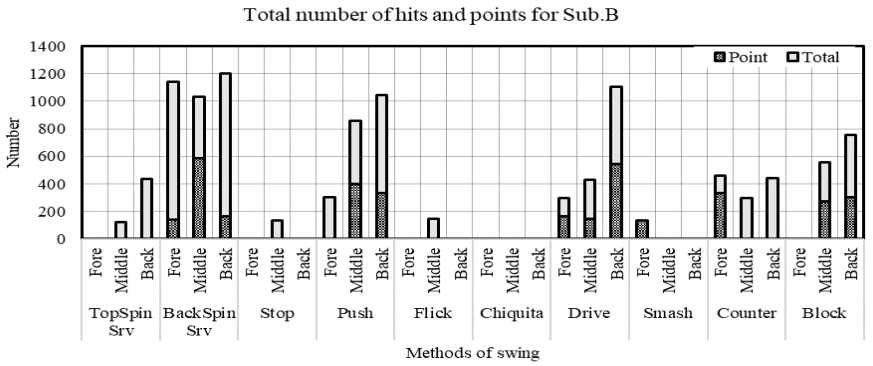

Fig. 4. Total number of hits and points for Sub. B in Sub. A vs Sub. B

4. DISCUSSION

In this experiment, the simulation was performed by calculating the probability from the transition of the hit ball and the score from the data of a total of 6 matches. It is evident from the values of the regression analysis that the simulation reproduced the actual match. The cause of an outlier give at the time of simulation execution is an input mistake of transition probability. The simulation results enable output of the number of hits and scores to hitting methods and course, therefore, it is considered that tactical analysis using Markov model is possible.

The simulation of Markov model has the disadvantage that it did not consider that psychological factors and physical factors change depending on the score. It is hence necessary to change the transition probability in the simulation according to the development of the match in comparison with the actual data. Taking into above account, it is possible to design an effective tactic for the opponent by changing the transition probability and executing the simulation so that the playing leading to the score increases.

5. CONCLUSIONS

In comparison with the data of the actual match, the data obtained by simulation were almost equal in all items: the match acquisition number, the number of points, the score rate, and the average rally number. In this study, the simulation using Markov models in table tennis competitions indicates that it reproduced the actual match. In the hitting method of the player and the ratio of the course can be understand from the simulation results, it becomes possible to view the characteristics and habits of the player as data. By performing this simulation, makes it possible to consider not only oneself but also the bias of the opponent's course and the score pattern. The simulation data make an objective advise, moreover, it diminish tactics based only on the subjectivity of the adviser. In perform this simulation, even if there are no adviser, it will be easier to develop own tactics and it may be useful for practical instruction. Moreover, tactical analysis using this simulation can be performed with one commercially available personal computer. It can be said that cheap and easy to handle by anyone.

The future direction of this study will be analysing the effective tactics from the data of victory probability by playing and the score rate by the rally number. In addition, we plan to use it for the actual match and to study how it affects players.

REFERENCES

Fei, Y. (2009). Analysis of the ball fall point in the table tennis game. *International Journal of Table Tennis Sciences, 6*, 131-138.

Hillegass, A., & Preble, A. (2014). *Cocoa programing for MAC OS X* 4th Edition. Tokyo: Tokyo Denki University.

Kamijima, K. (2010). The examination for evaluating skills during the rally of the Table Tennis game. *International Journal of Table Tennis Sciences, 6*, 127-130.

Kern, J. (2003). *Taktik im Sport*. Tokyo: Taishukan Publishing Co., Ltd.

Takahashi, Y., & Morimura H. (1979). *Markov analysis: OR Library18*. Tokyo: JUSE Press, Ltd, 5-13,30-32.

Takashima, N. (2002). *A table tennis tactics notebook*. Tokyo: Table Tennis Kingdom, 18-19, 66, 171. (in Japanese)

Ushiyama, Y., & Yoshida, K. (1998). Computer use for Table Tennis Coaching. *CIEC Computer & Education, 5,* 91-96.

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A study on imagery ability, flow experience and player satisfaction in table tennis

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Abstract: The objective of the study is to discuss the correlation between imagery ability, flow experience and satisfaction in table tennis. It takes players from institutes of higher education as subjects and gets 212 results by convenience sampling. The method to carry out this study is using the factor analysis, canonical correlation analysis and multiple stepwise regression analysis. ability and flow experience are in significantly positive correlation. Furthermore, the satisfaction can be predicted by imagery ability (imagery, target image) and flow experience (concentration, self-efficacy, self- accomplishment). To sum up, the significant conditions of satisfaction for players are imagery ability and flow experience. Hope the study raises player s' training satisfaction and enhances the performance on players and coaches.

Keywords: skilful imagery, target image, concentration

1. INTRODUCTION

1.1 Background

The importance of how flow experience affects sport performance has gained more gravity recently. Couch and athletes gradually take flow experience as a serious issue in these few years. It has also been regarded as an important issue in athletes' regular practices and an factor to getting good grades (Hu, Sun, Ji, Sun and Jiang, 2004).

However, when it comes to the studies regarding athletes and flow experience, most of them aimed at tennis players (Jiang, 2008), sport of athletics (Nai, 2013), judo in high school (Li, Xu, Xu, & Yang, 2010), etc. Many studies focused on non-athletes or other leisure sports than on table tennis. Only two studies have discussed about table tennis. One took college students as the subject (Xu & Qiu, 2008), and the other aimed at the mental state of table tennis's players as excising, and the flow experience was regarded as one of the aspect of confidence (Chen, Huang, & Hong, 2011).

Nowadays, table tennis has become more and more popular. Players in our nation also perform excellently recently. Besides, the mental state and the excellent performances are closely related in playing table tennis (Chen, Huang, & Hong, 2011). In this circumstance, it is worth to investigate the effect of the flow experience on table tennis players.

Richardson (1969) defined mental imagery as: *"All those quasi-sensory or quasi-perceptual experiences of which we are all self-consciously aware, and which exist for us in the absence of those stimulus conditions that are known to produce their*

genuine sensory or perceptual counterparts, and which may be excepted to have different consequences from their sensory or perceptual counterparts."

Athletes should be able to simulate their practical experiences from mental imagery and then stimulate their brain area where the practical experience may relate. Afterwards, the athletes may acquire the similarity on nerves and behaviour (Ji & Chen, 2017). Many psychologists considered that imagery may help improve athletes' experiences and better improve their performances (Koehn, Morris, & Watt, 2014). Moreover, it may also ameliorate athletes' flow experience (Koehn, Morris, & Watt, 2006; Nicholls, Polman, & Holt, 2005). There have already been hundreds of studies about the relation between mental imagery and exercise experiences. Many of them indicated specific techniques in imagery in the sports that help improve one's physiological performances (Martin, Moritz, & Hall, 1999). It is claimed that image training may be useful to change the thinking of athletes and may improve their performances, especially in the current sports science (Koehn, Morris, & Watt, 2006). Furthermore, image training may not only help raise athletes' attention but downgrade their anxiety. It can also be used in rehabilitation or other fields. Chi and Chen (2017) claimed that image training was the most wide-spread method in Psychological Skill Training (PST) and that it had been proven to be helpful in strengthening one's exercise performances.

Taiwanese table tennis players are well-known for their excellent performances in the international competition. Chen, Huang and Hung (2011) has stated that excellent performances have much to do with healthy mental conditions. Other countries also attach importance to mental skill training when it comes to the discussion of trend and tactics (Chen, Zheng, Qiu, & Chen, 2017). However, it is quite a pity that Taiwanese coaches take physical practice into first consideration but neglect psychological training. We hope that this study will make people understand the relation between imagery ability and flow experience. We also hope that this study may strengthen our table tennis players' mental ability and help them perform their best and get good grades in International competitions.

Once the players get better physical coordination in table tennis, they may be able to stimulate their biggest potential. If the athletes can practice imagery in table tennis training moderately and combine "thinking" and "exercising" at the same time, it may be able to improve their reaction, judgment, techniques and execution of tactics.

1.2 Research Purpose

(1) To realize the imagery ability of table tennis player.

(2) To realize the relations between imagery ability and flow experience.

(3) To realize the relations between imagery ability, flow experience and performance of table tennis player.

2. METHODS

2.1 Sample

Taking collegiate table tennis athletes as our target participants, the questionnaires were issued by convenience sampling. 250 questionnaires were

issued and 235 questionnaires were collected. 23 of them were removed as invalid samples, and 212 valid samples were adopted. The effective response rate was 85%.

2.2 Research Instrument

2.2.1 Sport imagery ability questionnaire, SIAQ

This study adopts the sport imagery ability questionnaire, SIAQ, by that of Lin, Cheng and Chang (2014), which includes the strategy, skill, affect, mastery and goal. The composite reliability are .84, .80, .80, .84 and .85. The questionnaire is evaluated by Likert seven-point scale.

2.2.2 The questionnaire of flow-experience.

The questionnaire of the flow-experience was adopted from that of Wang, Huang, Lee and Hsieh (2012), which includes clear feedback, self-contained experience, mastery of control, concentration, and competency. Coefficient of the internal consistency are .80, .74, .81, .75 and .85. The questionnaire is evaluated by Likert five-point scale.

2.2.3 The questionnaire of sport performance satisfaction.

The questionnaire of sport performance satisfaction is adopted from that of Hus, Wu, Wang and Lee (2018).

3. RESULTS AND DISCUSSION

3.1 Data Collection

The participants of this study were 145 males (68.4% of all) and 67 females (31.6% of all). Among all the participants, 62 of them were freshmen (29.2%), 65 of them were sophomores (30.7%), 32 of them were juniors (15.1%), 36 of them were seniors (17%) and 17 of them were master students (8%) as shown in Table 1.

Table 1. *The Bio- and Academic- Background Survey of the Participants*

Feature	Person(s)	Proportion to all
Male	145	68.4%
Female	67	31.6%
Freshman	62	29.2%
Sophomore	65	30.7%
Junior	32	15.1%
Senior	36	17.0%
Graduate Student	17	8.0%

3.2 Data Analysis

The main purpose of this section is to investigate whether there is a canonical correlation between imagery ability and flow experience. We take five imagery abilities, which are affect, mastery, strategy, goal and skill imagery ability, as control variables (variable x). Five factors of flow experience, which are clear feedback, self-contained experience, mastery of control, concentration, and competency, are taken as the criterion variables (variable Y). The linear combination results of the two sets

of variables are shown in Table 2.

Table 2. *Results of Canonical Correlation Analysis on Imagery Ability and Flow Experience*

Control Variables	**Canonical Factors**				**Criterion Variables**	**Canonical Factors**			
(Variable x)	χ^1	χ^2	χ^3	χ^4	(Variable Y)	η^1	η^2	η^3	η^4
Affect imagery	-.859	.502	.014	.030	self-contained experience	-.886	.292	-.242	.151
Mastery imagery	-.805	-.154	-.306	-.479	Competency	-.713	-.644	.033	.154
Strategy imagery	-.872	-.260	-.176	.345	Mastery of control	-.670	-.482	-.359	.381
Goal imagery	-.741	-.128	.619	-.147	Clear feedback	-.860	-.240	.113	-.260
Skill imagery	-.698	-.253	.185	.319	Concentration	-.619	-.405	-.563	-.318
% of variance	63.645				% of variance	57.344			
	8.478					19.070			
Overlap	41.055		2.062		Overlap	36.991		4.639	

	ρ2	.645	.243	.061	.051
Canonical Correlation		.803	.493	.247	.226
	P	.000*	.000*	.004*	.022*

*p< .05

According to Table 2, we find that four of the canonical correlation coefficients are above the significant level of .05, and the other one came to be .803 (p<.05). Four out of the five factors are the main factors the affected the criterion variables.

The primary factor χ^1 of the control variables can elaborate 64.5% of the total variances of the factor η^1 of the criterion variable. On the other hand, η^1 also explains 57.344% of the total variance of all the criterion variables. There are 36.991% of the control variable and the criterion variable have overlapped each other. That is, we can infer that the five control variables (i.e., affect, mastery, strategy, goal and skill imagery) would explain 36.991% of the variance from the five factors of flow experiences (i.e., clear feedback, self-contained experience, mastery of control, concentration, and competency). Therefore, this primary factor may directly explain 57.344% of the total variance of the motivation the senior citizens being willing to take part in recreational activities.

The factors that have higher values in the control variables are the affective, the mastery and the strategy imagery. These imagery factors all value higher than .80. Among the criterion variables, the factors that are more relevant to factor η1 are the self-contained experience, and the clear feedback, where both of them value higher than .80 in coefficient. The competency also has a neutral correlation to the canonical coefficient, which is valued at .70.

As the structure coefficient is negative, we can infer that the higher imagery ability the player owns, the higher flow experiences, which are clear feedback, self-

contained experience, mastery of control, concentration, and competency, they may have. Once the imagery ability has been set as control variables, the flow experience may become the criterion variables. Thus, 36.991% of the control variables and the criterion variables will overlap each other in this circumstance.

According to Table 2, we could find that two canonical correlation coefficients are significant at a higher than .05 level. Also, another canonical correlation coefficient is ρ= .493 (p<.05). The five control variables affect the criterion variables mainly by the two canonical factors. The canonical factor, χ^2, from the control variables could elaborate36.991% of the variance by the canonical factor η^2 from the criterion variables.

On the other hand, η^2 also explains 4.639% of the total variance of all the criterion variables. There are 4.639% of the control variables and the criterion variables have overlapped each other. That is, we can infer that the five control variables (i.e., affect, mastery, strategy, goal and skill imagery) would explain 4.639 % of the variance from the five factors of flow experiences (i.e., clear feedback, self-contained experience, mastery of control, concentration, and competency). Therefore, this canonical factor may directly explain 4.369% of the total variance of the table tennis players' flow experience.

Our results coordinate with those of Hsiao et al. (2013) and Koehn et al. (2006). It shows that imagery training can not only help concentrate, relieve the anxiety in sports, improve sport confidence but also work in the process of physical rehabilitation. There is no limitation on the timing using this method, which makes it quite convenient.

3.3 Preliminary Results

3.3.1 The prediction on imagery ability and sport performance.

The prediction on the level of the table tennis players' satisfaction on the imagery ability being used in sports performances has been conducted as follows. We took the five imagery abilities, which were affect, mastery, strategy, goal and skill imagery ability, as predictive variables and the satisfaction on sports performances as criterion variables. A stepwise regression analysis was employed to analyse how the five predictive variables affected the satisfaction on sports performances, which has been shown in Table 3.

Table 3. *The Results of Stepwise Regression Analysis on the Imagery Ability towards the Satisfaction on Sports Performances*

Variables	Multiple correlation coefficient	Coefficient of determination	Total Variance Explained △R	F	Standardized Regression Coefficients (Beta)	t value	VIF
1.Mastery imagery	.447	.200	.200	52.527	.345	4.997*	1.304
2.Goal imagery intercept	.484 4.000	.234	.034	9.309	.211	3.051*	1.304

**p <.05*

There are two out of five predictive variables being significant in the analysis. The multiple correlation coefficient is .484, and the joint explained variance is .234, which suggests that the two variables may jointly predict 23.4% of the variance of the satisfaction.

Individually, the mastery imagery is the most predictive ability by means of explained variance, which is 20%. The second predictive ability is the goal imagery, and its explained variance is 0.234%. The joint predicting effect of the five variables is 23.4%. All of the VIF is 1.304 and is lower than 10, which may indicate there is no collinearity among each variable and may further improve the explanatory power of this study.

The standardized Regression Formula is as follows:

The satisfaction of the athletes= .345 × mastery imagery+ .211 × goal imagery

3.3.2 The Prediction on flow experience and performance satisfaction.

The prediction on the level of the table tennis players' satisfaction on the flow experience being used in sports performances has been conducted as follows. We took the five flow experiences, which were clear feedback, self-contained experience, mastery of control, concentration, and competency, as predictive variables and the satisfaction on sports performances as criterion variables. A stepwise regression analysis was employed to analyse how the five predictive variables affected the satisfaction on sports performances, which has been shown in Table 4.

Table 4. *The Results of Stepwise Regression Analysis on the Flow Experience towards the Satisfaction on Sports Performances*

Variables	Multiple correlation coefficient	Coefficient of determination	Total Variance Explained △R	F	Standardized Regression Coefficients (Beta)	t value	VIF
1.Concentration	.626	.392	.392	135.138	.312	4.338*	2.088
2.Competency	.671	.450	.058	22.103	.272	3.930*	1.937
3.Self-contained experiences	.696	.485	.035	14.144	.231	3.761*	1.526
intercept	1.880						

**p <.05*

There are three out of five predictive variables being significant in the analysis. The multiple correlation coefficient is .696, and the joint explained variance is .485, which suggests that the three variables may jointly predict 48.5% of the variance of the satisfaction.

Individually, the concentration is the most predictive experience by means of explained variance, which is 39.2%. The second predictive experience is the competency, and its explained variance is 5.8%. The third one is the self-contained experience, and its explained variance is 3.5%. The joint predicting effect of the five

variables is 48.5%. The VIF is respectively 2.088, 1.937 and 1.526, and they are all lower than 10, which may indicate there is no collinearity among each variable and may further improve the explanatory power of this study.

The standardized Regression Formula is as follows:

The satisfaction of the athletes= .272 × concentration+ .231 × self-contained experience

The 'mastery imagery' and 'goal imagery' of the imagery ability and the 'concentration,' 'competency' and 'self-contained experiences' of the flow experiences can be used to predict the collegial table tennis players' satisfaction on sport performances.

Imagery may ameliorate the best experience in sports and, thereafter, improve the athletes' sport performances, which may also improve the athletes' flow experiences (Koehn, Morris, & Watt, 2006; Koehn, Morris, & Watt, 2014; Nicholls, Polman, & Holt, 2005). Ji and Chen (2017) considered imagery training as the most widely-used in Psychological Skill Training. Furthermore, this training has been proven that it may yield quite effects on athlete's sport performances. Koehn, Morris and Watt (2006) also indicated that imagery training was a quite useful method, which can be applied in current sport science and can later be used to improve athletes' cognition toward sport performances.

6. CONCLUSIONS

There seems to be positive correlation between imagery ability and flow experience of participating in table tennis. Players' experiences may be predicted by imagery ability concentration, competency, and self-contained experience and flow experience.

Suggestion

Increase the ability of imagery. After the technical training, you can increase the time to practice imagery to increase the chances and feelings of smooth experience, because, These conditions, including imagery ability and flow experiences, are vital to one's satisfaction on sports performance in table tennis. We hope this research may benefit one's satisfaction of sports performance on table tennis player and offer help to the training program to the players and coach and help them get the good grades on International competence.

REFERENCES

Chen, S., Zheng, W.L., Qiu, G.G., & Chen, W.X. (2017). The effect of imagery training on the imagery ability and anxiety of Taekwondo players. *Sports research, 26*(2), 13-31.

Chen, Y.T., Huang, C.G., & Hongru, H.C. (2011). Excellent billiard player's psychological performance status for best sports performance. *College sports journal, 13*(1), 44-54.

Chi, L. K., & Chen, R. Z. (2017). Imagery training for athletes. *Taiwan Medical Journal, 21*(3), 281-287.

Hsiao, C. W., Yang, R. G., & Cai, C. B. (2013). Image training in the application of the skate racing skater. *Sports and Health Research, 2*(2), 1-12.

Hu, Y.M., Sun, Y.L., Ji, C.S., Shu, S.A., & Jiang, D.W. (2004). The study of the characteristics of the smooth and mental state of the athletes in the skill performance group. *Journal of Beijing Sport University, 27*(6), 671-673.

Hus, C.Y., Wu, Z.D., Wang, M.Y., & Li, K.Z. (2018). Research on positive emotions, psychological capital and athletic performance of college billiard players. *Leisure career research, 16*(2), 45-57.

Ji, L. K., & Chen, R.J. (2017). Imagery training for athletes. *Taiwanese medicine, 21*(3), 281-287.

Jiang, Z.G. (2008). From the development of sports policy in mainland China, we predict the effectiveness of hosting the Olympic Games in 2008. *Journal of wake-up, 28*, 323-348.

Koehn, S., Morris, T., & Watt, A.P. (2006). Correlates of dispositional and state flow in tennis competition. *Sport Psychol, 25,* 354-369. Doi:10.1080/10413200.2012.737403

Koehn, S., Morris, T., & Watt, A.P. (2014). Imagery intervention to increase flow state and performance in competition. *Sport Psychologist, 28*(1), 48-59.

Li, S.B., Xu, J., Xu, Z.Y., & Yang, X.F. (2010). An empirical study on the social support and smooth experience of high school judo players in China. *Sports and recreation research, 5*(2), 31-49.

Lin, M. G., Zheng W. L., & Zhang, D. Q. (2014). The ability of college athletes to move and exercise imagery: analysis of culture and current situation in the scale. *Sports Research, 23*(2), 1-19.

Martin, K.A., Moritz, S.E., & Hall, C.R. (1999). Imagery use in sport: A literature review and applied model. *The Sport Psychologist, 13*, 245-268.

Nai, H.F. (2013). Research on athletics, sports involvement and smooth experience of track and field athletes. *Sports coach science, 30*, 53-66.

Nicholls, A.R., Polman, R.C.J., & Holt, N.L. (2005). A phenomenological analysis of coping effectiveness in golf. *Sport Psychologist, 19*, 111–131.

Richardson, A. (1969). *Mental imagery*. New York: Springer.

Wang, M.Y., Huang, Z.H., Li, T.G., & Xie, S.J. (2012). A research on the motivation, smooth experience and athletic performance of billiard players. *Sports and recreation research, 7*(1), 89-101.

Xu, M.G., & Qiu, J.H. (2008). College students' participation in the smooth experience of billiards - taking the students of National Chung Hing University as an example. *Xingda Sports Journal, 9*, 35-46.

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Research on participation motivation, participation benefit and behavior intention of university table tennis clubs students

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Abstract: *Objective:* The purpose of this study is to find out the distribution pattern of participation motivation, participation benefit and behavioral intention of table tennis college students in National Taiwan University. *Methods:* By conducting a questionnaire survey among college students participating in the table tennis clubs. The questionnaires were distributed to the table tennis clubs in National Taiwan University from November to December, 2018. 50 questionnaires were distributed on the spot and 175 questionnaires were distributed on the Internet. The total questionnaires were 225, and the invalid questionnaires were eliminated. 200 valid questionnaires were obtained, with an effective recovery rate of 88.88%. Data analysis using SPSS19.0 version of the suite of statistical software, along with the use of exploratory factor analysis, KMO factor analysis validity, reliability and validity for this research, after that, descriptive statistics, and regression analysis are in progress. *Results:* In 200 people, males of 103 (accounted for 51.5%). Females of 97 people (accounted for 48.5%). The first grade students took up 28% among the other. Most of them practiced table tennis only for 1 hours per week, and most of their pro-year was 1 years or less, followed by more than 3 years. The study showed that the motivation of self-achievement was the highest, followed by social motivation, while the motivation of family and friends was the lowest, and the degree of benefit of college students' participation in table tennis club was interpersonal, emotional and physiological. Most students participated in the table tennis clubs were to learn new technology and train themselves. In behavior intention, they were more willing to spend more money in table tennis (suits and gears). The physiological and interpersonal benefits played an intermediary role between participation motivation and behavioral intention. *Conclusion:* University students participated in the table tennis clubs mainly because of self-achievement motivation, and most students participate in the table tennis clubs were willing to spend more money on table tennis sports to train themselves, improve self-skills and develop regular exercise habits. Physiological and interpersonal benefits will affect the degree of participation motivation and behavioral intention.

Keywords: table tennis clubs, participation motivation, participation benefit, behavior intention, intermediary effect

1. INTRODUCTION

1.1. Background and motivation

Due to Taiwan's high population density and the policy of environment protection, building sports courts face lots of tough challenges. Therefore, almost all the courts were transformed from outdoor into indoor, such as badminton, table tennis and volleyball are common. What's more, table tennis is the most advantage and suitable for all people ranging from the young to the old. Table tennis does not only require too much running space, but also it is relatively unaffected by body shape, gender, and the impact of weather. Besides, table tennis is in connection with the interesting of watching in games. Though table tennis was popular in Europe at first, it has become a competitive sport and been actively developing Asian countries (Liu, 2004).

In recent years, Taiwan's sports has involved and rewarded in many international tournaments, because of this, exercise trend has been developed, and in the number of international table tennis tournaments, we have many excellent players made amazing performance, including Zheng yi-Jing, Chen Si-yu won the second place in the 2017 Open Women's doubles in the German, and Lin Yun Ru won the third place in the 2018 Qatar Open men's singles, and the second place in team competition in the 2017 Universidad in Kazan. Throughout the outstanding performance of the players, gradually, international tournament of table tennis has drawn lots of attention to the people in Taiwan.

The primary motivation and consideration of table tennis, to make it become an all-people exercise, and for the better and healthy life of people in a long run.

1.2. Purpose

Various of types of clubs (extra curriculum activities) are made up in university, consisting of qualities of academic, service, recreational, autonomous and physical. The major purpose of this study is to investigate and understand students' motivation, benefit, and behavior intention of participating in table tennis, their correlations between each other, most importantly, find out the main factors affecting students' motivation in participating table tennis, in order to gain substantial benefit while promoting. Ultimately, to provide crucial reference to official units in our governments.

2. LITERATURE REVIEW

Tang (2014), motivation of participation is that the individual wants to participate and enrol on the basic factors of curiosity, learning and sightseeing, social, and health and challenging. Ajzen (1985) puts forward the theory of planned behavior. He thinks that attitude, subjective norm and behavior-control perception are three variables, which determine the actions of personal intention. Pan (2007) states, subjective norm and perceptual action are the main factors of participation. Chen, Luo and Wang (2011) subjective norm has a significant impact on users' intentions and indirectly influences themselves. The response of the user is usually not spontaneous (Wang, Li, & Guo, 2015). The experience is different from each other. It is a sensory perception and mental state formed by a person after an activity

(Huang, 2016). For personal preferences, individuals feel different, that the higher the satisfaction is, the higher the intention of revisit will be. Lin, Xu, Yang and Fang (2016) believe that are involved in motivation, satisfaction and behavioral intentions. It is found that participation motivation can directly affect behavioral intention in the study of participation motivation, involvement and leisure benefits, and that participation motivation has a significant positive impact on involvement and leisure benefits (Cheng, 2017). Wang, Xie and Tanaka (2013) defined satisfaction as the degree of difference between each satisfaction after the its actual experience of leisure activities.

3. RESEARCH METHODS

3.1. Object and scope of research

The object and scope of this research is focused and set on a table tennis club students in the southern regional colleges and universities of Taiwan. Questionnaires were sent to the table tennis clubs in National Taiwan universities from November to December, 2018. 50 questionnaires were distributed on the spot and 175 questionnaires were sent out on the Internet. The total questionnaires were 225, and invalid questionnaires were deleted. As a result, 200 valid questionnaires were obtained, with an effective recovery rate of 88.88%.

3.2. Research framework and research hypotheses

The architecture of this research is built as following (Figure 1):

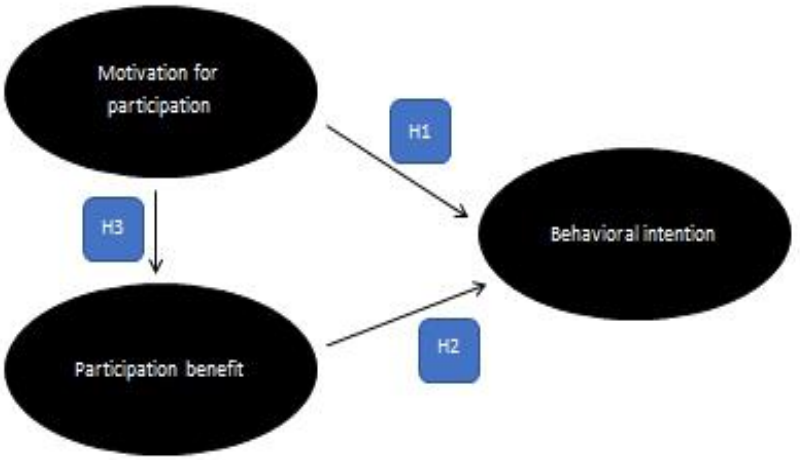

Fig.1. Architecture of the research

The study's assuming and the representation of each icon:

H1: The participation of college students in table tennis club positively affects their behavioral intentions.

H2: The participation benefit of college students in table tennis club will positively influence their behavioral intentions.

H3: The participation opportunities of college students in table tennis club positively affects their participation efficiency.

3.4. Research tools

This study used the questionnaire survey as a research method, which was self-designed and based on students' participation motivation, participation benefit and behavior intention in colleges and universities. The questionnaire was introduced by Lin (2016), Wu (2018), Chen (2018), Lai (2018) and other researches. The questionnaire consisted of three scales, “Participation Motivation”, “Participation Benefits” and “Behavior Intent”. The measurement of the scale topic was presented according to the scale of Likert Scale 7. The order shown as “very agree” and “agree”. "Slightly agree", "No opinion", "Slightly disagree", "Disagree", "Very disagree". The questionnaire was distributed from November to December, 2018 among Taiwan’s colleges and universities. The questionnaires were distributed on the spot (50) and 175 online (totally 225). By deleting the invalid questionnaires, 200 valid questionnaires were obtained.

3.5. Verification of the reliability and validity of the scale

Primarily, the questionnaire was analyzed by items-analysis and exploratory factors. The maximum variation orthogonal axis method of principal component analysis was used to extract common factors with eigenvalue greater than 1. The validity of the KMO factor analysis was measured according to the Kaiser (1974). The KMO value was unacceptable and cancelled if less than 0.5., whereas represented excellence (at least greater than 0.6) if it greater than 0.8, besides, the value of explanatory variation is requested at least 50%.

In this study, 15 items of motivation were involved. The KMO value of the test results was .823, and the total cumulative variation was 66.491%. After the execution of the maximum axis variation method, we gained the value of factor load (greater than 0.5), and the three result of factors were extracted, which were "self-achievement motivation", "friends and friends agree to participate in motivation" and "social participation motivation". Based on Cronbach's internal consistency reliability, the reliability coefficients of each subscale ranged from 846 to 843. In the benefit of involved 14 items, the KMO value was .897, and the total cumulative variation was 79.274%. The outcomes of factor analysis extracted from and produced three factors: , “interpersonal participation benefit”, “emotional participation benefit” and “physical participation benefit”. The reliability is tested by Cronbach's internal consistency reliability, and the reliability coefficients of each subscale were between .928 and .794. The Cronbach's α (value=0.915) of test confidence of the behavioral intention was obtained.

3.6. Data processing

This study employed descriptive analysis, factor analysis, reliability analysis, and regression analysis (adopting the B-K Method, Baron and Kenny, 1986) to analyze the mediating effects of participation.

4. RESULTS ANALYSIS AND DISCUSSION

4.1. Descriptive statistics

The number of males surveyed in this study was 103 (51.5%) and 97 (48%) for females; the maximum number of freshmen was 56 (28%); The frequency of weekly participation was 108 (54%); Training for one hour is up to 85 (42.5%); at least three hours and 32 (16%). The years of playing: up to 88 (44%) for one year, at least 46 (23%) for 1 to 2 years. 114 (57%) for having not working. 146 (73%) for not bearing position in club.

In the average ranking of table tennis students' participation motivation, the self-achievement motivation (M=5.803) is the highest, on the opposite, the lowest (M=4.582) is for “relatives and friends agree.” Among the three subscales, the highest went to “students participate in the table tennis club in order to learn new table tennis”; while "participating in the table tennis club because of the introduction by senior students" got the lowest. The emotional participation benefit reached highest value (M=5.711) in participation, on the contrary, physiological benefit is lowest (M=5.500). Making oneself have happy mood occupying the highest (M=5.920), while keeping shape was lowest (M=4.955). Willing to spend more money on table tennis (e.g. rackets or related books) was highest, continuing on training self and sharpen skill arrived on second highest place; compared to other activities, "will join table tennis as a priority" reached lowest (M=5.110), followed by "I will help propagating table tennis club" (M=5.145).

4.2. Regression analysis

In order to further understand the relationship between participation motivation, participation benefit and behavioral intention, this study use regression analysis to establish single / a set of explanatory variable(s) X and a dependent variable Y. Taking the motivation of participation, the sub-dimension for participation in the benefit as the independent variable, the behavior intention as the dependent variable; meanwhile, using forced entry method to carry out the regression analysis.

Moreover, took the motivation for participation as the self-variation, the participation benefits as dependent one to construct the regression model to detect the participation motivation (interpersonal, emotional, physiological), as shown in Table 1, as a result, the interpretive ability of this model reached R2=.532, the F value was 74.336 and the p value was 0.000, it all had proven that this experiment revealed a significant level, indicating that this regression model had demonstrated predictive capability significantly.

In the part of the model's self-variant interpretation ability, the participation motivation had a positive and significant influence on the participation benefit, and the interpersonal influence is higher (β=0.353; p=0.000<0.05), which also indicated

that the higher the motivation of students participating in the table tennis club, the higher the participation benefit.

Table 1. *Regression analysis of participation motivation vs interpersonal, emotional, physiological factors*

Correlation coefficient R	R^2	Adjusted R^2	*F value*	Significance *p* value
.730	.532	.525	74.366	.000
factor	Unstandardized coefficient Estimated value of B	Standardization coefficient Beta allocation	*t*	Significance
(Constant)	.955		3.154	.002
Interpersonal B1	.353	.349	4.602	.000
Emotional B2	.125	.141	1.973	.050
Physiological B3	.310	.332	4.897	.000

4.3. The intermediary effect

According to B-K Method (Baron and Kenny, 1986), the mediation effect of overall participation motivation, participation benefit and behavioral intentional over different aspects was analyzed. This study used multiple regression methods to analyze via the following three stages. (1) Regression analysis of the intermediation variables of the self-variant items, from the analysis result, participating motivations were both significant to the non-standardized coefficient B value and P value (0.734 & 0.000 respectively). (2) Regression analysis of the self-variant term, based on the disguised phase, the result showed that the non-standardized coefficient B value (0.832) and the P value (0.000) returned from the result addressed participation in the effect of benefit intention was significant. (3) Regression analysis of the self-variant (motivation) vs behavioral intention, obtained B value (0.590) and the P value (0.000) also told that motivation played an influential role on behavioral intention. (4) As the above two results ((1) & (2)) were reached significant values and effect, the self-variation and the mediating variables were simultaneously used as predictive variables in the regression analysis, in line with analyzing the effects of the variables on the dependent variables. The outcome exhibited that non-normalized coefficient B and P values were 0.201 (0.02) and 0.691 (0.00), respectively (motivation & benefit), which significantly indicated that the mediation effect actually existed, the self-variable coefficient decreased (from 0.708 to 0.201) as well. Table 2 showing the collected data from above four stages:

Table 2. *Intermediary effect*

(1) participating motivations (self-variant) vs participation benefit (dependent variant)				
Correlation coefficient R	R^2	Adjusted R^2	*F value*	Significance *P* value
.719	.518	.515	212.374	.000
factor	Unnormalized coefficient Estimated value of B	Standardization coefficient Beta allocation	*t*	Significance *P* value
(constant)	2.221		8.040	.000
Motivation for participation	.734	.719	14.573	.000
(2) Variable：Behavioral intention				
Correlation coefficient R	R^2	Adjusted R^2	*F value*	Significance *P* value
.708	.501	.498	198.617	.000
factor	Unnormalized coefficient Estimated value of B	Standardization coefficient Beta allocation	*t*	Significance *P* value
(constant)	.069		.188	.851
Participation benefit	.832	.708	14.093	.000
(3) Variable：Behavioral intention				
Correlation coefficient R	R^2	Adjusted R^2	*F value*	Significance *P* value
.590	.348	.345	105.635	.000
factor	Unnormalized coefficient Estimated value of B	Standardization coefficient Beta allocation	*t*	Significance *P* value
(constant)	1.395		3.694	.000
Motivation for participation	.708	.590	10.278	.000
(4) Variable：Behavioral intention				
Correlation coefficient R	R^2	Adjusted R^2	*F value*	Significance *P* value
.590	.348	.345	105.635	.000
factor	Unnormalized coefficient Estimated value of B	Standardization coefficient Beta allocation	*t*	Significance
(constant)	-.139		-.368	.713
Motivation for participation	.201	.167	2.341	.020
Participation benefit	.691	.587	8.215	.000

5. CONCLUSION

Regression analysis of the mediation variable of the self-variables, it shows that the impact of participation motivation on participation benefits is significant. Besides, the regression analysis of the self-variant term in the disguised phase also indicates that the effect of participation benefit on behavioral intention is significant. When the above two effects are significant, we insert both the self-variation and the mediating variable simultaneously, treating them as predictive variables in the

regression analysis, along with analyzing their effects on the dependent variables. As a result, it shows that the participation motivation and participation benefit have significant influence on the behavior intention. Furthermore, the coefficient of self-variation becomes decreased, which is expressed as a partial mediating effect. In summary, the participation benefit plays an intermediary role between participation motivation and behavioral intention.

REFERENCES

Ajzen, I. (1985). From intentions to action: A theory of planned behaviour. In J. Kuhl, & J. Beckmann (Eds.), *Action-control: From cognition to behavior* (pp.11-39). Heidelberg: Springer-Verlag.

Baron, R. M., & Kenny, D.A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical consideration. *Journal of Personality and Social Psychology, 51*(6), 1173-1182.

Chen, C.-H. (2017). Research on Participation Motivation, Involvement Degree and Leisure Benefits of National Lohas Cup Table Tennis Championship in 2015. *Sports Coaching Science, 46*(1), 1-14.

Chen, J., & Luo, D., & Wang, W. (2011). Research on participation intentions of travel and food blog users. *Taiwan Business Performance Journal, 5*(1), 41-59.

Chen, Q. (2018). *The Joining Motivation and Belonging of Clubs for EMBA Students: A Case of Feng Chia University, Business and Management*. Retrieved from https://hdl.handle.net/11296/3g8e2s**.**

Huang, R. (2016). The influence of local identity and festival experience on tourists' benefit perception, festival recognition and festival support: a case study of Tainan Xigang's incense. *Capital Leisure Journal, 2*(1), 1-38.

Kaiser, H.F. (1974). An index of factorial simplicity. *Psychometrika, 39*, 31-36.

Lai, M. (2018). A Study on the Relationship between Participation Motivation, Satisfaction and Behavioral Intentions of Participants in Cycling Touring-Taking Nantou Group Cycling Lohas as an example. Retrieved from https://hdl.handle.net/11296/e37d9u.

Lin, H. (2016). *The Effects of Learning Strategy, Club Experience, Parents' Attitude, Leisure Participation on Participation of Students' Clubs: An Example of Commercial and Technical Vocational School in Changhua, Sports Leisure and Leisure Management*. Retrieved from https://hdl.handle.net/11296/8h6t4g.

Lin, Y., Xu, G., Yang, J., & Fang, X. (2016). Research on the relationship between participation motivation, satisfaction and behavior intention in traditional religious festivals. *Leisure and Social Studies, Issue 13*, 91-111.

Pan W. (2007). *The application of planning behavior theory to the study of junior middle school students' willingness to enter a higher education-taking Kaohsiung City junior high school students to choose technical vocational schools as an example*. (Master's thesis). The Institute of Management, Gaoyuan University of Science and Technology: Kaohsiung.

Tang, Y. (2014). *A study on the motivation and satisfaction of participants in thematic road running.* (Master's thesis). Institute of Sports Recreation and Catering

Management, National Taiwan Normal University: Taipei City. Retrieved from https://hdl.handle.net/11296/dz5748

Wang, H., Li, H., & Guo, Z. (2015). Consumer motivation and leisure experience in the night market: Take the night market in Beimen District, Tainan City as an example. *Capital Leisure Journal, 1*, 19-40.

Wang, M., Xie, G., & Tanaka, T. (2013). A study on the motivation and satisfaction of Japanese silver-haired people coming to Taiwan for long-stay leisure. *Sports and leisure dining research, 8*(4), 27-48.

Wang, M., Xie, G., & Tanaka, T. (2013). A study on the motivation and satisfaction of Japanese silver-haired people coming to Taiwan for long-stay leisure. *Sports and leisure dining research, 8*(4), 27-48.

Wu, J. (2018). *A study on the relationship between college students' leisure participation motivation, experience and satisfaction.* Retrieved from https://hdl.handle.net/11296/fj6czr.

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Consideration about "Nagare" in table tennis games - Analysis of the factors in the continuous lost points-

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Abstract: The definition is that "Nagare" is a series of the trend in human mental, focus on the continuous lost point. It has been considered attention to the continuous lost points in games. Under what circumstances does it occur. The analysis will help the improvement of my own competition ability and mentality. The definition is continuous lost points as continuous 3 lost points or more. 8 students in table tennis club played games. After that, this study observed and analysed their mental states and contents of games with them. As written below, we will reveal the factors in the continuous lost points paying attention to the 7 parameters. ①The first lost point in the continuous lost points ②The second lost points ③The third lost points ④The scored point after breaking the continuous lost points ⑤The first lost point which is not included in the continuous lost points ⑥The second lost point which is not included ⑦The third get point which is not included, this experiment didn't get the result in the mental states. However, the results obtained the data about the significant difference in the contents of games. We found that it is related to the difference in competition ability among subjects. The origins of the continuous lost points are different one by one. It is important to grasp the contents of the continuous lost points which is prone to occur, understand the situations in the point, and modify the tactics effectively in the situations.

Keywords: table tennis, the continuous lost points, "Nagare"

1. INTRODUCTION

In the interpersonal game, there is "Nagare" during game progress. The factors that change the match situation in one play have not been clarified. At the 51st World Table Tennis Championships in Rotterdam, the men's singles final was the motivation for this study. Zhang Jike and Wang Hao (both from China) played against each other. Zhang Jike leads 3-2, 9-5. At that point, Wang Hao made a service mistake, and the match went to championship point at 10-5. It seemed that Zhang Jike was going to win the tournament. But then he was caught up 10-10. The events that actually happened should have worked in Zhang Jike's favour. Based on the

results of the above match, this study analyse why the continuous lost points continued.

Tezuka (2010) and Yonezawa (2010) state that the reason for the poor flow of the game is the continuous lost points due to mistakes. Table tennis is a sport that can be won if you make fewer mistakes than your opponent, and the less often you make the continuous lost points, the better your chances of winning. According to the rules of table tennis, the winner is decided by 11 points per game (excluding deuce). With such a small number of points, the odds of losing a game will increase if you lose too many the continuous lost points. In table tennis, it is very important to avoid losing the continuous lost points. Tsuchida (2007) states, "The Nagare is of human mind movement". In other words, "Nagare" is considered to be born from the mental change of players. The purpose of this study is to control "Nagare" by assuming that "Nagare" is related to continuous lost points and the mental change of players.

2. METHODS

Only the players themselves can tell how good or bad their play is in a match. For example, if a player fails to receive a serve from an opponent, it could be a "receiving error" or an outstanding "service ace". In other words, "success" and "failure (mistake)" are two sides of the same coin, and cannot be easily distinguished by a third party. The same goes for mental states. So, we talked to some of the players who played the game.

A video camera was used to record the game, and the mental state and content of the game were observed and analysed. In this study, continuous points were defined as three or more consecutive points.

Table tennis club 8 students at Niigata University played games (Subjects A, B, C, D, E, F, G and H). Focus on the following seven to clarify the factors.

①The first lost point in the continuous lost points
②The second lost point in the continuous lost points
③The third lost point in the continuous lost points
④The scored point after breaking the continuous lost points
⑤The first lost point which is not included in the continuous lost points
⑥The second lost point which is not included in the continuous lost points
⑦The third scored point which is not included in the continuous lost points

①The first lost point in the continuous lost points and ⑤The first lost point which is not included in the continuous lost points, ②The second lost point in the continuous lost points and ⑥The second lost point which is not included in the continuous lost points, the two above we thought that the difference make the continuous lost points or not. They were assumed to be relative. After the game, we analysed and analysed using recorded videos in one-on-one situations with both subjects. Table 1 is an example of a table used for observation.

Table 1. *Example of table used for observation*

E		2	-	1		F
comment	S	0	-	0		comment
	+	OT			−	Be bearish
	S	1	-	0		
	+	OT			−	
		2	-	0	S	
	+	OT			−	
		3	-	0	S	
	±0	ER			±0	
	S	4	-	0		
	±0	SA			−	
	S	5	-	0		
Indifferent play	±0			ER	±0	
		5	-	1	S	
The miss that there is no help for it	±0			GP	+	
		5	-	2	S	
The miss that there is no help for it	±0	OT			±0	
	S	6	-	2		
				GP	+	

Details of the table are as follows. Table 2 is a view of mental state. Table 3 is a view of play contents. In the "others" of the table, the contents of the plays were neither good nor bad.

Table 2. *Mental state*

+	Play in a positive mental state
—	Play in a negative mental state
±0	Plaring in a mental state that is neither positive nor negative

＋: Positive mental state refers to the subject's mental state when "attacking aggressively" or "fighting according to one's plan", etc.

－: Negative mental state refers to the mental state of the subject in the case of "sending a chance ball to the opponent" or "easy miss", etc.

±0: Not included in plus or minus, state of mind that belongs to neither. A casual score or mistake.

Table 3. *Play contents*

GP	Good play
ER	Error
SA	Service ace
RA	Receive ace
SM	Service mistake
LP	Lucky point (net in and edge ball, etc…)
OT	Others

The subjects were ranked for comparison. It is shown in Table 4. This was based on the club internal battle which took place in March-April, 2018.

Table 4. *Subject ranking*

Rank	subjects	Age (years)	Sex	Height (cm)	Weight (kg)	Career (years)	dominant hand	Best sports performance
1	A	20	Male	171.0	61.0	7	Right	All Japan National Public University TT Competition, Best4
2	B	22	Male	170.0	59.0	15	Right	Hokushinetsu Students TT Competition, Best8
3	C	20	Male	175.0	65.0	13	Right	Hokushinetsu Students TT Competition, Best4
4	D	19	Male	171.0	63.0	11	Right	Hokushinetsu Students TT Competition, 2nd rounded out
5	E	19	Male	171.0	59.0	8	Left	Hokushinetsu Students Newcomer TT Competition, Best32
6	F	20	Male	170.0	61.0	16	Right	Hokushinetsu Students TT Competition, Best32
7	G	21	Male	169.0	58.0	8	Left	Hokushinetsu Students TT Competition, Best32
8	H	21	Male	168.0	60.0	7	Right	Hokushinetsu Students TT Competition, Best32
Avg	±S.D	20.3±1.0		170.6±1.9	60.8±2.2	10.6±3.4		

3. RESULTS AND CONSIDERATION

3-1: 3-1: The number of times the continuous lost points of three or more points occurred was 109 times (①,②,③). Of the 109 times, 21 occurred at the end of the game. Therefore, ④the scored point after breaking the continuous lost points will no longer exist. Excluding those 21 games, it was 88 times(④). We counted the ones that player scored after the two lost points(⑤,⑥,⑦). Those were 76 times (Figure 1).

① mental states of lost point side

mental states of scoring side	-	±0	+
-	1	1	1
±0	26	33	7
+	10	26	4

② mental states of lost point side

mental states of scoring side	-	±0	+
-	1	2	1
±0	26	24	8
+	20	25	2

③ mental states of lost point side

mental states of scoring side	-	±0	+
-	0	1	0
±0	31	28	5
+	19	24	1

④ mental states of scoring side

mental states of lost point	-	±0	+
-	1	19	16
±0	3	25	19
+	2	3	0

⑤ mental states of lost point side

mental states of scoring side	-	±0	+
-	0	1	1
±0	12	27	2
+	15	15	3

⑥ mental states of lost point side

mental states of scoring side	-	±0	+
-	1	0	0
±0	14	27	3
+	14	14	3

⑦ mental states of scoring side

mental states of lost point	-	±0	+
-	0	14	12
±0	0	31	16
+	0	3	0

Fig. 1. When dealing with nine parameters (①,②,③= 109 ④= 88 ⑤,⑥,⑦= 76)

Chi-square tests were used for analysis on seven parameters ($p<.05$). ④ only had significance. It occurred because a negative state at the time of scoring and a positive state at the time of scoring occurred. Other than that, there was no significance. Next, we compared two parameters that were assumed to be opposite. But there was no significance. After that, we compared it from the actual result and the career, but there was no significance. This was not seen in "⑦ The third scored point which is not included in the continuous lost points". Therefore, it is considered that the negative state occurs when continuous lost points are made (Figure 2, 3, 4).

3-2: Next is the result of the play contents. After statistically processing all parameters, significant differences were seen in ①,③,⑥.

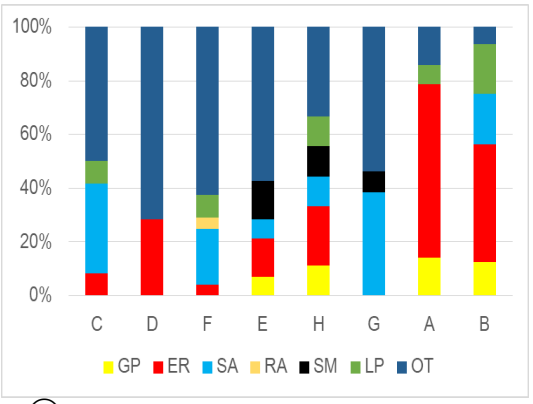

Fig. 2. "①The first lost point in the continuous lost points"
In the play content ratio of each subjects

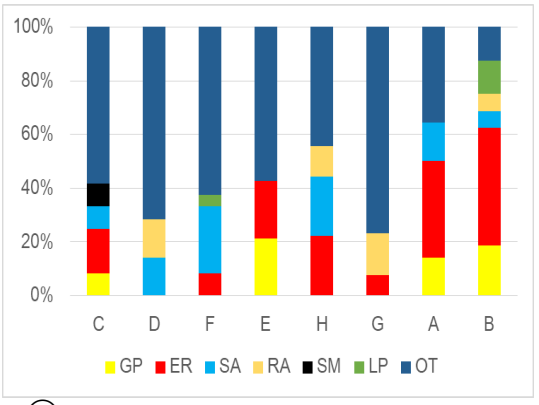

Fig. 3. "③The third lost point in the continuous lost points"
In the play content ratio of each subjects

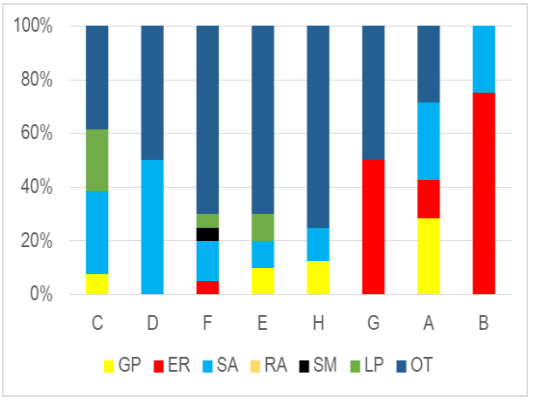

Fig. 4. "⑥The second lost point which is not included in the continuous lost points"
In the play content ratio of each subjects

The above three figures show three types of play contents at the time of lost points. In comparison with high-rank subjects, low-rank subjects showed more "ER". The percentage of "Others" was high. It was shown that there was a difference in the play content at the time of the goal loss depending on the subject's performance. However, there was no difference in relative parameters. Therefore, it became clear that relative parameters are not the factor of continuous lost points. It may have been caused by the subject's performance level. It is possible that the results will change as the performance of the subjects increases.

4. CONCLUSIONS

- After continuous lost points, negative mental states works even when scoring. On the other hand, it turned out that the scorer is likely to work a positive state even at the point of loss.
- There was a big difference in the number of play contents at the beginning of each subject's lost points. That is, it can be said that the contents of the points which are likely to be the start of the continuous points are different. As a way to avoid continuous lost points and reduce the chances of "Nagare", it is important to understand the contents of the points and to be able to make effective tactical changes and selections in that situation.
- Each player's mental state and continuous lost points were not factors affecting "Nagare". It is thought that the factors are hidden in "±0" and "other," which were the most common in all items. If we had looked at the two in a more detailed manner, we might have obtained different results.

The future direction of this study is to look more closely at things that put out many numbers, such as psychological "±0" and "Other" in the play content.

REFERENCES

Asai, Y. (2015). Transition of "flow" in the game of volleyball and the game situation about". *Coaching Science Research, 27*(1), 9-22.

Asai, Y., Sagawa, M., & Shite, N. (2011). In a game of volleyball Elucidation of factor structure of "flow". *Hokkaido Physical Education Research, 46*, 79-85.

Atsuaki, S. (2012). A essay on the" flow "of Aoi papers. *Hokkaido Institute of Physical Education R, 47*, 21-27.

Gilovich, T., Vallone, R., & Tversky, A. (1985). The hot hand in basketball: On the misperception of random sequences. *Cognitive psychology, 17*(3). (Translation) Yoshiaki Seki (2012) an Essay on Hokkaido Physical Education Research.

Tezuka, H. (2010) "*The true identity of 'Flow' becoming more like baseball*". Daily Sports Publishing

Tsuchida, H. (2007). The Strongest Mahjong Toda System. *Mainichi Communications,* 11.23

Ueda, M., & Hiroshi, S. (2015). In a badminton game. The relationship between the change in psychological state and the competition results. *Proceedings of the*

Annual Meeting of the Japan Physical Fitness Association 66 (0). (pp. 144). Japan; Japan Physical Education Association.

Yonezawa, T., & Tsuji, T. (2010) "Study on the" flow "of volleyball games -From the relationship between consecutive goals and wins/losses. *Fukuoka University sports science research, 41*, 1-7.

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Using table tennis record form to explore 2018 World Tour Grand Finals men's single player's crucial technical and tactical

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Abstract: In table tennis competition, player's on-the-spot response and coaches using different technical and tactical during the match are indispensable. The purpose of the study is to explore the technical and tactical performance and application of men's singles quarter-finals in 2018 World Tour Finals. The study used table tennis record form to record the match and analyse the data. The form record player's winning point, hitting technique and error position. The data through Excel to run statistical analysis and make hot zone to find out player perfect shot technique and error position. After statistical analysis and discussion, there are three conclusions. First, players of quarter-finals had high rate error on the position1 and position3. Second, the hitting technique of winning point mostly uses the backhand attack. Third, winning points are mostly hitting as slash direction. The results of data analysis enable the coach to communicate the tactics clearly and effectively to the player during the game. This analysis technology not only helps the player to improve their self-confidence and confront different opponent tactical changes but also the data can assist the player to strengthen their weaknesses technique during usual practice.

Keywords: table tennis record form, world tour grand finals, skill analysis, crucial techniques

1. INTRODUCTION

Ball games characteristic is fast tempo and openness. Even at different time when the player faces different opponents, they have unique strategy or playing style of individual or team (McGarry, Anderson, Wallace, Hughes, & Franks, 2002). Table tennis ball size is small, fast speed and changing fast during every shot. Therefore, a table tennis player needs to pay attention to judge the direction of the ball, rotation and movement to return the ball or using the different techniques in a short time (Qiu-fen, 2004). If the player's technical and tactical are not immature that will be more difficult to have good performance in the competition.

For several years, Taiwan table tennis players have been participating in many international matches. We even more often seen that players lost the winning chance at the critical moment, but it doesn't mean that players aren't working hard enough. It probably causes the coaches and players on-the-spot response and psychological quality are not enough and less to change different technical and tactical in the game (Anshel & Si, 2008). For example, as Taiwan's player; when the opponent changes the tactics or techniques during the match coach and player also response by short memories and their own experience to make player immediately

improve. There is no real-time information and analysis data to provide coach and player that can discuss the tactic in the intermission and make the right strategy to win (Fuchs et al., 2018). Compare with Japan and China which are the best in the world, both two countries for table tennis match analysis technology has been developed for several years also used the match analysis system for data collection in real-time or after-match (Zhang, Zhou, & Yang, 2018). Obviously, there still have much for improvement in table tennis sports science. No matter the real-time or after-match analyses data collection, skill analysis player's personal crucial techniques and tactics, develop the real-time match analysis system, cultivation the analyse talent and how to communicate and reach consensus with players and coaches are a very important topic. Review the research papers about match analysis and using the analyse technology during usual practice and competition to assist players to win the game.

2. METHODS

2.1. Participants

2018 ITTF World Tour Grand Finals was held on December 13th to 17th, 2018.

The top 16 players in the world have participated in this event. The event is an international high-level table tennis event. The study totally records seven games were analysed for athlete individual performance. The participants of the study have eight athletes who participated in the World Table Tennis Finals - Men's single quarter-final. Men's single quarter-final athletes including Tomokazu Harimoto (JPN), LIN Gao-yuan (CHN), Hugo Calderano (BRA), Jun MIZUTANI (JPN), JANG Woo-Jin (KOR), XU Xin (CHN), LIANG Jing-Kun (CHN), FAN Zhen-Dong (CHN).

2.2. Study Design

The table tennis record form of this study make the half table into six squares (Figure 1) In the record form, the score code is O, the error code is X, and the score of serve is △. Serve code is S, Forehand code is F, and Backhand is code B. The recording method is recording the last shot of each score in the game. According to the offensive and defensive technical content of the table tennis single match, the table tennis game record table is used for the behaviour of the table tennis players.

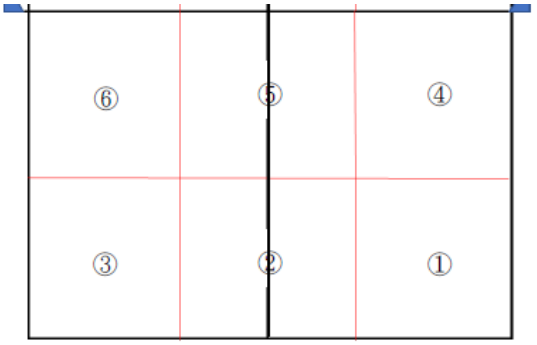


Fig. 1. Six squares of half table

2.3. Recorder

The study has two recorders used the record form to record the competition by YouTube video. Both recorders are major in table tennis, with more than ten years of professional training and own coach licenses of table tennis. For this new table tennis record form, two recorders have been training for more than one month. They are understanding the record standard operation procedure. After recording completed, recorders should comparison correction of two data. The study limit record time in two hours to avoid recorders fatigue to make the mistake or misjudgement during record.

2.4. Instruments

Table tennis record form (Figure 2): Recorder use the record form to record the data by player's performance. The form can record the player's stroke technique, winning point position and error position during the game.

Notebook: Watch the game video online by YouTube and record the data at the same time. Recording complete, the recorder will key the data into the computer for data analysis and build a big database.

Excel statistical analysis: Using Excel to collect the data for statistical analysis and draw the bar chart of player's performance percentage.

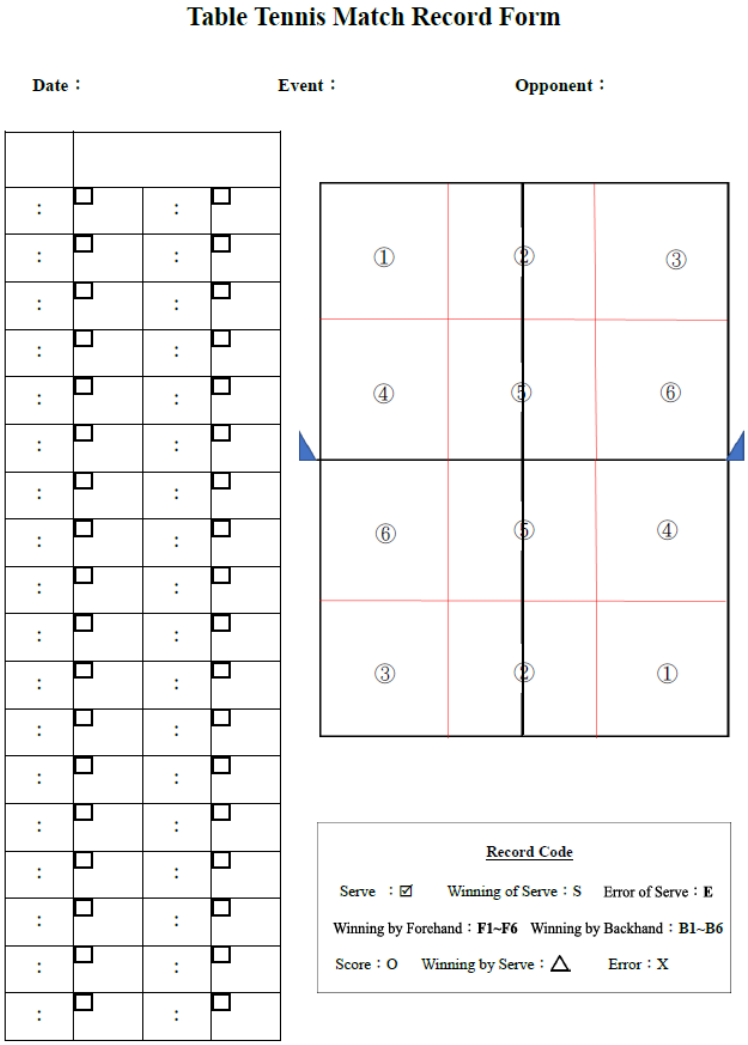


Fig. 2. Table tennis record form

2.5. Statistical Analyses

Statistics data of the study was calculated by the Excel Count IF function formula.

3. RESULTS

Stroke Technique

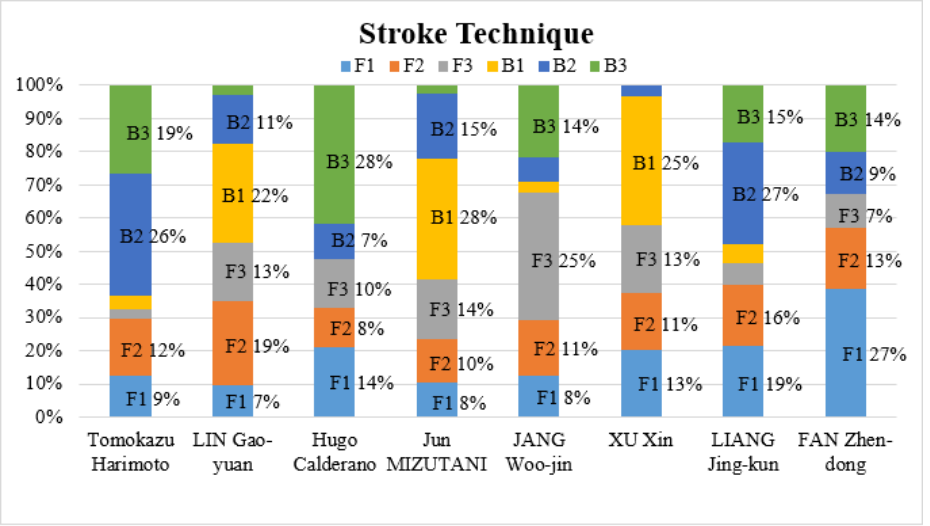
The first part of the results is to explore the table tennis stroke technique (Table 1). The stroke techniques are divided into forehand and backhand. If the study shows all stroke techniques not only increase the complexity of chart and the chart will not be clear but also international player's sustained rally ability are also better, the proportion of long shots in the game is quite high. Thus, the study selects the

forehand and backhand 1~3 positions for six stroke techniques to explore the highest percentage of stroke technique.

(1) Tomokazu Harimoto stroke from backhand second place winning percentage is 26%.
(2) LIN Gao-Yuan stroke from backhand first place winning percentage is 22%.
(3) Hugo Calderano stroke from backhand second place winning percentage is 28%.
(4) Jun MIZUTANI stroke from backhand first place winning percentage is 28%.
(5) JANG Woo-Jin stroke from forehand third place winning percentage is 25%.
(6) XU Xin stroke from backhand first place winning percentage is 25%.
(7) LIANG Jing-Kun stroke from backhand second place winning percentage is 27%.
(8) FAN Zhen-Dong stroke from forehand first place winning percentage is 27%.

Six of the eight players scored high with the backhand that means six player's backhand attacks were stability. The analysis of stroke technique can suggest coach and player use the backhand attack or sustained rally by backhand can be the best technique for winning in the game.

Table1. *The using percentage of stroke technique*



Winning Position

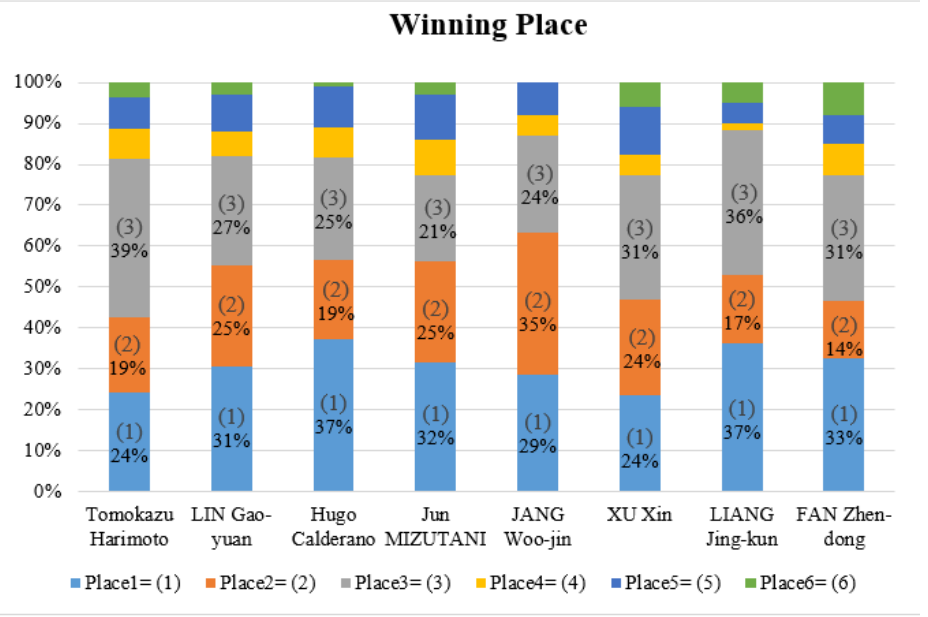
The results of the study, the winning position which places that player stroke the ball to the opponent's area.

(1) Tomokazu Harimoto hits the ball to opponent's third position winning percentage is 39%.
(2) LIN Gao-yuan hits the ball to the opponent's first-position winning percentage is 36%.
(3) Hugo Calderano hits the ball to the opponent's first- position winning percentage is 37%.

(4) Jun MIZUTANI hits the ball to the opponent's first- position winning percentage is 32%.
(5) JANG Woo-Jin hits the ball to the opponent's second- position winning percentage is 35%.
(6) XU Xin hits the ball to the opponent's third- position winning percentage is 31%.
(7) LIANG Jing-Kun hits the ball to the opponent's third- position winning percentage is 37%.
(8) FAN Zhen-Dong hits the ball to the opponent's first- position winning percentage is 33%.

It can be clearly seen from Table 2 that most of the scores are concentrated on the First, Second, and Third positions. Which show players also win the score in a sustained rally. The analysis of the winning position can suggest the coach and the player attack the opponent's weaknesses position in the game to achieve the best scoring efficiency.

Table 2. *The winning place that players score*



Error Position

The result of error position which the highest percentage of losing score. The error position also means the player's weakness place in the game (Table 3).

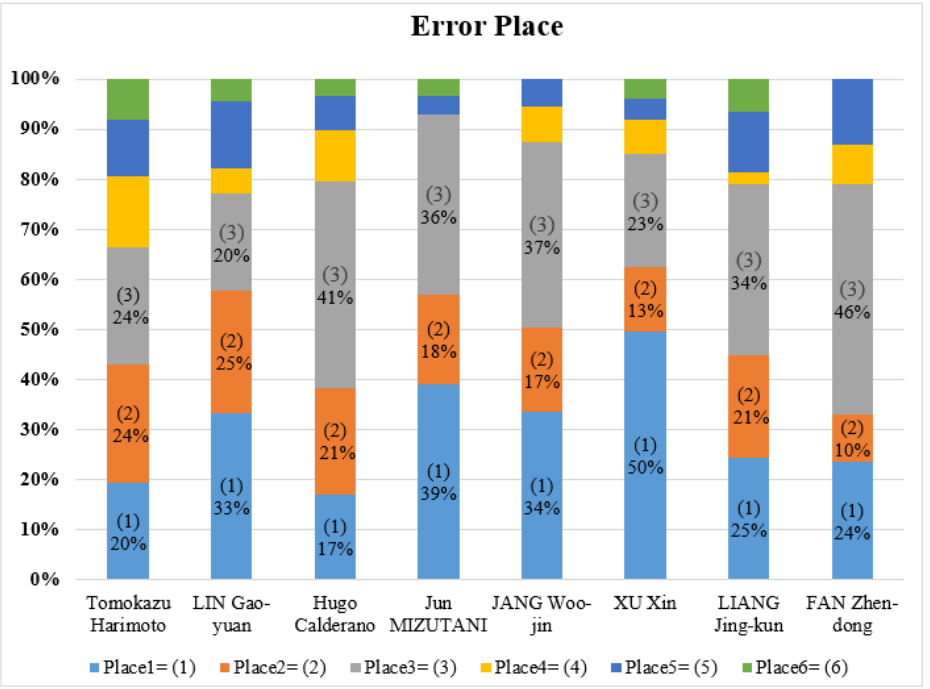
Tomokazu Harimoto highest error position is the second and third position. Two places have the same percentage are 24%.

(1) LIN Gao-Yuan highest error position is the first position the percentage is 33%
(2) Hugo Calderano highest error position is the third position the percentage is 41%

(3) Jun MIZUTANI highest error position is the first position the percentage is 39%
(4) JANG Woo-Jin highest error position is the third position the percentage is 37%
(5) XU Xin highest error position is the first position the percentage is 50%
(6) LIANG Jing-Kun highest error position is the third place the percentage is 34%
(7) FAN Zhen-Dong highest error position is the third place the percentage is 46%

The analysis of the error position found out the player's weakness position in the game. The data can provide the player to adjust the error technique in short-term or assist the player to strengthen their weaknesses technique during usual practice.

Table 3. *Error Place*



Use table tennis record form to collect and analysis player personal three different data of the game. Integrate 2018 World Table Tennis Finals Men's single quarter-final player's basic tactics, perfect techniques and weakness area. The study found that players had higher scores on first and third positions. Most of the stroke techniques use the backhand attack to win. The winning position is mostly attacked by the diagonal direction of the hitting position. The data provide the coach to communicate the tactics clearly and effectively to the player in the game or assist player evaluation with the coach after the game and strengthen their weaknesses technique during practice.

4. DISCUSSION

Record each stroke

Table tennis tempo are fast of each shot. Lots of tactical and technical analysis research record the last stroke performance for each point. In the future, the performance of each stroke and track of the ball in the game can be recorded by software and hardware.

Record Doubles

Wu et al. (1988) "three-phase evaluation method" and (Yang & Zhang, 2014)"four phase evaluation method" were recorded table tennis single player.

The biggest difference between singles and doubles is one player become two players that will increase the causes of the analysis. Table tennis doubles require players serve position should comply with the rules and one player cannot hit the ball twice. Those factors will increase the difficulty and complexity of doubles technical and tactical analysis.

Develop real-time record APP of table tennis match

The record form in this study needs to manual key the data into computer database after the game. In the future, the record form can develop the application to record table tennis game anytime, anywhere on tablet or smartphone also can upload the data to the database by network. Sharing application with table tennis hobbits not only allows them to understand the tactical analysis of table tennis, but also makes table tennis to be more popular.

Develop fast and convenient table tennis data analysis system

Nowadays, many data analysis systems should operate and analyse by professionals and explain the results of data analysis to coaches and players.(Wu et al., 2018)

If the system interface and data realization easier to understand, that will bring new advances to table tennis research.

REFERENCES

Anshel, M. H., & Si, G. (2008). Coping styles following acute stress in sport among elite Chinese athletes: A test of trait and transactional coping theories. *Journal of Sport Behavior, 31*(1), 3.

Fuchs, M., Liu, R., Malagoli Lanzoni, I., Munivrana, G., Straub, G., Tamaki, S., Yoshida, K., Zhang, H., & Lames, M. (2018). Table tennis match analysis: a review. *Journal of sports sciences, 36*(23), 2653-2662.

McGarry, T., Anderson, D.I., Wallace, S.A., Hughes, M.D., & Franks, I.M. (2002). Sport competition as a dynamical self-organizing system. *Journal of sports sciences, 20*(10), 771-781.

Qiu-fen, Z. (2004). Analysis on Attacking Point of Man's Team Final in 47th World Table Championship*. China sport science and technology 40*(6), 64-66.

Wu, Y., Lan, J., Shu, X., Ji, C., Zhao, K., Wang, J., & Zhang, H. (2018). ITTVIS: Interactive visualization of table tennis data. *IEEE transactions on visualization and computer graphics, 24*(1), 709-718.

Yang, Q., & Zhang, H. (2014). Construction and Application of "four phase evaluation theory" technique and tactics for table tennis. *Journal of TUS, 29*(5), 439-442.

Zhang, F. (2004). Analysis on Attacking Point of Man's Team Final in 47th World Table Championship. *China sport science and technology 40*(6), 64-66

Zhang, H., Zhou, Z., & Yang, Q. (2018). Match analyses of table tennis in China: a systematic review. *Journal of sports* sciences, *36*(23), 2663-2674.

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The study on predicaments and strategies of promotion professional table tennis in Taiwan

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Abstract: Professional sports will help the development and promotion of sports. It not only extends the sports career of the players, but also retains outstanding sports talents for the country, and can promote the development of the sports industry, improve economic efficiency and increase the spectating population. Table tennis is a very popular sport in Taiwan. It is also one of the sports that the people like to watch. In particular, the national table tennis team players have made great achievements in international competitions, creating great results and attracting the attention of the audience. Thus, the government announces the establishment of the professional table tennis. However, the announcement is passed for years but still can't become reality. What are the problem they faced and how to solve the problem? Therefore, the purpose of this study was to understand predicaments and offer strategies of promotion professional table tennis in Taiwan. Interview was used in the qualitative study. The content analysis was chosen in the result analysis. The subject was 6 coaches at national level, and 3 national players. The results indicated: (1) Predicaments of promoting professional table tennis in Taiwan were need to change mindset of government and table tennis association, lack of population dominant players, financial resource, and corporate investment; (2) Strategies of promoting professional table tennis in Taiwan were establishing new executive unit, increasing foreign players and related policy, establishing table tennis corporate league, changing the sports competition system and setting up a short and long season. Suggestions of this study were as follow: (1) There is a need to understand successful professional table tennis or sports abroad; (2) There is a need to create incentives for corporate sponsored table tennis; (3) The findings of this study should be taken into consideration in developing strategies on professional table tennis in Taiwan; and (4) There is a need for further studies on professional table tennis in Taiwan.

Keywords: predicament, strategy, professional table tennis

1. INTRODUCTION

Professionalization of sports has always been the goal pursued by various competitive sports development (Lin & Huang, 2018). Professional sports will help the development and promotion of sports. It not only extends the sports career of the players, but also retains outstanding sports talents for the country, and can promote the development of the sports industry, improve economic efficiency and increase the spectating population (Cheng & Huang, 2013). Wen (2003) mentioned that the first priority of the development of professional table tennis is to create a

variety of atmospheres to meet the needs of consumers and to improve consumer satisfaction; the second is to go through effective business strategies to create profits; the third is to use the relevant services, marketing, organization, information and finance to assist the professional table can continue to develop.

Table tennis is a very popular sport in Taiwan. It is also one of the sports that the people like to watch. In particular, the national table tennis team players have made great achievements in international competitions, creating great results and attracting the attention of the audience. Thus, the government announces the establishment of the professional table tennis. However, the announcement is passed for years but still can't become reality. What are the problem they faced and how to solve the problem? Whether Taiwan table tennis can go smoothly to professionalization is a very important part of the future development of table tennis. Therefore, the purpose of this study was to understand predicaments and offer strategies of promotion professional table tennis in Taiwan.

2. PURPOSE

This paper aimed to address the gap in understandings and contribute to a more comprehensive overview of the issues encountered by promoting professional table tennis in Taiwan. There were two purposes of this study. First, to identify predicaments of promoting professional table tennis in Taiwan. Second, to understand strategies of promoting professional table tennis in Taiwan. According to the purpose of this study, the following questions were examined: (1) What is predicaments of promoting professional table tennis in Taiwan? (2) What are strategies to promote professional table tennis in Taiwan.

3. METHODOLOGY

A qualitative research methodology reflects a realism paradigm (Mattew, 2006). Thus, this study used qualitative methods to understand the perspectives of predicaments and strategies of promoting table tennis in Taiwan. Interview was used in the qualitative study to collect data. Content analysis and a coding procedure was used to analyse the interview data. Following would discuss participants, data collection and interview procedure, and data analyses.

3.1. Participants

The study involved in-depth interviews with 8 persons (6 coaches at national level and 3 national athletes). Participants were selected for interview based on high performance athletes with world ranking and professional experience, coaching experience and their role as coaches of high performance athletes. In total 8 persons agreed to participate in this research. Characteristics of those coaches were: male, age from 35 to 60, and coaching experience from 10 to 20 years. Characteristics of those players were gender 2 male and 1 female, age from 27 to 38, and national player experience from 8 to 16 years. The study displayed "C" represented coach and "A" represented athlete. Using "C1" represented first one coaches and "A1" represented first one athlete.

3.2. Data collection and interview procedure

Data was collected through semi-structured interviews using open-ended questions. A pre-structured methodology (Yin, 2009) was used to develop an interviewer's guide which was then implemented through in-depth interview. Interviews were face-to-face and telephone with interviewees, which depend on their time and convenience. Each interview was around 30-60 minutes and these were audio-recorded, transcribed verbatim and returned to the participant for confirmation before data analysis began. Not one participant requested to withdraw their statements or to modify their transcript. The main questions focused on the coach and player perspectives of predicaments and strategies of promoting professional table tennis. For example, "What is your opinion to promoting professional table tennis in Taiwan? Can you tell me about what problems it will face with when promoting professional table tennis? What do you think how to cope with those problems?" And "What specific strategies you suggest to use in order to promoting professional table tennis in Taiwan?" This approach allowed each participant to incorporate any information they felt was relevant about the problems to establish professional table tennis and what specific strategies were required to solve those questions.

3.3. Data Analyses

The content analysis was chosen in the result analysis. Content analysis is defined as a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding (Stemler, 2001). Content analysis can serve as a method for studying communicated messages in a variety of forms (Merriam, 2016). Data analysis was conducted using NVivo 10SP6TM. A four-stage schedule was used to analyse the data through descriptive, topic, analytic and drawing conclusion stages (Sinkovics & Alfoldi, 2012). This process involved data being sorted from lower to higher order themes through the four stages of analysis. NVivo statistical and analytical tools (known as queries) were used to discern and interpret the data from each participant with reference to each of these themes. More complex aspects of the themes were undertaken using running queries (Bryman, 2008), specifically related to the predicaments of promoting table tennis and identifying strategies to address this.

4. FINDINGS AND DISCUSSION

Data analysis revealed four thematic categories on each research questions. These themes are presented as evidences by comments from the coaches and players interviewed. Results of the research questions were indicated as following:

4.1. Predicaments of promoting professional table tennis

Results of predicaments of promoting professional table tennis in Taiwan revealed that it needs to change mindset of government and table tennis association, lack of population dominant players, financial resource, and corporate investment.

4.1.1. Change mindset of government and table tennis association

From the interview, the result indicated that change mindset of the sport administration and the table tennis association was one of predicaments of promoting professional table tennis. It showed that establishing a new agency or organization to charge the professional table tennis and learn from other countries were mindset needed for the government. The development of professional sports requires the development of appropriate operation system based on the characteristics of the sport (National Hsinchu University of Education, 2015). Like Coach 2 said that *"Sport Administration of the government hopes the Table Tennis Association to charge it but they only have a few staffs and they need to take care too many things. The better way is to establish a new executive agency or organization to charge everything."* Moreover, coach 5 indicated that *"…We need to learn from other countries, such as Japan T League, Germany, France, etc.…to get something from them."* And Athlete 1 mentioned that *"I was participated professional table tennis in different country for several years. In Asia, Japan has T League recently and China has Table Tennis Super League. Also, Europe has many different professional table tennis club…We can take look how they did it and learn from it."* The result corresponded with prior research which Wen (2003) stated that the future of table tennis wants to be professional, and one side can learn from foreign countries. On the other hand, it is necessary to refer to other examples of successful sports. Wang (2016) noted that professional table tennis in Taiwan should promote the German regional club league system, take consideration on Japanese T League, combine the existing major events to promote one or two high-award contests and increase the number of schools and sub-clubs to enter the competition. Therefore, the government needs to consider having a new agent or organization to charge the professional table tennis and the government stand in assistant position. Also, the government needs to investigate other countries and learn from it in order to have a better understand the whole situation.

4.1.2. Lack of population dominant players

From the results, lack of population dominant players was also mentioned by interviewees. The competitive level of athletes is one of the elements of the process of entering the profession (National Hsinchu University of Education, 2015). On the practical level, there are not many players with similar level and the basic table tennis population is still a problem to be solved in Taiwan (Chang, 2017). The most important key to promote table tennis is cultivating dominant players (Wen, 2003). Like coach 6 mentioned that *"…population of dominant players is big problem…from the bottom, we need to flourish our younger player."* Athlete 2 stated that *"It can divide to short term and long term goal. At short term, it can hire foreign players and set regulation, such as how many native players or foreign players can play on the field. It can give native player participating high level competition and learn from it. For long term, it needs to establish a well system to flourish young players. Like China has China Table Tennis Super League, League A, B, C and D; Germany has divided 10 levels, 9 and 10 are professional levels…."* The training system of young potential athletes is an important basis for determining the sustainable development of

professional sports (National Hsinchu University of Education, 2015). Wang (2016) also indicated that the government should match some enterprises which are interesting to invest on table tennis before the professionalization. After a few years, several corporate team established, and can compete with the existing team then a truly professional league can be born. Therefore, a systematic cultivating player is a long term issue to promote professional table tennis.

4.1.3. Lack of financial resource

The financial resource is very important for establish professional sports. The result indicated that the financial resource was one of predicaments of promoting professional table tennis. The financial resource was an extremely important factor for professional sports. Wen (2003) stated that the necessary conditions for professional sports are high salaries and bonuses. This can effectively enhance the incentives of players and coaches, improve the skill level and quality of competition, and make the competition more attractive to the audience. Thus, a reasonable salary structure and bonus system can effectively enhance the motivation of players and coaches, improve the competitiveness of competition, and make the competition more attractive. Like coach 2 mentioned that *"we know there are tremendous challenges ahead to promote professional table tennis, especially finance."* Athlete 3 expressed that *"…Money is very important. No money we can't do anything, such as hiring high performance or high world ranking athletes." "At first, corporate support is important but marketing, ticket sale, product sale, advertisement and broadcasting are important, too." (C 3)* It corresponded with Wen (2003) noted that if professional sports need to be sustainable, it's not only to have strong support from large companies, but it must have multiple sources of funding. The financial source of professional sports is mainly ticket sales, merchandising, advertising revenue, and broadcast rights (Kuo, Lin, & Lin, 2012). The professional sports should develop authorized and branded products, and collect authorized product rights and brand goods sales to increases the team's income and to get profits (Chen, 2005). Therefore, financial support is important to sustain professional sports and needs to have multiple financial source funding.

4.1.4. Lack of corporate investment

Lack of corporate investment was also mentioned by interviewees. Wang (2016) expressed that the basic condition for a professional league to continue to operate is to have a market that continues to grow, and the participating corporates can make a profit. Taiwan's professional sports league lacks the "core industry driving force" and cannot fully promote the sports industry (National Hsinchu University of Education, 2015). The professional sports should increase consumers experience high satisfaction, and to enhance consumer brand loyalty, and then generate repurchase behaviour to create business opportunities (Lin & Huang, 2018). Like coach 4*"…the big issue is how to attract enterprise willing to invest table tennis. I think to create win-win situation is very important. Media report and marketing will help to increase the opportunity. Of course, players have good performance will help, too. Like the archery team has good performance in international competition, so*

they establish the professional archery league." Athlete 3 noted that *"…how to achieve win-win situation is a big issue to attract enterprises willing to invest…"* Thus, understand what the corporate needs and attract them willing to invest professional table tennis. Huang (2013) indicated that goal of corporate sponsorship was contribution to society, cultivation of table tennis players, building positive corporate image, development of the table tennis environment, and brand awareness of the corporation. Cordiner (2002) stated that the relationship between corporate sponsors and sport entities needs to be nourished and developed to make sponsorship work and for it to be effective. Gao (2000) indicated that in order to achieve sustainable operation, the sports industry must have three basic requirements. The first is to meet consumer demand and maintain user satisfaction. The second is to achieve four goals of quality, cost, profit and growth. The third is effective. Efficiently integrate functions such as service, marketing, organization, information and finance. The beginning of promoting table tennis, the government role is important. Wen (2003) expressed that many countries use some national resources to facilitate the development of professional sports in the early stage of promoting professional sports. Coach 3 stated that *"In the beginning, the government can help to match up corporates to invest professional table tennis."* Athlete 1 said that *"Taiwan has some enterprises they are interesting about table tennis. We need to have the right person willing to talk with them and to accelerate and have incentive to invest table tennis."* Thus, establishing well environment, creating win-win situation and the government's role are important to attract corporate to invest in professional table tennis.

4.2. Strategies of promoting professional table tennis

Strategies of promoting professional table tennis in Taiwan were building new executive agency or organization, increasing foreign players and related policy, establishing table tennis corporate league, changing the sports competition system and setting up a short and long season.

4.2.1. Establish new executive agent or organization

The result revealed that building new executive agent or organization was one of strategies of promoting professional table tennis in Taiwan. Wen (2003) stated that in order to promote professional table tennis, first it must establish an executive agency or organization to further promote the affairs and plans. Coach 1 indicated that *"It needs to have another executive unite in charge of it. The Sport Administration and the table tennis association can stand as supervisor or assistant position….."* Athlete 1 mentioned that *"…As I know, in some other countries, those leagues have an executive agency to take care whole things, not the government or table tennis association."* Like Germany professional table tennis has a company to charge event operation, management and marketing (National Hsinchu University of Education, 2015). However, professional sports system in China was almost whole-lead by government, In the development process due to the government involved in the deeper, the operating system still faces problems (Chang & Tseng, 2012).

Therefore, building new executive agent or organization was a strategy to consider promoting professional table tennis in Taiwan.

4.2.2. Increasing foreign players and related policy

The result revealed that increasing foreign players and related policy was one of strategies of promoting professional table tennis in Taiwan. The competitive level of athletes is one of the elements of the process of entering the profession (National Hsinchu University of Education, 2015). The policy is the basis for the professional sport development. The government should actively guide the development of professional sports, especially in laws and regulations, facilities construction, athlete cultivation, etc. (Wen, 2003). Such as athlete 2 indicated that *"…depend on the goal. If we want to cultivate young athletes, we can make the regulation which allows only one or two foreign player to play and at least one or two players must from native, such as Indian League, according the rule: one team at least one Indian men and woman players on the field; Japan T League has one player within world ranking 20 and at least one Japan player plays on the field."* Coach 2 mentioned that *"If we consider that we don't have enough high level athletes or we need to have a high quality competition to attract spectators then every team can hire a couple of high world ranking foreign athletes..."* Athlete 1 also noted that *"…Increasing the number of foreign players can increase the competition more competitiveness and diversity of the game. It gives us more opportunities to play with different countries players."* Such as Nagatsuka (2017) mentioned that Japan T League required each club to have at least one player who has achieved top-10 world ranking in the last two years. The league expects clubs to acquire some of the top global stars as well. Wen (2003) also stated that players who are not reaching the standard have entered the professional market, greatly reducing the excitement of the game and the willingness of the fans to watch the game. Lin and Huang (2018) stated that athletes' brilliant performance and uncertainty of game will continue to maintain the attractiveness of spectators and their attention to watch game, which is also the business opportunity. Thus, if the competition needs to attract people to watch games, increasing foreign players and related policy would consider as strategies to establish professional table tennis.

4.2.3. Establishing table tennis corporate league

The result revealed that establishing table tennis corporate league was one of strategies of promoting professional table tennis in Taiwan. Wang (2018) mentioned that the government should match some enterprises which are interesting to invest on table tennis before the professionalization. After a few years, several corporate team established, and can compete with the existing team then a truly professional league can be born. Like coach 5 stated that *"I think an easy way to do is to adopt the corporate league because we already have two or three team. At the beginning, four team is ok!...."* Athlete 1 also mentioned that *"Maybe at the beginning we don't have to establish professional table tennis directly, we can establish the corporate league at first. I think it is the quick way to do it."* The result corresponded with Cheng and Huang (2013) mentioned that Taiwan can establish the professional corporate league for table tennis in the first priority, and make thorough regulations for forming the

professional table tennis tournaments. Also, the use of media, the introduction of various sports trends, the establishment of national sports interest, should gradually increase new fans' market (Wu, 2001). Thus, establishing the corporate league is a feasible way for table tennis to enter the professional competition.

4.2.4. Changing the sports competition system and setting up a short and long season

From the result, it indicated that changing the sports competition system and setting up a short and long season was one of strategies of promoting professional table tennis in Taiwan. Wen (2003) stated that how to make the competition more attractive, the competition system is very important. The professional competition is a high-level performance. How to make the game more exciting and give more uncertainty are important factors to attract people. Thus, in order to enhance the confrontation of the competition, the requirements and designing of the competition system will be different. Like coach 1 said *"…such as in the T2 League, the new game of the "24-minute" time-based system was created: each game will be limited to 24 minutes; players must win as many points as possible within 24 minutes. It gives an uncertain outcome of the competition and attract people enjoy to watch it." Athlete 2 also mentioned that "….to attract people watching professional table tennis competition, change competition system is a good way to achieve it, such as India League arranges the team competition which included mixed double, men's singles, women's singles. Japan T League plays 4 points which included one double and 3 single, …."* Moreover, Athlete 1 revealed that *"The good way is to arrange shore term competition season because players play around the world, every player have different schedule. 2-4 month is the better."* Athlete 3 also stated that *"shore term competition season will solve our situation because we all belong to some company…"* Nagatsuka (2017) pointed out that The Premier League played the game between October 2018 and March 2019, 5 months for its first season. Each team will play nine matches at home, nine away and three at neutral sites in the regular season. The T2 League hold 6 rounds of regular season and 1 round of playoffs between June and December. It included Men's singles, women's singles and mixed doubles. Each game will be limited to 24 minutes; players need to win as many points as possible within 24 minutes. It produces high pressure and high rhythm competition, and also full of fun and freshness (Sina Sports, 2017). Therefore, changing the sports competition system and setting up a short and long season were considered as strategies for promoting professional table tennis in Taiwan.

5. CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH

According to results of this study, the following

indicated conclusions and suggestions of this study.

5.1. Conclusions

The conclusions of this study were: (1) Predicaments of promoting professional table tennis in Taiwan were need to change mindset of government and table tennis association, lack of population dominant players, financial resource, and corporate

investment; (2) Strategies of promoting professional table tennis in Taiwan were building new executive unit, increasing foreign players and related policy, establishing table tennis corporate league, changing the sports competition system and setting up a short and long season.

5.2. Suggestions for Future Research

The findings of this study should be taken into consideration in developing strategies on professional table tennis in Taiwan. The results of this study could be a useful resource to understand the situation of promoting table tennis in Taiwan in order to solve problems and offer strategies. However, this study only had coaches and athletes as participants so future research should continue to inquire viewpoints of government, business and scholar in order to gain a better understanding of promoting professional table tennis in Taiwan. Moreover, there is a need to create incentives for corporate to sponsor table tennis so the future study can investigate willingness or consideration of corporate sponsorship. Also, this study only concentrated on predicaments and strategies, the future study should consider spectators' needs, demographics, level of involving, etc. in order to understand the whole situation to establish professional table tennis. Furthermore, there is a need to understand successful professional table tennis or sports abroad so it is suggested future research to investigate professional table tennis in foreign countries, such as Japan T League, China Super League, India League, even in Europe Germany or France club. Although not all can apply it to Taiwan, but still can inspire or stimulate to Taiwan's professional sports marketing.

REFERENCES

Bryman, A. (2008). *Social Research Methods.* New York: Oxford University Press.

Chang, K.F. (2017). Table tennis professionalization series (1). There are many practical problems. The number of players needs to be increased. *ETtoday Sports Cloud.* Retrieved from https://sports.ettoday.net/news/902621#ixzz5fYsQoqTE

Chen, W.Z. (2005). Beijing Olympics and authorized products. *Journal of National Taiwan Sports Institute, 16*, 21-30.

Chang, C.Y., & Tseng, Y.T. (2012). The development process from competitive sport to professional sports in Mainland China. *Journal of both sides between Taiwan strait Physical Education and sports, 6*(2), 53-69.

Cheng, I.H., & Huang, M.J. (2013). The Study of Feasibility of Establishing Table Tennis Professional League in Taiwan: A Case Study of China Table Tennis Super League. *Sports Research Review, 124*, 16-23.

Cordiner, R. (2002). Boxing and sponsorship: a mismatch of a knockout combination. *International Journal of Sports Marketing and Sponsorship, 4*(2), 175-181.

Gao, J.X. (2000). *Sports Service Management*. Taipei: Luo Zheng-fang Publishing.

Holsti, O.R. (1969). *Content analysis for the social sciences and humanities*. Reading, MA: Addison Wesley.

Huang, M.J. (2013). *A study of corporate sponsorship in Taiwan table tennis teams.* The 13th ITTF Sports Science Congress. Paris, France.

Kuo, C.C., Lin, C.I., & Lin, I.C. (2012). In the name of "city" - on the relationship between franchise and professional sports management. *Sport Management Quarterly, 15*, 11-23.

Lin, C. N., & Huang C.K. (2018). Taiwan professional sports business opportunities and future orientation. *Journal of Sport Management, 17*, 21-27.

Mattew, D. (2006). *Case study research*. London: Sage.

Merriam, S.B. (2016). *Qualitative Research: A Guide to Design and Implementation.* San Francisco, CA: John Wiley & Sons.

Nagatsuka, K. (2017). *T. League unveils ambitious details for inaugural 2018 season, beyond*. Retrieved from https://www.japantimes.co.jp/sports/2017/09/15/more-sports/t-league-unveils-ambitious-details-inaugural-2018-season-beyond/#.XKDmRJgzZPY

National Hsinchu University of Education (2015). *Final report of professional sports development plan.* Taipei: Sport Administration, Ministry of Education.

Sina Sports (2017). *New game of table tennis! Who will score more in 24 minutes Ding Ning: New challenges*. Retrieved from https://read01.com/2GnjPxz.html

Sinkovics, R., & Alfoldi, E. (2012). Facilitating the interaction between theory and data in qualitative research using CAQDAS. In G. Symon & C. Cassel (Eds.), *Qualitative Organizational Research: Core Methods and Current Challenges.* London, UK: Sage Publications.

Stemler, S. (2001). An overview of content analysis. *Practical assessment*, *research & evaluation, 7*(17). Retrieved from http://pareonline.net/getvn.asp?v=7&n=17.

Wang, A. (2016). *The government promotes professionalism. Taiwan's table tennis couldn't be benefit from it*. Retrieved from https://tw.appledaily.com/new/realtime/20160101/766094/

Wen, C.T. (2003). *A research on the feasibility of developing professional table tennis in Taiwan*. 2003 annual sports academic seminar special issue. Taiwan.

Wu, C.Y. (2001). Economic value of the professional sports industry. *Sport Management, 1*, 6-7.

Yin, R.K. (2009). *Case study research: design and methods.* Los Angeles, CA: Sage Publications.

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"Match Analysis" using notational analysis and data analytics in table tennis with interactive visualisation

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Abstract: Asia has supremacy over World Table Tennis, with China in particular. Withal technical, physical, mental training in place, one crucial aspect they work on is "Specificities"!

With more and more science and technology permeating sports, Notational Analysis is an empirical method that collects objective data, analyses player's performance and helps coaches to work on specificities. Franks and Millers, during research (in 1986, 1991), stated that post a match, coaches can recollect only 30% of the key factors that determine performance. Thus, capturing objective data and analyzing a match plays a pivotal role in determining an athlete's performance.

The aim of this paper is to explain how advance data analytics is applied to notation analysis for creating "in-depth match analysis" solution and "athlete profiling". The in-depth "match analysis" solution, delves into every minuscule aspect of an athlete's performance, be it technical or tactical. Many matches have been analyzed for amateur and professional athletes from India, Junior & youth primarily during this study. The results from this match analysis were remarkable and the feedback from coaches was very encouraging. Further, a collection of the large set of athlete's data converges to "athlete profiling" that asserts trends, track patterns, errors and progress. This helps coaches in understanding the profound mistakes and anomalies of the players and planning a very specific training program accordingly. Additionally, player's reviews were also captured post their matches to substantiate discrepancies, if any. It is not strange but interesting that 80% of the players had presumptions about their performance that don't conform with match analysis. Such disparities clearly depict a strong role of in-depth match analysis and athlete profiling in redressing player's presumptions and apprehensions.

Of course, the real value of notational analysis is not only in being able to measure performance but in delivering a blueprint to develop a specific training plan with a clear roadmap. Unlike traditional coaching, it is indispensable in assisting coaches and players in developing measurable improvements in their game skills.

Keywords: notational analysis, match analysis, table tennis analysis, racket sports analytics, athlete profiling

1. INTRODUCTION

Data impacts everything—and athletes are no exception. Data Analytics in sports is being dominated by soccer, cricket, basketball and is widely used for performance analysis. For many other sports which are highly dynamic, such as table tennis, squash or badminton, there is a scarcity of gears that uses the power of Data

Analytics to comprehend an athlete performance. The intent of this work is to comprehend performance analysis in table tennis. Performance analysis comprises of notional analysis and biomechanical analysis, wherein, notional analysis record objective data of the performance for quantifying critical events and biomechanical analysis is more concerned with gross movements and individual sports techniques (James, 2009). Tapering off the wide funnel of performance analysis, we first attempted the research in notational analysis in table tennis using advance data analytics. Our extensive experience in technology, analytics and consulting with an intense knowledge of table tennis, cinches a little to understand the game and coaches' requirements. In 2017, Mr. Massimo Costantini, currently the high-performance manager in International Table Tennis Federation (ITTF), was then the National Indian Team Coach during 2016-2018, advised to develop a program for analysing a table tennis matches that allow the gaze to penetrate deeper and bring out the veracities of an athlete performance. Mr. Deepak Malik, Currently the National Team Coach of India, have further helped in identifying the crucial performance indicators and refining the requirements further.

Like many other sports, table tennis has specific game grammar such as Forehand and Backhand areas, strokes actions and placements, alternate two services, a series of events like sets, points, rallies, and lost & winning points and therefore, are suited very well for performing data analytics but being a highly dynamic sport, it involves a lot of complexities and variations because of ball spins, rubber combinations, playing style, fast-paced actions, quick movements and so forth. Further, the top athletes use subtle deception strategies and camouflaged stroke/serves, that make it more arduous to understand. For handling this, the data notation should be flexible enough to capture even miniscule aspects of the game to ensure accuracy. Moreover, with traditional coaching style, appropriate visualizations for insightful understanding are deemed important as currently the coaches are not accustomed with data analytics, visualizations and so forth.

To address the challenges and understand the requirements rationally, we netted the match videos from different athletes for data notation. All actions and events from match videos are notated to create the data set and requirements are gathered for analysing the match. Further techniques and algorithms like Descriptive analysis, Statistical analysis and mathematical modelling, Markov Chain and so forth are applied on the data along with strong visualization metaphors that resonates the critical performance indicators, supports game narration, statistical exploration, and pattern detection (Pfeiffer, Zhang, & Hohmann,2010). "R" is being used for Data Analytics (R Foundation, n.d.) and "Tableau" is used for visualizing data through sports metaphors, symbolic illustrations, graphs and heat maps (Tableau, n.d.).

During this study, the in-depth analysis for many professional table tennis athletes were conducted and shared with many coaches for their review and feedback. We tried to bring together a diversity of viewpoints and experiences from different coaches and athletes to evaluate the legitimacy of this analysis and the results were amazing. Coaches and athletes find this analysis intensely helpful and enlightening. Through this in-depth match analysis, an athlete's tactics, strategies, SWOT (strengths, weakness, opportunities and threats) could be mined, their

performance can be expounded and apprehensions can be clarified. This analysis encapsulates entire athlete's performance while the nub of it can be used for fan engagement and broadcasting data as well. As we are feeding the system with more and more matches data, an athlete's data base is being created that further creates an athlete profile to assert the playing patterns and the strategic trends. From a bunch of 20-25 matches per athletes against different opponents or similar opponent, we can spot the strategic trend and capture the playing patterns. This is equally important for analysing opponents and breaking into their strategies.

2. SCOPE OF STUDY

The scope of this study revolves around two key features, In-depth match analysis and Athlete Performance Profiling.

2.1. In-depth match analysis

The in-depth match analysis solution primarily focuses on one particular match for individual's players. This "Match Analysis" takes a ride through technical, tactical and movement analysis of a table tennis player, helping the coaches understand the effectiveness of game-plans, strategies and player's strengths and weaknesses. There are many technical aspects that are crucial in an athlete performance such as How the score is evolving in every game, where the balls like serve, returns, 3rd balls, or rest are being placed on the table, what tactics are being used and whether they are successful, from which zone of the table the athlete is making most errors, what are the unforced and forced errors, on which strokes of the opponents the errors are being made, what is the pattern for movement errors, how many time the attack is being initiated and converted, what is an athlete's serve strategy, long vs short, what are those rallies where most points are being missed, how the strategies changes in different games, what is the success vs error vs winning rate of the strokes, Is an athlete's attack effective, etc. All these crucial technical aspects are covered in match analysis. Moreover, the data is flexible enough to incorporate and customize many more technical aspects that are required to comprehend an athlete performance.

2.2. Athlete performance profiling

Athletes may not perform repeatedly similar but may possess invariant behavioural responses to certain similar situations, opponents, playing styles and so forth. Also, coaches usually design training regime for their athletes and often it is based on the capacities which they "perceives" about an athlete performance. It may differ from athlete's perceptions about their game. Therefore, there is a strong need of objective data analysis that can quantify and bring focus on "reality" from "perception". Athlete performance profiling identifies important performance attributes and encapsulates trends and pattern of play by taking into account the large amount of data. For creating an athlete profiling, historical data of around 20-30 matches was considered. Trends and pattern like, what is the placement to placement response, shot response to placements zones, shot to shot response, shot

response to serves, can be identified. We can even get the playing patterns with certain type of players like left-handed, odd rubber combinations and so forth.

Also, we tried to create normative profiles for some of the world top ranked prodigies as part of this study to compare the profiles and understand the difference in the playing patterns from our athletes. Hughes, Evans and Wells, (Hughes, 2001) produced calculations to suggest the number of matches that needed to be analysed to determine "normative" profiles and to assess whether performance variables had "stabilized" (i.e. invariant behaviour), (James, 2009).

3. TECHNICAL ASPECTS

3.1. Data Classification

We tend classify the data in a way it is easy to notate, game relatable and quick to understand by the users. We managed to capture stroke techniques, spins and actions together and abbreviated them for better understanding. For instance, Forehand topspin is FH-TS, Forehand Block is FH-BK, Forehand push is FH-P, Banana Flip is BN-FP, Backhand Topspin is BH-TS, Backhand Counter is BH-C and services as forehand backspin short serve is FH-BSS, Backhand Sidespin long is BH-SSL, Shovel Back Spin Long is SH-BSL, Forehand reverse Sidespin with Backspin short is FH-RSBS, Forehand Tomahawk short is FH-TMHS etc. Similarly, the placements zones are abbreviated as BHS for Backhand Short, BHH for Backhand half, BHL for Backhand long, FHS for Forehand short, CH for Centre half, CL for Center Long, Extreme Forehand Long as EFHL and so forth. The one side of the table is distributed in 9 major zones and 6 extreme angle zones. Below Figure 1 explains these 15-placement zone on one side of the table for a right-handed player. For the left-handed player, the forehand and backhand sides will switch.

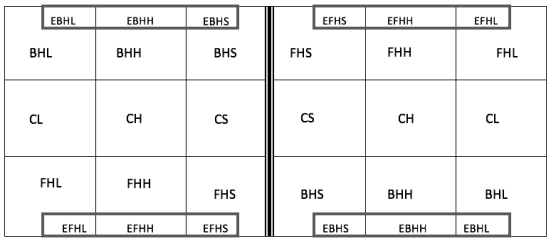


Fig. 1. Placement zones of table tennis table

Also, three type of error types were defined – Forced, Unforced and Others. Forced error, where athlete forced the opponent to make an error, for example, winner shots or aces, strategic ball placements for making opponent to give error, others, where the point is lost due to table edge, ball touched the net and fell on the table etc. Rest all errors other than Forced and Others are captured in Unforced error, where opponent gave the error due to misjudgements, serve errors, etc.

3.2. Data notation

Data is notated for the match videos procured from the athletes. We have captured each and every attribute with complete information about the game, point,

shot number, stroke technique, ball spins, placement along with the lost point categorized in different error codes. Every shot is counted and assign with a number within that rally. Below Table 1 provides the list of attributes covered during data notation:

Table 1. *List of Data attributes*

Game ID	ID number given to every game
Point ID	ID number given to every point
Shot ID	ID number given to every shot within every point
Shot Type	The type of stroke played
Placement	Placement of the stroke
Error Type	Type of error, like out, net or missed

3.3. Data modelling

The collected data is then used for further data modelling and data analytics. Many calculations, and scripts were developed to structure and model the data in a way it is easily visualized. Multiple techniques like descripting analysis, statistical modelling, Markov chain and so forth are applied. For Data analytics, "R" is used. R is a language and environment for statistical computing and graphics that provides a wide variety of statistical (linear and nonlinear modelling, classical statistical tests, time-series analysis, classification, clustering, …) and graphical techniques, and is highly extensible (R Foundation, n.d.).

3.4. Interactive visualization

Once the data is cleansed and modelled according to the functional requirements, it is further processed to create interactive visualizations. Information should be presented in a way that is familiar to the user. Vision is the most powerful of our senses and visualizations have more deeper impact in cognizing and comprehending the data quickly. Moreover, data analytics is a little complex to understand by a coach or an athlete if presented raw. To express the insights, we have used familiar sports metaphors that has a profound impact and are easy to understand by sports persons. Presenting the data in dashboard is an example of enhance presentation that uses the collection of key information in a way that helps rapid understanding and decision making (Ambikesh Jayal, 2018)

We are using "Tableau" for interactive visualizations as it provides greater flexibility and functionality for visualizing data than statistical analysis packages. Tableau creates data visualizations through dashboards that provide actionable insights with real-time updates presenting on web (Tableau, n.d.). There are many more open source libraries available like chart.js, d3.js for developing customized visualizations but they require a longer time to develop such visualizations.

4. KEY FEATURES OF IN-DEPTH MATCH ANALYSIS

The in-depth match analysis tool covers various segments which are described one by one. For describing the analysis, we have taken a classic match between Ma

Long, China and Timo Boll, Germany, Men's Semi-finals from World Championships, 2017. The match was won by Timo boll with score 4-3.

4.1. Match summary – 1st dashboard

Match summary is the first dashboard of the in-depth match analysis that provides basic summary of the match such as the score information, strokes played during the match with success, error and winning ratio, number of Forced and unforced errors and information about athletes such as world rank, Dominant hand, Rubber combination and so forth. In the Figure 2, the top right corner and the bottom left corner bar charts provides the details on number of strokes played by both Ma Long and Timo boll, categorized by errors, winners and successful (landed successful on the table within the rally). The red bars appearing below the axis represents errors from that stroke, grey bars in the middle represents successful and blue bars at the top represents winning. At the middle of the dashboard, score board is presented with information on the number of games and their scores.

Fig. 2. Match Analysis 1st dashboard- Match Summary

4.2. Tactics analysis

Tactics are very important because they're used (in conjunction with technical ability) to force the opponent to make an error or play a weak stroke, which means that you'll be likely to win the point (Hughes, n.d.). A service has a strong impact on the scoring or losing tendency in the early phase of rallies. If an athlete has good serving skills and vary the serves with spins and directions, it becomes difficult to anticipate by the opponent and the athlete would get high scoring rates at the first and third shots and the opponent would get high losing rates at the second and fourth shots (Tamaki, 2018). Therefore, first four balls are very crucial and illustrates a lot about the tactics and underlying strategies. There are multiple dashboards in for Tactic analysis primarily focuses on first four balls, and the correlation between the point won/loss with respect to the type of serve, returns or strokes played or the combination of these along with placements. We will go through each of them one by one.

2nd Dashboard (tactics analysis) - First four contact analysis with rally visualization

This dashboard primarily focuses on the analysis of first four contacts of rally during the match. Most of the points are lost during the first four ball contacts of the rallies, primarily 3rd contact and 4th contact (Tamaki, 2018). These are correspondingly crucial as they unwind the strategies and tactics of the players. Moreover, if one ball is missed by one player, it's a win for another. For example, if we are studying 4th ball lost by Ma Long & Timo boll, the vice versa describes the 3rd ball win of Timo boll & Ma Long. Similarly, 3rd ball lost by athletes also describes the serve-return win of opponent and 2nd ball (serve-return) lost, provides information of service point won by the opponent. Below Figure 3 shows the dashboard view of first four ball analysis. In left side top, we can see a drop down to select the rallies ended at 2nd, 3rd and 4th shot, i.e. presently, "4th ball" is selected. The first graph on the left side displays the information on the type of strokes played by both the athletes at 4th ball with their frequency along with the information on whether it lead to rally conversion or losing a point in a tooltip view. Two crosstabs at the bottom of the dashboard describes the complete rally information for the rallies ended at 4th contact, therefore the point is won by the opponent at their 3rd ball attack. Post selecting the point, the whole rally information appears on table tennis table in animated view. For example, Figure 4 describes the rally selected from left cross tab view i.e. Game 2, point 5. Correspondingly Figure 5 demonstrates the rally on table tennis table. We can press the "play" button for an auto run of the rally. As we can see, Ma Long placed shot number 1 (serve) - FH-SBL (Forehand Sidespin with Backspin long) serve to Timo Boll's Forehand half (FHH), Timo replied with a FH-P (Forehand Push) on centre long (CL) of Ma Long, on which Ma Long turned into pivot position and hit a winner - Forehand Turnover Topspin (FH-TT) and Timo was not able to reach to the ball and hence missed the 4th contact.

Similarly, other rallies can be watched. This animated feature extended to watch all the rallies of the match, the Rallies dashboard (another dashboard) provide flexibility to watch any rally played during the match, therefore, if a coach wants to see, he can imagine the players on left and right side of the table and can visualize the rally being played by them.

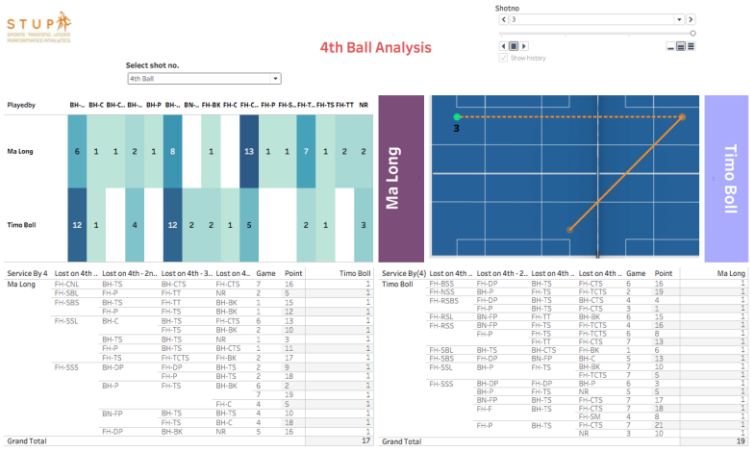


Fig. 3. First four ball contacts analysis dashboard

Service By 4	Lost on 4th ..	Lost on 4th - 2n..	Lost on 4th - 3..	Lost on 4..	Game	Point	Timo Boll
Ma Long	FH-CNL	BH-TS	BH-CTS	FH-CTS	7	16	1
	FH-SBL	FH-P	FH-TT	NR	2	5	1
	FH-SBS	BH-TS	FH-TT	BH-BK	1	15	1
		FH-P	FH-TS	BH-BK	1	12	1
	FH-SSL	BH-C	BH-TS	FH-CTS	6	13	1
			FH-TS	BH-BK	2	10	1
		BH-TS	BH-TS	NR	1	3	1
		FH-P	BH-TS	BH-CTS	1	11	1
		FH-TS	FH-TCTS	FH-BK	2	17	1
	FH-SSS	BH-DP	FH-DP	BH-TS	2	9	1
			FH-P	BH-TS	2	18	1
		BH-P	FH-TS	BH-BK	6	2	1
					7	19	1
				FH-C	4	5	1
		BN-FP	BH-TS	BH-TS	4	10	1
			FH-TS	BH-C	4	18	1
		FH-DP	BH-BK	NR	5	16	1
Grand Total							17

Fig. 4. A cross tab view of rallies ended at 4th contact for Timo Boll

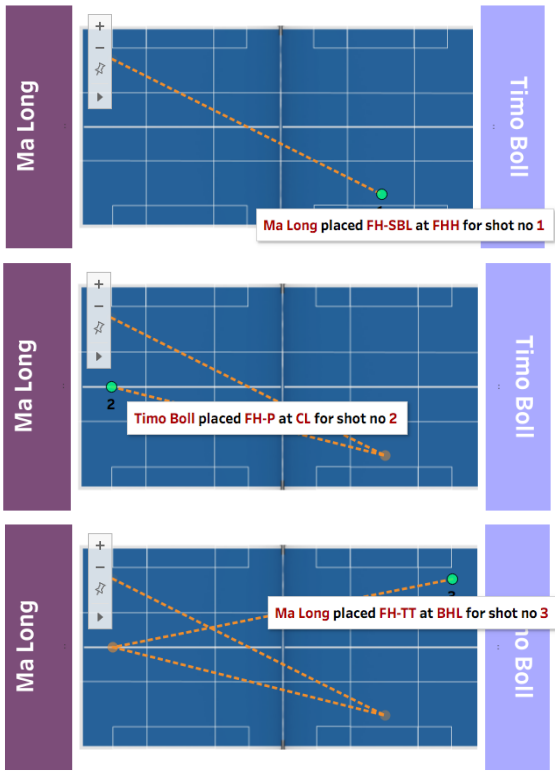


Fig. 5. Animated view of Rally selected from crosstab view

2nd Dashboard (tactics analysis) - Service & serve-return analysis

Serve and Serve-return analysis involves numerous attributes like the type of serve or serve-return, long vs short, placements, in which game, at what point, whether it leads to convert the rally in your favour and so forth. The visualization for this analysis is in lollipop chart form, on hovering, we can view each attribute for both serves and serve returns. In Figure 6 we can see the lollypop chart, colour coded by players and segregated by type of serves and returns whereas Figure 7 provides the tooltip view, the first tool tip provide information on Ma Long's FH-SSL (Forehand Side spin long) serve and the second tooltip is of Ma Long's serve return shot – Backhand drop. One of crucial aspect which is most common to analyse is the point conversion ratio between long vs shot services. This is also covered in this dashboard.

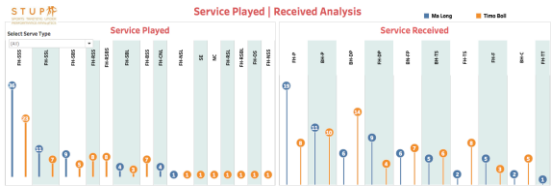


Fig. 6. Serve & return comparative Analysis

17% of Total Services Played by Ma Long were FH-SSL

Game	Point	Rally Won By	PlayerA	Score | ..	Player B	Placement
1	3	Ma Long	Timo Boll	1-2	Ma Long	BHH
	8	Timo Boll	Timo Boll	5-3	Ma Long	CH
	11	Ma Long	Timo Boll	6-5	Ma Long	FHH
2	10	Ma Long	Ma Long	5-5	Timo Boll	FHH
	17	Timo Boll	Ma Long	9-8	Timo Boll	EFHH
3	8	Timo Boll	Timo Boll	5-3	Ma Long	FHH
4	6	Timo Boll	Ma Long	4-2	Timo Boll	FHH
5	7	Timo Boll	Timo Boll	4-3	Ma Long	FHH
6	10	Timo Boll	Ma Long	3-7	Timo Boll	FHH
	13	Ma Long	Ma Long	5-8	Timo Boll	BHL
7	12	Timo Boll	Timo Boll	7-5	Ma Long	BHL

9% of Total Shots Received by Ma Long are BH-DP Shots

Game	Point	Rally Won By	PlayerA	Score ..	Player B	Placement
1	2	Ma Long	Timo Boll	1-1	Ma Long	CS
	17	Ma Long	Timo Boll	6-11	Ma Long	FHS
2	12	Timo Boll	Ma Long	6-6	Timo Boll	CS
5	1	Timo Boll	Timo Boll	1-0	Ma Long	FHH
	17	Timo Boll	Timo Boll	10-7	Ma Long	CS
6	3	Timo Boll	Ma Long	1-2	Timo Boll	FHS

Fig. 7. View of tooltip that appears on hovering the bars from serve & return analysis

3rd Dashboard (tactics analysis) - 1-3 & 2-4 ball contact analysis

1-3 combination is serve and first ball attack and 2-4 combination is serve-return and 4th ball contact. Here, we tend to analyse if certain combinations of serve and 3rd ball attack or return and 4th ball are being used repeatedly. Further, whether these combinations lead to a point conversion or rally conversion is also classified for analysing the winning strategy of the athletes. From Figure 8, we can identify that Ma Long, 20% of the times have used 1-3 combination of FH-SSS – BH-DP, i.e. 1st shot (Serve) Forehand sidespin short and 3rd ball Backhand drop during this match with Timo ball.

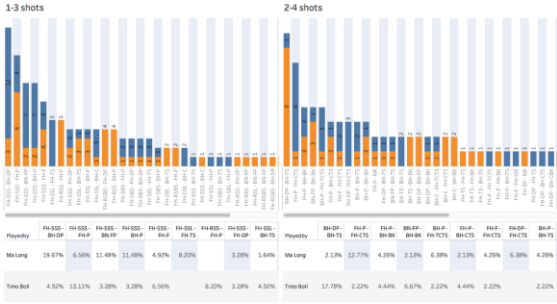


Fig. 8. View of 1-3 & 2-4 balls combinations dashboard

4.3. Detailed analysis on errors & winners

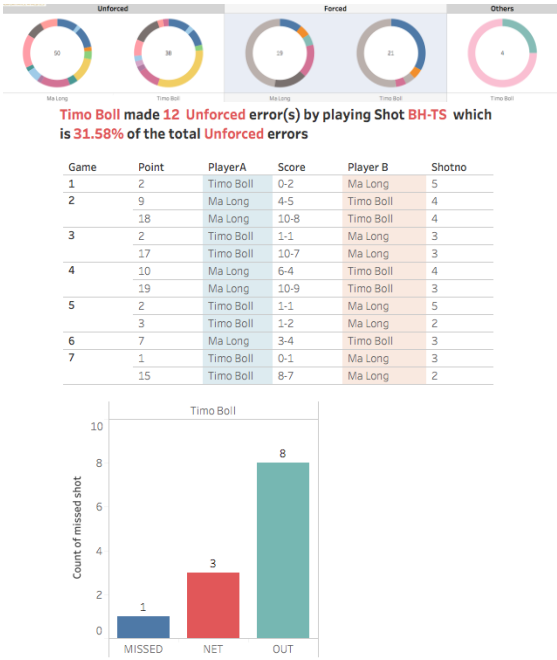
The point lost during a match is categorized as unforced, forced or others and the strokes played at this time is considered to be as error stroke whereas the previous stroke to error stroke is considered as winning stroke of the opponent. There are three dashboards under this category that provide in depth analysis of errors & winners

4th Dashboard & 5th Dashboard (error/winner analysis) – Error/winner placements & strokes

Error/winner placements dashboard (4th Dashboard) highlights the zones of table that lead an athlete losing the point. It is visualized on a table tennis table with respective percentage on each placement zone and interactive buttons that segregates the errors by respective shot numbers. For example, Figure 9 demonstrates the percentage of errors made by Ma Long and Timo boll from different placement zones. When clicking on any of the button from the top ribbon, it will pop out the placements zone marked with percentage of error made by the athlete from that zone, along with the information on the type of error (stroke information) made from that zone.

Fig. 9. Error strokes distributed by placement zones

Additionally, errors are also categorized by the shot numbers, missed stroke type and also the stroke type of opponent that lead the athlete losing the point (5th Dashboard). For example, in Figure 10, the errors are categorized with the type of strokes in a doughnut chart. The tooltip shows the detailed information sorted by % of strokes missed, game, point, score and shot number. Further, the additional information is added, whether the athlete was not able to make a contact to the ball, or hit the ball out of the table or hit the ball to the net and so forth.



Game	Point	PlayerA	Score	Player B	Shotno
1	2	Timo Boll	0-2	Ma Long	5
2	9	Ma Long	4-5	Timo Boll	4
	18	Ma Long	10-8	Timo Boll	4
3	2	Timo Boll	1-1	Ma Long	3
	17	Timo Boll	10-7	Ma Long	3
4	10	Ma Long	6-4	Timo Boll	4
	19	Ma Long	10-9	Timo Boll	3
5	2	Timo Boll	1-1	Ma Long	5
	3	Timo Boll	1-2	Ma Long	2
6	7	Ma Long	3-4	Timo Boll	3
7	1	Timo Boll	0-1	Ma Long	3
	15	Timo Boll	8-7	Ma Long	2

Fig. 10. Categorisation of error by forced, unforced, stroke types sorted by detailed information.

Transitional errors (6th Dashboard)

Movement in table tennis is considered to be a crucial technical aspect and it encompasses a lot of footwork agility, rapid stepping, explosiveness and so forth. It is not only important to reach to the ball, but also important to maintain balance, gain momentum to hit the ball with power. Withal, this is also studied to be an important part of an athlete strategies for gaining the point against the opponents through strategic placements. It is a deliberate effort by the athletes to place the balls in such a manner that the opponent gives error while transitioning from one side of the table to another side of the table.

We have classified transitional errors in three different types: lateral, diagonal and forward-backward. Lateral movements errors are described as an athlete making an error while moving horizontally straight from left to right and right to left zones of the table. For example – Backhand Long (BHL) to Forehand Long (FHL). Diagonal movements errors are moving from one diagonal short/half zone to another long or vice versa, For example, Forehand Short (FHS) side to Backhand Long (BHL). Forward-backward movement errors are moving from one vertically straight zone to another. For Example, Forehand Short (FHS) to Forehand Long (FHL). Figure 11 represents the transitional analysis dashboard, wherein we can compare the number and type of transitional errors given by both the players. Selection of type of errors can be done from the dropdown at the left side if the table. Figure 12, represents one example of each, diagonal, lateral and forward-backward movement

along with the tooltip providing the information of the stroke played from the placements while transitioning.

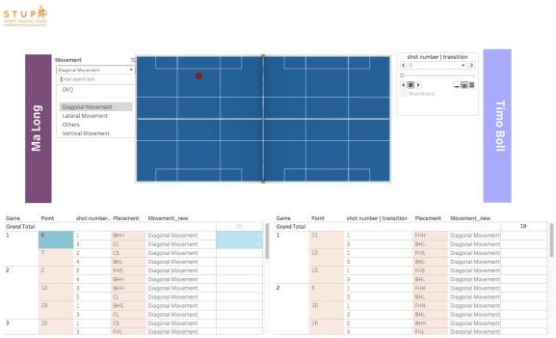


Fig. 11. Transitional Analysis Dashboard

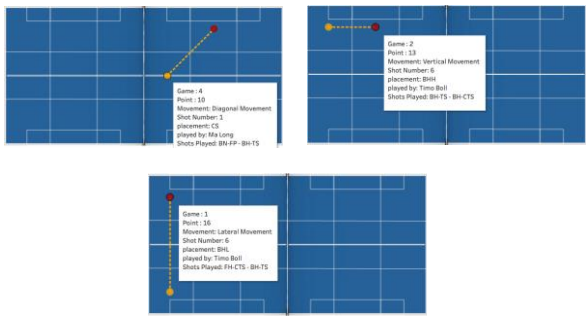


Fig. 12. Illustration of Transitional errors

Winning strokes & placements

The strokes which lead the opponent make an error are winning strokes, however, we have categorized them in two – Conditional & Unconditional Winners (Ambikesh Jayal, 2018). Conditional winning strokes are those which are win because an opponent made an unforced error whereas unconditional winners are the ones which lead the opponent to make a forced error. These further separated by the types of strokes, like whether it is a forehand topspin or backhand block etc., and also the placements at opponent side table zone (Figure 13).

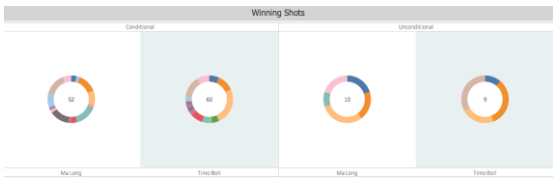


Fig. 13. Winning points segregated by strokes type

4.4. Ball placement Analysis

Ball placements analysis provides a quick snapshot of where the balls are being placed over 9 plus 6 (explained above) zones on the table. It is visualized on a table tennis table with respective percentage on each placement zone with interactive buttons at the top of the dashboard will segregates the balls placements by respective shot numbers like serves, returns, 3rd contact, 4th contact and others. Upon clicking on any of the button, it will pop out the placements zone marked with percentage of balls placed by the opponent to his side of the table, along with the information on the type of strokes placed. For example, Figure 14 shows the overall ball placements of the match.

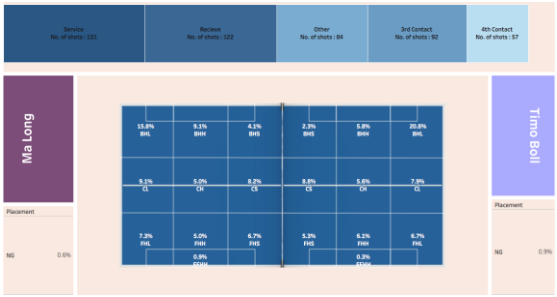


Fig. 14. Ball placement analysis dashboard

4.5. Attack analysis

Attack initiation analysis (7th Dashboard)

Most of the players have an attacking playing style and the most effective tactic is to serve and attack on the returned ball, however it is equally important to understand how many times an athlete is initiating the attack and at the same time converting the rally as well. The intent of the dashboard is to identify how many times both the athletes initiated the attack vis-a-vis winning the rally. The attack initiation depicts in the form of trend line wherein every ball in the line exhibits the number of times attack initiated by the athletes. From Figure 15, we can understand that Timo boll initiated the attack most of the times during the match.

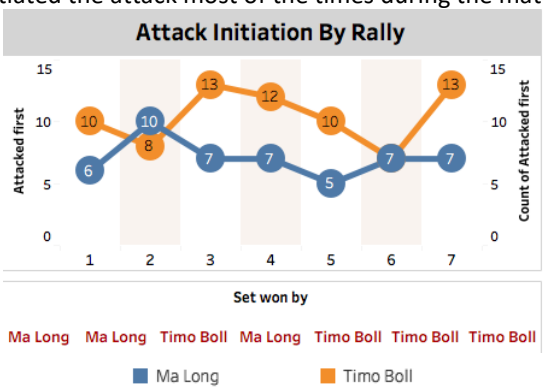


Fig. 15. Attack initiation trend by game

On hovering to the balls in trend line, we can view the tool tip that provide the information on who won the rallies, at what point the attack was initiated and what was the score, refer Figure 16.

Game	Point	PlayerA	Score	Player B	Won By
1	6	Timo Boll	2-4	Ma Long	Timo Boll
	8	Timo Boll	3-5	Ma Long	Ma Long
	9	Timo Boll	3-6	Ma Long	Ma Long
	11	Timo Boll	3-8	Ma Long	Ma Long
	12	Timo Boll	3-9	Ma Long	Ma Long
	13	Timo Boll	4-9	Ma Long	Timo Boll

Game	Point	PlayerA	Score	Player B	Won By
1	1	Timo Boll	0-1	Ma Long	Ma Long
	2	Timo Boll	0-2	Ma Long	Ma Long
	3	Timo Boll	0-3	Ma Long	Ma Long
	4	Timo Boll	1-3	Ma Long	Timo Boll
	5	Timo Boll	1-4	Ma Long	Ma Long
	7	Timo Boll	3-4	Ma Long	Timo Boll
	10	Timo Boll	3-7	Ma Long	Ma Long
	15	Timo Boll	5-10	Ma Long	Ma Long
	16	Timo Boll	6-10	Ma Long	Timo Boll
	17	Timo Boll	6-11	Ma Long	Ma Long

Fig. 16. Tool Tip view of attack initiation analysis

We have grouped the strokes as attacking, defensive or non-attacking strokes. For example, forehand topspin, backhand topspin, forehand flip, banana flip, forehand topspin in pivot position, forehand smash, backhand smash etc. are categorized as attacking strokes whereas counter, block etc. are categorized in non-attacking strokes.

4.6. Score analysis

While analysing a match, it is indeed very important to analyse the score information as it is strongly associated with game situation. As the score evolve and match progresses, a trend of winning and losing points can be visualized. We have used step chart for indicating the score analysis, where in the x axis is the point number and y axis is the score. For any gain of a point, the athlete rises by one point and for a point loss, it continues to remain in the same line. This analysis when collectively seen for many matches can provide insights about athlete behaviour at different stages of the game. Figure 17, represent the score progression of 7 games between Ma Long (in blue) and Timo boll (in pink). At any point, we can understand the score by hovering on the dots.

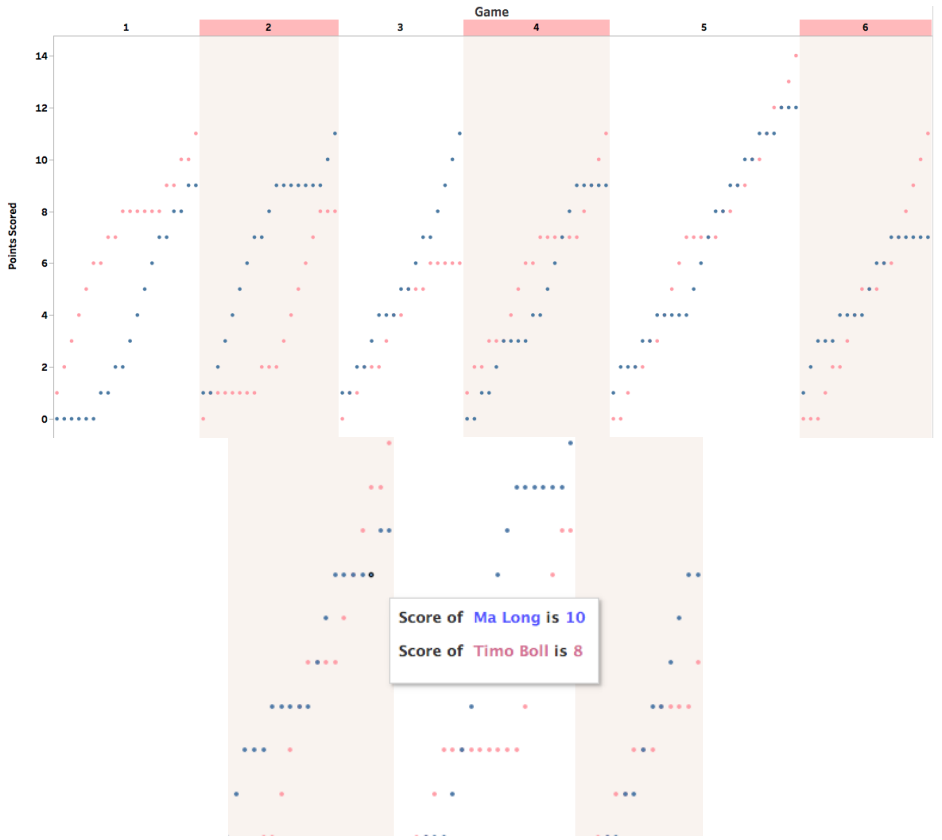


Fig. 17. Score progression during the match

5. ATHLETE PROFILING

5.1. Athlete profile summary

This is a snapshot of athlete profile that captures specific performance facts such as top 3 effective services or top 3 effective rally strokes that leads to maximum point conversion, Deuce point conversion rate, average attack rate, average unforced and forced error rate, etc. and also provide performance trends, for example, trend of errors w.r.t to opponents, trend of match win or losses and so forth. We are showing athlete profile of "Madhurika patkar", an Indian table tennis athletes in Women's category, currently ranked as India number 3.

5.2. Pattern of play

Shot response to serve

Serve and serve-return are indeed very crucial strokes of the match. Service is the most important stroke in the game because it provides the only situation in which you have control over how and where you play the ball and return is the second most important stroke in the game as it provides the first opportunity for you to play the ball (Hughes, n.d.). Therefore, identifying the pattern for shot response to

serve plays a pivotal role in understanding the underlying strategy and also to enhance the framework of returning the serves.

Shot response to serves identifies the types of returns played to an athlete to the different serves served by the opponent and also the shot response of opponents to the athlete's serves. Further, it provides insights on opponents serves, where the athlete is uncomfortable, i.e. provide maximum number of errors while returning to opponents serves and vice a versa. Figure 18, provide detailed information on the types of shot responses from Madhurika to the services given by the opponents. In the first bubble chart, the x axis represents the services placed by opponents to Madhurika and Y axis represents the responses of Madhurika to those services. The frequencies of responses is proportionate to the size of bubbles, for example, bigger size of the bubbles explains the mass responses of Madhurika and vice a versa. Similarly, the graph at the bottom, is reverse of the first one, as it shows the patters on what opponent returns to Madhurika on her services.

We can also see the placements of the responses by hovering on to the bubbles. Figure 19 provides the tool tip view of the bubble, providing the segregation of responses with placements.

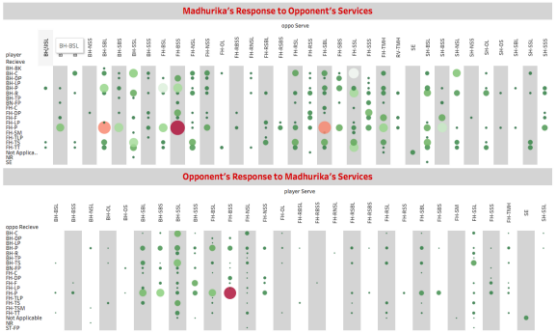


Fig. 18. Shot response to serve pattern

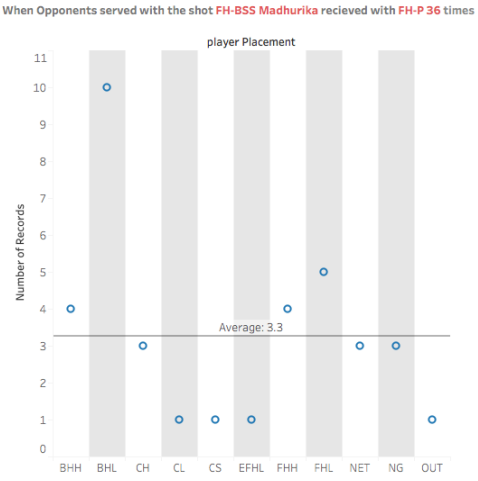


Fig. 19. Tool tip view of Shot response to serve pattern

Placement to placement response

This would describe the pattern of player's placement response to placements zones, i.e. whenever an athlete gets balls on their side of table zones, then, what are the main placements zones of the opponent's end where they places the ball. Figure 20 shows the placement to placement response dashboard, where in the top placement buttons show the number of times Madhurika received ball from opponents. She received total 813 balls on her Backhand long from different opponents, 364 on her forehand long etc. when we click on the buttons, for example, if we click on BHL, from Figure 21, we can see the break of 813, on the opponent's side. Out 813, 279 shots lead Madhurika to lose point, and from rest of the one, she placed 219 on opponents BHL, 141 on CL, 96 on FHL and so forth.

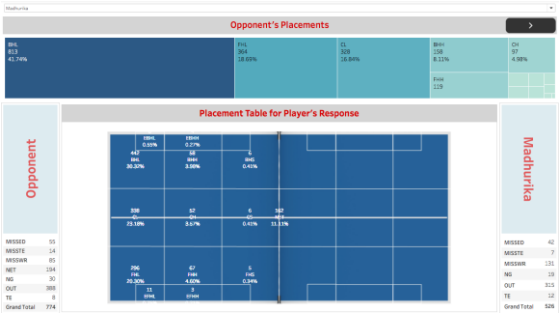


Fig. 20. Placement to placement response pattern dashboard

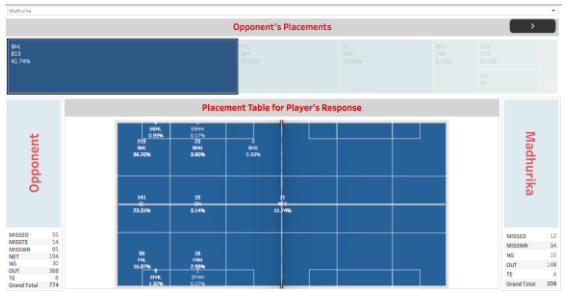


Fig. 21. Breakup of shot placement upon clicking BHL button

Shot response to placement

This describes the pattern of player's shot response from different placement zones, i.e. the shots played by an athlete when the previous shot placed by the opponent on these table zones of an athlete's side. It also identifies the success rate of that shot response from different placement zones and provide insights about the error zones i.e. maximum number of errors from certain placement zones by an athlete.

In Figure 22, we can see the table tennis table with number of shots placed by the opponents, when we click on any of the button, we can right the number of shots played by an athlete at the left side. For example, in Figure 23, we clicked on

BHL of Madhurika, that provides the breakup of 813 shots played by Madhurika on the left side of the table through bubbles, wherein the size of bubble is proportionate to the frequency of shots played from that zone.

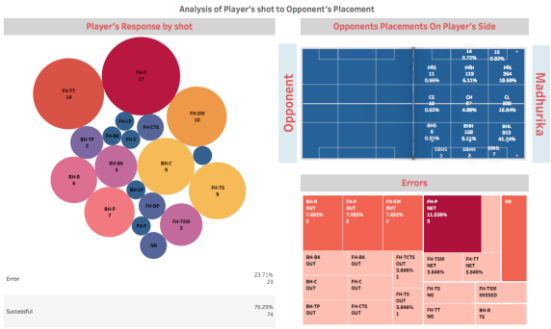


Fig. 22. Shot response to placement pattern

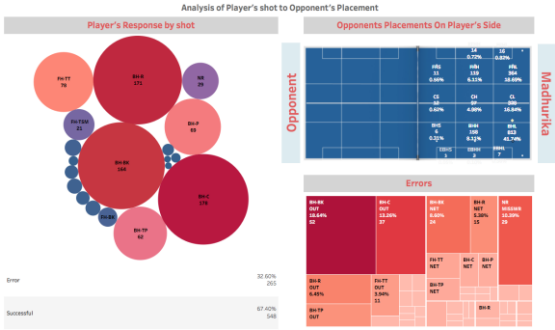


Fig. 23. View of shots response after clicking on one of the placements

6. CONCLUSION

Effective coaching is crucial for optimal performance and notational analysis using advance data analytics has increased the coaching effectiveness. While it is clear that quantification and assessment of performance are required, systematic and objective observations through notational analysis provide reliable, consistent and accurate data for coaches to rely on. The most common form of data analysis is to reckon the frequencies of events and their respective positions and certainly derives the sums, percentages etc. Notational analysis, when merged with advance data analytics derives insightful and profound analysis supporting the game narration and visual metaphors that provides a great advantage to coaches and athletes for comprehending the performance data and perform best to their capacities.

The analysis offers visual exploration of table tennis data that offers the domain experts, coaches, athletes as new perspective of understanding their technical performances.

REFERENCES

Ambikesh Jayal, A. M. (2018). *Sports analytics.* (R. s. analysis, Ed.) Routledge.

Hughes, M. (n.d.). *Tactics in Table Tennis*. (M. Hughes, Editor) Retrieved April 17, 2019, from allabouttabletennis: https://www.allabouttabletennis.com/tactics-in-table-tennis.html

Hughes, M., Evans, S., & Wells, J. (2001). Establishing normative profiles in performance analysis*. International Journal of Performance Analysis, 1*(1), 1-26.

James, N. (2009, November). *Performance analysis to improve sport performance.* UWIC, Cardiff, UK., School of Sport, . Reader in Performance Analysis of Sport. Retrieved from http://altorendimiento.com/performance-analysis-to-improve-sport-performance/

R Foundation, T. (n.d.). *The R Project for Statistical Computing*. Retrieved from R Project: https://www.r-project.org

Tableau. (n.d.). *About us*. Retrieved from https://www.tableau.com/about

Tamaki, S., Yoshida, K., & Yamada, K. (2017). A Shot Number Based Approach to Performance Analysis in Table Tennis. *Journal of Human Kinetics, 55*, 7-18 *DOI: 10.1515/hukin-2017-0002 7 Racket Sports*.

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Tactical analysis of top ranked players and its implications to educating players and coaches in table tennis

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Abstract: Top ranked players 2016-19 representing main type-styles of play were selected: topspin and fast attack (ex. Ma Long, Fan Zhendong, Harimoto, Lin Gaoyuan, Boll, Ding Ning), pen-hold topspin and fast attack (ex. Xu Xin, Wang Hao, Zheng Peifeng), fast and topspin attack (ex. Falk, Ito), chopping defence (ex. Joo Sehyuk, Filus, Ma Te, Li Qian, Wu Yang), 'kombi-attack' (ex. He Zhuojia, Fukuhara, Ni Xialian, Zhou Xintong).

Over 30 matches among and against top ranked players were selected to perform statistical analysis. The method of game analysis of professor Wu Huanqun, modified by the author, enabled statistical results in main fragments of the game: service-counterattack, return-counterattack, push-counterattack, attack-counterattack, block-counterattack, chop-counterattack, attack-against-chopping. The implications for building training systems in table tennis, especially for FUNdamental 1&2 stages children (ex. talent identification and long-term training) and Level 2 coaching education programs will be presented.

Keywords: tactical analysis, FUNdamental stage 1&2 training, Level 2 coaching education

1. INTRODUCTION

Objectives of the article. The aim of the article is to present the change that has taken place in the awareness of trainers learning about tactical training at level 2 (the second stage of coaching education): (a) what is the structure of the winning actions from the world's top-ranked players in the basic types-styles of games, how they win and how they lose ; (b) what is the reason for planning and how to improve the tactical preparation of trained children; (c) what this implies for trainer training and how to improve their tactical coaching knowledge and skills.

National Table Tennis Development Program in Poland 2018-33. Since Grubba's glory, one of the most important reasons for the defeats of the leading players in Poland was the low level of adaptation to the various types of competitor's types-styles. For example, Grubba could never beat fast attacking Teng Yi, 20-year-old Lucjan Błaszczyk at the World Championships 1995 beat the three Chinese champions to the quarter-finals, but lost for the medal with defensive Ding Song. The leading Polish players never defeated the Ni Xialian "combi-attack" representative. Partyka and Grzybowska played about 20 times with Li Qian, but none of them ever has beaten her. For years, we know that building each training group, especially at the level of the national team, should be based on the appropriate proportions of different styles of the game - the so-called "small world" (Grycan, 2007, 2009, 2017; Wang, 2005; Wu & Zhang, 2008; Wu & Lin, 2005). For

example, Professor Wu Huanqin describes four main types (leixing) and 18 styles (dafa) of table tennis (Wu & Zhang, 2008). In the years 2010-17, tactical preparation was part of the training of trainers and children in the program "Fundamentals, from dreams to mastery". The program involved over 300 trainers at level 1 and 40 level 2 trainers. At least the initial stage of training was about 3,500 children. The training took the form of workshops, camps, coaching resources and teleconferences. The key questions were: How to develop the "small world" in every Fundamentals 2 center. How to raise all types-styles of the game to the next level of training? Until now, many Polish trainers have never trained a penholder, a defender, a combi-attacker (playing with long pimples player) or playing a fast attack players. A "small world" appeared on nationwide camps for children and was the basis for the highest quality of training. However, after a few years we found that players trained by our trainers in styles other than the topspin attack do not play at a satisfactory level, training tactical awareness is still neglected, and at the FUNdamentals 1 stage. The development of the "small world" has become one of the most important elements of further training as part of the National Table Tennis Development Program 2018-33 created on the basis of the "FUNdaments, from dreams to mastery" program.

Tactical training program for trainers. On the basis of literature, the tactical training program should include, among others: (a) Development of tactical awareness and basic tactical principles implemented at the initial stage of training children (FUNdamenty 1) (Grycan, 2007, 2017; Su, 2009; Wu, 2005; Wu & Zhang, 2008); (b) Development of the individual type-style of the game (topspin attack, fast attack, attack with penhold grip, chop defense, combi-attack) (Grycan, 2007, 2017; Liang, 1985; Wang, 2005; Wu, 2005; Wu & Zhang, 2008; Wu & Lin, 2005; Wu & Su, 2010; Zhang & Zhang, 2008); (c) Development of individual tactical combinations within the basic parts of the game (attack-counterattack, block-counterattack, attack-against-chop, chop-counterattack, push-counterattack, serve-counterattack, return-counterattack) in basic training stage (FUNdamenty 2) (Grycan, 2007, 2017; Liang, 1985; Liu et al., 2010; Zhang & Zhang, 2008).

Polish Qualifications Framework 5 for trainers (level 2). ITTF assumes also levels 1, 2 and higher as part of its trainer's training system. However, it does not specify any learning effects, nor does it provide training for tactical awareness, development of the "small world", fragments of the game and tactical strategies. The Polish Qualifications Framework 5 for trainers on level 2 is different than in the ITTF's manuals (Molodzoff, 2008; Tepper, 2007). In PRK5, as part of the development and implementation of the annual training plan, the trainer at level 2, among others: formulates training goals, prepares a plan for their implementation (including an annual organizational and training plan, plans training lessons taking into account different types of game styles); conducts evaluation of the implementation of training objectives; assesses the players' disposition to participate in the training process and competitions; assigns players to training groups; prepares players in technical, physical, mental and tactical aspects. Trainer preparing players in a tactical aspect, among others: (1). Shapes and develops the individual type-style of players' play: topspin attack (shake-hand, pen-hold, one-sided, two-wings, etc.); fast attack (shake-hand, pen-hold, one-sided, two-wings, etc.); chop defense (passive, active in

various combinations); combi-attack (shake-hand, pen-hold in various combinations); (2). Teaches players of tactical strategies within each of fragment of the game: attack-counterattack, block-counterattack, attack against chop, defense with chop-counterattack; pushes-counterattacks; serve-counterattack; return-counter-attack. As part of the preparation of players to participate in competitions, the trainer, among other things, gets information about opponents (e.g. analyzes statistical data on opponents' tactics) and develops tactics (e.g. selects tactical strategies of the game to the player's individual characteristics, conducts analysis of the course of the game, etc.), analyzes the effectiveness of adopted game tactics.

Fundamentals 5. From 2017, a separate tactical training program for trainers was introduced, called "Fundamentals 5" in the form of 3-day workshops Grycan, 2017). As part of the program, there was a need to do additional research of players from the world's tops representing various types of game styles from recent years, especially after the introduction of plastic balls. In the last two years, two three-day pilot tactical training was conducted.

2. METHODS

Game analysis. Over 30 best possible (available on the Internet) games of players representing all basic types of game styles were selected for analysis (ITTF; www.youtube.com). The most interesting confrontations between different types-styles were selected. The analysis of the game by Professor Wu Huanqun modified by the author (Grycan, 2007, 2009; Wu, 2005; Wu & Zhang, 2008) was used, so as to get information about the winning actions of both players, and to get information about the winning actions in each fragment of the game.

Action research. The course of two 3-day training workshops together for 16 trainers and the initial process of implementing the newly acquired knowledge into the practice of training children were examined. The Ernest T. Springer method was used (Springer, 1999). The following procedures were used in this process: (a) observation - data collection; (b) thinking - researching and analyzing: what is happening? how? why? (c) operation - plan, application and evaluation.

After Action Review. One of the tools systematically used as part of the program "Fundamentals, from dream to Mastery" is the method of "after action review" (Salem-Shatz, Ordin, & Mittman, 2010). According to this method, participants answered the following questions: (a) what was going to happen, what was the goal, (b) what actually happened, (c) what went well and why, (d) what could be improved and how?

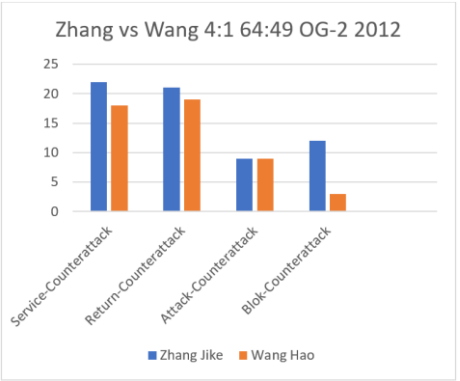
3. RESULTS

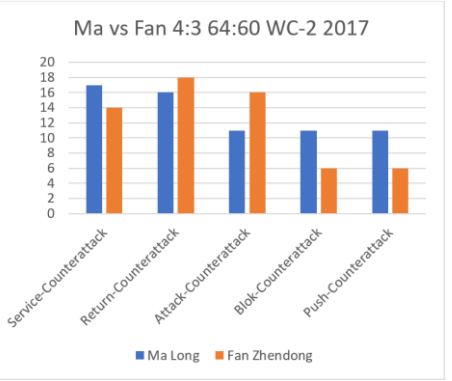
As part of the tactical training, the coaches made the characteristics of their pupils, began designing the annual tactical training plan, creating their hypotheses about the tasks, volume and structure of training, for the group and for each child, etc. Later they received updated knowledge of how do the top ranked players representing various types-styles play (how do they win or lose) etc..

3.1. How do players of topspin attack win?

Zhang Jike vs Wang Hao. 70% of all rallies are "the first four balls". Zhang won the serve-counterattack 22:18 (34%), return-counterattack 21:19 (33%), and long rallies 21:12 (33%). The decisive factor for the victory, however, seems to be block-counterattack of Zhang Jike (12:2). Look below-left.

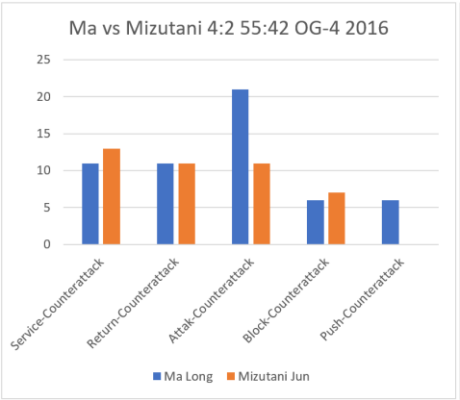
Ma Long vs Fan Zhendong. The first 4 balls accounted for 52%. Different structure of winnings of long rallies. Ma has achieved following results: service-counter-attack 17:14 (26%), return-counterattack 16:18 (25%), attack-counterattack 11:16 (17%), block-counterattack 11:6 (11%) and push-counterattack 11:6 (11%). Fan attacked more. Ma was more effective in push- and block-counterattack. See below-right.

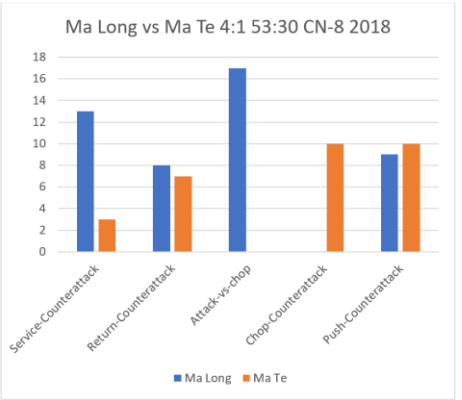




Ma Long vs Mizutani. Mizutani played the topspin attack a little further behind the table. There were 46 short rallies (47%). Ma Long had a decisive advantage in two parts: attack-counterattack (21:11, 38% of winnings of his rallies) and push-counterattack (6:0). A great duel. Look below-left.

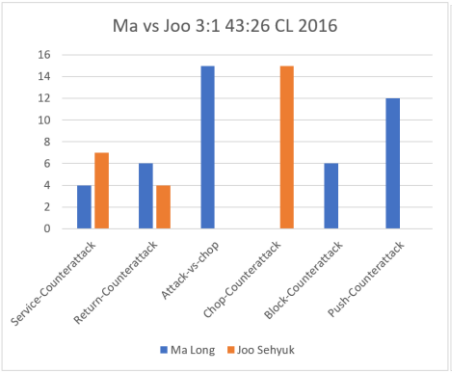
Ma Long vs Ma Te. Ma Long had a significant advantage on the first four balls (21:10, 39% of his winning points). Ma Long dominated in service-attack (13:3), and attack-against-chop (17:10). Ma Te - lost the serve-, return-, and chop-counterattack in confrontation with Ma Long. Recently, ex-world champion, defender Ding Song, pointed out that the defender of the future should have a much better serve-counterattack - like Chen Xinhua or Ding Song- and defense like Joo Sehyuk, but also return-counter-attack similar to attackers). Look below-right.

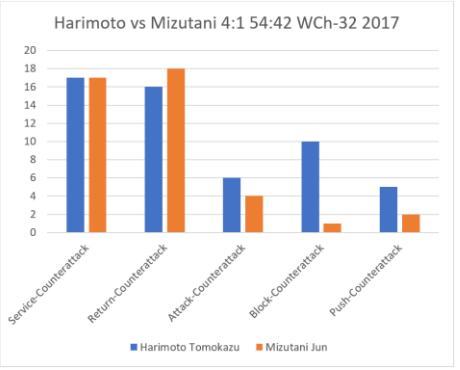




Ma Long vs Joo Sehyuk. 30% of all "first 4 balls" (10:11). Ma was definitely better in the block- and push-counterattack (18:0). Joo's attack was too weak for Ma Long. Clearly much better chopping defense against the attack of Ma Long (15:15). For comparison, chopping Ma Te against Ma Long had 10:17.

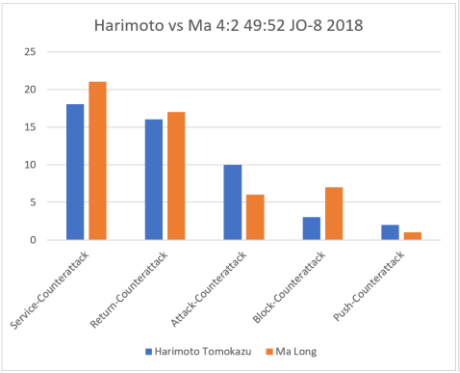
Harimoto vs Mizutani. Over 70% of both players' rallies are "the first 4 balls". Harimoto had a big advantage in long actions – push-, block-, attack-counterattack (21:7).

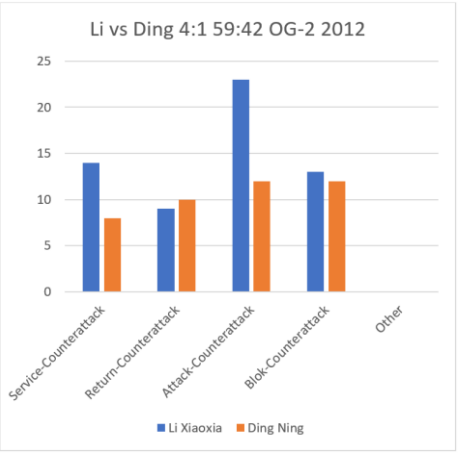




Harimoto vs Ma Long. Sensational victory of Harimoto at the 2018 Japan Open. 70% winnings of the first 4 balls of both players with a Ma Long advantage (38:33). Harimoto played a little more aggressively than Ma Long.

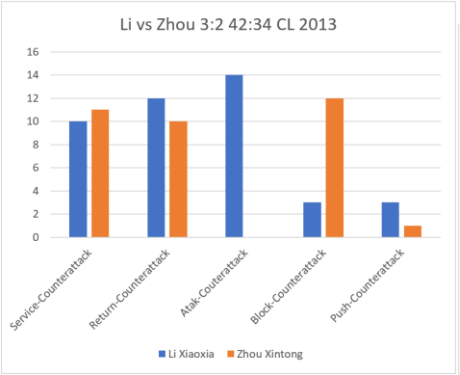
Li Xiaoxia vs Ding Ning. 40% of the rallies of the first four balls. The advantage of Li. Received servings from Ding Ning. Li's predominant advantage in service-attack (14:8) and attack-counterattack (23:12).

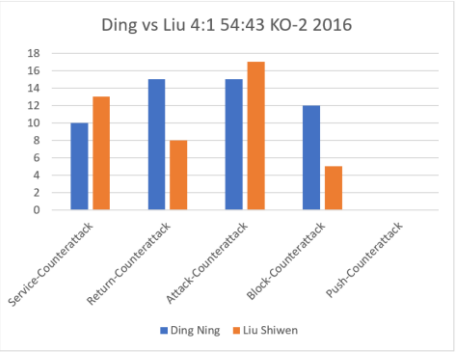




Li Xiaoxia vs Zhou Xintong. Short actions - 22:21 for Li, it's about 70% of all rallies. Li Xiaoxia had an advantage in long actions (18:13). Zhou - weak attack-counterattack (0:12), but excellent block-counterattack (12:3).

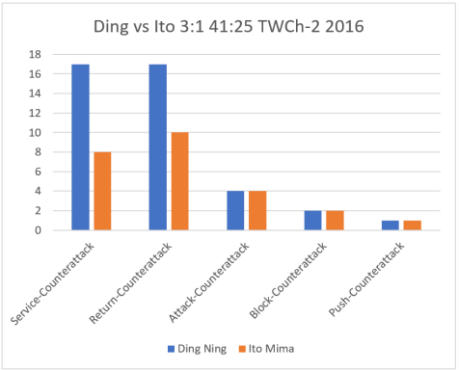
Ding Ning vs Liu Shiwen. 50% of the first four balls (46 balls). Ding clearly dominated the return-counterattack (15:8) and block-counter-attack (12:5).

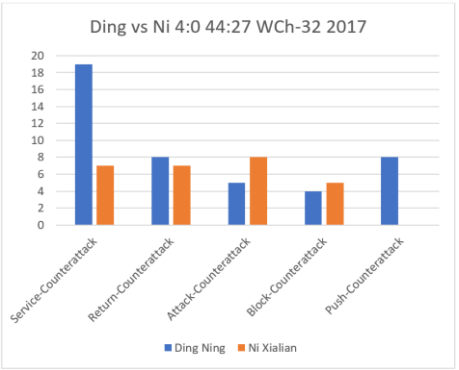




Ding Ning vs Ito. 52 rallies of the first 4 balls (almost 80%). Domination Ding in the first 4 balls (34:18).

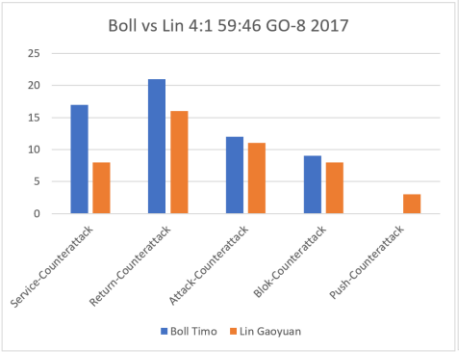
Ding Ning vs Ni Xialian. Domination of Ding: service-counter-attack (19:7) and push-counter-attack (8:0).

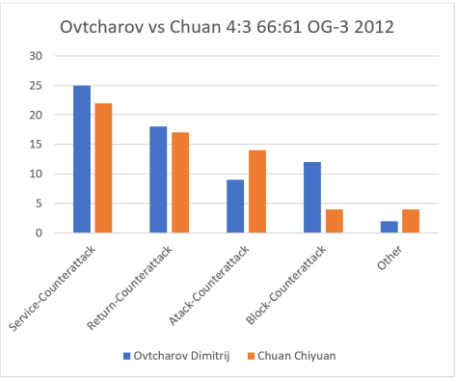




Boll vs Lin Gaoyuan. Boll's decisive advantage in service-attack (17:8) and return-counterattack (21:16).

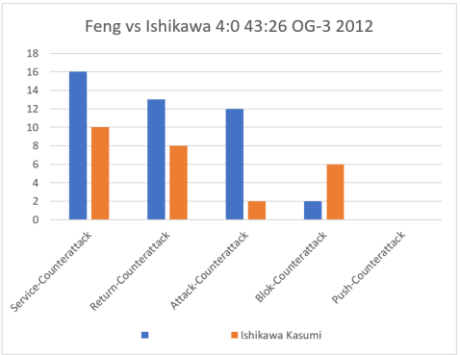
Ovtcharov vs Chuan Chiyuan. Over 65% of rallies are the first 4 balls. A slight advantage of Ovtcharov (43:39). Ovtcharov's significant advantage in the block-counter-attack (12: 4).

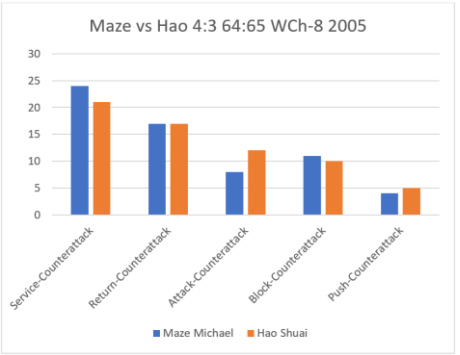




Feng Tianwei vs Ishikawa. Feng's dominance in the service-attack (16:10), return-counterattack (13:8) and attack-counterattack (12: 2).

Maze vs Hao Shuai. Maybe after watching the TV coverage, you'd get the idea that Maze won the match mainly with lobbing? Very nice and balanced duel in every part of the game. Among 11 actions of defense (block)-counterattack, there are 6 points, which Maze won by the lobbing defense.

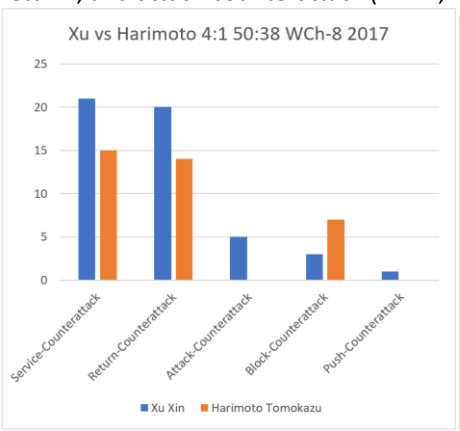


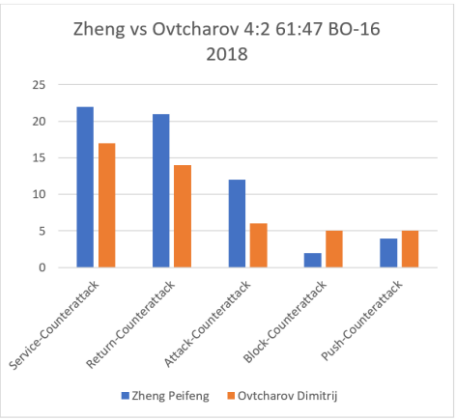


3.2. How do pen-hold topspin attackers win?

Xu Xin vs Harimoto. Xu dominance in the first 4 balls (41 win rallies, it's 82% of all won rallies).

Zhen Peifeng vs Ovtcharov. 70% of the first 4 balls. Zhen's domination in service-, return-, and attack-counterattack (22:17, 21:14, 12:6).

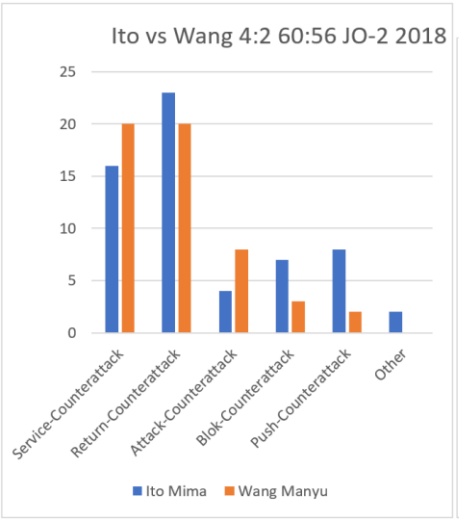


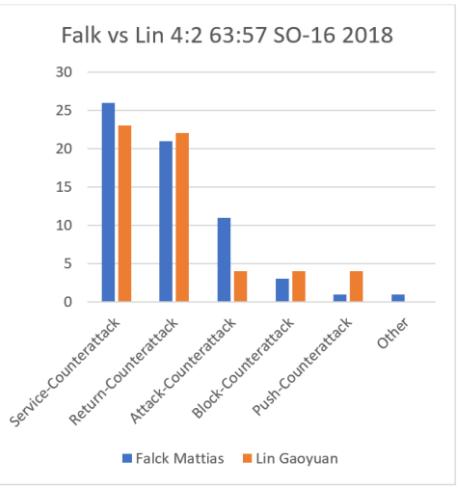


3.3. How do fast attackers win?

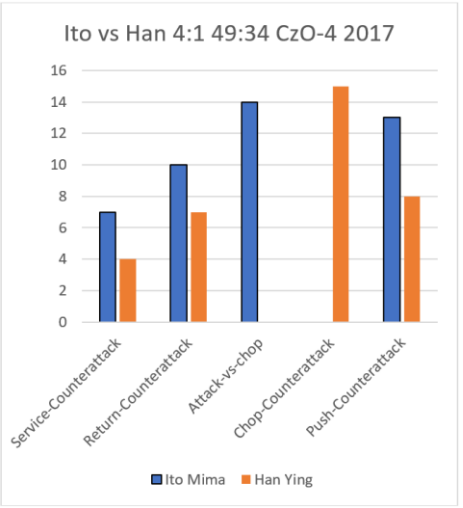
Ito Mima vs Wang Manyu. A fast attack player who won the Japan Open and Swedish Open 2018. Defeating almost all the best Chinese representatives. Let's see how she won with Wang Manyu: service-attack 16:19 (32%), return-counterattack 23:20 (38%), long rallies 19:13 (32%). First four balls - 79 rallies (about 75%). Ito gained advantage in the block-counter-attack (7:3) and push-counterattack (8:2).

Falck Mattias vs Lin Gaoyuan. 80% of rallies are the first 4 balls - balanced fight (47:45). Falck's won rallies: service-counter-attack 26:23 (41%), return-counterattack 21:22 (33%), long rallies 15:12 (24%). The difference was made in the attack-counterattack for Falck (11:4).





Ito Mima vs Han Ying. In Ito's attack-against-chop-counterattack of Han there was a balance (14:15). Ito gained advantage in a service-attack (7:4), return-counter-attack (10:7), and push-counter-attack (13:8).

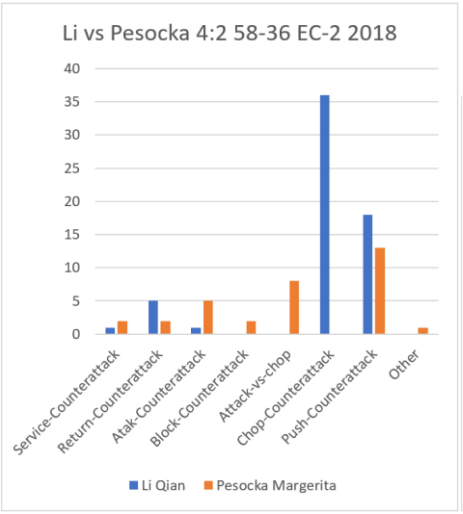


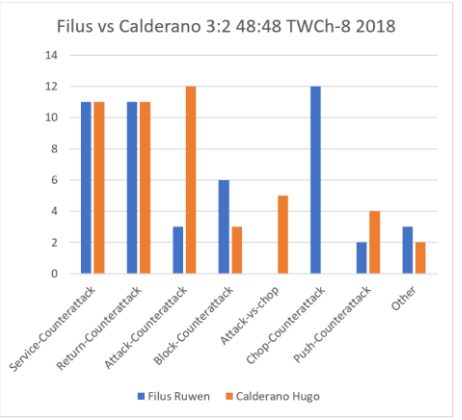
3.4. How do defensive players win?

Li Qian vs Pesocka Magerita. All the rallies of the first 4 balls were 10 (12%). Li won: service-attack 1:2 (2%), return-counterattack 5:2 (9%), attack-counterattack 1:5 (2%), chop-counterattack vs attack-vs-chop 36: 8 (62%), push-counterattack 18:13 (31%). Li won mainly chop-counter-attack against Pesocka's attack (36:8). In addition, Li won the push-counter-attack actions 18:13 (31%). Pesocka vs Li Qian,

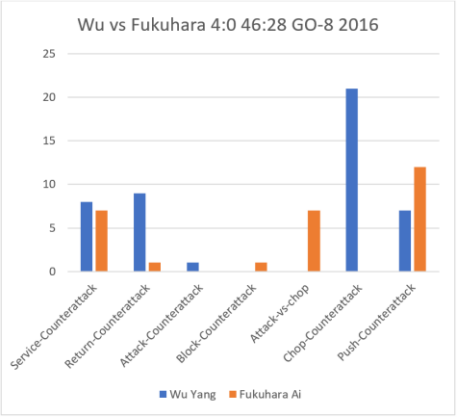
played mainly push=counterattack (13 wins). In attack-against-chop she won only 8 points.

Filus Ruwen vs Calderano Hugo. How did Filus win with Calderano? Service-counterattack 11:11 (23%), return-counterattack 11:11 (23%), attack-counterattack 3:12 (6%), chop-counterattack vs attack-vs-chop 12:5 (25%), push-counterattack 2:4 (4%). Very balanced game in the first 4 balls (22:22, 46% of all rallies). Chop-counterattack of Filus against attack-vs-chop of Calderano (12:5) was decisive. Calderano had weak attack-vs-chop.





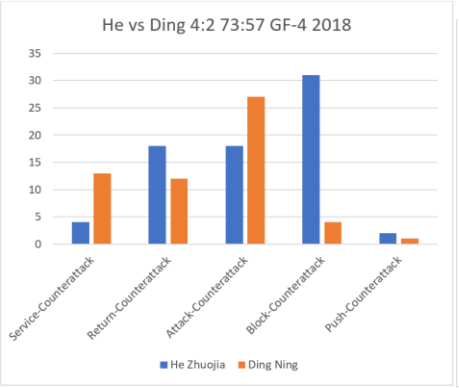
Wu Yang vs Fukuhara. Leading Chinese chopper, against the Olympic vice-champion in the team, and the fourth player in the single in Rio. Wu is definitely more effective in chop-counterattacking vs attack-vs-chop (21:7) and return-counterattack (9:1).

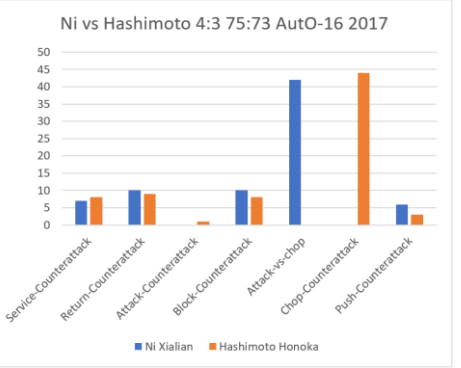


3.5. How do combi-attackers win?

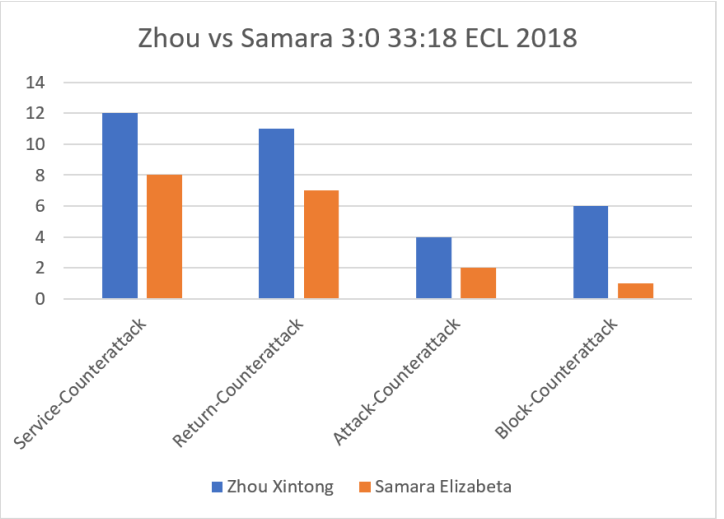
He Zhuojia vs Ding Ning. He Zhuojia defeated the best player in the world of recent years. What did she win? Service-attack 4:13 (5%), return-counterattack 18:12 (25%), attack-counterattack 18:27 (25%), block-counterattack 31:4 (42%), push-counterattack 2:1 (3%). He won as many as 31 (40%) of block-counter-attack (31:4) and clearly won a return-counterattack (17:12). Interestingly, He had a relatively weak service-attack (4:13). The backhand of He recalls backhand of Deng Yaping's "table tennis queen". She plays long pimples very offensively and does not change sides of the bat.

Ni Xialian vs Hashimoto. Ni Xialian - rallies of the first 4 balls constitute slightly over 30% of all rallies. The majority of rallies (almost 60%) are long-attacking chop-rallies of Ni Xialian (42 won rallies) against Hashimoto's chop-counter-attack (44 won rallies). Ni gained a minimal but significant advantage in the block- and push-counterattack (10:8 and 6:3).





Zhou Xintong vs Samara. Zhou domination in all fragments of the game: service-attack 12:8 (36%), return-counterattack 11:7 (33%), attack-counter-attack 4:2 (12%), and block-counter-attack 6:1 (18%)). Samara – 2 rallies won with attack-counterattack actions out of 50. Comparing to the game Li Xiaoxia vs Zhou Xintong: Li has won 18 attack-counterattacks, Samara only 2. Li was able to play a lot of two-wings topspins in many rallies (each rallie with several topspins). Samara - attack against block-counterattack of Zhou was much weaker then that of Li. Here is the technical difference between Li Xiaoxia and Samara.



4. DISCUSSION AND CONCLUSIONS

Coaches participating in the tactical program stated that this is "the most neglected subject in their entire training to date". One trainer said that "FUNdamentals 5 workshops are the best part of the entire program" in which he has participated so far.

The workshop and supplementary materials gave the trainers "a great deal of systematized, new knowledge about game styles, game fragments and tactical strategies".

The training participants stated that the requirements for trainers at level 1 should be raised: (1) consistently develop tactical awareness, while teaching each new game technical skill, (2) fully implement lessons of general tactical principles, (3) reflect from the beginning on specific talents, strengths and preferences of each child; and (4) create and test early hypotheses about the type-style of the game for everyone.

We should definitely develop our tactical awareness training at the FUNdamentals 1 stage: (1) daily training should include learning the general principles of "how to win in table tennis"; (2) develop the children's awareness every day, "how I won", "how I lost", etc.; (3) create an environment in which children, from the beginning, can see the best and diverse patterns of good and effective global competitors.

Identifying talents for each type-style of play: (1) most level 1 and working with beginners trainers did not think about looking for talents for different type-style of play; (2) one should start thinking about this at the initial stage; (3) during trainings in the workshop, trainers began to discover ideas for the further development of each child.

The training participants stated that the requirements for trainers at level 2 should be raised: (1) tactical training has so far been a neglected element of training in the training of children at stage 2; (2) trainers hardly carry out any technical and tactical analysis of their pupils, this should be learned and systematically carried out; (3) only some trainers in stage 2 develop a "small world" to a limited extent that should be developed in each training group; (4) harmoniously all fragments of the game should be developed; (5) and prepare clear tactical strategies for each player.

For participants of the workshop appeared to become a priority coaching skill to conduct a technical-tactical analysis of the game of their pupils: (1) it "opens the eyes" to the real determination of strengths and weaknesses and characteristics of each young adept, but also the main opponents; (2) it is the starting point for any rational training plan, including an annual plan; (3) a good mastery of the "live" analysis can be a very useful tool in the process of "coaching" during competitions.

Further development of the training planning skills requires reorganization of the whole weekly and annual planning idea: (1) the image of trainers before and after the training has completely changed - what, how and in what proportion, for whom to plan etc.; (2) plans for the whole group should be developed, taking into account the "small world" building in each training group; (3) each piece of the game should be harmoniously developed for each young athlete, including his/her type-style of play; (4) all elements of the training plan- technical, tactical, physical and mental training - should be integrated.

Attack-counterattack development: (1) trainers studying together the world's leading players, have found that "every top player's attack-counterattack is played differently"; (2) trainers realized the need to develop a variety of ways of attack in each group - topspin vs fast attack; attack closer vs off the table; one-sided vs two-sided etc.; (3) participants have developed "preliminary hypotheses" of how each of the pupils can attack.

The training participants stated that (1) in most cases they do not use or plan a tactical block-counter-attack training; (2) the development of block-counter-consciousness is another challenge that can significantly improve the effectiveness of the whole game.

Development of chopping-counterattack: (1) participants of the training stated that their pupils "poorly play chop and counterattack" and "poorly play against the choppers"; (2) it is a beautiful and spectacular game; (3) look for children who are agile, patient, intelligent, play consistently, relentlessly; and not those that are "unsuitable for attack"; (4) bravely train good defenders; (5) deal with numerous myths about the defense game.

The development of the attack-against-chop: (1) to develop this skill, which is in our case low level, it is necessary to train good defenders; (2) participants here have experienced their weaknesses and commented that "you have to start working professionally", "raise the bar", "raise the requirements in our training work" etc..

Development of a push-counterattack: (1) training participants discovered studying the best players in the world, that "if the player does not have a good push-counterattack, there is no good game"; (2) the trainers stated that they often neglected the push-counterattack, and this must change.

Development of service-counter-attack: (1) participants of the training underestimated the importance of service-counter-attack and return-counterattack, at the beginning they would plan about 10-20% of training time, but after our workshops, at least 40-50%; (2) Trained trainers realized that by building a "small world" in their clubs and centers, they must take into account the diversity of services and attacks of the 3rd ball; (3) and that they must have a good one-year training plan for service-counter-attack for each player.

The development of return-counterattack: (1) after studying the return-counterattack of the world's leading players, the training participants stated that the most important parts of the game are the service-counter-attack and return-counter-attack, and unfortunately the training of these parts of the game is very neglected; (2) Each of our pupils must be prepared to receive any type of service-counter-attack.

The creation of a mutual support culture of trainers in the field of tactical training should be updated at subsequent workshops, teleconferences, consultations, camps and workshops for children.

All participants of the training emphasized: (1) the gratitude with which they remain; (2) willingness to further improve and improve their qualifications; (3) motivation to continue working after the training.

REFERENCES

Grycan J. (2017). Fundamental stage of development in table tennis (Polish experience). Proceeding Book of the 15th ITTF Sports Science Congress, Düsseldorf, May 27th-28th 2017

Grycan, J. (2007). *Integralny tenis stołowy* [Integral table tennis]. Kraków: JGTT.

Grycan J. (2009). Międzynarodowe Mistrzostwa Węgier Kadetów 2009. http://integralnytenisstolowy.com/miedzynarodowe-mistrzostwa-wegier-kadetow-2009/

Grycan, J. (2017), Program szkolenia w sporcie: Tenis stołowy. Załącznik do rozporządzenia Ministra Edukacji Narodowej z dnia 29.03.2017. Warszawa: PZTS.

Liang, ZH. (1985). Youguanpingpangqiu jishuxunlian he zhanshuxunlian qufengde yanjiu [Study about differences in technical and tactical training in table tennis]. Beijing: Zhongguo Tiyu Keji.

Liu, JH., et all. (2010). *Pingpangqiu jiaoxue yuxunlian* [Teaching and training table tennis]. Beijing: Renmintiyuchupianshe

Molodzoff, P., (2008). *Advanced coaching manual*. Lausanne: ITTF.

Official ITTF Channel https://www.youtube.com/user/ittfchannel/videos

Salem-Schatz, S., Ordin, D., & Mittman, B. (2010). *Guide to the after action review*. Retrieved on April 26th 2017 from https://www.cebma.org/wp-content/uploads/Guide-to-the-after_action_review.pdf.

Springer, E.T., (1999). *Action research*. Thousand Oaks, London: Sage Publications.

Su, P.R. (2009). *Xiandai pingpangqiuyundong jiaoxue yuxunlian* [Modern table tennis teaching and training]. Beijing: Renmin tiyu chupienshe.

Tepper, G. (Ed.) (2007). *ITTF-PTT level 1 coaching manual*. Lausanne: ITTF.

Wang, J.C., (2005). The present situation and prospect of talent identification of table

tennis players in China. In X.P. Zhang, D.D. Xiao & Y. Dong (Eds.), *The proceedings of the Ninth International table tennis federation sports science congress – Shanghai, China, April 27th-30th 2005*. 2nd ed. (pp. 313-320). Beijing: People's sports publishing house of China.

Wu, H.Q., (2005). Research on the principles of Chinese table tennis training. In X.P. Zhang, D.D. Xiao & Y. Dong (Eds.), *The proceedings of the Ninth International table tennis federation sports science congress –Shanghai, China, April 27th-30th 2005*. 2nd ed. (pp. 329-345). Beijing: People's sports publishing house of China.

Wu, H.Q., & Zhang, X.P. (2008). *Zhongguo pingpangqiu jingjizhisheng guilu dekexue yanjiu yuchuanxin shizhan* [Scientific studying and innovating of winning principles in Chinese table tennis]. Beijing: Renmin tiyu chupianshe.

Wu, T.C., & Lin, S.H. (2005). Analysis of the success of the China table tennis team under the national sports system. In X.P. Zhang, D.D. Xiao & Y. Dong (Eds.), *The proceedings of the Ninth International table tennis federation sports science congress –Shanghai, China, April 27th-30th 2005*. 2nd ed. (pp. 268-276). Beijing: People's sports publishing house of China.

Wu, T.C., & Su, P.R. (2010). How to coach world-class athletes of table tennis. *International Journal of Table Tennis Sciences, 6,* 195 – 199.

https://www.youtube.com/

Zhang, X.P., & Zhang, J.R. (2008). *Da hao pingpangqiu*. [Play good table tennis]. Beijing: Beijing Science-Education Audiovisual Publishing House.

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Home-advantage in table tennis league competitions

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Abstract: Home-advantage researches examine the performance difference of teams and athletes between home field or halls and away field or halls. A non-typical aspect of researching the presence or absence of home-advantage in table tennis is the balanced (e.g. national leagues) schedules perspective. A previous paper didn't find the home-advantage as a significant phenomenon in the men's German Bundesleague 1.

The Austrian Bundesleague 1's team matches between 2008 and 2018 were examined.

46% of the matches ended with a home victory, 41% ended with a guest victory and 14% ended with a draw. The presence of home-advantage was significant for the final result of team matches ($Z(604) = -2.910$, $p < 0.01$) and for the difference of won and lost individual matches by the home teams ($Z(604) = -3.623$, $p < 0.01$). There was no significant difference between top, average and low level teams in the difference of home and away winning ratio ($\chi^2(114) = 1.339$, $p > 0.5$) and in the difference of gathered individual matches at home and away ($\chi^2(114) = 0.796$, $p > 0.5$).

The result is suitable to other team sports' results but unusual if we take into consideration the individual sport competitions like tennis or boxing. However the difference is maybe caused that the individuals are cooperating as a team in this situation.

Keywords: home advantage, balanced schedule, league competitions, table tennis

1. INTRODUCTION

Home-advantage researches examine the performance difference of teams and athletes between home field or halls and away field or halls. Team competitions have two different types from the point of view the presence of home or away matches. If the possibility exists for both of the two opponent teams to play at home and away against each other then we call this competition a balanced scheduled competition (e.g. the classical league competitions like FA Premier League or German Table Tennis Bundesleague). If only one of the two opposite teams has the possibility to play at home field or maybe none of them has this possibility then we call it unbalanced schedule (e.g. FIFA World Cup, World Table Tennis Team Championship) (Legaz-Arrese et al., 2012). Origins of home-advantage research go back to the balanced leagues from North America (e.g. NHL, NBA etc.) but more and more analyses were made especially for the European soccer too. Much less papers were produced about the relationship of individual sports and home-advantage.

In the case of balanced competition, Pollard (1986) expressed the home-advantage as the ratio of gained championship points at home and the total gained

points during the championship, while Courneya and Carron (1992) defined it how much the victory rate of a home team exceeds the 50% victory rate. According to Bray (1999) the home advantage exists if the difference between the wins at home and away is greater than 5 percentage points.

Table tennis is an individual sport so unbalanced tournaments are typical in its competition system. However there are e.g. the national team championships where the balanced competitions exists in this sport too. This is the reason why we have to take into consideration the former researches in individual sports but in team competitions too.

Studies have confirmed the presence of home-advantage for several team sports with balanced competitions, including American football (Pollard-Pollard, 2005), rugby (Morton, 2006), ice-hockey (Dennis-Carron, 1999; Pollard-Pollard, 2005), basketball (Watson- Krantz, 2003; Pollard-Pollard, 2005), European football (Pollard, 2006).

Most of the research papers found no significant presence of home-advantage in different individual sports (Nevill et al., 1997) but some of them had significant results in short track, boxing or wrestling. (Koning, 2005; Balmer et. al., 2005; Gayton-Langevin, 1992, McAndrew, 1992). Home-advantage was present in such individual sports where the so called subjective factors like the referees or judges decisions and subjectively evaluation could be important influencer of the final results (Balmer et al., 2001; 2003). Jones (2013, 2017) also confirmed in his review studies that the presence of home-advantage in sports that can be measured by objective performance indicators cannot be detected.

Several hypotheses have emerged in the literature to explain the reasons of home-advantage, but these are not always confirmed by the researchers (Legaz-Arrese et. al., 2012):

- Positive impact of home fans (number of fans, fullness of stadium, volume of spectators): It can be stated that these factors affect the psychological state of the players, depending on the nature of the sport and the presence of mediators (e.g. referee decisions in doubtful situations, length of season), but several studies have shown that referees will prefer the home team because of fan pressure. (Downward-Jones, 2007; Sutter-Kocher, 2004) Results have shown that there is no significant home advantage in individual sports opposite in team sports. One possible explanation is that home spectators' presence influences the coordination of the guest team negatively (deteriorating communication between team members, poorly timed player changes etc.). (Jones, 2013)
- Knowledge of domestic environment and facility: Clarke-Norman (1995) and Barnett-Hilditch (1993) have proven that teams with a different size of home pitch compared to the standards are in favour of guest teams. Other research suggests that teams moving to a new facility will lose their existing home-advantages (Pollard, 2002), while others did not find it significant (Loughead et al., 2003; Moore-Brylinsky, 1995)
- Travel fatigue for the guest team: Several studies examined the distance travelled (Clarke-Norman, 1995), the overstepped time zones (Balmer et al.,

2001) and the jet lag effect (Recht et al., 2003). however they did not have a significant effect or only very weak, so this could only explain a little on the home-advantage.

- Rules that benefit the home team and subjective decisions by the referees (Balmer et al., 2001; 2003).
- Territorial and cultural impact: In some cases, the home-advantage in some countries or regions is more pronounced compared to other areas that may arise from the historical roots, ethnic composition, or religious conflicts of a particular area. Thus Pollard (2005) found a home-advantage in particular in the Balkan countries (Bosnia and Albania) while in the Baltic states it was less than average.
- Impact of the local community and settlement: in the case of relatively small settlements and their local communities the home-advantage is more pronounced, which is probably due to the stronger local ties (Mizruchi, 1985).
- History and tradition: If the home team has a long and glorious history and a great fan loyalty it strengthens the home-advantage (Mizruchi, 1985).

Especially only one paper was found by us researching the presence of home-advantage which was carried out on the German Bundesleauge level. This paper didn't find a home-advantage for the German table tennis teams. However the player's performance, was positively influenced by the social support of home spectators and the specific competition rules. (Klein-Soetebier et al., 2014)

We wanted to know whether some home-advantage could be identified at the table tennis team competitions however which are balanced competitions. Our hypothesis was that it doesn't exists because table tennis is a relatively objective measured sport and relatively small home spectator support is usual.

2. METHODOLOGY AND DATABASE

10 seasons of Austrian Men Table Tennis Bundesleague were analysed between 2008-2018. The analysis included 29 teams in this period (which means that these teams had a league participation number of 114) and 604 pairings (and 1208 team matches) where all teams had the possibility for playing at home and away against each other opponent teams. We analysed the pairings from the point of view of the team who played at home in the first leg and not the single matches to avoid the duplicated accountancy of the matches.

The teams consist of 3 players in the Austrian TTBL and there were two different playing system in this period. There were 1 double and 9 single matches from season 2008/2009 until 2011/2012 and 1 double and 5 single matches from season 2012/2013 until 2017/2018. All the team matches lasted only until the winning of one team or until a draw.

There were different numbers of teams in the different seasons. The most competitors were in 2008/2009 (13 teams) and the least in 2015/2016 (8 teams).

Three different analysis were made when testing the presence of home-advantage (comparing the home and away results of all the 604 pairings):

- Comparison of team match final results where 2 points were given for the winner team, 0 point for the looser team and 1-1 point for both of the teams if they made a draw.
- Comparison of individual matches and their differences by the teams during the team matches.
- Analysis of difference between home and away winning ratios and gained points between three groups of teams: so called top teams, average teams and weak teams. The classification of teams based on the following method: total winning ratio (total matches won / total matches played during the 10 year long period – as host and as visitor team too) in the TTBL was calculated for all the teams. The average value ($\bar{\mathbf{x}}$) and standard deviation (σ) was calculated for the whole sample and the teams were categorised with the help of these figures (see Table 1). (Bray, 1999)

Table 1. *Categorisation of teams in the sample*

Category	Total winning ratio	Number of teams
Top	over $\bar{\mathbf{x}} + \boldsymbol{\sigma}$	22
Average	between $\bar{\mathbf{x}} - \boldsymbol{\sigma}$ and $\bar{\mathbf{x}} + \boldsymbol{\sigma}$	84
Weak	below $\bar{\mathbf{x}} - \boldsymbol{\sigma}$	8

All the analysed variables had a not normal distribution so non-parametric tests were used. Wilcoxon signed rank test was used for analysing final match results and individual match results and independent Kruskal-Wallis test was used for searching differences between the three categories. Test statistics were computed by Microsoft SPSS for Statistics 22.0 software.

3. RESULTS

There was a little dominance of home wins in the sample. Fast the half (46%) of the matches finished with the win of the home teams and 41% were won by the visitor teams. 14% of the matches were finished as a draw. (Table 2)

Table 2. *Number and percentage of matches in the sample*

	Number of matches	Percentage of matches
Home wins	553	46%
Draws	164	14%
Visitor wins	491	41%

Categorisation of pairings based on the 1st and 2nd leg results produce three different categories. First category is when both of the teams made the same results in both of the legs (home teams win always, visitor teams win always, both matches ended as a draw). Second category is when teams perform better at home as away (e.g. home teams won both of the matches) and third category is when teams perform better away as at home (e.g. visitor teams won both of the matches). (Table 3)

Table 3. *Categories of pairings based on the two legs team results*

		2nd leg		
	Winner of the 1st or 2nd leg matches	Visitor	Draw	Home
1st leg	Home	No difference	Home > Visitor	Home > Visitor
	Draw	Visitor > Home	No difference	Home > Visitor
	Visitor	Visitor > Home	Visitor > Home	No difference

Comparing the final team results of matches there were 402 pairings (66,6%) where no difference was between the two leg's results. There is no importance of home-advantage in these cases. 123 pairings (20,4%) were when home-advantage existed. 79 pairings (13,1%) were when a home-disadvantage existed. (Figure 1)

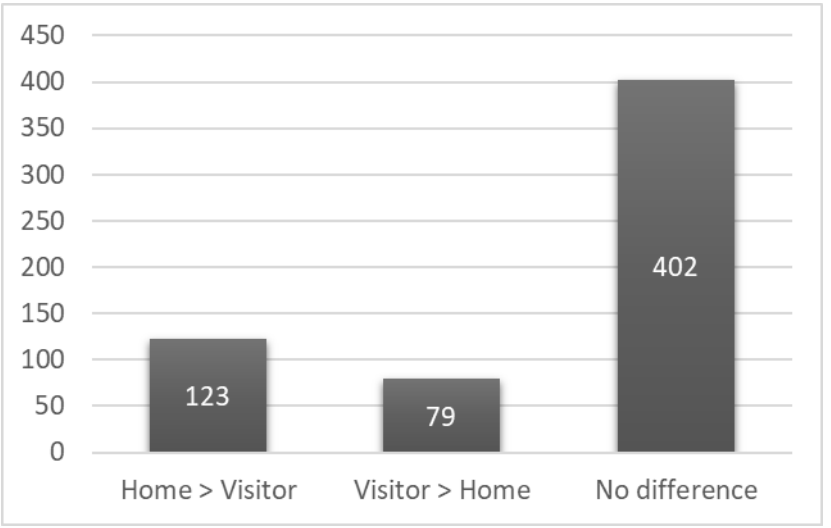

Fig. 1. Final results of pairings (number of pairings)

When comparing the realised team points in the first and second legs (2, 1, 0) it seems that home-advantage existed. (Z[604]=-2.910; p=0.004)

We calculated the difference between the two participating team's individual matches won in the 1st and in the 2nd leg. Comparing the difference of these two data series there were 156 pairings (25,8%) where no difference was between the two leg's results. There is no importance of home-advantage in these cases. 273 pairings (45,2%) were when home-advantage existed and teams were able to reach a better difference in individual matches at home as away. 175 pairings (29,0%) were when a home-disadvantage existed and visitor teams were able to reach a better difference in individual matches as home teams. (Figure 2)

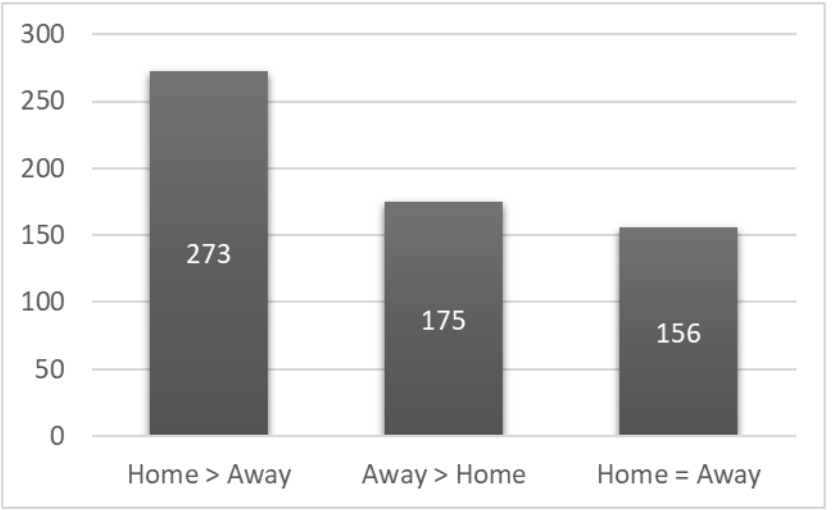

Fig. 2. Final individual results of pairings (number of pairings)

When comparing the differences of individual matches in the first and second legs it seems that home-advantage existed. (Z[604]=-3.623; p=0.000)

Analysing the three performance categories of the sample we can say that the so called top teams have a really dominant ratio of winning at home and as a visitor too. Average teams winning ratios are below 40% as a host and as a visitor team too and weak teams won almost nothing from their matches. It can be seen that home winning ratio is higher in all categories compared to the away ratios. (Table 4, Figure 3)

Table 4. *Winning ratios and their differences in the three performance categories*

Category	Mean and St. Deviation of winning ratio at home	Mean and St. Deviation of winning ratio away	Difference of home and away winning ratio (Mean and St. Deviation)
Top	83.66% ± 13.79%	78.57% ± 13.83%	5.09% ± 7.20%
Average	39.90% ± 19.97%	34.46% ± 20.93%	5.44% ± 16.28%
Weak	2.27% ± 4.21%	1.39% ± 3.93%	0.88% ± 6.35%

A better performance looks like in both categories at home as away but we didn't find any significant differences between the groups. However weak teams' performance was not so much weaker as a visitor than a host team but their performance was extremely low at all circumstances and maybe the low number of this category's teams made the analysis insignificant. (χ^2[114]=1.339; p=0.512)

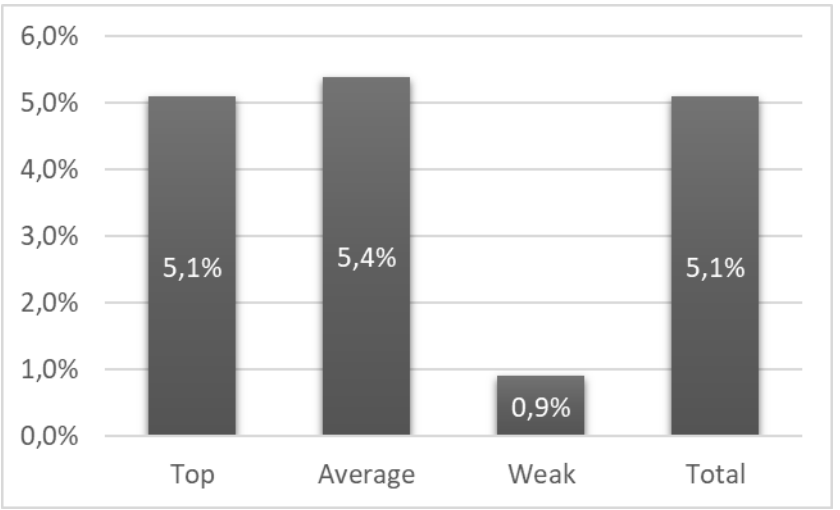

Fig. 3. Differences between home and away winning ratios in the three performance categories

Analysing not only the winning ratios but the ratio of gained points (2, 1, 0) from the possible gained points at team matches, we can say that there was no significant difference to the previous analysis. However all categories' performance was higher than performances at winning ratios but the reason was the modifying effect of the draws. The basic tendencies were the same, top teams gained very big amount of possible points, average teams gained them between 50-40% and poor teams below 10% did. The presence of home-advantage can be considered from the data. (Table 5, Figure 4)

Table 5. *Gained points ratios and their differences in the three performance categories*

Category	Mean and St. Deviation of gained points ratio	Mean and St. Deviation of gained points ratio	Difference of home and away of gained points ratio (Mean and St. Deviation)
Top	88.90% ± 9.91%	83.98% ± 9.88%	4.92% ± 10.99%
Average	47.22% ± 19.96%	42.02% ± 21.42%	5.19% ± 15.65%
Weak	7.20% ± 6.95%	5.37% ± 6.84%	1.83% ± 6.47%

We didn't find any significant differences between the groups. Similarly the weak teams' performance was not so much weaker as a visitor than a host team but their performance was extremely low at all circumstances and the low number of this category's teams made the analysis insignificant. ($\chi^2[114]=0.796$; $p=0.672$)

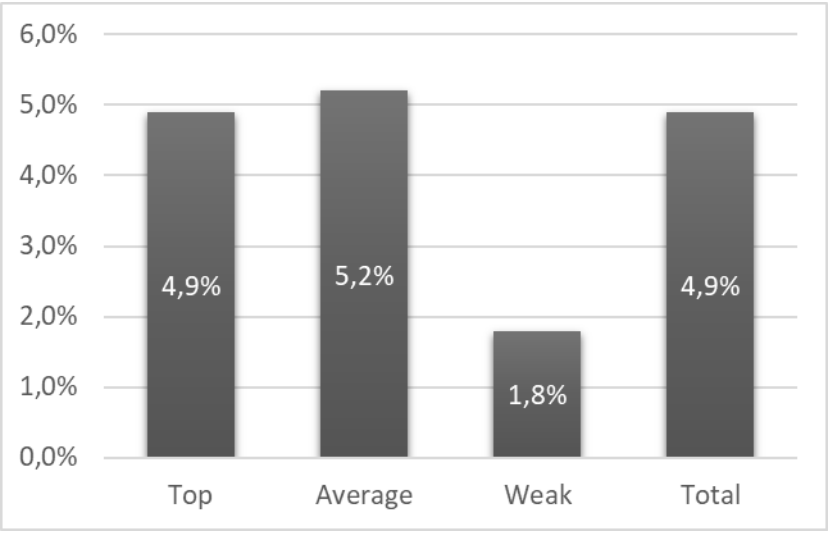

Fig. 4. Differences between home and away winning ratios in the three performance categories

4. CONCLUSIONS

Based on the results it can be stated that if we consider table tennis – which is an individual sport - as a team sport and the individual matches are summed up as a team match, then the home-advantage in this sport can be demonstrated in the same way as other team sports. The home-advantage is present independently whether we examine the outcome of the matches or the changes of the difference between individual victories giving a more detailed picture.

The research didn't search causes of home-advantage in the case of table tennis, but we can assume that the factors studied in other sports can have an impact on this sport as well. This is supported by the fact that Klein-Soetebier et al. (2014) showed a significant impact of the audience on exploiting the home-advantage. They have also shown that at the first individual match of the team matches, the home player Nr. 1 win with a significantly higher possibility than the visitor team's Nr. 2 player, which is also a manifestation of the presence of the home-advantage. However our opinion is, that this is not necessarily relevant, because due to the sequence of matches the player with the highest player level of the home team is playing this match with a player who is only a Nr. 2 player in the guest team, i.e. it can be assumed that the favourable results for the home team is coming from the different playing level of the two players. This would mean a pronounced home-advantage if the same pairings would have significantly different results at the rematch. However, Klein-Soetebier et al. (2014) did not cover or controlled the difference in playing level.

Together with these, we can rightly assume that better knowledge of the parameters of the home hall, the characteristics of the tables and balls used at home field and the influence of the home spectators can all result the fact that the home teams perform better at home than the visitors.

If we assume that better knowledge of playing conditions results a better performance of home teams, this may partly explain why it was not possible to show the advantage of the home-advantage in individual tournaments. These individual tournaments are typically run in sports halls where the host nation's competitors do not train and play regularly, i.e. they do not know the playing conditions better than the visitor nation's players.

The results did not prove that better teams could be more effective in transforming their home-advantage into their own benefit than the weaker teams. At the same time, based on the percentages, we cannot completely reject this hypothesis, as the winning rates' differences for the top and average teams are higher than those for the weak category, but no statistically significant results were found. This may be partly due to the low number of items in the weak team category compared to the entire sample, so it may be useful to test this hypothesis on a larger number of samples.

REFERENCES

Balmer, N.J., Nevill, A.M., & Lane, A.M. (2005). Do judges enhance home advantage in European championship boxing? *Journal of Sports Sciences, 23*(4), 409-416.

Balmer, N.J., Nevill, A.M., & Williams, A.M. (2001). Home advantage in the Winter Olympics (1908- 1998). *Journal of Sports Sciences, 19*(2), 129-139.

Balmer, N.J., Nevill, A.M., & Williams, A.M. (2003). Modelling home advantage in the Summer Olympic Games. *Journal of Sports Sciences, 21*(6), 469-478.

Barnett, V., & Hilditch, S. (1993). The effect of an artificial pitch surface on home team performance in football (soccer). *Journal of the Royal Statistical Society, 156*(1), 39-50.

Bray, S.R. (1999). The home advantage from an individual team perspective. *Journal of Applied Sport Psychology, 11*(1), 116-125.

Clarke, S.R., & Norman, J.M. (1995). Home advantage of individual clubs in English soccer. *The Statistician, 44*(4), 509-521.

Courneya, K.S., & Carron, A.V. (1992). The home advantage in sport competitions: A literature review. *Journal of Sport and Exercise Psychology, 14*(1), 13-27.

Dennis, P.W., & Carron, A.V. (1999). Strategic decisions of ice hockey coaches as a function of game location. *Journal of Sports Sciences, 17*(4), 263-268.

Downward, P., & Jones, M. (2007). Effects of crowd size on referee decisions: Analysis of the FA Cup. *Journal of Sports Sciences, 25*(14), 1541-1545.

Gayton, W.F., & Langevin, G. (1992). Home advantage: Does it exist in individual sports? *Perceptual and Motor Skills, 74*(3/1), 706.

Jones, M.B. (2017). Differences in home advantage between sports. *Psychology of Sport and Exercise, 34*, 61-69.

Jones, M.B. (2013). The home advantage in individual sports: An augmented review. *Journal of Sport and Exercise Psychology, 14*, 397-404.

Klein-Soetebier, T., Senff, A., & Weigelt, M. (2014). Kein Heimvorteil in der 1. Tischtennisbundesliga der Herren. *Sportwiss, 44*, 71-77.

Koning, R.H. (2005). Home advantage in speed skating: Evidence from individual data. *Journal of Sports Sciences, 23*(4), 417-427.

Legaz-Arrese. A., Moliner-Urdiales. D., & Munguia-Izquierdo, D. (2012). Home Advantage and Sport Performance: Evidence, Causes and Psychological Implications. *Universitas Psychologica, 12*(3), 933-943.

Loughead, T.M., Carron, A.V., Bray, S.R., & Kim, A. (2003). Facility familiarity and the home advantage in professional sports. *International Journal of Sport Psychology and Exercise Psychology, 1*(3), 264-274.

McAndrew, F.T. (1992). The home advantage in individual sport. *Journal of Social Psychology, 133*(3), 401-403.

Mizruchi, M.S. (1985). Local Sports Teams and Celebrations of Community: A Comparative Analysis of the Home Advantage. *The Sociological Quarterly, 26*(4), 507-518.

Moore, J.C., & Brylinsky, J. (1995). Facility familiarity and the home advantage. *Journal of Sport Behavior, 18*(4), 302-311.

Morton, R.H. (2006). Home advantage in southern hemisphere rugby union: National and international. *Journal of Sports Sciences, 24*(5), 495-499.

Nevill, A.M., Holder, R.L., Bardsley, A., Calvert, H., & Jones, S. (1997). Identifying home advantage in international tennis and golf tournaments. *Journal of Sports Sciences, 15*(4), 437-443.

Pollard, R. (2002). Evidence of a reduced home advantage when a team moves to a new stadium. *Journal of Sports Sciences, 20*(12), 969-973.

Pollard, R. (1986). Home advantage in soccer: A retrospective analysis. *Journal of Sports Sciences, 4*(3), 237-248.

Pollard, R. (2005). Long-term trends in home advantage in professional team sports in North America and England (1876-2003). *Journal of Sports Sciences, 23*(4), 337-350.

Pollard, R. (2006). Worldwide regional variations in home advantage in association football. *Journal of Sports Sciences, 24*(3), 231-240.

Recht, L.D., Lew, R.A., & Schwartz, W.J. (2003). Baseball teams beaten by jet-lag. *Nature, 377*(6550), 583.

Sutter, M., & Kocher, M.G. (2004). Favoritism of agents - the case of referees' home bias. *Journal of Economic Psychology, 25*(4), 461-469.

Watson, J.C., & Krantz, A.J. (2003). Home field advantage: New stadium construction and team performance in professional sports. *Perceptual and Motor Skills, 97*(3/1), 794-796.

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Absence of home-advantage in table tennis individual competitions

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Abstract: Home-advantage means that a player performs better at home field like at away field (e.g. can beat a higher ranked opponent with higher possibility). The individual competitions don't guarantee that two players can compete in both of their own land against each other usually.

The Hungarian youth and senior national team players' individual matches were examined between 2009 and 2018. In addition they were asked by a questionnaire about their feelings playing in front of the home crowd.

The home-advantage wasn't significant at the Hungarian World Tour and World Junior Circuit events by the examination of the number of gained medals. Regarding the final positions of the players the senior players in the singles competitions and the juniors in the doubles had a light home-disadvantage.

22% of the Hungarian national players think that they can do a better performance in Hungary and 17% feel that they play worst at home. There was a significant relationship between the Hungarian players' subjective feeling about their home success and their willingness to play in Hungarian international competitions. (χ^2 = 21,66, $p < 0.01$, Cramer V = 0.776)

The results are similar like at other individual sports which means that in the individual sports with objective measured results there is no home-advantage for the players.

Keywords: home advantage, unbalanced schedule, table tennis, individual competitions

1. INTRODUCTION

Home-advantage means that a player performs better at home field like at away field (e.g. can beat a higher ranked opponent with higher possibility). The individual competitions don't guarantee that two players can compete in both of their own land against each other usually. The North American and European team sports' leagues are really well researched but there is a lack of papers amongst the individual sports and especially in table tennis. We found only one paper in table tennis which researched the presence of home-advantage but this research was carried out on the German Bundesleauge level and not on the level of the individual competitions (Klein-Soetebier et al., 2014).

Table tennis individual competitions belong to the unbalanced competition systems because the home and away matches between two players are not guaranteed, the number of home and away matches for the two opponents are not the same or some of the opponents have absolutely not home field (Legaz-Arrese et al., 2012). Such types of competitions are the FIFA World Cup, the tennis Grand Slams, the table tennis World Tours or the table tennis World Championships.

Usually the home-advantage of unbalanced competitions is measured by the winning frequency and possibility of a lower ranked home player against a higher ranked player who doesn't play at home field compared to other competitions where none of the two players have home field. (Nevill et al., 1997)

Most of the research papers found no significant presence of home advantage in different individual sports (Nevill et al., 1997) but some of them have significant results in short track, boxing or wrestling. (Koning, 2005; Balmer et. al., 2005; Gayton-Langevin, 1992, McAndrew, 1992). Home-advantage was present at such individual sports where the so called subjective factors like the referees or judges decisions and subjectively evaluation could be important influencer of the final results (Balmer et al., 2001; 2003). Jones (2013, 2017) also confirmed in his review studies that the presence of home-advantage in sports that can be measured by objective performance indicators cannot be detected.

Several hypotheses have emerged in the literature to explain the advantages of home-advantage, but these are not always confirmed by the researchers (Legaz-Arrese et. al., 2012). Such reasons could be the positive effects of spectators, knowledge of domestic environment and facility, travel fatigue for the guest team, subjective decisions of the referees, rules favouring for the home team, territorial and cultural impacts, local community and settlement impacts or history and traditions. Higher-skilled teams and players are able to turn these to a greater extent for their own benefit. (Bray et. al, 2003; Jamieson, 2010)

We wanted to know whether some home-advantage could be identified at the table tennis individual competitions however our hypothesis was that it doesn't exists because table tennis is a relatively objective measured sport.

2. METHODOLOGY AND DATABASE

The Hungarian youth and senior national team players' individual results were examined: youth results between 2009 and 2017, senior results between 2010 and 2018. As Hungarian TTA organised different categories of ITTF World Tour (Pro Tour) and ITTF World Junior Circuit Events in this period we included into the analysis only the same level of WT and WJC events participated by the Hungarian national team which was organised in Hungary in the same year too.

We compared the final positions reached by the Hungarian players (e.g. final, semi-final etc.) and the number of the medals won at the home and abroad competitions. A head to head comparison between players was not possible because world rankings were inaccessible during this period.

The single and double competitions were analysed by sex and age. Total number of analysed appearances was 753. (Detailed number of cases included in Table 1).

Table 1. *Number of Cases in the Sample*

Number of cases (N)		
Women – Men	348	405
Singles – Doubles	416	337
Senior – Youth	248	505
Domestic - Abroad	218	535

Crosstables and χ^2 test statistics were computed by Microsoft SPSS for Statistics 22.0 software.

In addition the Hungarian national players (seniors and adults too) were asked by a questionnaire about their feelings playing in front of the home crowd and their perceived efficiency at the domestic competitions compared to abroad.

3. RESULTS

If we measure the success with the existence or absence of medal winning, then no significant relationship can be established, there is no difference in the success of Hungarians in domestic and foreign competitions from this point of view. There are no differences on the level of youth or senior players, on the level of competition types or on the level of sexes too (Table 2).

Table 2. *Comparison of the results of Hungarian table tennis team players at home and abroad (whether or not players have won medals) with χ^2 test*

		Pearson χ^2	p
total sample	total	0,221	0,638
	men	1,379	0,240
	women	0,333	0,691
	singles	0,586	0,444
	doubles	0,032	0,858
	youth players	0,001	0,980
	senior players	0,405	0,525
youth players	boys	0,523	0,470
	girls	0,783	0,376
	singles	0,098	0,754
	doubles	0,059	0,808
senior players	men	0,414	0,520
	women	0,046	0,830
	singles	0,057	0,811
	doubles	0,496	0,481

If we measure the success achieved at domestic and foreign competitions with the round of players' loss then there is no significant difference between the results at home or abroad.. There is a not very strong relationship in case of certain age groups and competitions types.

Table 3. *Comparison of the results of Hungarian table tennis team players at home and abroad (Depending on the number of rounds when the players have fell out) with χ^2 test*

		χ^2	p	Cramer V
total sample	total	10,176	0,179	
	men	8,499	0,291	
	women	3,547	0,738	
	singles	15,293	0,032 **	0,192
	doubles	9,715	0,137	
	youth players	8,837	0,265	
	senior players	14,289	0,027 **	0,240
youth players	boys	9,508	0,218	
	girls	2,046	0,915	
	singles	10,104	0,183	
	doubles	11,385	0,077 *	0,205
senior players	men	7,305	0,199	
	women	9,980	0,125	
	singles	16,802	0,010 **	0,305
	doubles	3,561	0,469	

When analysing the relationships that appear to be significant but weak relationship, the following can be identified:

- When splitting the total sample for singles and doubles events than Hungarians reached positions 9-16 at foreign tournaments relatively more times than at Hungarian tournaments, however positions 17-32 are present to a greater extent at home competitions. Positions 65-128 are overrepresented at home competitions too, however their total number (n=4) is basically low and additionally more Hungarian competitors are allowed to participate at domestic competitions, which means in turn that worse positions in domestic competitions are more frequent. Based on these it can be stated that Hungarian players perform somewhat better at foreign competitions but only regarding positions 9-32.
- When splitting the total sample into age categories it can be observed that senior players reached relatively more times positions 9-16 at foreign competitions than at Hungarian tournaments. However, positions 17-32 are present to a greater extent at the Hungarian competitions. This means that Hungarian senior players performed better regarding the 9-32 positions abroad.
- Analysing the youth players there is a minimal difference between domestic and abroad competitions regarding the doubles competitions. There is a higher proportion of placements 33-64 at Hungarian tournaments like abroad tournaments, which means that Hungarian players performed slightly better abroad. (Figure 1)

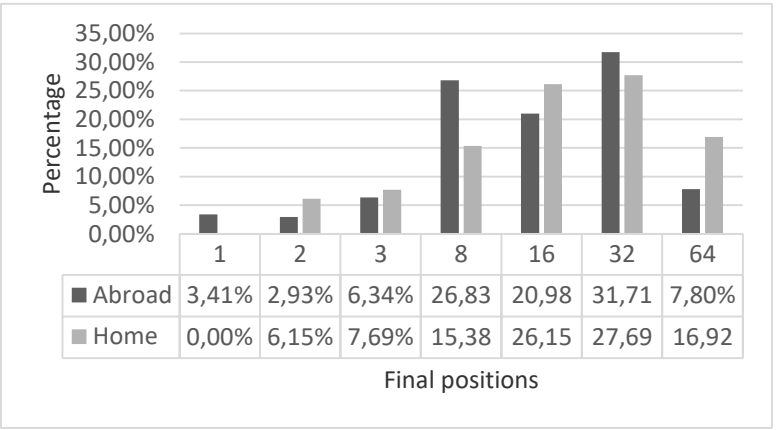

Fig. 1. Final positions of Hungarian youth national team players in doubles events

- Analysing the senior players there is a difference between domestic and abroad competitions regarding the singles competitions. The proportions of positions 9-16 are higher at foreign competitions like domestic competitions, however regarding positions 17-32 the same is true but reversed. This means again that Hungarian players performed better at abroad competitions. (Figure 2)

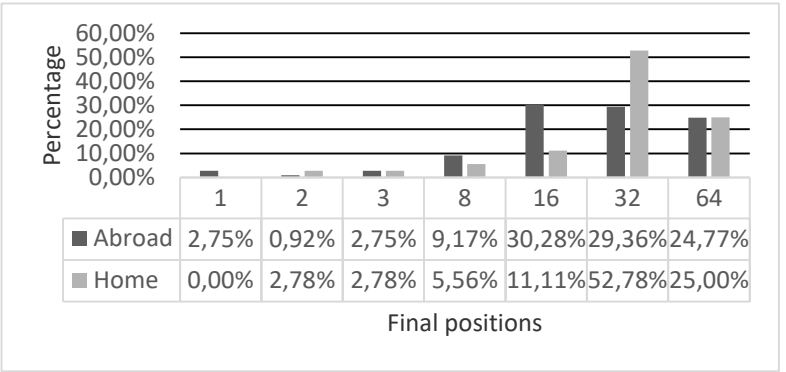

Fig. 2. Final positions of Hungarian senior national team players in singles events

After analysation of the self-reported questionnaire for national players 22% of them think that they can do a better performance in Hungary and 17% feel that they play worst at home. 61% think that they don't feel any difference at home or abroad. (Figure 3)

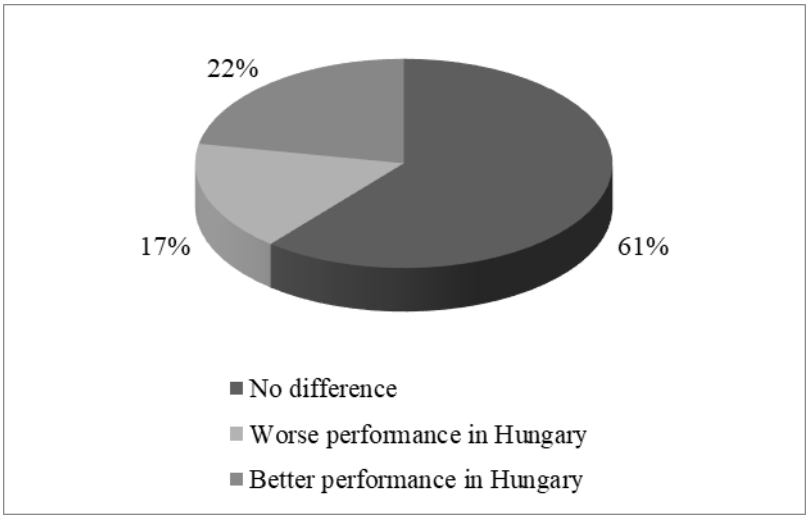

Fig. 3. Hungarian national team players' subjective feelings about their performance

There was a significant and strong relationship between the Hungarian players' subjective feeling about their home success and their willingness to like playing in Hungarian international competitions. ($\chi^2 = 21.66$, $p = 0.006$, Cramer V = 0.776)

The subjective performance evaluation was also supported by objective performance indicators, as for those who considered their home performances better (4 players), there was some positive in their domestic success.

4. CONCLUSIONS

The results are similar like most of the other individual sports with objective measured results. (It is not surprising when we know that the subjective factors like the judgement of referees have a relatively small effect onto the results of a table tennis match.) We didn't find a home-advantage at the individual competitions in table tennis, however some home-disadvantage was identified at the Hungarian players.

It looks that measuring success with the round number of players' loss is more accurate like measuring success with the number of medals. On the one side it means that it is more detailed and much more players can be taken into account but on the other side Hungarian national players were not so dominant at the international competitions which could produce enough number of medals won and be able to analyse.

However in case of the final positions' analysis we found that some lower final positions are overrepresented at the domestic competitions (e.g. senior players round of 32 in singles, youth players round of 64 in doubles) and little bit better positions are overrepresented at the abroad competitions amongst the senior players (round of 16 in singles).

All organising national associations – like the Hungarian Table Tennis Association – have the right as an official ITTF World Tour or World Junior Circuit event organiser to nominate a bigger contingent of home players like other participating countries. It means that many players with weak international experiences or maybe lower playing level have the possibility from the host country to participate at home field however they wouldn't have this possibility at another international event organised by another association abroad. This could result that these players eliminate at a relatively early stage of the competitions which could mean that the hosting nation could have a weaker aggregated home performance like it would be abroad. Controlling this problem this analysis contained only such players who belonged to the core of the Hungarian national teams and participated both Hungarian and abroad competitions too.

It looks like that players' self-evaluation is really objective because it shows correlation with the hard facts. However the success at home field and loving playing at home are not the same but we can say that there is a correlation between them. Players who love play at home field are more successful usually and players who don't like play in Hungary have less achievements at home.

Another measurement type would be useful to evaluate the home success too. This could be the possibility of beating a higher ranked (based on world ranking) player by the national team players in Hungary or abroad. However the ITTF world ranking database was not available during the research process because of the database rebuilding of ITTF competitions made by ITTF in 2018 so it was not possible to analyse from this aspect.

This research didn't want to analyse the causes of this home-disadvantage but maybe it would be useful to compare the Hungarian results with other nations' results. It is a question whether it is only a speciality for the Hungarian national team or the disadvantage or at least the absence of home-advantage is a general phenomenon at table tennis individual competitions.

Individual competitions have another psychological and tactical aspects like team competitions which could have consequences for the presence of home-advantage too. For example a player has the possibility to play more matches during a team match and maybe he can improve his performance after a single defeat when playing a second one, the responsibility between the team members will be shared which reduces the stress level or there are some players who have preferences to be written onto specific team positions which is part of tactic too. On the other hand there are differences between team competitions too because World Table Tennis Championship is an unbalanced competition but a national team league (like e.g. German Bundesleague) is a balanced one. We have to widen our knowledge about these aspects and their relationship with home-advantage too.

REFERENCES

Balmer, N.J., Nevill, A.M., & Lane, A.M. (2005). Do judges enhance home advantage in European championship boxing? *Journal of Sports Sciences, 23*(4), 409-416.

Balmer, N.J., Nevill, A.M., & Williams, A.M. (2001). Home advantage in the Winter Olympics (1908- 1998). *Journal of Sports Sciences, 19*(2), 129-139.

Balmer, N.J., Nevill, A.M., & Williams, A.M. (2003). Modelling home advantage in the Summer Olympic Games. *Journal of Sports Sciences, 21*(6), 469-478.

Bray, S.R. (1999). The home advantage from an individual team perspective. *Journal of Applied Sport Psychology, 11*(1), 116-125.

Gayton, W.F., & Langevin, G. (1992). Home advantage: Does it exist in individual sports? *Perceptual and Motor Skills, 74*(3/1), 706.

Jamieson, J.P. (2010). The Home Field Advantage in Athletics: A Meta-Analysis. *Journal of Applied Social Psychology, 40*(7), 1819-1848.

Jones, M.B. (2017). Differences in home advantage between sports. *Psychology of Sport and Exercise, 34*, 61-69.

Jones, M.B. (2013). The home advantage in individual sports: An augmented review. *Journal of Sport and Exercise Psychology, 14*, 397-404.

Klein-Soetebier, T., Senff, A., & Weigelt, M. (2014). Kein Heimvorteil in der 1. Tischtennisbundesliga der Herren. *Sportwiss, 44*, 71-77.

Koning, R.H. (2005). Home advantage in speed skating: Evidence from individual data. *Journal of Sports Sciences, 23*(4), 417-427.

Legaz-Arrese. A., Moliner-Urdiales. D., & Munguia-Izquierdo, D. (2012). Home Advantage and Sport Performance: Evidence, Causes and Psychological Implications. *Universitas Psychologica, 12*(3), 933-943.

McAndrew, F.T. (1992). The home advantage in individual sport. *Journal of Social Psychology, 133*(3), 401-403.

Nevill, A.M., Holder, R.L., Bardsley, A., Calvert, H., & Jones, S. (1997). Identifying home advantage in international tennis and golf tournaments. *Journal of Sports Sciences, 15*(4), 437-443.

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In the beginning was the half-volley: The history of defence in table tennis-revised

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Abstract: The term "defensive play" is known in many different sports. In the field of racket sports, however, the word defensive player is quite distinct to table tennis. While technically relying to a great extent on backspin defence, defensive players in table tennis are also called "choppers". This article on the technical development of table tennis shows that defensive play in this sport is as old as competitive table tennis itself. Nevertheless, it becomes evident that playing a long-range defence while standing rather far away from the table, as it is commonly known, was originated not earlier than around 1930; this was about three decades after the start of competitive table tennis. It is said that choppers were dominating the early era. Beginning in the 1950s, various alterations in table tennis turned to a decline of backspin defence. Inventions such as rubbers based on sponge and sticky surfaces, the modern topspin stroke (loop drive), the fresh-gluing of rubbers, and the so-called two-color rule favoured offensive play. In this article it is described how defensive players continuously reacted and adapted by finding effective remedies to ensure that defensive play can be a still existing specific style in the world of table tennis.

Keywords: *stroke technique, racket covering, match strategy, variation, adaptation, postmodern defence*

1. EARLY TECHNIQUES – EARLY STRATEGIES (1901 - 1910)

Defensive play is as old as competitive table tennis. One of the very first open table tennis tournaments was held in the London Royal Aquarium from 11 to 14 December 1901 with over 240 competitors (Duke, 2009, 2017). The winner was R. D. Ayling, a defensive player with a very cautious half-volley game close to the table (Wesasa, 1902). The half-volley was perhaps the most popular stroke among table tennis players in those days. For a lot of athletes, the half volley was the main technique (Harrison, 1901/2000). The half-volley was characterized as a purely defensive shot where "the ball was taken at the moment of bouncing, and rebounds almost by its own impetus" ("The Language of Ping Pong", 1902, p. 3). Nevertheless, a half-volley was a quick shot that passed over the net low and was placed close at the net. Around the year 1900, backhand play was more common than forehand play (Harrison, 1901/2000). That meant that on the forehand side of the table the ball was frequently played with the backhand side of the racket (Gurney, 1993; "How to Play Ping Pong", 1994; Mainland, c. 1902/2001). About 25 years later, at the time of the first World Championships, this technique was called "fore-backhand" (Szabados, 1936; Uzorinac, 2001) or "forehand backhand" (Barna, 1950/2010). At the beginning of the last century, plain wood rackets were in use, as well as rackets

covered with sandpaper, vellum, cork, or plush ("Tournament Items", 1902). Besides, rubber faced bats were already used ("Club Notes", 1902; Ritchie, 1902/2005), and battledores with vellum were still known (Ayres, 1902; Uzorinac, 2001).

At the beginning of the year 1902, there was a debate in the world of table tennis on the so-called "stonewall tactic", a strategy which cast a poor light on the new emerging sport of table tennis (Ritchie, 1902/2005). The writer of a letter to the editor described it as follows:

"[…] I think that all who watched tournaments will agree, that a more uninteresting spectacle than a couple of 'stonewallers', playing a soft half-volley game in the centre of the table, would be difficult to find. […] The 'stonewaller' returned every shot in exactly the same manner, never making the smallest attempt to attack, or give a stroke that a novice could not return easily. […]" (Rae, 1902, p. 3)

Matches between stonewallers sometimes lasted several hours. At the Oxford Open Championships, the duration of a game (!) was two hours, and one of the rallies included 175 hits ("Notes", 1902). Apart from this overcautious way to play table tennis, there were further playing styles at the beginning of the 20th century. Arnold Parker, winner of the 1903 All England Table Tennis Championship and author of a famous early textbook on table tennis, was known as an uncompromising offensive player (Schmicker, 2000). Besides, the term "all-round" was in use ("The North London Ping Pong Championships", 1902). The "Ping Pong Craze" (Pardy, 1902) did not last for very long: In England, National Championships were held until 1904 (Schmicker, 2000). Central Europe experienced a "minor boom" between 1905 and 1910 even so (Uzorinac, 2001).

2. PING PONG'S RETURN (1921 - 1929)

After a phase of recession, Wales and England were pioneers at the beginning of the 1920s in running table tennis competitions (Grant, 2010; Trimming, 1995; Uzorinac, 2001).[1] The first World Championships took place in London from 6 to 13 December 1926 ("The First World Championships", 2003). The most successful players of this tournament, the Hungarians Maria Mednyanski, Roland Jacobi and Zoltan Mechlovits, played the "old" style based on half-volleying. Defensive and offensive shots complemented each other (Schmicker, 2000; Uzorinac, 2001).

"The Hungarians with Dr. Jacobi, Mechlovits, Dr. Pecsi were vastly superior to other nations as far as the even mastery of offense, defence and constantly varying the game was concerned." (Eckert, 1954, p. 46, translated by the author)

Ivor Montagu (England), the first President of the International Table Tennis Federation, considered a student from India the progenitor of all defensive players.

"[...] R. G. Suppiah, small, dark, curly-haired, fierce and concentrated in play, full of smiles between games, [...] and from whom (through Bull and Perry) all defensive players of the present day are descended." (Montagu in an article entitled "Famous Men", cited after Hoey, 2012)

[1] The Table Tennis Association of Wales was founded in 1921 ("Table Tennis Association of Wales", 2018), the English Table Tennis Association was refounded in 1921 ("English Table Tennis Association", 2018).

Suppiah reached the semi-finals in men's singles at the 1926 World Championships. Charles Bull and Fred Perry, whose names are also included in the quotation, became runner-up in men's doubles at the 1928 World Championships and third at the World Championships one year later. The future Wimbledon Lawn Tennis Champion in men's singles, Fred Perry, won the gold medal at the 1929 Table Tennis World Championships. In those days, the players used pimpled rubber or wooden rackets (Eckert, 1954; Uzorinac, 2001).

3. THE "MODERN" GAME (1929 - 1951)

It was in Vienna in 1929 when Victor Barna and Miklos Szabados, young leaders of a second generation of Hungarians, showed that it is possible "to return a ball while standing in four meters distance from the table" (Eckert, 1954, p. 22, translated by the author). In retrospect, Barna described this change in table tennis technique as follows:

"[…] Then we came along. By 'we' I mean chaps like Szabados, Bellak, Glancz, Kelen, Hazi and Liebster, who were pioneers in developing the art of long-range defence. Our seniors had taught us ball control, how to score with a hit, and how to use the half volley for close defence. But on top of this, we had youth and speed of foot - in a word - the agility to be able to retrieve the ball further from the table and still be capable of getting up for the drop shot. Our game was called the 'modern' game, and I believe that there is little, if any, difference between the game we played in the early 1930s and the game as it is to-day. What difference there may be is due rather to changes in the rules than to anything else. Fundamentally the technique is the same. It is interesting to note that rubber-faced bats were introduced with the idea of improving attacking strokes and to baffle the half volley defence. This, in turn, led naturally to the counter-measure of long-range defence. A new kind of spin required an adjustment of the old kind of style. To-day, however, I realise that rubber, with its capacity for heavy chop, has improved defence far more than attack […] The solution must be found in equipment which gives greater advantage to the attacker than to the defender […]" (Barna, 1950/2010, p. 10)

Thus, the emergence of the long-range defence seems to have taken place almost 30 years after table tennis had become a competitive sport. This is interesting, especially if one has in mind that backspin *per se*, seen as a kind of spin and named "under-cut", was already known at the beginning of the 20th century ("The Language of Ping Pong", 1902). In international competition, athletes appeared whose play was mainly based on long-range defence or chopping, respectively (e.g., the Pole Alojzy "Alex" Ehrlich and the Frenchman Michel Haguenauer). It is said that defenders were dominating this era (Li, 2009). Some defenders carried it to an extreme extent and specialized on nothing but pushing, chopping and lobbing. They almost never attacked which made playing against them very time-consuming. This development can be seen as a kind of retrogression (Angenendt, 1995) and reached its climax at the 1936 World Championships in Prague. Michel Haguenauer (France) and Vasile Goldberger-Marin (Romania) played a marathon match which lasted more than 7 hours and was decided by a coin toss (Angenendt, 1995; Uzorinac, 2001). The duration of the final in the men´s team

event was 11 hours, and the match between Alex Ehrlich (Poland) and Farkas "Lupu" Paneth (Romania) included a famous rally whose length was about two hours. In regard to the exact time, four diverging specifications exist – from 1 hour 58 minutes up to 2 hours 15 minutes (Angenendt, 1995; Uzorinac, 2001).[2]

The half-volley lost its status as the shot which dominates the game. It was still seen as a defensive answer to strokes with topspin and backspin (Purves, 1945), but it was used more selectively, for example, in case there is not enough time to gain space for a long-range defence (Leach, 1951). Besides, it was a kind of bridge unit for the change from long-distance defence to offense close to the table (Fuller, 1942). The toolset of strokes became differentiated. The term half-volley remained until the late 1960s (Barna, 1970; Carrington, 1960), but it was substituted by the word "block" much earlier (Fuller, 1942). The expression "push" occurred naming a shot where the ball is hit near the peak of ball flight trajectory (Purves, 1945). Trude Pritzi, World Singles Champion in 1938, mainly relied on a defensive game and had the surname "The Queen of the Push" (Uzorinac, 2001). Friederich (2018) gives us a list of the diverse techniques shown in the 1930s (translated by the author):

Offensive strokes:
Topspin drive (drive shot, ball gains topspin)
Plain-hit (shot with a vertical blade or smash)
Drop-shot (sudden short shot)
Flick (ball is taken above the table and gains topspin)
Defensive strokes:
Half-volley (ball is taken shortly after the bounce, regardless the type of ball spin)
Chop (ball gains backspin)

The emergence of the high defence, named "balloon defence" (Leach, 1951), took place in the 1930s and 1940s, too. Leach (1951) describes it as a kind of double or parallel invention. He reports that he did not develop this technique consciously, but it occurred accidentally. Leach never observed this particular stroke in other players until the day he saw Richard Bergmann playing for the first time. Bergmann was a long-range defender who won the world singles title four times. He also performed balloon defence. By observing Bergmann Johnny Leach felt motivated to improve his balloon defence even more (Leach, 1951).

Leach's recollections may support two conclusions: To begin with, his balloon defence was not just borrowed from tennis, where a high defensive ball is known as a "lob", nor was it directly connected to the technique of "lobbing" in table tennis, which already existed at the beginning of the 19th century (Ritchie & Parker, 1902, p. 39). Leach's remarks make clear that his balloon defence developed on its own.

[2] In the World Championships of the following year (1937) the outcome in the women´s singles final was spectacular: Trude Pritzi (Austria) and Ruth Aarons (USA) were disqualified because they exceeded a newly created match time limit of 1 hour 45 minutes (Uzorinac, 2001). Starting from the same year, the net height was reduced from 16.75 to 15.25 centimeters in order to promote offensive play (Clemett, n.d.; Östh & Fellke, 1992).

Furthermore, Leach's balloon defence might be only an early form of what we call balloon defence in the modern era.[3]

"The aim is to return the ball without any spin, and so, although the point of contact is under the ball as in the long range backspin stroke, instead of swinging the bat downwards, you swing up from underneath and behind the ball. In effect, you are playing a push stroke a long distance from the table. Playing the ball in the way I have described, it naturally rises and bounces fairly high at the other end of the table. […] If your return is short, you can expect no mercy; but, strangely enough, a high deep return without spin is one of the most difficult shots to attack. […] One balloon shot should be mixed in after a rally has got going with your opponent top-spinning and you defending; after hitting back four or five of your backspin shots, he will probably be unprepared for a change in your next stroke and will overlook the fact that it has no backspin to lift." (Leach, 1951, pp. 71-72)

Thus, the Englishman emphasizes that playing the balloon defence in principle means "pushing" the ball, whereby no particular spin is imparted to the ball. Besides, it is stressed that balloon balls do not only have a considerable high trajectory but also a placement which should be near the baseline.[4] From a modern perspective, one might describe Leach's original version of balloon shots as float balls which are deliberately played fairly high. The starting point for Leach's innovation was the experience that in table tennis high balls, which are supposed to be received easily, are frequently missed by opponents. Leach was encouraged by his coach, Jack Carrington, to experiment by playing the ball much higher than usual (Wykes, 2012).

At the beginning of the 1950s, the terms "short-chop" ("Kurz-Chop"; Mauritz, 1954, p. 146), "close-to-the-table backspin" and "short-range defence" (Leach, 1951, p. 51, pp. 79-81) were in use. One idea behind this stroke was producing a rather fast defensive play near the table not allowing the opponent enough time to get into a good position to attack. Another idea was to be in a good position to return drop-shots. A short defence should also be a kind of makeshift move either to get into the position to attack or to gain space on the table later on (Leach, 1951). The notion of a "short-arm defence" can be traced back to the 1930s (Findon, 1936). The playing style of Richard "Dick" Miles was substantially based on the short-range defence, which was occasionally combined with a strong forehand attack (Schöler & Schöler, 2012; Uzorinac, 2001). The well-known player from the USA even advanced to the semi-finals of the men's singles event at the 1959 World Championships. After having beaten two opponents from the Middle Kingdom, Miles lost against China's very first World Champion Rong Guotuan by 2-3 (Uzorinac, 2001). As early as in 1952, it could be heard that "the very hard close-to-the-table chop defence and

[3] Despite that nowadays a high defensive shot is officially called "lob" in the English-speaking world (Tepper, 2003), sometimes the word "balloon defence" has been used instead (e.g., Muhr, 2003; Munivrana, Furjan-Mandić, & Kondrič, 2015; O'Sullivan, 1974).

[4] This all corresponds with Eckert's definition of the term "balloon defence" as a "high and soft defence, without spin, preferably on the opponent's baseline" (1954, p. 150, translated by the author).

sudden smash game […] always caused problems for the pengrip player" (George in the Swaythling Club Bulletin, Oct., 1985, 2-3, cited in Boggan, 2003).

Throughout the 1950s, a couple of medal winners at World Championships could be identified who played defensively very near the table, mainly relying on pushing and blocking (Schöler & Schöler, 2012). Hiroji Satoh from Japan probably was the most noted representative of this steady playing style, albeit chopping was part of his game too (Wild Goose Productions, n.d.). The 1952 World Champion in men's singles was a penhold player and the first World Singles Champion from Asia. He also became famous because his racket was covered with sponge which had a thickness of seven millimeters (Montagu, 1952; Uzorinac, 2001).

An established table tennis technique at that time was the "chop-drive" (Leach, 1951) or "side chop smash" (Bergmann, 1950). This was an aggressive stroke which put backspin on the ball, preferably shown as an answer to a somewhat higher ball by the opponent which descends near the net.

In addition, the drop-shot could be observed frequently and followed a particular logic. It was preferably combined with attacking shots in order to unsettle the opponent as far as assessing the right distance was concerned. The intention to play a drop-shot should be concealed as long as possible. There was the advice to play a drop-shot when the opponent was engaged in a *backward* movement trying to put a distance between him and the table (Barna, 1970; Leach, 1951).

The post-war World Championships from 1947 to 1951 were dominated by agile and stable defenders who performed chop defence or half-volley defence. Famous players from the pre-war period like Pritzi, Barna, Bergmann, and Bohumil Vana (Czechoslovakia) still belonged to the top of the world (Albers, 1990). Richard Bergmann, four times Men´s Singles World Champion between 1937 and 1950, played one of the most dramatic and significant matches in the history of defense play. It took place in the semi-finals of the 1948 World Championships in which Bergmann was confronted with the Czech attacker Ivan Andreadis. Bergmann finally won "the most nerve-racking match of [his] career" by 3-2. Personal reports on this epic semi-final encounter can be found in the books of Bergmann (1950, pp. 119-122) and Uzorinac (2001, pp. 86-87).

In 1951, the Englishman Johnny Leach won for the second time the Singles World Championship title, and this was the last time the men´s singles crown was captured by a man whose play mainly, or to a large extent, relied on defence (Barna, 1949/2007; Uzorinac, 2001).

4. HARDBAT VERSUS SPONGE – "THE FUTURE BELONGS TO OFFENSIVE PLAY" (1952 - 1959)

At the 1952 World Championships in Bombay (now Mumbai), sponge as a surface for a racket took centre stage. Sponge enabled the athlete to play faster and prevented that the opponent could hear the bounce of the ball on the bat. Some of the Japanese players were equipped with this modern material (Eckert, 1954). Athletes from Japan won four of seven gold medals. Throughout the following years there was a political dispute in the world of table tennis about this rather new kind of equipment, and only a part of the players changed to this innovation (Uzorinac,

2001). In addition, table tennis tactics and technique were developed further by the players from the Far East. They showed a game which was rendered conspicuous by powerful shots and a very good footwork (Östh & Fellke, 1992). After the 1954 World Championships, the General Secretary of the German Table Tennis Association, Josef "Jupp" Schlaf, was quoted as saying: "The future belongs to offensive play!" (Eckert, 1954, p. 72, translated by the author) As Table 1 shows, this prediction seems to have proven true in the short run as well as in the long run.

The most successful female player of the 1950s, however, was Angelica Rozeanu (Romania), who was a defensive player. She won the gold medal in the women´s singles event of the World Championships six times in a row (1950-1955). Beside other things, this series of wins was due to fact that she improved her offensive game in her late twenties (Uzorinac, 2001). The first European Champion in men´s singles was a defensive player too. Zoltan Berczik (Hungary) won the gold medal in 1958 and successfully defended his title two years later. Berczik was a very passive player who could produce strong backspin (Uzorinac, 2001; Hudetz, 2008). After the 1959 World Championships surfaces made of pure sponge were abandoned. From now on the blade of a bat had to be covered with pimpled rubbers or sandwich rubbers (Clemett, n.d.). The latter is a combination of sponge and pips-in or pips-out rubbers.

5. THE RISE OF THE LOOP (1960 - 1969)

In 1960, the Japanese national team played some matches against a European squad and showed a new technique, the so-called loop or topspin shot (Hudetz, 2008; James, 2008). The term "top-spin" had been part and parcel of competitive table tennis since its beginning ("The Language of Ping Pong", 1902), and words like "topspin drive" or "topspin attack" had been in use over the past decades (Friederich, 2018; Leach, 1951). The term loop, or topspin stroke in its modern definition, names an offensive stroke whereby the racket movement is distinctly marked from down behind to up and forward. The racket hits the ball tangentially producing a strong topspin. The development of the loop benefited from sandwich rubbers with sticky pips-in surfaces which had been invented in Japan in the 1940s (Östh & Fellke, 1992). Originally, the topspin stroke in its exaggerated or modern form had been developed as a technical mean against defensive play and made the Japanese players quite successful at the beginning. However, the defenders learnt to compensate heavy topspin as time went by (Hudetz, 2008).

The 1960s generated some masters of lobbing on international stage. These included Sweden's allround player Hans Alser and Japan's Nobuhiko Hasegawa. The progenitor of balloon defense, Johnny Leach (England), had emphasized that a high defence from a long-range distance is a technique that is thought to lift or push the ball near the baseline of the opponent, trying to impart no spin to the ball (Leach, 1951). Now, in contrast, Alser and Hasegawa performed high defence in a modern form, that is to say, decidedly with topspin and considerably higher than it probably was on Leach's mind. The Japanese World Champions in men's singles, Ichiro Ogimura (1954, 1956) und Toshiaki Tanaka (1955, 1957), had already shown the

"high lob" in competition throughout the past decade (Wild Goose Productions, n.d.).[5]

In the 1960s, new options were created for defensive players in regard to equipment. Usually, defenders played with two inverted rubbers or one pips-in rubber combined with pips-out but no sponge (Uzorinac, 2001; Nelson, 2010). At the 1968 National Championships of Austria, Anton "Toni" Hold advanced to the final in men´s singles using a homemade anti-topspin rubber. Over the course of the following years he distributed this rubber through inhouse production (Nelson, 2009b). The anti-topspin rubber most notably comprises of a non-sticky pips-in surface which deactivates spin. In subsequent years, this kind of material was produced by diverse firms. By Hold´s own account, the anti-topspin rubber was already existing since 1965 (Hold, 2018). Trupkovic (1978) speaks of a player from Yugoslavia named Stolcer who played some kind of anti-spin rubber in 1960 or shortly after. Hudetz (2004) refers to the Hungarian defender Janos Börzsey who played in the singles final of the 1968 European Championships using an anti-topspin rubber.

A long-pimpled rubber was used for the very first time around the year 1960 by Zhang Xielin (China) who was a defender playing the penhold grip. A penhold player in those days used one and same side of the racket for forehand and backhand strokes. A special penhold grip for defenders was taught which enabled the player to hit forehand and backhand strokes with the same side of the racket (Ogimura, 1973). The very first National Champion of China, Chiang Yung-Ning (1952), was a penhold chopper too. At the 1953 World Championships, Chiang defeated two-times World Singles Champion Johnny Leach. This was the first time an athlete from China beat a World Champion in any sport whatsoever (James, 2010).

Zhang came across long pimples rather accidentally in Shanghai during the severe Chinese economic crisis resulting from the Great Leap Forward. In the spring of 1959, Zhang was in search of a substitute for his old worn pips-out rubber and found a top sheet of an inverted rubber in the waste of a factory which produced table tennis equipment. This top sheet had rather long pimples (1.5 mm) which originally had been glued to a sponge in the traditional way. The penhold defender from China did this the other way around: He glued this top sheet to his racket so that the pimples faced the outside (James, 2009). Long-pimpled rubbers have the effect to twist if the player strikes the ball tangentially so that the spin is reinforced by this catapult-like mechanism (Geske & Mueller, 1999). Zhang won the bronze medal twice in men´s singles at World Championships (1961, 1963). He earned the nickname "Magic Chopper" (Boggan, 2000a) or "Shanghai Wizard" (Uzorinac, 2001) because his uncommon way of playing compelled his opponents to make many mistakes which defied any explanation. In the men's team final of the 1963 World

[5] Much earlier to this and for long periods in table tennis history, topspin shots could be of a distinct defensive nature when balls were played with slow speed or a high trajectory (see Straub, 2015, for references). For example, Montagu (1961) mentioned that "lob-topspin" was part of a strategy used by Alfred Liebster, who competed for Austria at World Championships between 1928 and 1938.

Championships, his two Japanese opponents did score less than ten points in each (twenty-one up) game which was played (James, 2009). On the backwash of Zhang, there were further Chinese players in those days who started using the so-called combination bat. A combination bat is a racket covered with two different types of rubbers, which has been also called "Yin-Yang" in the Middle Kingdom (Liang, 1981; James, 2009).

Not only German table tennis supporters remember Zhang Xielin because at the 1965 World Championships in Ljubljana he faced Eberhard Schöler in "the most thrilling table tennis match ever played" (Brucker, 1983, p. 117, translated by the author). About 10.000 spectators watched this men´s singles quarterfinal match. It lasted more than two hours and was won by the German in the decisive set by 27-25 (Riess, 1970).

In 1963 Zhang Xielin became World Doubles Champion. This was the first doubles title for China at World Table Tennis Championships. Zhang Xielin´s partner Wang Zhiliang, who was a shakehand retriever, used two inverted rubbers and perfected the variation of chop and float balls. In contrast to the first named technique, where backspin is imparted to the ball, the last-mentioned technique looks like a chop, but no perceptible spin is produced (Hammersley-Parker & Eaton, 1985). Wang Zhiliang "celebrated as the first world-class defender the art of radical and simultaneously hard to read backspin variation" (James, 2010, p. 18, translated by the author). However, the idea of varying the amount of backspin is much older (Fuller, 1942). In Germany, there is a very own term for varying the amount of backspin in successive shots: This is traditionally called "Schnittwechsel" ("spin change"; e.g., Gäb & Schneider, 1977).

The women's team event of the 1965 World Championships produced a tactical masterstroke. As coaches, Fu Qifang and Rong Guotuan, decided to nominate Lin Huiqing and Zheng Minzhi for the final, and the two chopping players won this team match against Japan by 3-0. In the earlier rounds, two players who preferred the attacking style had competed for China ("Abwehrfalle schnappte zu", 1965; Uzorinac, 2001).

A peak in the history of defensive play was the individual silver medal of Eberhard Schöler (Germany) at the 1969 World Championships in Munich. In 1965 and 1967, he had already won the bronze medal in men´s singles. Schöler's playing style was based on quick feet, outstanding anticipation, continual variations in terms of chopping and a severe attack (Gäb & Schneider, 1977). In addition, he was very self-controlled and showed a high mental strength in competition. Thus, German sport journalists named him "Mr. Pokerface" (Gäb & Schneider, 1977). In the course of the 1960s, three female defenders reached the singles final of the World Championships and secured the silver medal: These were Maria Alexandru from Romania (1963), Lin Huiqing from China (1965) and GDR player Gabriele Geißler from East Berlin (1969).

6. THE COMBINATION BAT PLAYERS ARE COMING (1971 - 1983)

Male and female chopping players from the Middle Kingdom appeared on the international political stage at the beginning of the 1970s. Lin Huiqing, her doubles

partner Zheng Minzhi (runner-up in women's singles at the 1971 World Championships) as well as Liang Geliang and Zhang Xielin were part of the squad and delegation that travelled to the USA in April 1972 in order to play friendly matches. This was a return visit happening as a part of what was called "ping-pong diplomacy". During the ping-pong diplomacy era, the People's Republic of China and the United States of America resumed their political relationship which was interrupted by the Cultural Revolution (Boggan, 2000a, 2000b). In 1971, defensive player Dick Miles was in the U.S. delegation that had originally been invited to the People's Republic. During the stay China, Miles, who was a bronze medalist in men's singles at the 1959 World Championships in Dortmund, played an exhibition match. His Chinese opponent was a player Miles had defeated back then in Germany (Weber, 2010).

At the 1971 World Championships, the rather unknown Frenchman Jean-Paul Weber defeated some world-class players using an anti-topspin rubber. Weber was a defensive player (Boggan, 1999a), and he was good at feinting: He relied on a distinct arm movement and feigned heavy backspin chops which actually had only little spin (Östh & Fellke, 1992). Apart from the anti-topspin rubber, long pimples became a permanent feature in the table tennis world of the 1970s.[6] At the 1971 World Championships, Liang Geliang (China) used a combination bat covered with an inverted rubber and a semi-long pimpled rubber (Gotsch & Ziegler, 1998). After the 1975 World Championships, long-pimpled rubbers became effectively popular (Tamasu Co., n.d.). Shakehand players who preferred the defensive style usually employed two different types of rubbers which had the same colour. Combination bat players began to twirl their racket during the rally or shortly before the serve so that the forehand rubber became the backhand rubber and vice versa (Uzorinac, 2001; Östh & Fellke, 1992). By doing this, the defensive player could vary their game even more. Additionally, their opponents had problems to see which rubber was actually used because, back then, both sides of the racket usually had the same colour. The two Chinese Lu Yuansheng (Östh & Fellke, 1992) und Huang Liang (Uzorinac, 2001; Boggan, 2008) became role models in terms of this tactic of twirling the racket. At the 1977 World Championships, Lu and Huang won the silver medal in men's doubles. Both used a combination bat with pips-in and long pimples.

Later in this period, combination bat players began to stamp a foot in order to disguise the sound a ball made when it contacted the rubber. Furthermore, a new generation of anti-topspin rubbers was produced. The surface of these rubbers looked very similar to ordinary rubbers. This meant that, acoustically as well as optically, it became very difficult to distinguish which one of the two materials on the racket has just been used (Glatzer, 1982; Sklorz, 1983). The combination bat was used by some well-known offensive players too (Hudetz, 2004; Östh & Fellke, 1992; Liang, 1981).

[6] However, as a counterexample, Japan's famous defensive player Norio Takashima, who won a bronze medal in men's singles at the 1975 World Championships, can be named. He used inverted rubber on both sides of his racket almost throughout his entire career (Feldstein, 2015).

During the 1970s, the best defensive players in the world increasingly used offensive strokes. Again, a leading figure was the Chinese defender Liang Geliang who saw himself forced to give up playing his semi-long pimples after 1971. Jiang Qing, who was the fourth and influential wife of Mao Zedong, considered the use of long pimpled rubbers as unfriendly. At the 1973 World Championships, Liang was a pure offensive player. Later on, he returned to the defensive style (Gotsch & Ziegler, 1998). Liang did not only perform effective offensive shots but also worked on reducing the length of the arm movement when playing the chop (Uzorinac, 2001; Gotsch & Ziegler, 1998; Freise, 1986). Liang Geliang was a very successful athlete. He was a World Champion six times in men's team, men's doubles, and mixed doubles. In men's singles he won two bronze medals at World Championships (1977, 1979). In 1976, he became Asian Champion in men's singles, and in 1974 and 1978, he received the gold medal in men's singles at the Asian Games.

Simultaneously, the topspin stroke became a mainstream technique in the 1970s mainly due to a new successful generation of Hungarian and Yugoslavian players. The traditional offensive style which was based on direct plain-hit or counter strokes lost ground. Playing topspin was closely linked to the change of rotation and speed as well as varying placement (Hudetz, 2008). In the second half of the 1970s fresh-gluing came up (Fellke, 2008; Östh & Fellke, 1992). More and more offensive players applied fresh glue to the sponge before playing. The emitted gas of the fresh glue infiltrated the sponge and the surface of the rubber. This resulted in a tension and a catapult effect when the ball touched the rubber. Controlling a fresh glued rubber was rather difficult, but by fresh-gluing a topspin shot gained much more spin and speed.

In the 1970s, there was another famous Chinese player who performed defensive strokes while playing the penhold grip. The female athlete Ge Xinai occurred at World Championships for the first time in 1975 and became World Champion in women´s singles in 1979 (Uzorinac, 2001). Ge Xinai was known as "the penholder retriever". However, she did not play the classic defensive style but frequently liked to attack and block close to the table (Uzorinac, 2001; Jeler, 2011). Eight years ago, at the 1971 World Championships, Lin Huiqing (China) had already won the title in women´s singles by playing an orthodox defensive style (Uzorinac, 2001). In 1981, Tong Ling (China) won the Singles World Championship title, and this was the last time so far, the women´s singles crown was captured by a defensive player. All three world champions, even penhold player Ge Xinei, used combination bats with pips-in and long pimples (Schmicker, 2000; Uzorinac, 2001). At the end of the 1983 World Championships, Martin Sklorz, the outgoing National Coach Education Manager of the German Table Tennis Association, concluded:

"According to Chinese sources, 20 to 25% of all players in China are defenders though. […] Defensive play has become more popular. Whenever possible, good long-range defenders take the opportunity to smash a badly placed drop-shot. Counter-looping on occasion belongs to the tactic of some defensive players in order to put the offensive player off his stride." (Sklorz, 1983, p. 28, translation by the author)

7. FROM 1983 UNTIL THE END OF THE MILLENIUM

In order to reduce the number of inexplicable errors and to make the game more transparent for spectators, the International Table Tennis Federation (ITTF) introduced the two-colour rule, which came into effect internationally on 1 January 1984 (Nelson, 2009a; Oakley, 1984).[7] From now on, the two sides of a table tennis bat had to have different colours. The twirling of the racket during a rally or shortly before the serve in order to confuse the opponent lost effectiveness. The anti-topspin rubber was not any longer used at world-class level, to a great extent due to the two-colour rule (Schmicker, 2000; Hudetz, 2004; Nelson, 2009a). Apart from that, stamping a foot while serving was banned starting 1 July 1983 (Giesecke, 1983).

Since the 1970s, offensive play progressed favoured by fresh-gluing. Erik Lindh (Sweden) was inspired by impressions made in a 1980 training camp in China and became the pioneer of "the playing style of the 80s" (Östh & Fellke, 1992, p. 55, translated by the author). The most distinctive feature of this new way of playing was the counter-loop close to the table whereby the ball was hit in the rising phase of its trajectory with a short and quick arm movement. Likewise, passive play became more dynamic. Beginning in the 1980s, a distinction could be made between a passive block and an active block (Sklorz, 1976; Michaelis & Sklorz, 1982). Besides, *offensive* pushing had been observed in competition (Hudetz, 1984). The two-colour rule made the table tennis industry focus on further developing long pimpled rubbers. Since the mid-1980s, pimples were sold whose length was more than 1.5 millimeters, which had been common so far (James, 2009; Kamizuru, 2011). The extension of long pimples should increase the amount of spin produced by a chop. Furthermore, there were long pimples with a reduced width so that they were thinner and more instable than former products. A medium-fast ball which contacted the rubber diametrically made long pimples bend in an unpredictable manner. The flight characteristics of such "flutter balls" were hard to anticipate by the opponent and baffled them (Petrasch, 2009a).

In the 1980s, the numbers of medals won by defensive players in men´s and women´s singles at World Championships were lower than in the foregone decade (see Table 1). Between 1981 and 1989, only one male defender captured a singles medal: Chen Xinhua (China) won bronze in 1987. But, in addition, Chen was the only defensive player, male or female, who won the World Cup in the singles discipline (1985), an annual event which is held for men since 1980 and for women since 1996 ("Table Tennis World Cup", 2018). He was charismatic and full of smiles, and because of this reason he was called "the Smiler" in German-speaking countries. Chen liked to attack but also to play chops and floats with his forehand. He used long pimples on the backhand and a pips-in rubber on his forehand with a 2.0-millimeter sponge (Glatzer, 1985). Thus, Chen´s inverted rubber was quite fast compared to forehand rubbers used by other choppers in those days (Lauer & Schäfer, 1984).

In 1987, the female defender Guan Jianhua (China) could win a bronze medal in women´s singles at the World Championships. At the 1989 World Championships,

[7] Since 1 July 1986, one side of the racket has to be bright red and the other side has to be black (Hughes, 1918).

the North Korean men´s team won the bronze medal, led by Li Gun-sang, a defensive player who achieved a 16-3 record (Nelson, 1989). In 1993, Li Gun-sang won the Asian Cup ahead of Wang Tao and Liu Guoliang, both from China ("Asian Cup Table Tennis Tournament", 2018).

Ever the tinkerer, Toni Hold who had already developed the anti-topspin rubber in the 1960s started to refine long pimples in the 1980s (Hold, 2011; Neubauer, 2011). He treated the surface of the pimples by using a special spray and liquid in order to varnish or polish them (Nelson, 2009b). *Frictionless* long pimples offered only little resistance to a ball when contacting the rubber diametrically so that the amount of spin was hardly reduced (Petrasch, 2009a). Thus, frictionless long pimples promoted chop-blocking among recreational athletes. Some players could experience optical illusions: Offensive player Erich Arndt (Germany), for example, saw "zigzag balls" in his final against Toni Hold at the 1988 World Veterans Championships (Arndt, 1988). The frictionless long pimpled rubber was a bestseller on the market so that it was copied by other providers.

A vivid element in the table tennis world of the 1980s was "Le Show Secrétin Purkart". In the "Show Secrétin Purkart", 1976 European Singles Champion Jacques Secretin played exhibition matches against two-time French Singles Champion Vincent Purkart including plenty of funny moments and gimmicks in between (Stöckmann, 1981). Chopping as well as lobbing were substantial building blocks of the show as far as table tennis technique was concerned.[8] Secretin, also World Mixed Doubles Champion in 1977, was known for frequently lobbing in serious competition too. Lob defence remained a part of table tennis in the modern era. In somewhat more recent times, the Dane Michael Maze showed tremendous character to come back with the help of the lob in the quarterfinals in men´s singles of the 2005 World Championships. He had already used this technique successfully a couple of times the round before (Nelson, 2005).

In the 1990s, there was another male defender who played in the semi-finals of a World Championship singles event: Ding Song (China) won the bronze medal in 1995 using short pimples on the backhand side of his racket. Ding had a spectacular strong forehand attack and, as a server, preferred attacking over defending (Nelson, 1998). Ding started his carrier as an offensive player and switched to the defensive style at a later time (James, 2010). In the Middle Kingdom, Ding Song might have been seen as a kind of confidential matter because, after his international debut in 1990, he did not emerge at world-class level until the 1994-1995 season (Schäfer, 1995). Ding switched to short pimples in 1993, and in those days, defensive play in China was

[8] Show presentations in table tennis had been already executed in the first decade of the 20th century (Gäb & Schneider, 1977). The legendary chopping player and four times World Singles Champion Richard Bergmann gained publicity by playing such show fights throughout the 1940s, 1950s, and 1960s. During World War II, Bergmann played for the benefit of the Red Cross (Bergmann, 1950), later on he went on tour for his own financial purposes. Beside other events, he showed up in the accompanying program of the Harlem Globetrotters (Uzorinac, 2001). In England, however, there had been show presentations in table tennis prior to Bergman's journeys around the world ("The Tour of England", 1936; Grant, 2010).

taught with short pimples as a matter of principle (Geil & Ziegler, 1998; Nelson, 1998). Short-pimpled rubbers enable the defender to generate backspin autonomously, regardless the amount of spin of the oncoming ball. This also makes the variation of spin (chop and float) much easier (Nelson, 1997; Petrasch, 2009b). Furthermore, short pimples are faster than long pimples so that the ball comes back to the opponent more rapidly (Geil & Ziegler, 1998). Ola Einarsson (1998), at that time Coach of the Hessian Table Tennis Association in Germany, classified Ding Song as a *modern defensive player* whose game was characterized by three features:

1. forehand attacking shots first and foremost after his own serve and if a chance has opened up during the rally (e.g., as an answer to soft offensive shots or drop-shots)

2. backhand chops comparatively close to the table (with short pimples) and forehand chops and floats (with the pips-in rubber), but also forehand counter-loops at mid-distance from the table with the inverted rubber

3. very early contact point on the ball when pushing short serves and attempts to attack with the forehand when the opponent serves mid-long or long (Einarsson, 1998, p. 5, translated by the author)

The distinction between an aggressive and a passive form of defensive play in table tennis can be traced back at least to the early 1980s (Leiß & Wolf, 1983; Boggan, 1999b). In modern China, defenders seem to be conceptionally characterized and denoted as “chop-and-attack players” or “chop-attacking players” (Chen, Sun, & Ding, 2013; Wu & Tang, 1996). Experts were sometimes split about the potential and future of defensive play. After the 1995 World Championships, Radivoj Hudetz (Croatia), an internationally known authority in table tennis, stated that defensive play is on the decrease even among female athletes (Hudetz, 1995). Two years later, he took the view that defensive play had no chance of being successful at the very top of the table tennis world. At the same time, he admitted that defence was capable of surprising because even some world-class players showed weaknesses against this particular playing style (Hudetz, 1997). As opposed to this, the German table tennis journalist Rahul Nelson felt positive about the prospects of defensive play. At the 1997 World Championships, some good results of male and female defenders made him conclude the following:

“Despite all prophecies of doom: Defensive play is still alive, partially because more and more athletes have problems to play against defence, but also due to innovations such as short pimples.” (Nelson, 1997, p. 8, translated by the author)

As long ago as in the mid-1990s, Hudetz pointed to the fact that in China defensive play was far more than a margin phenomenon, that is to say, defence play was an integral component of the training system over there. In China, a higher percentage of players was schooled as defenders, and the play against defence belonged to the basic table tennis education in the People’s Republic (Hudetz, 1995). In 1986, Anton Lehmann and Georg Silberschmidt from Switzerland had already travelled to China and reported later on that there had been one defensive player in each training group (Lehmann & Silberschmidt, 1987).

On 1 July 1999, the ITTF reduced the *aspect ratio* of the long pimples, that is the ratio between their length and their diameter. The aspect ratio decreased from 1.3 to 1.1. Long pimples became somewhat thicker again, more stable and better to control (Nelson, 2009a; Petrasch, 2009a). At some time before, a rather new playing style had emerged, essentially due to the refined long pimpled rubbers. This new playing style was called chop-blocking. Chop-blockers normally use a pimpled rubber and play rather close to the table. They actively block with backspin on their backhand side, and if the opportunity is given, they try to end the rally with a killing forehand shot. In the 1985 World Championships, chop-blocker Lo Chuen Tsung (Hong Kong) took the bronze medal in men´s singles. The origin of chop-blocking can be traced back to the early 1970s or even 1960s where it emerged as a part of the Chinese playing culture. Boggan (2000c) points out that the penhold attacker Li Furong, three-time men's singles finalist at World Championships (1961-1965), was very good at chop-blocking. This allowed him to vary the spin very much (backspin, topspin, no-spin). At the 2001 World Championships, Kim Yun-mi (North Korea), bronze medalist in women's singles, shocked her opponents with an inconvenient playing style which was described as follows:

"The penhold player uses an inverted rubber on her forehand and performs consistent as well as powerful loops. On the back of the racket, she uses long pimples to *stab disgustingly* the ball without twirling her racket. This made one after the other opponent despair. […] Remarkable alternatives are established for the classic weak point of penhold play, which is the backhand. Besides the use of the long pimples which enable Kim to take the ball in the ascending phase and pulling down the racket as in chopping, there is the possibility to play backhand counter and backhand block which are performed with the inverted rubber in the familiar penhold style." (Nelson, 2001a, p. 18, translated by the author)

8. DEFENSIVE PLAY AT THE START OF THE THIRD MILLENIUM

At the beginning of the third millennium, the block shot in table tennis had already experienced another metamorphosis: Top-class players had started to perform "topspin blocks" with the backhand on a regular basis (Hampl, 2002). Now, it could be distinguished between a *topspin block* and a *punch block* (Schmittinger, 2001).[9]

On 1 October 2000, the 40-millimeter table tennis ball was introduced internationally. The diameter of the new ball was two millimeters larger than the diameter of its predecessor. Thus, rallies should lose speed and spin and become more attractive to spectators. The former German national coach of the women´s team Martin Adomeit (2001) predicts that the somewhat bigger ball will have to face more air resistance and lose momentum. He names some new challenges for defensive players:

[9] However, following Tim Boggan's observations in the era of ping-pong diplomacy, or even earlier, the idea of aggressive blocking is much older: He writes that "[s]ometimes the Chinese can block a shot almost as hard as they can slam the ball" (2000c).

- Drop-shots will become shorter
- Speed contrasts performed by offensive players will become more severe
- Offensive players will have more time to adjust to the next ball contact
- Defensive players will have to modify their footwork: They have to reinforce the training of forward movements and ought to stand closer to the table in principle
- Attacking will become more difficult for defenders: Counter-loops and topspin shots close to the table will be slower
- It will be more difficult for defensive players to generate heavy backspin as well as to mix varying degrees of backspin

Despite all difficulties brought by the introduction of the 40-millimeter ball, defensive players called attention to themselves. At the 2001 German Open, Nelson noticed that two female defenders from South Korea were able to create extreme backspin, in spite of the larger diameter of the new ball in use. He attributes their success to several causes (Nelson, 2001b):

- The players applied fresh glue to both rubbers on their rackets. Thus, even the long pimples were freshly glued
- The players made good use of their wrists
- While chopping, they contacted the ball very early, often in the rising phase of the ball trajectory. This increased the time pressure for the opponent and made attacking close to the table easier for the defender
- They combined backspin with sidespin using an aggressive arm movement which made the shot more offensive
- The change of the point scoring system, which also took place in 2001 (Clemett, n.d.), shortened the duration of a game and did not give an offensive player so much time to adjust to defence
- Half-long high-toss backhand serves made it difficult for the opponents to attack
- In women's doubles, variation of backspin was very advantageous: One player preferred generating heavy backspin while her partner favoured float balls

At the 2003 World Championships in Paris, defensive players came impressively into picture with Joo Sae-hyuk (South Korea) leading the way. As number 61 ranked player in the world, he advanced to the men´s singles final. By winning the silver medal in this event, he emulated Eberhard Schöler who had won silver in singles 34 years before in Munich. This success was mainly due to both his outstanding forehand counter-loop (using a freshly glued rubber) and awesome chopping on his backhand side. In addition to Joo Sae-hyuk, Austria's Chen Weixing could advance to the quarterfinals. On their ways, each of them had defeated an opponent from China, Joo in the quarterfinals and Chen in the round of 16. At that time, it was observed that more and more young players and even the Chinese showed a deficit against defensive play. This deficit could be attributed to the fact that young top

players have less and less opportunity in daily training and competition to play against defence (Amizic, 2004; Nelson, 2003). Another cause for the wins of Joo and Chen against opponents from China could have been the fact that in the Middle Kingdom defensive players were mainly equipped with short-pimpled rubbers in those days (Geil & Ziegler, 1998). Joo and Chen both used long pimples on their backhand (Nelson, 2003).

At the 2004 Olympic Games in Athens, the female defender Kim Kyung-ah (South Korea) won the bronze medal in women´s singles. In 2007 and 2009, Joo Sae-hyuk reached the quarterfinals in men's singles at the World Championships; in 2004 and 2011, he became fourth and third, respectively, at the Men's World Cup (ITTF, 2018). The top-class performances of Joo Sae-hyuk and Kim Kyung-ah were historically flanked by further high-class results achieved by defenders in major international tournaments (see Straub, 2012, for an overview from 2000 and 2012). Regarding the European continent, the highlights in the history of defence play throughout the last decade have been the three European Championship titles in women's singles (Viktoria Pavlovich from Belarus in 2010 and 2012; Li Qian from Poland in 2018). Besides there are the victories of Li Qian in the 2009 Europe Top-12 tournament and Li Jie (The Netherlands) in the 2017 Europe Top-16 tournament. Panagiotis Gionis from Greece shall not be forgotten: He reached the semi-finals in men's singles at the 2013 European Championships. The last defender who had won a bronze medal in this event was Tibor Kreisz (Hungary) in 1978.

Effective from 1 July 2008, frictionless long-pimpled rubbers were banned by the ITTF. Currently, only nonslip long pimples are allowed to be used (Neubauer, 2018). Since 1 September 2008, fresh-gluing or using volatile organic compound-based glues, respectively, is illegal too (Fellke, 2009a). Defenders and chop-blockers who had used frictionless long pimpled rubbers had to give up the opportunity to use the full amount of the oncoming spin. Attackers without freshly glued rubbers need a better hitting technique and footwork now (Fellke, 2009b). For the vast majority of male world-class defenders, forehand topspin shots play a voluminous role nowadays. Straub (2013b) suggests the term "postmodern" defensive player to denote defenders who play in principle topspin strokes on the forehand side when standing rather far away from the table. In contrast, the old words "modern defence player" (Einarsson, 1998) and "aggressive defence player" (Leiß & Wolf, 1983) refer to defenders who still rely on forehand chops to a significant extent. Switching racket sides by twirling still makes some sense for serving, but only a very few individuals at world-class level twirling their bat during the rally.

Further rule changes and changes in material and equipment are discussed now and then. Some of them could affect defensive play, such as increasing the net height, increasing the diameter of the ball once again and developing rubbers which are even faster than the current ones (Petrasch & Teuffel, 2006). In the meantime, defenders give thought to new weapons, such as:

- rackets with two pips-in rubbers (Nelson, 2010)
- a tactical mix of chopping and lobbing (Nelson, 2010)
- chop balls with sidespin (Leidheiser, 2007; Nelson, 2010)

- improving the short game above the table (Adler, 2010)
- block and topspin shots with the backhand (Adler, 2010)
- an even more graded spectrum of spin variations, in regard to backspin as well as topspin (Shibutani, 2007)

9. DEFENSIVE PLAY IN THE WORLD OF TODAY

At the international level, on 1 July 2014, the celluloid balls were replaced by new plastic or poly balls (Table Tennis England, 2019). Due to a new production method, these 40-millimeter balls are slightly larger than the 40-millimeter balls that are completely made of celluloid. As a consequence, the capability to impart spin to the ball is somewhat reduced. In addition, compared to the old celluloid ball, the poly ball which is nowadays in use shows a somewhat steeper ascent and higher bounce when backspin is on the ball (Fürste, 2014). Both consequences of the plastic ball are also true for topspin balls. In general, these attributes tend to make heavy chopping as well as varying the amount of backspin more difficult. Hence, a long placement of the ball and a rather close posture of the chopper's body to the table might become even more important in the future (Nelson, 2018).

Even after the year 2014, defensive players have been able to show that they can still be successful at the highest level. Kim Song-i from North Korea won the bronze medal in women's singles at the 2016 Olympic Games in Rio de Janeiro. China's Wu Yang advanced to the quarterfinals in women's singles at the World Championships three times in a row: two times before 2014 and another time after 2014 (2011, 2013, 2015). At the time of this writing (December 2018), there were 13 female and 3 male defenders ranked among the Top 100 of the world (ITTF, 2018). At the time of the publication of the original article in English language (Straub, 2012), there had been 19 female and 9 male defenders ranked among the Top 100 of the world (July 2012). Thus, despite the fact that defensive play in table tennis has proven itself to be competitive (Straub, 2013a), the number of defensive players at elite level in table tennis currently seems to decrease. It might well be that more than ever skilled coaches are needed: skilled coaches who are able to identify specific talents, skilled coaches who have a broad knowledge about (defensive and offensive) techniques and tactics, and, after all, skilled coaches who have the courage and social competence to take up and pursue this special way of playing table tennis (Straub, 2013a).

Table 1. *Medals in men's and women's singles won by defensive ("chopping") players at the World Table Tennis Championships 1949-2017 (see already Straub, 2013a)*

Year (Number of championships)	Number of medals won in men's singles by male choppers (gold / silver / bronze)	Number of male defenders who won these medals	Number of medals won in women's singles by female choppers (gold / silver / bronze)	Number of female defenders who won these medals
1949 – 1953 (5)	7 (3 / 1 / 3)	5	8 (4 / 1 / 3)	4
1954 – 1959 (5)	2 (0 / 0 / 2)	2	4 (2 / 0 / 2)	2
1961 – 1969 (5)	7 (0 / 1 / 6)	4	5 (0 / 3 / 2)	4
1971 – 1979 (5)	4 (0 / 0 / 4)	3	7 (2 / 2 / 3)	5
1981 – 1989 (5)	1 (0 / 0 / 1)	1	2 (1 / 0 / 1)	2
1991 – 1999 (5)	1 (0 / 0 / 1)	1	0	0
2001 – 2009 (5)	1 (0 / 1 / 0)	1	0	0
2011 – 2017 (4)	0	0	0	0

Table 2. *Obstructive framework conditions and resulting adaptions in the development of defensive play in table tennis*

Time Period / Starting Point	Obstructive framework conditions	Adaptions
Pre-1930	Introduction of rubber-faced bats "with the idea of improving attacking strokes and to baffle the half volley defence" (Barna, 1950/2010)	Starting around 1929: "This, in turn, led naturally to the counter-measure of long-range defence" (Barna, 1950/2010)
1952	Sponge as a surface for a racket took center stage (J. Schlaf: "The future belongs to offensive play!", cited in Eckert, 1954)	● Remaining passive while producing strong backspin (Z. Berczik) ● Including more solid attacking strokes in one's defensive play (A. Rozeanu) ● Short-range defence (R. Miles) ● Lobbing (I. Ogimura, T. Tanaka)
1960	Invention of the loop as the topspin stroke in its exaggerated or modern form using backside sandwich rubbers (sponge + pips-in)	● New options were created in regard to equipment: Anti-topspin rubber (around 1965), long pimples (starting in 1959), combination bat (two different types of rubbers) ● Perfecting the variation of chop and float balls ("Schnittwechsel")
1970s	Continual improving attacking play favoured by fresh-gluing (starting in the second half of the 1970s)	● Feinting arm movements (J.-P. Weber) ● Twiddling the combination racket during the rally or shortly before the serve (whereby both rubbers had the same colour)

(to be continued)

Time Period / Starting Point	Obstructive framework conditions	Adaptions
1970s		● Reducing the length of the arm movement (Liang Geliang) ● Stamping a foot in order to disguise the sound a ball made (at the beginning of the 1980s)
1983/ 1984	Banning foot-stamping in service / Invention of the two-colour rule	● Immediately focusing on further developing long-pimpled rubbers: Extending the length of the pimples, reducing their width, frictionless long pimples ● Starting to counter-loop (around 1983) ● Starting to use thick pips-in rubbers (2.0 mm) ● Intensifying attack play („modern defence“) ● In the 1990s: Using short-pimpled rubbers for chopping play
1999	Decreasing the length of long pimples and increasing their diameter (“aspect ratio”)	● Fresh-gluing for defensive players too ● Contacting the ball in the ascending phase of its trajectory when chopping ● (Counter-)Looping with the forehand in principle (“postmodern defence”) ● Combining backspin with sidespin ● Modifying the footwork: Reinforcing the training of forward movements and standing closer to the table in principle ● Improving the short game above the table (Chen Weixing) ● Block and topspin shots with the backhand (Ruwen Filus: “One might call me an allround player”, cited in Petrasch, 2009b) ● Establishing an even more graded spectrum of spin variations, in regard to backspin as well as topspin
2000	Introduction of the 40-millimeter ball	
2008	Ban of frictionless long-pimpled rubbers	
2014	Introduction of the plastic or poly ball	Intensifying a long placement of the ball and a rather close posture to the table might become even more important

REFERENCES

Abwehrfalle schnappte zu [The defense trap snapped shut] (1965). *Deutscher Tisch-Tennis Sport, 19*(9), 5.

Adler, R. (2010). Die Abwehr ist noch zu retten [Defense play can be rescued. Interview with Chen Weixing]. *Tischtennis, 63*(1), 16-17.

Adomeit, M. (2001). Leere Bälle noch leerer [Dead balls will further lose spin]. *Deutscher Tischtennis-Sport, 54*(5), 42-44.

Albers, H. (1990). *Die Tischtennis-Weltmeisterschaften von 1947 bis 1965 unter Berücksichtigung materieller, regel- und spieltechnischer Veränderungen [The table tennis world championships from 1947 to 1965 considering changes in*

terms of equipment, rules, and playing technique]. Unpublished Master´s Thesis, German Sport University Cologne.

Amizic, M. (2004). Abwehrer sind eine Bereicherung für‘s Tischtennis! [Defenders are an asset for table tennis!]. Butterfly News [Electronic newsletter], May, 7-8. Retrieved from http://www.butterfly-world.com/newsletter/butterflynews-d13.pdf. Accessed: 16 June 2009

Angenendt, G. (1995). That in(famous) rally. *The Table Tennis Collector*, 7, 5-7.

Arndt, E. (1988). „Zuschauer-Killer“ [“A killjoy for the audience”. Letter to the editor in regards to disruptive material]. *Deutscher Tischtennis-Sport, 42*(7), 16.

Asian cup table tennis tournament. Wikipedia. Retrieved from https://en.wikipedia.org/wiki/Asian_Cup_Table_Tennis_Tournament#Men's_singles. Accessed: 30 December 2018

Ayres, F. H. (1902, March 15). Manufacturer of indoor & outdoor games & sports. *The Table Tennis and Pastimes Pioneer*, 9, 8.

Barna, V. (1949/2007). On Johnny Leach. *The Table Tennis Collector*, 45, 13.

Barna, V. (1950/2010). Time marches on. *The Table Tennis Collector*, 58, 10.

Barna, V. (1970). *Der Weg zum Erfolg: Ein Tischtennis-Leitfaden [The road to success: a table tennis guide]* (5th ed.). Lübeck: Oskar Klokow.

Bergmann, R. (1950). *Twenty-One Up*. London: Sporting Handbooks.

Boggan, T. (1999a). History of U.S. Table Tennis Vol V - Part I: Ping-Pong Oddity, Chapter III [Electronic version]. Retrieved from http://216.119.100.169/articles/ppoddity03.shtml. Accessed: 28 December 2018

Boggan, T. (1999b). History of U.S. Table Tennis Vol V - Part I: Ping-Pong Oddity, Chapter XI [Electronic version]. Retrieved from http://216.119.100.169/articles/ppoddity11.shtml. Accessed: 28 December 2018

Boggan, T. (2000a). History of U.S. Table Tennis Vol V - Part II Grand Tour, Chapter I [Electronic version]. Retrieved from at http://www.usatt.org/articles/gtour/gtour01.shtml. Accessed: 28 December 2018

Boggan, T. (2000b). History of U.S. Table Tennis Vol V - Part II Grand Tour, Chapter VI [Electronic version]. Retrieved from http://216.119.100.169/articles/gtour/gtour06.shtml. Accessed: 28 December 2018

Boggan, T. (2000c). History of U.S. Table Tennis Vol V - Part II Grand Tour, Chapter VII [Electronic version]. Retrieved from http://216.119.100.169/articles/gtour/gtour07.shtml. Accessed: 31 December 2018

Boggan, T. (2003). History of U.S. Table Tennis Vol II - Chapter XXXVIII [Electronic version]. Retrieved from http://216.119.100.169/articles/history02/history02_38.shtml. Accessed: 2 January 2019

Boggan, T. (2008). History of U.S. Table Tennis Vol VIII - Chapter XXXV [Electronic version]. Retrieved from http://216.119.100.169/articles/history08/history08_35.shtml. Accessed: 28 December 2018

Brucker, O. (1983). *Kämpfe, Siege, Sensationen: Sportspektakel aus aller Welt [Fights, wins, sensations: sports spectacles from around the world]*. Bad Homburg: Limpert.

Carrington, J. (1960). *Modern Table Tennis* (4th ed.). London: G. Bell.

Chen, W., Sun, Q., & Ding, S. (2013). *Research on the Development of Chop-Attacking Skills of Table Tennis [Poster]*. 13th ITTF Sports Science Congress. Paris.

Clemett, C. (n.d.). Evolution of the laws of table tennis and the regulations for international competitions. Retrieved from http://www.ittf.com/wp-content/uploads/2016/10/ColinEvolution.pdf. Accessed: 27 December 2018

Club Notes (1902, March 8). *The Table Tennis and Pastimes Pioneer*, 8, 5.

Duke, A. (2009). Early references in The Times – part 2: Tournaments (continued). *The Table Tennis Collector*, 54, 6-7.

Duke, A. (2017). The first table tennis tournament. *Table Tennis History*, 82, 17-24.

Eckert, H. (1954). *Die Welt des weißen Balles: Das Buch vom Tischtennis-Sport [The world of the white ball: the book on the sport of table tennis].* Kiel: Dr. Hans Eckert.

Einarsson, O. (1998). *Schulung zum modernen Abwehrspieler [Developing modern defensive players]*. [VDTT] Trainerbrief, 14(3), 5-8.

English Table Tennis Association (2018). Wikipedia. Retrieved from https://en.wikipedia.org/wiki/English_Table_Tennis_Association. Accessed: 21 December 2018

Feldstein, S. (2015, February 27). Mr. Norio Takashima interview. Retrieved from http://ooakforum.com/viewtopic.php?f=56&t=27446. Accessed: 4 January 2019

Fellke, J. (2008). Klampar entdeckte den Klick: Die Geschichte des Frischklebens – Teil 1 [Klampar discovered the click: The history of fresh-gluing – part 1]. *tischtennis, 61* (11), 38-40.

Fellke, J. (2009a). Kontrolle ist besser: Die Geschichte des Frischklebens – Teil 3 [Trust, but verify: The history of fresh-gluing – part 3]. *tischtennis, 62*(1), 36-38.

Fellke, J. (2009b). Die Stars fordern Strafen: Die Geschichte des Frischklebens – Teil 4 [The stars demand sanctions: The history of fresh-gluing – part 4]. *tischtennis, 62*(2), 34-36.

Findon, E. (1936). Learn to play: Forehand and backhand defence. *Table Tennis: the official organ of the E.T.T.A., 2*(2), 5.

Freise, U. (1986). Liang Geliang – einen besseren Allroundspieler gab es nicht [Liang Geliang – there has not been a better allround player]. *Deutscher Tischtennis-Sport, 40*(12), 34-35.

Friederich, H. (2018). Geschichte der Weltmeisterschaften: 12. Weltmeisterschaften – Wembley 1938 – Der Angriff im Vormarsch [The history of the world championships: 12th world championships – Wembley 1938 – Offense on the rise]. Retrieved from http://pingpongbuch.de/. Accessed: 27 December 2018

Fuller, E. M. (1942). *Top-Notch Table Tennis*. Chicago: Little Technical Library.

Fürste, F. (2014). Plastikball (mit und ohne Naht) versus Zelluloidball [Plastic ball – with or without seam – versus celluloid ball]. *[VDTT] Trainerbrief, 30*(4), 32-37.

Gäb, H.W., & Schneider, E. (1977). *Tischtennis*. Bad Homburg: Limpert.

Geil, S., & Ziegler, V. (1998). Die Zukunft des Abwehrspiels [The future of defensive play. Interview with Liu Pang]. *[VDTT] Trainerbrief, 14*(3), 26-27.

Geske, K.M., & Mueller, J. (1999). *Tischtennis-Taktik: Dein Weg zum Erfolg [Table tennis tactics: Your way to success]*. Aachen: Meyer & Meyer.

Giesecke, H. (1983). Materialfrage entschieden: zweifarbig wird Pflicht [The question of equipment is decided: bicolored becomes compulsory]. *Deutscher Tischtennis-Sport, 37*(6), 18-19.

Glatzer, G. (1982). Europa verliert weiter an Boden [Europe further loses ground]. *Deutscher Tischtennis-Sport, 36*(3), 10-12.

Glatzer, G. (1985). Chen, der Lächler [Chen, the smiler]. *Deutscher Tischtennis-Sport, 39*(5), 43.

Gotsch, Q., & Ziegler, V. (1998). Interview mit Liang Ge Liang [Interview with Liang Ge Liang]. *[VDTT] Trainerbrief, 14*(3), 19-21.

Grant, S. (2010). The mystery of Annie Hall. *The Table Tennis Collector*, 57, 6-10.

Gurney, G. (1993). Early publications – part 2. Spalding´s athletic library: Table tennis (April 1902). *The Table Tennis Collector*, 3, 4-5.

Hammersley-Parker, J., & Eaton, R. (1985). *Table Tennis*. London: A & C Black.

Hampl, H. (2002). Sechs goldene Regeln [Six golden rules]. *tischtennis, 55*(9), 29-31.

Harrison, W. (1901/2000). Ping-pong or table tennis. *The Table Tennis Collector*, 23, 3-6.

Hoey, C. (2012, March 9). Personal information.

Hold, A. (2018). Erfolge [Successes]. Retrieved from http://www.tonihold.com/html/erfolge.html. Accessed: 28 December 2018

Hold, A. (2011, March 14). Personal message.

How to play ping pong told in photographs by Mr. Arnold Parker, the winner of the Queen's Hall tournament (1994). *The Table Tennis Collector*, 6, 5. (Reprinted from The Tatler, No. 34, 1902, February 19).

Hudetz, R. (1984). *Alles über Tischtennis Technik [Everything about table tennis technique]*. Saarbrücken: Tibhar.

Hudetz, R. (1995). Mit chinesischer Präzision ins nächste Jahrtausend [Chinese precision for the next millennium]. *Deutscher Tischtennis-Sport, 49*(6), 26.

Hudetz, R. (1997). Kein Fortschritt ohne Vision [No progress without having visions]. *Deutscher Tischtennis-Sport, 51*(9), 8-9.

Hudetz, R. (2004). *Taktik im Tischtennis: Mit dem Kopf gewinnen [Tactics in table tennis: winning with your head]*. Saarbrücken: Tibhar.

Hudetz, R. (2008). Wunderwaffe Topspin [Wonder weapon loop]. *tischtennis, 61*(6), 26-31.

Hughes, M. (2018). How to choose your table tennis rubber. Retrieved from https://www.allabouttabletennis.com/table-tennis-rubber.html. Accessed: 30 December 2018

ITTF [International Table Tennis Federation]. (2018). http://results.ittf.link/. Accessed: 31 December 2018

Kamizuru, Y. (2011, March 2). Personal message.

James, H. (2008). Mission Kringelbekämpfung [Mission: combating the loop]. *tischtennis, 61*(6), 32-33.

James, H. (2009). Zauberwaffe aus Abfall [Magic weapon from waste]. *tischtennis, 62*(2), 10-11.

James, H. (2010). Jeden einzelnen Ball zurückbringen [Returning each and every single ball]. *tischtennis, 63*(1), 18.

Jeler, E. (2011, October 5). Personal information.

Lauer, E., & Schäfer, M. (1984). Mit diesem Material spielen die Besten – Bundesranglistenturnier 1984 [The best play with these equipments – 1984 German ranking top 12 ranking tournament]. *Deutscher Tischtennis-Sport, 38*(1), 13.

Leach, J. (1951). *Table Tennis for All*. London: Kaye.

Lehmann, A., & Silberschmidt, G. (1987). Trainer in China [Coaches in China]. *Deutscher Tischtennis-Sport, 41*(1), 42-43.

Leidheiser, F. (2007). Abwehr nach Bolls Abkehr [A defender following Boll's departure]. *tischtennis, 60*(10), 22.

Leiß, J., & Wolf, J. (1983). *Tischtennis-Lehrplan 3 – Training und Wettkampf [Table tennis curriculum 3 – training and competition]*. München: BLV.

Li, X.-D. (2009). How to achieve victories in modern table tennis. Retrieved from http://www.uatassociation.org/community/viewthread.php?tid=56. Accessed: 26 December 2018

Liang, G. (1981). Die Anwendung des Kombischlägers. *Deutscher Tischtennis-Sport, 35*(6), 63-64.

Magic carpet (1939). *Table Tennis [The official organ of the English Table Tennis Association], 4*(7), 3.

Mainland, L. G. (c. 1902/2001). How to become a ping pong champion. *The Table Tennis Collector, 27*, 4-7.

Mauritz, D. (1954). Der Weg zur internationalen Spitzenklasse [The way to international top-level]. In H. Eckert (Ed.), *Die Welt des kleinen Balles, Das Buch vom Tischtennis-Sport* (pp. 145-147). Kiel: Dr. Hans Eckert.

Michaelis, R., & Sklorz, M. (1982). *Tischtennis-Lehrplan 1 – Technik [Table tennis curriculum 1 – technique]*. München: BLV.

Montagu, I. (1952). The Satoh racket: An authoritative and complete review on the 'sponge' bat. *Table Tennis [Official magazine of the English Table Tennis Association], 10*(9), 14-15.

Montagu, I. (1961). The loop drive – it´s not new. *Table Tennis [Official magazine of the English Table Tennis Association], 19*(4), 12-13.

Muhr, K. (2003). Bigger ball – why? [Interview with Andrzej Grubba]. *Table Tennis News, 290*, 28-29.

Munivrana, G., Furjan-Mandić, G., & Kondrič, M. (2015). Determining the Structure and Evaluating the Role of Technical-Tactical Elements in Basic Table Tennis Playing Systems. *International Journal of Sports Science & Coaching, 10*(1), 111-132.

Neubauer, H. (2011, March 9). Personal message.

Neubauer, H. (2018). Das Unternehmen. Retrieved from https://www.drneubauer.com/index.php?p=2&lang=de. Accessed: 31 December 2018

Nelson, R. (1989). Die Kleinen kommen [The small ones are coming]. *Deutscher Tischtennis Sport, 43*(4), 12.

Nelson, R. (1997). Und die Abwehr lebt doch [And yet defensive play lives]. *Deutscher Tischtennis-Sport, 51*(6), 8.

Nelson, R. (1998). Die letzten Artisten [The last artists]. *Deutscher Tischtennis-Sport, 52*(9), 4-8.

Nelson, R. (2001a). Korea-Uschi [„Korea-Uschi" – an allusion to the unorthodox German player Ursula Oswald-Ziegler]. *Deutscher Tischtennis-Sport, 54* (5), 18.

Nelson, R. (2001b). Unglaublich viel Unterschnitt [An incredible amount of backspin]. *Deutscher Tischtennis-Sport, 54*(11), 20-21.

Nelson, R. (2003). Die Abwehr lebt [Defense play lives]. *tischtennis, 57*(6), 13.

Nelson, R. (2005). Michael, der Mondmann [Michael, the moon-man]. *tischtennis, 59*(5), 22.

Nelson, R. (2009a). Das war meine Idee [That was my idea]. *tischtennis, 62*(2), 8-9.

Nelson, R. (2009b). Der Hirsch hat protestiert [Hirsch has objected. Interview with Toni Hold]. *tischtennis, 62*(2), 12.

Nelson, R. (2010). Die Abwehr darf nicht sterben [Defense play shall not die]. *tischtennis, 63*(1), 12-13.

Nelson, R. (2018). Der kleine Unterschied [The small difference]. *tischtennis, 71*(11), 36-41.

Notes (1902, March 8). *The Table Tennis and Pastimes Pioneer*, 8, 5.

Oakley, J. (1984). Spotlighton… David Barr. *Table Tennis News*, 141, 12.

Ogimura, I. (1973). *Tischtennis [Table tennis]*. Landau: Schmitt.

O'Sullivan, J. (1974). Gerard Holdsworth films on table tennis. *Table Tennis News*, 66, 33.

Östh, G., & Fellke, J. (1992). *Wie wird man die Nr. 1 im Tischtennis? Das Geheimnis der schwedischen Tischtennis-Weltmeister [How to become no. 1 in table tennis? The secret of the Swedish table tennis world champions]*. Aachen: Meyer & Meyer.

Pardy, G. T. (1902). Ping-Pong. In *A Little Book of Ping-Pong Verse* (p. 25). Boston: Dana Estes.

Petrasch, J. (2009a). Flattern ist nicht [Flutter balls may not exist]. *tischtennis, 62*(2), 14-15.

Petrasch, J. (2009b). Im Kopf muss es stimmen [You must be clear in mind. Interview with Ruwen Filus]. *tischtennis, 62*(11), 26-27.

Petrasch, J., & Teuffel, F. (2006). Ein Spiel mit Zukunft [A game with a future]. *tischtennis, 60*(3), 18-21.

Purves, J. (1945). *Table Tennis* (3rd print). New York: A.S. Barnes.

Rae, A. H. (1902, March 8). Correspondence: To the editor. *The Table Tennis and Pastimes Pioneer*, 8, 3.

Riess, C. (1970). *Einsam vor Millionen Augen: Große Sportler und ihre Schicksale [Lonely in front of a million eyes: great athletes and their destinies]*. Gütersloh: Bertelsmann.

Ritchie, M. J. G. (1902/2005). Ping pong. *The Table Tennis Collector*, 39, 8-9. (Reprinted from The Yorkshire Weekly Post, 1902, November 8)

Ritchie, M. G., & Parker, A. (1902). *Ping Pong: The Table Tennis Game as Played in America*. New York: Street & Smith.

Schäfer, M. (1995). Chinas geheime Verschlusssache [China's confidential matter]. *Deutscher Tischtennis-Sport, 49*(6), 20.

Schmicker, J. (2000). *Das große Buch vom Tischtennis [The great book of table tennis]*. Rieden: WB.

Schmittinger, K. (2001). Basis zum Erfolg – Blocktechniken [The foundation for success – blocking techniques]. *Deutscher Tischtennis-Sport, 54*(4), 48-53.

Schöler, D., & Schöler, E. (2012, July 18). Personal information.

Shibutani, H. (2007). Die Balance bestimmt das Abwehrspiel [The balance determines defensive play]. Butterfly News [Electronic newsletter], 12, 14-15. Retrieved from http://www.butterflyworld.com/newsletter/butterfly-news-d56.pdf. Accessed: 2 July 2009

Sklorz, M. (1976). *Tischtennis – vom Anfänger zum Könner [Table tennis – from a novice to a skilled performer]* (3rd ed.). Munich: BLV.

Sklorz, M. (1983). Qualität des Returns hinkt hinter der des Aufschlags her [The quality of the receive lags behind the quality of the serve]. *Deutscher Tischtennis-Sport, 37*(6), 28-29.

Stöckmann, W. (1981). Eine perfekte Show. *Deutscher Tischtennis-Sport, 35* (2), 45-46.

Straub, G. (2012). In the beginning was the half-volley: The history of defence play in table tennis – part IV. *The Table Tennis Collector*, 66, 22-24.

Straub, G. (2013a). The spreading and playing ability of defensive players in competitive table tennis. *International Journal of Table Tennis Sciences*, 8, 179-183.

Straub, G. (2013b). Zur Technik und Taktik des modernen Abwehrspiels: Analyse von Spielbegegnungen im Rahmen der Weltmeisterschaft 2011 [On technique and tactics of the modern defensive playing style: Analysis of matches of the 2011 world championships]. *Tischtennis-Lehre, 27*(3), 22-25.

Straub, G. (2015). In the beginning there might have even been some kind of loop. *The Table Tennis Collector*, 75, 32-34.

Szabados, M. (1936). My favourite strokes. *Table Tennis: the official organ of the E.T.T.A.*, 2(2), 6.

Table Tennis Association of Wales (2018). Wikipedia. Retrieved from https://en.wikipedia.org/wiki/Table_Tennis_Association_of_Wales. Accessed: 21 December 2018

Table Tennis England (2019). Plastic balls: Your questions answered. Retrieved from https://tabletennisengland.co.uk/news/archived/plastic-balls-your-questions-answered-2/. Accessed: 1 January 2019

Table tennis world cup (2018). Wikipedia. Retrieved from https://en.wikipedia.org/wiki/Table_Tennis_World_Cup. Accessed: 30 December 2018

Tamasu Co. (n.d. [c. 1980]). *Feint: A guide for its characteristics and its effective use [Package insert]*. Tokyo.

Tepper, G. (2003). *ITTF-IPTTC Level 1 Coaching Manual*. Shanghai: Minsun.

The first world championships (2003). *The Table Tennis Collector*, 33, 10-14.

The language of ping pong as given by a contemporary (1902, January 18). *The Table Tennis and Pastimes Pioneer*, 1, 3.

The north London ping pong championships (1902, February 22). *The Table Tennis and Pastimes Pioneer*, 6, 1.

The tour of England (1936). *Table Tennis: the official organ of the E.T.T.A.*, 2(2), 3.

Tournament items (1902, March 15). *The Table Tennis and Pastimes Pioneer*, 9, 4.

Trimming, G. (1995). England's first international team. *The Table Tennis Collector*, 9, 4.

Trupkovic, J. (1978). *Wege zum Leistungstischtennis* [Ways to high-level table tennis]. Flensburg: Gebh.

Uzorinac, Z. (2001). *ITTF 1926-2001 Table Tennis Legends*. Zagreb: Skaner.

Weber, B. (2010, October 23). Dick Miles, record-setting U.S. table tennis player, dies at 85. Retrieved from https://www.nytimes.com/2010/10/24/sports/24miles.html. Accessed: 2 January 2019

Wesasa (1902, February 1). Correspondence: To the editor. *The Table Tennis and Pastimes Pioneer*, 3, 4.

Wu, X., & Tang, J. (1996). An analysis of the characteristics of the main skills performed by excellent chop-and-attack players and a discussion of their uses of these skills [Abstract]. *International Journal of Table Tennis Sciences*, 3.

Wykes, B. (2012, March 29). Personal information.

Wild Goose Productions (n.d.). *Table Tennis - Legends Of Table Tennis 1931-1995 [Video file]*.

The journal "The Table Tennis Collector" (later on: "Table Tennis History") can be retrieved from https://www.ittf.com/history/documents/journals/

The early journal "The Table Tennis and Pastimes Pioneer" can be retrieved from https://www.ittf.com/history/documents/table-tennis-magazine/

The official organ of the English Table Tennis Association, "Table Tennis (later on: "Table Tennis News"), can be retrieved from https://tabletennisengland.co.uk/our-sport/news/archives/table-tennis-news-archive/

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PART 2
Professional and review papers

Classification, impairments, and research in para table tennis: Past, current, and future

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Abstract: Classification is the most important and complicated issue in disability sports. Currently, table tennis (TT) players with physical impairments (PI) and intellectual impairments (II) have been included at the Paralympic Games. There are ten classes for TT players with PI (five classes for wheelchair and five classes for standing players) and one class for players with II. TT-specific classification systems for PI players are physical and functional approaches and for II players are functional and cognitive approaches. 3S (speed, spin, and spot) principles are used to classify players with PI, and 3S and 3C (control, consistency, and change) principles are used to classify players with II. Para-TT classification systems are based on evidence and physical and functional evaluations. Medical and technical competent classifiers need to work together to make fair classifications for players. Recently, countries focused on winning medals at the major Championships and started to include elite able-bodied players with very mild impairments in Para-TT. The objective minimal impairment criteria (MIC) are urgently required by ITTF-PTT to maintain fairness of competition and protect actual disabled players. Therefore, evidence-based research is helpful to revise the TT classification system scientifically. In the presentation, the related evidence and information will be provided to identify and tackle the main issues and the future directions for Para-TT classification and research will be offered to include more scientists and classifiers.

Keywords: para table tennis, physical impairment, intellectual impairment, evidence-based classification

1. INTRODUCTION

Table tennis (TT) for players with physical impairments (PI) has been included at the Paralympic Games since 1960. In the early stage of international TT for PI focused on players with spinal cord injuries (SCI). In the 1992 Barcelona Paralympic Games, players with several kinds of PI including SCI, cerebral palsy (CP), amputation, dysmealia, poliomyelities, and les autreas (i.e., the others) have been included to compete together. However, how might players with different kinds of PI completed fairly became an important issue in Para TT since 1992? Particularly, the old classification system for TT was a medical-based classification system including 10 classes for players with PI. According to the examinations of the old TT classification system at the 1996 Paralympic Games, the system was proved that it was unfair in the standing system (Wu, 1998). The similar follow-up studies from 1998 to 2002 had proved again the system was unfair in standing classes (Wu, 2002).

Later, the functional TT classification has been applied to the international events since 1st January 2003. Most countries, players, coaches and classifiers were agreed to accept the new functional approach, instead of the pure medical approach (Wu, 2010).

Players with intellectual impairments (II) have been included at the 2000 Paralympic Games. However, they were excluded since 2001 due to the reasons of unclear classification and intentional misrepresentation in classification and competition (Wu, 2011). Until October 2010, International Table Tennis Federation (ITTF) announced to include players with II at the 2012 London Paralympic Games. The current TT classification system for II has been developed in 2010 and fully applied to classify players with II (Wu, Vecko, Burchell, Verspeelt, Stefak, van Biesen, & Vanlandewijck, 2011). Since then, a few research studies have examined the fairness of classification for players with II and related topics (Gilderthorp, Burns, & Jones, 2018; van Biesen, Mactavish, Keremans, & Vanlandewijck, 2016; Wu, et. al., 2011).

Because classification is so essential for the fairness and credibility of disability sports, therefore, the purpose of this paper was to describe the classification, impairments, and research in Para TT and to discuss the current and future research directions of Para TT and classification.

2. CLASSIFICATION AND RELATED RESEARCH IN TT

Generally, classification is not a new concept in able-bodied competitive sport. Gender, body weight, age, skill levels, and other factors have been applied in different sports for a long time (Tweedy & Vanlandewijck, 2011). However, "body" factor (e.g., the amount of muscle and residual functional levels) is essential in disability sports (Wu & Williams, 1999). Thus, the severities and the types of PI obviously affect performance and fairness of competition in Para TT. This is the reason why we need to have fair classification in Para sports to group the similar characteristics of players with PI in the same class to compete with each other. A simple meaning in disability sport classification is that "No fair classification, no fair competition". When classification is unfair, many athletes with disadvantages will drop out competition (Wu & Williams, 1999).

To reach a fair classification in Para sports, there are three essential components need to be achieved. They are "fair sport-specific classification systems", "competent classifiers", and "clear interactive classification processes" (Wu, Williams, & Sherrill, 2000). In TT, the old medical-based classification system has been proved unfair by several studies. Thus, a new functional TT classification system has been introduced to improve main problems appeared in the old and medical-based classification system. There are 10 classes including 5 classes for wheelchair and 5 classes for standing players with PI. After the application of the new functional classification system since 2003, many players and coaches recognized that TT-specific and functional classification is generally fair. The total numbers of active players have been increased dramatically over three times compared with the 1998 and 2010 ITTF databases (Wu, 2011). Players with II have been included as a class (i.e., class 11) since 2011 and they have been allowed to

attend the ITTF events. In the past 10 years, over 200 players with II participated in Para TT. Gradually, the numbers of active TT players have reached stable after 2011. The active Para TT players were about 2000 in the early spring of the 2019 database.

In addition, international classification should be conducted by qualified and experienced classifiers to achieve right and fair classification results (Wu, Williams, Sherrill, 2000). Therefore, international TT classification should be conducted by authorized ITTF medical and technical classifiers together. ITTF-PTT has a solid training system to train international classifiers from level 1 to level 3 after having theoretical and practical parts in international classification courses. Most of international TT tournaments, ITTF-PTT arranges level 3 and/or senior classifiers to set up panels to classify players around the world events. Medical classifiers need to conduct physical evaluations and technical classifiers need to conduct TT-related skill and movement tests, and 3S (spin, speed, spot) and 3C (control, consistency, change) evaluations of players to decide the possible classes for players (Perez & Lucarevic, 2017). All of testing results should be recorded on the international classification card (ICC) clearly and logically.

The third component in fair classification is clear interactive classification processes between classifiers and players. In TT classification process, physical evaluations, technical TT test, and observation during competition should be fulfilled to complete the whole processes to finalize the class of a player. Each player has been treated equally. If a player believes that his or her class may be wrong. He or she has the right to ask for the review (i.e., reevaluation in the next major event). Thus, the clear classification process in Para TT can protect players' rights. Classifiers also need to follow the rules and procedures to make sure that every player is classified in a right class (Wu, 2013).

Regarding TT classification for players with II, the basic concepts are similar to classify players with PI. The detailed approaches are obviously different. Players with II should go through general criteria for II from INAS and then register for ITTF events and ask for classification. When players with II come to ITTF events for classification, they need to go through the computer test to evaluate their sport cognitive functions, TT-specific test for II, and observation during competition. The final decision for II is either Yes or No for ITTF events. The decision for II may be simple, but the whole processes are very complicated which need to be evaluated by experienced classifiers (Wu et al., 2011).

Currently, Para TT has been ranked as the top 3 sports at the Paralympic Games in terms of participant numbers and the number of medals. The successful development of Para TT may be partially related to fair classification and proper sport organization. Coaches and players do not need to worry about unfair classification, but they can focus on training and competition. However, the present number of female players in lower classes (such as classes 1, 2 and 6) still needs to be improved strategically and practically, even ITTF has made a lot of efforts on promotion of Para TT around the world.

3. EVIDENCE-BASED CLASSIFICATION IN PARA TT

Currently, there are limited studies to examine the fairness of TT classification system. Wu and Williams (1999) have evaluated the outcomes of swimming classification if three criteria have been achieved to maintain fairness of the system. First, the higher the classes, the better the swimming performance. Second, each type of PI of swimmers should have similar possibilities to advance finals or to win medals. Third, each class of swimmers should have different performance between classes. After the evaluation of the classification outcomes at the 1996 Paralympic Games, the functional swimming classification was generally fair but a few problems in classification were found. Using the scientific examination to evaluate the fairness of TT classification, Wu (1998, 2002, 2011b) in his longitudinal studies has proved that the old classification system in standing classes was not fair because the lower class (such as class 7) may perform better than the higher class (such as class 8). Thus, he suggested that the new functional and TT-specific approach including medical and technical evaluations can be used to classify standing players with PI in greater depth. Later, Wu (2011c) introduced another approach including 3S and 3C (control, consistency, and change) principles to distinguish different classes of players with PI. However, no empirical examination has proved the fairness of the functional approach in Para TT scientifically.

Recently, International Paralympic Committee (IPC) requested the scientific evidence to support classification systems in each Para sport. ITTF started to aware the need of evidence-based classification. A recent study has been conducted to evaluate the objective minimal impairment criteria (MIC) in class 10 (Wu, Li, Perez, & Stefak, 2019). They used the document analysis to evaluate ICC and also checked the results of physical evaluations in each class 10 player. Based on the findings of this study, the current TT classification system for players with PI may need further revisions to decide the objective MIC. In addition, this study also proved that a lot of ICCs have not been completed properly and so some errors occurred by classifiers and decision making was unclear. Thus, this study provided the objective evidence to guide the directions for revisions of MIC in class 10 (Wu, Li, Perez, & Stefak, 2019).

In addition, Jen and Wu (2002) compared the hitting abilities and ranges between male wheelchair classes 4 and 5. They found that no significant differences in hitting abilities and ranges between classes 4 and 5. They proposed that classes 4 and 5 should be combined to increase the competition levels because they reported almost no difference regarding speed, spot and spin (3S) between those two classes. However, ITTF still maintains two classes due to political decisions. Thus, it seems to be an issue whether scientific evidence for classification should be considered seriously.

Comparing with TT classification in PI, more research studies focused on examination of players with II. When players with II have been discussed whether they should be included at the 2012 London Paralympic Games, research studies provided scientific evidence to persuade ITTF, governing body IPC and TT classifiers (Van Biesen, et al., 2010). Wu and colleagues (2011) have developed the main criteria to evaluate the II classification system and also proved to include TT players with II at the 2012 London Paralympic Games. Later, the Leuven group continued to

conduct II players with more evidence (van Biesen, et al., 2016a, 2016b) to support the II classification system in TT.

Although a few research studies have examined the TT classification system with PI or II, scientific evidence is still far too weak to prove the whole classification system with PI. For example, how can we distinguish main difference in adjacent classes in terms of functional abilities and physical limitations? How many classes are needed to fairly classify players with PI? Many important questions in TT classification still need to be asked and answered through scientific examinations.

4. CONCLUSION AND FUTURE DIRECTIONS

Para TT and classification may have proper development and structure in the past thirty years. Comparing with most Para sports, TT may be in the right direction in terms of classification, promotion, and popularity around the world. However, female players in lower classes such as 1, 2, and 6 should be encouraged to have more participation and also to increase the standard of competition. After improvement, we can expect the success of Para TT at the Paralympic Games.

The future directions for fair classification and research should include the following three main parts. First, more competent classifiers and scientists should work together to conduct the useful studies in this field. Second, ITTF should develop the expert group to conduct research projects to solve the main issues in TT classification. Third, more international collaboration among countries and research groups should be encouraged and supported to promote Para TT and classification research in the world.

REFERENCES

Gilderthorp, R., Burns, J., & Jones, F. (2018). Classification and intellectual disabilities: An investigation of the factors that predict the performance of athletes with intellectual disability. *Journal of Clinical Sport Psychology, 12*, 1-31.

Jen, C. Y., & Wu, S. K. (2002). Hitting abilities and ranges of male wheelchair table tennis players between classes 4 and 5. *Journal of National Taiwan College of Physical Education, 11*, 147-162.

Perez, P., & Lucarevic, J. (2017). *ITTF Para Table Tennis Classification Manual- Level 1*. Lausanne, Switzerland: International Table Tennis Federation.

Tweedy, S. M., & Vanlandewijck, Y. C. (2011). International Paralympic committee position stand: Background and scientific principles of classification in Paralympic sport. *British Journal of Sports Medicine, 45*, 259–269.

Van Biesen, D., Mactavish, J., Keremans, J., Vanlandewijck, Y. (2016a). Cognitive predictors of performance in well-trained table tennis players with intellectual disability. *Adapted physical activity quarterly, 27*(3), 324-337.

Van Biesen, D., Mactavish, J., McCulloch, K., Lenaerts, L., & Vanlandewijck, Y. C. (2016b). Cognitive profile of young well-trained athletes with intellectual disabilities. *Research in Developmental Disabilities,* 377–390.

Van Biesen, D., Verellen, J., Meyer, C., Mactavish, J., Van de Vliet, P., & Vanlandewijck, Y. (2010). The ability of elite table tennis players with ID to adapt their service/return. *Adapted Physical Activity Quarterly,* 27(3), 242–257.

Wu, S. K. (1998). *Recommendations for the improvement of the functional classification in table tennis*. Unpublished paper presented at the meeting of the 1998 World Disability Table Tennis Championships, Paris, France.

Wu, S. K. (2002). *Standing classification system in table tennis*. Unpublished paper submitted to the International Table Tennis Committee for the Disabled, Lausanne, Switzerland.

Wu, S. K. (2010). *Table tennis classification system for players with intellectual disabilities*. Unpublished paper submitted to ITTF-PTT, Lausanne, Switzerland.

Wu, S. K. (2011a). *History of table tennis classification*. Unpublished paper submitted to ITTF-PTT, Lausanne, Switzerland.

Wu, S. K. (2011b). *Analysis of table tennis performance and functional standing classification system at the 2002 and 2010 World Championships*. Unpublished paper presented at the 2011 VISTA conference, Bonn, Germany.

Wu, S. K. (2011c). *3S and 3C principles in table tennis classification*. Unpublished paper submitted to ITTF-PTT, Lausanne, Switzerland.

Wu, S. K. (2013). *New disability sport classification.* Taipei, Taiwan: Ho-Chi Publishers.

Wu, S. K., Li, Y. C., Perez, P., & Stefak, T. (2019). *Minimal impairment criteria in Para table tennis for standing players with physical impairments: Evidence-Based support for revisions*. Unpublished paper presented at the 2019 VISTA conference, Amsterdam, Netherland.

Wu, S. K., Vecko, G., Burchell, A., Verspeelt, N., Stefak, T., van Biesen, D., & Vanalndewijck, Y. (2011). *Development of table tennis specific classification system for players with intellectual disabilities: A pioneering work*. Unpublished paper presented at the 2011 VISTA conference, Bonn, Germany.

Wu, S. K., Williams, T. (1999). Paralympic swimming performance, impairment and the functional classification system. *Adapted Physical Activity Quarterly, 16*, 251-270.

Wu, S. K., Williams, T., & Sherrill, C. (2000). Classifiers as agents of social control in disability swimming. *Adapted Physical Activity Quarterly, 17*, 421-436.

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Beneficial effects of IT solutions in the sport of table tennis

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Abstract: The attracting and retaining amateur table tennis players requires a completely different approach than the one used in case of active professionals. The motivation for amateurs includes:

- spending their leisure time with sport activities
- health promotion
- and of course, earning prestige in their micro-community by getting good results in tournaments

There are several known on the benefits of table tennis, especially among elderly people. Our study shows the possible IT solutions for motivating a delicate, but essential group of the sports audience, which is beneficial for all. It is important for:

- the individual for health promotion and sport experience,
- the sport federations to reach and rouse a wider crowd,
- the national healthcare by reducing healthcare costs.

This study is based on data provided by the Csongrád County Table Tennis Federation consisting a 5-year period with participation of 385 people. The basic problem which we search practical answers for: the declining number of amateur players, and the trend of decreasing activity among them. Our goal was/is to reverse this tendency.

The software, developed in association with the federation produced measurable results, which opens new horizons for improving the activity of amateur players, mainly by providing a social experience for the participants.

We succeeded not only in stopping the above-mentioned decrease, but we were able to attract new groups for the sport.

The IT capabilities are still far from being utilized; we see a lot of new possibilities in this development.

Keywords: amateur table tennis players, software, game development

1. INTRODUCTION

Until the 21st century, Hungary would appear on the pages of glory in table tennis yearbooks. The most successful player, to date, was Viktor Barna, winner of 22 World Championship titles between 1929 and 1954, though the name of Miklós Szabados, with 15 gold medals, must not be forgotten either. As for the ladies, Gizi Farkas, Mária Mednyánszki and Anna Sipos, all of whom hold more than 20 world titles each, shall be remembered. In the 1970s and 1980s, Tibor Klampár, István Jónyer and Gábor Gergely added further medals to this precious collection, thanks to which the sport of table tennis remained widely popular in Hungary.

The scope of the Hungarian Table Tennis Federation (MOATSZ – www.moatsz.hu) is currently divided into eight regions and further counties, with up to 430 registered

clubs. Our investigation focuses on the Southern Great Plain region, more specifically, on Csongrád county and its capital, Szeged, due to a number of reasons:

- out of all regions, Csongrád county is the one with the lowest number of active licensed players,
- Szeged is the country's third biggest city with a population of 160 thousand inhabitants,
- the software's development is based in Szeged.

Table Tennis SC Szeged (ATSK - www.atsk.hu), one of the five registered county clubs in Csongrád, founded in 1996, is considered to be the reference point in recruiting and supporting leisure activities within table tennis. Rather than pursuing economic interests, club manager Ernő Márki, through group sessions, takes on the task of supporting and improving recreational table tennis activities by personal conviction.

The reference period was 2013-2018, with table tennis CRM software PONGER joining the test phase since the 2017 season. The number of leisure athletes can only be determined through estimates, given that the federation, similarly to other sport associations, does not possess any authentic and representative survey. The basis of our estimates was gained by data related to ATSK Szeged events.

Chart 1. *Shows the distribution of players during the reference period.*

	2013	2014	2015	2016	2017	2018
Licensed players	42	38	35	35	36	37
Leisure players	385	370	340	315	330	350

ATSK's Table Tennis Hall offers 6 tables and functions exclusively as a table tennis hall, allowing fans of leisure sports to do activities between 6 to 9 PM, three times a week. Furthermore, there are other existing non-profit organisations, groups of friends with equipment (tables, rented premises), however, these have a capacity of only one or two weekly occasions to offer. Based on the identified possibilities, it is fair to say that more clubs or halls with greater capacity are needed, the lack of which sets a limit to newcomers.

Attracting and retaining amateur table tennis players requires a whole different approach than that of professional athletes. The primary motivation of amateurs are.

- spending free time in an active and gratifying way,
- preserving and improving health,

Direct goal: to develop, through regular activity, the basic physical skills that are necessary to compete on a hobby or recreational level. Establishing, through deliberate training, the physical background needed to compete as an amateur.

Indirect goal: to improve, with the help of exercises, long-term performance at work, to extend life expectancy after retirement. Overall, to improve the muscular, musculoskeletal, nervous and cardiorespiratory systems using the benefits of constant and dynamic exercise – which is the sport of table tennis.

- and, of course, achieving acknowledgement in their microenvironment through results.

REASONS BEHIND THE CREATION OF THE SOFTWARE

Between 2013 and 2017, leisure sport activity could only be measured through events organized by ATSK, also, it was the club's tournament structure that provided the ranking of players. The tournament structure consisted of three formats and was designed exclusively for leisure athletes (that is, for those who had no license or had not been licensed for the past 5 years):

1. Leisure tournaments - Individual
2. Amateur tournaments - Individual
3. Team championship

Team championship was designed based on the framework of the National Championship, with teams of three competing in categories of different levels, depending on the number of teams registered. These categories were named County I, II, III, where County III equals players with the lowest skills, while County I represents those of the highest quality. The aim of the championship is to allow amateur players to play on a regular basis, as well as to get promoted to a higher division (those who rank 1-2 in each category) and to enter the National Championship (winner of category County I).

Individual tournaments were also divided into two: Leisure and Amateur tournaments. Those competing in County II or having similar skills, could not enter leisure tournaments, whereas the amateur category was open to any player.

Statistics of tournaments were also conducted separately. In individual tournaments, players received points according to their tournament ranking, which were aggregated in charts, determining the level each player represented within a category. The only thing team tournament paperwork, through match records of games played among one another, outlined was the ranking of teams participating in each category. Both individual and team tournament results were recorded and aggregated in Excel charts, resulting in the annual final ranking in all three formats.

Chart 2. *Shows the distribution of players in different tournament formats*

Year	Tournament	№ of tournaments	Average № of competitors
2013	Leisure tournaments	4	30
	Amateur tournaments	5	60
	Team tournaments	(3x8)*	80
2014	Leisure tournaments	4	35
	Amateur tournaments	5	70
	Team tournaments	(3x9)*	100
2015	Leisure tournaments	4	30
	Amateur tournaments	5	65
	Team tournaments	(3x10)*	110
2016	Leisure tournaments	4	30
	Amateur tournaments	8	40
	Team tournaments	(3x10)*	110
2017	Leisure tournaments	6	16
	Amateur tournaments	8	22
	Team tournaments	(3x11)*	130
2018	Leisure tournaments	6	20
	Amateur tournaments	8	26
	Team tournaments	(4x10)*	150

** Meaning of data in brackets within the № of team tournaments cell: № of actual categories x № of teams per category*

PONGER was introduced in 2017, making the presence and distribution of leisure players in the tournament structure measurable. In the meantime, the Csongrád County Table Tennis Federation renewed its tournament structure in the framework of an agreement that involved two local clubs in the organisation of tournaments (Floratom Szeged Table Tennis Club and Móraváros Table Tennis Club). These new venues provided players with the same level of conditions, and new types of tournaments (A-B-C-D finals) were held and tried out. As a result, more days of tournament were introduced into the season calendar, while calls for tournaments were also modified:

1. Leisure tournaments - Individual
2. Amateur tournaments - Individual
3. Open tournaments - Individual
4. Team tournaments

Open tournaments come as a new format, in which anyone can participate, even those competing in the National Championship. Another novelty from 2017 is that, thanks to PONGER, up to three events can be organised, allowing all three formats to be held on the same day. Requisites for entering a specific category are determined by the athletes live ranking points.

Amateur table tennis sport in the region has been showing a downward tendency in the last 5 years. Although the number of tournaments remained practically the

same until 2016 when, in consultation with ATSK, another recreational club started to organise events, number of competitors in the tournaments fell exponentially. Not only was the division of tournaments not a good idea but general attendance at all events dropped by 30%. It was interesting to see, nevertheless, that the number of athletes playing in the county team championship even rose, instead of plunging. However, for some reason, these people were difficult to motivate on an individual level, resulting in low participation numbers, compared to team tournament standards. We intended to investigate what the crucial factors might be behind the considerable gap between individual and team tournaments. The sources of the problem were identified through actual tournaments and personal interviews, and listed in order of importance as follows:

1. Tournament quality from the player's perspective
2. Tournament schedule
3. Tournament venue
4. Team championship

1. Tournament quality from the player's perspective

Before PONGER:

One of the main reasons was that the majority of players dedicated their whole day (or weekend) to a specific event, then, after four games, went home. Splitting leisure and amateur tournaments seemed to be a temporary solution but, due to the wide range of skills players represented, the problem kept coming back. Although contestants were well known as a result of experience and rankings of previous years, newcomers could still compete in a certain category based merely on their self-assessment, which in many cases did not turn out to be objective.

After PONGER:

Live ranking points, an achievement of the software, contributed additional ideas and opportunities to the organizers. Though a rise in the number of contestants was already perceived, it was when the „similar skills" issue was solved that significant changes occurred. The introduction of the live ranking point system made it possible for us to measure players' current skills. From then on, tournaments were not announced based on whether or not a player falls into a certain category, rather than setting a ceiling of maximum ranking points. Those whose points exceeded this limit, regardless of the category they belonged to, were not allowed to compete, while those who had less points could enter the competition even if their category status would not have let them do so. As a matter of fact, thanks to the software, we managed to create an environment where, to everybody's entertainment, players of equal or very similar skills could enjoy close matches.

2. Tournament schedule

Before PONGER:

Difficulties of organisation constituted another problem. Despite the organisation and coordination of experienced and accomplished experts, events were greatly delayed. Players were far from playing „continuously", as circumstances (many contestants, few tables, paper-based documentation) did not enable a player-friendly and comfortable delivery. The question was out there: how could tournaments become faster, smoother and more flexible, yet more exciting for all players? The idea of a software was born. One that could greatly help the organizers of both tournaments and team championships, an innovation that is clear, easy to handle and inspires every player. A software that „measures" actual performance, recent improvement or decline of players, and is able to determine, with reliable accuracy, their skills facing practically any other opponent.

After PONGER:

Thanks to the achievement of the software, we could hold, first two, then three tournaments of different formats within a period of time that, earlier, would have only been enough to organise one single event. Following the creation of the software, individual tournament system in the county has completely changed. Innovation has given way to an entirely new territory in the organisation of tournaments. Benefits that come with the software have made the duration of tournaments significantly shorter. The end of paper-based seeding and draw has saved up hours. Continuous utilisation of tables has also improved. The increased amount of free time allowed us to hold tournaments in not two but four formats, leading to a rise in both registration fees and, eventually, income.

3. Tournament venue

Before PONGER:

The hall of ATSK is of 240 m^2, which does not qualify for an ideal venue for tournaments with over 40 contestants playing at the same time. Athletes would often disrupt each other in the past (balls from other tables), while players waiting for their turn could also be an obstacle (e.g., in case of a far-away backspin). In time, these negative experiences all added up and led to a drop-out effect, discouraging athletes from competing. As a consequence, every year, ATSK would hold a season opener tournament in a sports hall with 16 tables, which meets entirely the rules and regulations set by the federation. These events were considered widely successful as it would feature an annual number of 100+ contestants, however, costs of organisation could only be covered by funds, which were no longer available since 2015.

After PONGER:

Following a thorough analysis of possibilities and the inclusion of two clubs, the tournament structure was divided. Prior coordination of tournaments, as well as the

joint application of the software, resulted in the rise of contestants at all three venues. Thanks to the software, the starting time of a certain format could be precisely determined, which means that barely anyone is present in the hall other than the contestants of the actual format. In the meantime, those who wish to follow the games and results, can do so online.

Before introducing the software, only one format could be held on a specific match day. The delivery demanded the coordinated work of at least two people (registration at the venue, collection of entry fees, conducting draws both in the group stage and the play-offs). PONGER uses algorithms to carry out and check these tasks, reducing the duration of the most time-consuming part (draws) to almost zero. Now, all that is needed is the presence of one single supervisor, while any further changes throughout the tournament (posterior registration, misdocumentation) can be dealt with immediately. Earlier, that was either not possible or took a significant amount of additional time. Another achievement of the program for the organizer, is the increased income that lies within the possibility of holding tournaments of three different formats on the same day. The order of matches is determined by the skills of categories, starting with the weakest and followed by stronger ones, in the case of which players were allowed to „play upwards". Practical experience demonstrated that more than 30% of contestants preferred entering a stronger category, increasing the money the organizers raised from the fees.

4. Team championship

Before PONGER:

Team tournaments have traditionally been the most popular events in Csongrád county table tennis life. The number of participating teams is constantly around 30, making this the format that attracts, involves and mobilizes the highest number of players. The venue of matches would always be provided by the home team, which either meant their own premises (in accordance with the conditions set in the announcement) or a time slot rented by ATSK. As a result, most problems and work stem from the organization and coordination of team tournaments.

Before PONGER, determining one's skills was always an issue when it came to registration. Take a group of friends, for example, that is made up of players with a more or less similar set of skills and have been playing together for years. It is understandable that they want to enter the tournament together but, if one of them is simply much better than fellow teammates, it will not always be feasible as the decision is based on the organizer's subjective judgement.

Another awkward issue was the problem surrounding match records. These sheets often disappeared, facts and figures were not recorded accurately, match results were introduced incorrectly in the final chart. The place of home teams and visitors were mixed up, players who were not listed among the registered athletes later appeared in charts, together with an endless number of further errors we

found during the analysis of tournaments. And even when match records were filled and submitted accordingly, manual data inputting could still take additional weeks. Thus, it was basically impossible to record up-to-date, actual championship standings. Not to mention players' performance ranking, which was practically inexistent at the time.

Weekly rounds would often suffer delays. Teams would organize their matches at leisure, without great motivation. Although a day of the weekend was designated to take a rain check on the many „cancelled" games, and in principle it would have been obligatory to recover these matches, it did not happen all the time eventually, having an impact on the championship result itself.

After PONGER:

The subjective self-assessment of players' skills has been replaced by a measurable, objective figure, supported by numbers, which determined accurately a specific player's skills, allowing the organizer to make a safe call whether or not the contestant could enter a category.

The issue of match sheets has been entirely solved. It is the home team's captain that records the sheet in the online system, which is, practically, the digital equivalent of the handwritten match sheet. When handling the data, he can only select from registered names, thus, undue participation is impossible. The result is generated by the program itself, and incorrect recording of the outcome is only possible in case the original score is notified incorrectly. We have also come up with a solution to that: the recorded match sheet must be justified by a photo of the original sheet. If everything is handled duly, the captain of the visitor team approves the already filled-in match sheet with a single click, which is followed by an immediate update of the championship table and players' performance list. In order to achieve a faster and more fluent delivery, the system sends an automatic notification and e-mail about those match sheets pending approval.

Since the application of the program, not one single game had to be cancelled. The system warns captains of both teams about games to be played in the actual round by marking red matches that are falling behind schedule. As players are constantly browsing and checking up on results, team members tend to remind each other about upcoming matches. That would have been impossible in the pre-PONGER era.

Besides players, the greatest „winners" of the software are those organizing tournaments and being responsible for the delivery of the team championship. Following the announcement of the tournament, the system runs practically on its own, with the collaboration of captains. The only time the organizer might have to take on some tasks is in case of disputes, the registration of a new player, however, this makes up a tiny part of the enormous workload they witnessed before the introduction of the system. That freed capacity can be now dedicated to the analysis and modernization of team championship, allowing the sport of table tennis to embrace its leisure athletes. Another success story has been the creation of a season finale tournament, featuring the best players of the team championship, who could be easily identified through statistical data.

Metrics, statistics:

The activity of an athlete – either professional or leisure – can be encouraged and motivated by their achievements in sport. In addition to immediately updating both team and individual results online, the system of PONGER offers several further metrics that are able to motivate players. Players that are recorded in the system have access to all individual statistics of other fellow players competing in the team championship, making data, such as championship results, individual rankings and even the hierarchy among members of a certain team, available to everybody. Live ranking points reflect the players' skills within their environment; however, it is not inspiring enough to make them enter more tournaments. In order to solve that, a federal ranking point system has also been elaborated, which is the combination of live ranking points and previous result-based ranking. This ranking has been invented as a tournament category, thus, in accordance with the formats that are held on a match day, it is divided into leisure, amateur and open county rankings. As a result of the new (combined) ranking, activity of leisure athletes has increased. Not only did this ranking reflect the difference of skills athletes possess, but it also demonstrated different levels of activity. It was not unimaginable that a player, according to his live ranking point, was ranked № 160 out of 385 athletes, yet could possibly reach the № 1 spot on the new federal ranking if he was active enough in tournaments.

In every season, the Csongrád County Table Tennis Federation organizes 4-4 tournaments awarding points to amateurs, which are considered highlights of the season calendar. These tournaments constitute the so-called Csongrád County Amateur Ranking Tournament (ART) that is open exclusively to those players residing in the county or who are members of a county team. Previously, this ranking was based on points assigned to each result. Due to occasional absence or unfortunate draws, the previously used ranking barely resonated with actual levels and skills. That explains why our goal was to create a ranking that, using tournament results and benefits of the software, reflects more accurately players' actual skills. The new ART ranking points are basically added up by two figures. One of them is the previously used point assigned to the result, the other one is the 10% of the contestant's live ranking point.

Chart 3. *Shows ranking points that can be taken through ART*

Open			Amateur = 1500-2100		Leisure < 1500	
Ranking	Play-off round	Repechage	Ranking	Play-off round	Ranking	Play-off round
1.	250	200	1.	200	1.	150
2.	245	195	2.	195	2.	145
3-4.	240	190	3-4.	190	3-4.	140
5-8.	230	180	5-8.	180	5-8.	130
9-16.	220	170	9-16.	170	9-16.	120
17-32.	210	160	17-32.	160	17-32.	110
Group 3.			Group 3.	130	Group 3.	90
Group 4.			Group 4.	110	Group 4.	80

Calculating ranking points works as follows: out of the last 6 tournaments, only the best 4 are taken into account, thus, missing an event does not really affect the actual ranking, contributing to a much more realistic standing. The goal of including one-tenth of players live ranking points in the final point was obviously to motivate them to participate, even between two ranking tournaments, in more team or other tournaments, given that their live ranking points can be increased that way as well. The new ranking point system was set up after calculating the results of 7 tournaments. The review of players and experts have been unanimous: skills turned out to be demonstrated more accurately and we get a more realistic picture than the one we used to have.

The introduction of point systems, of course, is not the only method to promote the interest of a sporting community – innovation of tournament formats is also a factor. As for amateurs, the most popular tournament format has been the four-final system, handled efficiently by PONGER. In this tournament type, following the group phase, contestants ranked first and second in a group qualify to the play-off, while those who rank third and fourth are not eliminated either, rather continue in repechage. That is the novelty that makes a difference, as contestants losing their first match do not get eliminated, but keep competing in the B finals, where another defeat will, in fact, leave them out of the tournament. Those who lose in the first round of repechage will continue in the D finals, until they lose again. This requires the organizer to deal with two play-offs and two repechages at the same time. In addition to the 3 games played in the group phase, contestants go on to play at least another 2 matches, even if they are defeated in both. As a consequence, everybody gets to play at least 5 matches per tournament, which has a motivational impact on leisure and amateur players.

Future development plans include the programming of the double KO tournament system (a quite unusual one that is hard to handle on paper), which allows contestants to eventually win the whole tournament despite an initial defeat. Many other sports are currently using this format, however, applying it without IT backup is considerably difficult to do, mainly if the play-off is combined with a group stage.

Though doubles tournaments rather attract a very small number of leisure athletes, DC (Davis Cup) team events tend to be popular. Currently, two versions are being tested:

- one of them features teams of two and ranking is decided by a round-robin tournament,
- in the other one, DC teams made up of players of two clubs compete for club victory.

We wish to take PONGER to a level where its use is in line with all tournament formats currently applied in Hungary. Our goal is to have a system that comprises every element of the Hungarian tournament system (individual and team tournaments, rankings), with PONGER providing complex and professional IT background. The data gathered by professional and leisure athletes, and managed in a single system, opens up a new horizon in the field of innovation, which is crucial to us as well. The system's easy handling and speed is beneficial to everybody, for example, it reduces the administrative workload of the federation, to name just one. MOATSZ is aware of that, thus, negotiations are under way to integrate PONGER into the federation's operation.

SUMMARY

In leisure sport, the major goal people pursue is staying healthy, but choosing a sport and the experience of being part of it are also fundamental. A leisure athlete is exposed to the same motivational forces as a professional: measuring performance, developing within the community, which leads to a more active participation and „human" community experience, taking place not in a virtual but an actual space. For many, it is only a „playful" way of spending time, nevertheless, if their environment provides them with opportunities (tournament formats) that exceed the ordinary, allowing them to be compared to others, retention and motivation to continue will significantly increase (for instance, there are several active registered members in the system over 70 years of age). The overwhelming majority of participants are male, but activity of women is also demonstrated. The popularity of a sporting discipline is greatly influenced by national success stories; however, Hungary is currently far from the international elite (Georgina Póta being the only driving force at the moment), thus, it is leisure sport that could give momentum to improve recruiting young professionals. A rookie, whose first contact with the sport should take place at the age of 6-7, has to almost entirely fall back on his or her parents when it comes to choosing between options. So, if either one or both parents are actively related to table tennis, youngsters will gladly follow the pattern.

Thanks to the software, the presence and quantity of leisure sport in the test environment have become clearly measurable and now can be easily monitored. IT solutions have contributed to stopping a declining trend. Reasons behind the solution stem from the diversity and quality of holding tournaments, which could only be solved successfully with the inclusion and help of IT tools. We have set different metrics to measure athletes' activity; created tournaments that, aiming at boosting intensity, take into account each player's skills; through the use of the software, made the organisation and delivery of tournaments efficient – in terms of both time and resources. Multiple studies have confirmed that the introduction of live point ranking had beneficial effects on motivating athletes, which can only be supervised and kept up-to-date with the help of a sophisticated IT background. If carried out manually, the administration required by current legislation (GDPR) in EU territory still constitutes an unbearable economic burden even for non-profit organizations. Through software-based administration, these tasks can also be automated, and are in compliance with legal requisites.

In every field of sport, energy efficiency and the smallest ecological footprint all give priority to digitalization (paperless operation, smallest energy consumption or renewable energy sources), while today's marketing trends (social media, instant publishing of results that are accessible anywhere) also point to this direction. Although digitalized tasking and system operation are generally solved when it comes to the international federation (ITTF), currently it is not widely available in leisure sport in its complexity.

Our solutions, with minor modifications, might also have positive effects on the efficiency of recruiting youth, which we could investigate in a future study.

REFERENCES

Haoyu Liu, H., & Wu, X. (2017). The Current Situation and the Developmental Prospects of the Public Table Tennis Rating Game in China.

Qilin, S., & Weiwei, C., (2015). Exploration of the International Popularization of the Table Tennis Grading System.

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Strategic plan of Brazilian Table Tennis Confederation: looking for development

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Abstract: The Brazilian Table Tennis Confederation (CBTM) has systematically advanced in the modernization of its management and is attentive to the new demands of the sport market. According to these premises, in 2016 CBTM developed a strategic plan that could allow institutional orientation for the new challenges of modern sport. The planning methodology consisted of documental study, semi-structured interviews, workshops and benchmark with main reference cases of sport and entertainment. The result was the redesign of functions and institutional approach from the year 2017, with KPIs measurement. The organizational structure was based on 6 major areas: (1) International Talents, linked to the Brazilian team; (2) National Talents, linked to competitions and the Brazilian ranking; (3) Table Tennis for Leisure, associated with table tennis enthusiasts; (4) Marketing and Business, connected to communication, media, sponsorship and relationship with fans; (5) Corporate University, focused on the training and promotion of knowledge; (6) Management and Governance, oriented to the administrative aspects of the entity. From this strategic plan, CBTM begins to reach a differentiated level, both nationally and internationally, with the expectation of consolidating a sustainable management model for the future.

Keywords: strategic plan, management, organization

1. INTRODUCTION

The business model of traditional sports organizations needs a major transformation. The appearance of players with agility and better ability to develop strategies of relationship with the clients brought a natural distance from the people by the traditional sports entities.

Because of this process, most Olympic and Paralympic sports organizations are dependent on public resources, guaranteed by specific legislation. The bonuses generated by these laws, with the contribution of significant resources in the sports confederations, entails proportional charges. The main one is related to the bureaucratic obstacles of the use of public resources. But it is not limited to this: the managerial cost is more than 1/3 of the value received, since it is necessary to maintain a structure of personnel dedicated to the accountability, added to the legal and control sectors for the correct application of these values.

The turning point for the breakdown of this vicious cycle lacks a consistent plan with a long-term vision. In order to capture new resources, whether from sponsors or the marketing of broadcasting rights, there are actions that precede it: dialogue positively with sports practitioners and fans, communicate the entity's brand,

disseminate the selection beyond sports results, transform product competitions and increase digital presence.

Therefore, the objective of this study is to show, in a summarized way, the logic of construction of the strategic planning proposed for the Brazilian Confederation of Table Tennis (CBTM) in 2016 against the achievements and advances until 2018 regarding the performance indicators proposed at the time.

2. LITERATURE REVIEW

Strategy is classified as a plan or guide on how to deal with present and future situations, added by the standard and consistency of the organizational behaviour, the market position in relation to the environment to which it is inserted, the perspective on its capacity and culture of identity and by the challenge of playing with the trends and the market entities (Mintzberg, 1987). This means that the proposition of strategic paths predicts a series of controllable and non-controllable variables, which requires special attention to numerous details.

In defining strategies, sports organizations opt for actions related to the attractiveness of the programs offered or to improve the competitive level or both. This depends on the typology of the organization and its respective area of convergence (Thibault & Slack, 1994). Part of the result of this study is relevant to be noticed by the time it was applied. At the time, the sporting aspect had significant evidence in detriment to the business environment that sports entities need to develop in the second decade of the 21st century.

In fact, companies can and must adjust their strategies and philosophies to keep up with the times, too (Sinek, 2017). Reinvention is therefore the basis for survival and growth. The latter is added in case there is a positive response from the market to the offers made by the organization.

3. RESULTS

The evaluation of the strategic actions implemented by CBTM is based initially on its Mission, Vision and Values statement and, consequently, on its Strategic Map (Figure 1), both presented sequentially. They derive the strategic objectives that will be analysed in this chapter.

The Mission of CBTM is “Organize and disseminate table tennis in Brazil”. The Vision is “To be considered the best confederation of the Brazilian sports system, by 2020, with excellence in management and governance and achievement of international expression results”. And the Values are “Integrity and Transparency; Individual Responsibility; Cooperation; Agility; Interactivity and Innovation”.

Based on these topics, the priorities of CBTM in this planning cycle (2016 - 2024) are:

(1) Brazilian Team and International Talents: promote high income in order to achieve results in international level for Brazil;

(2) National Elite: develop table tennis, in all age groups, through state, regional, national and international competitions;

(3) Leisure Players: promote the practice of table tennis as leisure, in its different manifestations;

(4) Table Tennis University: create, disseminate and absorb practical and scientific knowledge that will contribute to the development of Table Tennis in Brazil;

(5) Communication, Marketing and Business: business-oriented management model to enable the creation of products and services in synergy with sponsors, media, public sector and table tennis fans and players;

(6) Management and Governance: be recognized as the entity with best practices of management and governance in Brazil, based on the consolidation of performance indicators and stimulating good management practices.

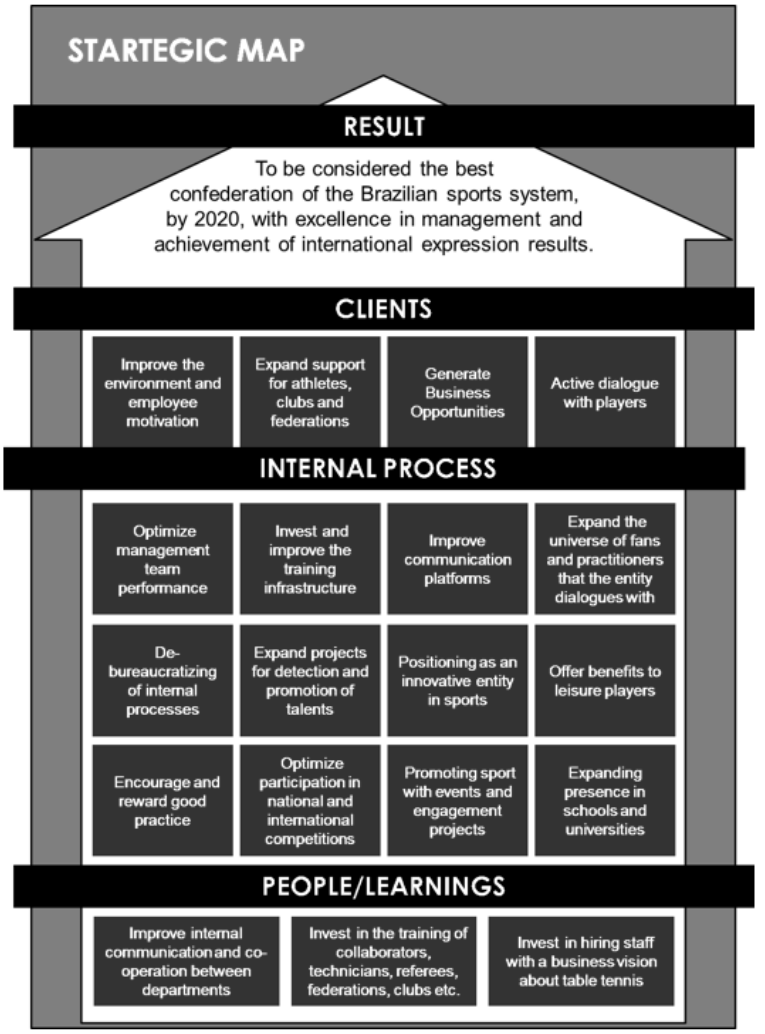

Fig. 1. The Strategic Map of CBTM

Based on the priorities topics and looking for strategic issues, the proposition is to analyse and observe the main progress of the plan. So, Table 1 show us each item, with respective objectives and its execution.

Table 1. *Analysis of Strategic Goals and Future Targeting*

	Strategic Goals	**Outcome Assessment**	**Analysis**	**Action for 2019**
Brazilian Team and International Talents	Systematically qualify the training processes of the Brazilian National Team	Goal Accomplished	In the Men's Olympic, most athletes play in Europe. In the Women, the structure was maintained in São Caetano do Sul, with the follow-up of technicians remunerated by CBTM. In Paralympics, in both suits, the progress with the use of the Paralympic CT structure, with technical team, multidisciplinary support and accommodation.	Maintain the current structure and expand the offer of periodic and intensive training, with a meeting of all the members of the teams. Evolve into technology and performance analysis.
	Provide technical, infrastructure and materials support to elite athletes	Partially fullfiled	Structure of CTs available to elite athletes, with full and / or partial financing of CBTM.	Maintain support and technical support in the current format.
	Identify talents with development potential	Partially Fulfilled	Future Diamond Training and National Detection training actions were completed (3 in all). But below expectations - 1 detection action was planned for each of the 5 regions of Brazil. Also, that the 20 State CTs did not present the talents required in Term of Collaboration (2 of each suit and category by CT).	Improve the talent detection program by conducting Training Camp with foreign technicians. Review the models of State CTs to ensure their effectiveness.
	Maintain constant international exchange for the growth and qualification of athletes.	Unattended	With the exception of participation in international competitions for athletes of the Pre-Mirim and Mirim categories, there were no further advances from 2017, with the international athletes going for international camping. Participation in the ITTF Hopes Program was sporadic. In competitions, 31 Paralympic athletes and 121 Olympic athletes traveled to international competitions. .	Proposition of Individual Development Plan for all athletes. More effective participation in the Hopes Program. Maintain and expand international travel to raise the technical level in competitions.

(to be continued)

	Strategic Goals	Outcome Assessment	Analysis	Action for 2019
	Continuously associate elite athletes with the practice of sport as leisure	Unattended	The communication of the athletes performance is still reactive, according to the results of each one of them. There is no communication oriented to the fan of sport and table tennis to effect the relationship beyond what is done in the sporting environment.	Structure a marketing and communication department to respond more efficiently to the market's demand and the modern perspective of engaging with the public. Modify the digital communication strategy, using more playful and engaging elements.
National Elite	Encourage competitions at the national, regional, state and international levels	Partially Fulfilled	Realization of 3 Brazil Cup instead of 5, as foreseen in the planning. However, due to financial and technical circumstances, it is understood that the increase in the amount of Copa Brasil is not the best strategy. Indicator will be reviewed. State and Regional competitions were made as scheduled. No international competition was held in Brazil in the period.	Structuring a new model of integrated competitions for 2020. In 2019, will be held 4 Brazil Cup and 1 Brazilian Championship, in the same model of previous years. Each Federation must also carry out at least 3 stages of the State Championship. There will be no international competition, which is scheduled to take place in 2020 - a successful bid.
	Gather and consolidate information and data of all participants of national competitions (clubs and practitioners)	Partially Fulfilled	The data of participants of national competitions are collected automatically, by CBTM Web. However, these data were not processed and transformed into managerial information. The data of clubs are under the custody of the State Federations.	Implement systematic analysis and constant monitoring of information, with improvement of the system for the delivery of intelligible information, aiming for action and decision making.
	Consolidate and improve content delivery of national events	Unattended	The design and the look of the event stayed the previous way, without evolution. Only 40% of the participants of the Brazilian Championship, held in Concordia / SC, said they were satisfied with the event. Streaming was interrupted for financial reasons.	Resumption of the structuring of the event area, with the hiring of an Event Leader with experience in sports mega events. Partnership with TVNSports for the transmission of 2 stages of national competitions - and others, according to fundraising.
	Organize national stages with excellence, promoting the ranking and national rating	Unattended	The national stages presented important organizational failures. The proper activation of the ranking and the national rating was not made, in order to highlight the highlights at a national level. Significant and systematic failures of the site and the current system.	Hiring a company specialized in web design. Improvement of CBTM Web system to present more friendly interface to the general public. Implementation of new communication strategies to better disseminate the ranking and national rating.

(to be continued)

	Strategic Goals	Outcome Assessment	Analysis	Action for 2019
	Activate table tennis, broadly, on national territory	Partially Fulfilled	The achievement of 23 interstate tournaments, by the State Federations, is the best indicator of territorial reach achieved. But the activation of these competitions is still flawed. The integration is only due to the sport aspect, with a score in the ranking and national rating. There is no brand synergy to strengthen the territorial presence. There were no engagements.	Reinforcement of activities related to the interstate, representing a source of income for the State Federations. Participation in World Table Tennis Day (April 6), together with ITTF. Expand integration of state and interstate tournaments.
Leisure Players	Build guidelines for the development of "Urban Table Tennis" or TTX	Unattended	Unrealized. There was a proposal to hold a large "Urban Table Tennis" event, which has not yet been implemented. Partnerships with other entities are punctual, without being part of a structured program.	Achieving and initiating the implementation of actions with this bias depends on a process of structuring a marketing team. Or by isolated actions. If implemented, it will be done from the second semester of the year or in partnership with private entity (agency or sponsor).
	Gather and consolidate information and data of practitioners and event promoters	Unattended	There was no institutional opening to dialogue with informal sports. Parallel events and regional leagues are treated as "pirate events." There was no action to promote partnerships with these promoters.	Structuring of a web-system to allow the registration of events of different natures. Review of the model of partnerships with State Federations, Regional Leagues and Independent Promoters by 2020.
	Consolidate and disseminate content related to the modality	Unattended	Communication focused on the sports results of national teams or competitions. No action was taken to build exclusive content for fans of the sport.	Implementation of an Institutional Communication Policy. Work communication with unique and differentiated content. Partnership with TVNSports may bring different content and vision of CBTM competitions.
	Coordinate activities of clubs and federations for the development of new practices	Unattended	It did not. It is also observed a distancing of the communications of the confederation with its affiliates. CBTM also needs to structure team and marketing department to better implement these actions - which are not yet prioritized by the demands of national selections and events.	Marketing area structuring to start first steps related to sport as leisure. Possible deployment for the second half of the year.

(to be continued)

	Strategic Goals	Outcome Assessment	Analysis	Action for 2019
	Organize events that promote the sport	Unattended	A large annual meeting of "Urban Table Tennis" was scheduled, which has not yet been held. There were consultations to promote Ping Pong, but that did not advance due to lack of resources and personnel dedicated to this segment.	Participation of the "World Table Tennis Day", promoted by ITTF. The annual "Table Tennis Urban" event is scheduled for 2020, as soon as the marketing and event team is structured.
Table Tennis University	Invest in the training of coaches from a Coach School and attract young teachers to the modality	Partially Fulfilled	The coaching courses were conducted in a conventional format, following the premises and guidelines of the ITTF. But there was a 30% drop in the number of qualified trainers from 2016 to 2018. There was no training action of teachers to attract the modality.	Sistematizar os cursos da ITTF Nível I, II e III – ao menos 5 cursos ao longo do ano. Estruturar modelo de curso livre para atração de profissionais para a área. Realizar parcerias com a ITTF para financiamento. Promover cursos online, com técnicos estrangeiros.
	Invest in the training of referees from a School of Arbitrators	Partially Fulfilled	The referees courses were carried out in partnerships with the State Federations, in the conventional model. No permanent courses were implemented, so little coaching process.	Event Leadership with more active action before the Arbitrator Coordinator. Promotion of new arbitration courses in the country (at least 5).
	Invest in the training of managers through a systematized program	Unattended	There was no offer of courses with this bias, through a systematized program.	Incentive for free and online courses. Study of the possibility of implementing a specific online course starting in the second half of the year. Search for partnership with university and / or promoters of free courses.
	Empowering clubs and federations in sport management and business	Unattended	There was no promotion of activities with this focus.	Semi-structured dialogue with entities to promote the modality. Build templates so affiliate members work in a different perspective of managing their own content. Offer online training with this approach as of the second half of the year.
	Disseminate knowledge with booklets and manuals that contribute to access to information	Unattended	There was no construction of content for the dissemination of information.	Structuring the team and establishing partnerships with universities for the production of content useful for use by Clubs, Leagues and Federations. Playful and practical approach that encourages application.

(to be continued)

	Strategic Goals	Outcome Assessment	Analysis	Action for 2019
Communication, Marketing and Business	Reformulate the Digital Communication Platform, which includes the official website and editorial line related to social networks	Unattended	The communication through social networks remained in the journalistic format. It would be necessary, in addition to journalism, to add aspects of engagement and relationship with the public. The site has not been redrafted.	Reformulation of the website (web design), with change of user experience and generate better navigability. Modernize the actions related to the digital area, with design, videos and messages of engagement.
	Integrate the communication activities of the confederation with that of the state federations	Partially Fullfilled	Reactive action, following the demands of the federations. It would be necessary to set up a news agency model to meet all the demands of the federations. There is no appeal for this service.	Systematization of the collection by news of the federations. Work for language standardization and posting in CBTM media.
	Standardize the brands linked to CBTM for the same signature and visual identity	Unattended	There were not enough resources in 2017 and 2018 to implement this action.	Hiring design services to start rebranding work of the CBTM brand, with subsequent construction of sub-brands and search for visual standardization of all actions.
	Organize sponsorship properties to ensure better results for sponsors	Partially Fulfilled	Sponsorship quotas plan submitted and approved at the end of 2018. Partnership with XYZ Live agency restarted to attract sponsorship.	Consolidation of sponsorship quotas and approach to the market. Beware of the distribution of the marks according to the amount invested and respective counterparts.
	Generate proprietary content to increase visibility of the mode	Unattended	No specific content was built in 2018.	Partnership with TVNSports for the generation of national event content. Use of images of the participation of athletes of the selection in competitions of the ITTF. Interviews with athletes and technicians.
Management and Governance	Monitor governance indicators to ensure transparency, democratization and modernization of the entity.	Objective Accomplished	CBTM is among the 5 best confederations in Brazil's governance indicators assessments. He won the 2nd place of the Sou do Esporte Award. It also develops a monitoring process for the COB's GET (Management, Ethics and Transparency) and the Ethos Institute's Rating in partnership with CPB. The latter have indicative indicators, without disclosure of classification and indexes.	Maintenance and evolution of governance and transparency activities. Promotion of procedural and statutory changes to meet regulatory requirements and governance guidelines. Climb up the indicators of analysis of sports entities.

(to be continued)

Strategic Goals	Outcome Assessment	Analysis	Action for 2019
Analyze the performance and results of projects and collaborators	Parcially Fulfilled	The analysis of project performance was done in a reactive way, mainly on the demand of the Committees (Olympic and Paralympic), in addition to the governance premises. The lack of a "Project Office" and "Human Resources Management" structure, due to lack of resources, affects the good flow of this item.	To resume the construction of a systematic evaluation of projects through a management tool, as was done in the entity until 2015. Modernize indicators and implement continuous evaluation processes. Provide structured feedback to employees 2 times a year.
Establish guidelines for improving management in federations in line with the strategic guidelines of the confederation	Unattended	No guiding document has been set up for the federations since the proposal was made in 2016.	To propose a manual with clear and objective guidelines for the performance of the State Federations. Constitute a Matrix of Responsibilities, with complementary objectives among the different organizations of the system.
Establish guidelines for improving management in federations in line with the strategic guidelines of the confederation	Unattended	The management of the federations is done from the perspective of each one, without concrete alignment with the assumptions of national scope.	Propose a Matrix of Responsibilities, which guides the State Federation's line of action combined with the strategic objectives of CBTM.
Building an integrated view of the system	Unattended	The State Federations have autonomy of management and must continue. But the system standardization guidelines have not yet been fully implemented.	Proposition of a model of development of the modality with the wide participation of State Federations, Clubs and Regional Leagues, in order to guarantee the sustained growth of table tennis in Brazil.

For the Table 1, we can note that only 7% of the strategic objectives were achieved and 33% partially fulfilled. This low index is due to the inexistence of a monitoring and collection routine for the achievement of results. And, also, by the abrupt drop of resources destined to the sports confederations in Brazil after the Games Rio 2016, which forced the execution of a leaner plan. oriented exclusively to meet the basic demands of athletes.

4. CONCLUSIONS

The main challenge is to achieve the goals behind projected. And universalize the ideas of the strategic plan to the hole organization. The proposal is to achieve a planning culture in which every action and bring decision-making into account the assumptions of planning.

The difficulties observed between 2017 and 2018 to achieve the main goals was the result of legal uncertainty regarding the transfer of resources through lottery funds. The significant reduction of revenues by CBTM generated contingency plans. Thus, the development projects were left aside, with the possibility of future implementation, as the country's economic scenario improves.

But the importance to think strategically shows the relevance of having a guide as a basis for everyday decisions and to make efforts for common sense in the organization.

REFERENCES

Mintzberg, H. (1987). The strategy concept I: five ps for strategy. *California Management Review*, pp. 11-24.

Sinek, S. (2017). *Leaders eat last: why some teams pull together and others don't.* New York: Penguin Group.

Thibault, L., & Slack, T. (1994). Strategic planning for nonprofit sport organization: empiriracal verificativon fo a framework. *Journal of Sport Management*, pp. 218-233.

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Governance indicators in Brazilian Table Tennis Confederation: how the concept impacts in the management of a sport federation

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Abstract: Due to numerous external changes in regulations and legislation from Government and independent institutions in Brazil, which have given objective focus on aspects related to Governance, the sport system in the country has seen a significant transformation of several traditional entities. With the need to have a vision oriented to the external environment and to the impact of various organizational decisions on different stakeholders, sports federations have adopted new organizational models that are impacting their management. In this sense, the Brazilian Table Tennis Confederation (CBTM) was one of the pioneer institutions in this regard. Since 2015, it has been executing objective changes that, together with the organization and processes implemented in the past, have contributed to placing CBTM among the best entities in Brazil in terms of performance on Governance. The methodology of this work consists of the organization of documents and processes that were implemented from 2015 to 2018 in relation to Governance, observing how much this changed the way of managing and making decisions in the entity. The result points to a differentiated posture of employees, athletes, clubs and other sports leaders for a greater awareness of the need to respond clearly with their actions to the external environment, as well as to ensure predictability, transparency and compliance of CBTM's management actions. It is understood that the entity, for the work developed, is prepared for the future changes and the continuous evolution of its management system.

Keywords: governance, indicators, stakeholders

1. INTRODUCTION

The complexity of managing sports organizations has been greater every day. This is due, of course, to the need to evolve the management model to deal with the changes that the modern world presents - in particular, new technologies and different life habits between different generations. But it is not limited to this, even because any organization that is in the market needs to continually reinvent itself to stay in it.

It is reinforced by the continuous expansion of society by demands for changes in sports organizations. And this external pressure requires managers of the present and the future to respond to misunderstandings or managerial failures of the past, making evolution a task of the greatest difficulty.

In this context, the great challenge is to find a balance of forces that respects the different stakeholders and their desires. Many of them, who until the end of the twentieth century were far from the field of sports organizations, now have a sense

of urgency, which imposes quick and consistent responses of these entities, under penalty of loss of credibility and investments.

In Brazil, valuations related to governance began to become very important, especially since 2015. Until then, these indicators belonged almost exclusively to the corporative world, of the large companies listed on the Stock Exchange. But since the period mentioned, terms and nomenclatures analogous to governance have become commonplace in day-to-day sports organizations in the country.

The challenge facing sports entities in Brazil is to ensure a balance between the response needs demanded by society with its vocation to deliver and develop the sport at a national level. Therefore, the purpose of this study is to make an account of the evolution of the concept of governance and how the Brazilian Confederation of Table Tennis has sought to adapt to this wave of transformations to grow and evolve in the market as a whole.

2. LITERATURE REVIEW

The references point to a no-return model. The transformation of the sports world, which witnessed the entry of a significant amount of financial resources, especially since the 1980s, contrasts with an internally oriented organizational culture. That is, its affiliated members.

Thus, governance can be understood as the reflection of people involved in groups with common interests and goals. It is therefore a concern to ensure that those in charge of the management of an entity are taking decisions in the common interest (of all) and not only to meet their personal needs (individual) (Clarke, 2004).

Governing sports organizations involves establishing global direction or strategy to guide the organization in order to ensure that all members involved with the organization have something to say about how the strategy is developed and articulated (Hoye & Cuskelly, 2007). In this sense, organizations have to know better explain the “why” they did or make some decision in the field.

3. RESULTS

In Brazil, the proposition of the “Sou do Esporte” Award in 2015 year contributed to the creation of a virtuous cycle of improvements in the principles and premises of the national federations of the country. Accustomed, until then, with premises of oversight, sanctions and severe punishments in cases of non-compliance, the inverted logic has brought a positive agenda for the sport.

In the case of the Brazilian Table Tennis Confederation, the search for adaptation in the principles of Transparency, Equity, Accountability, Institutional Integrity and Modernization can be observed in Table 1. This table shows the summary of the indicators compared from 2015 to 2018.

Table 1. *Evolution of Governance Indicators between 2015 and 2018 in CBTM*

	2015	2018
1) Transparency	7,1	10
1A) Financial Documents Publication	7,5	10
1B) Convocations and Notices	10	10
1C) Internal Control	10	10
1D) Access to Information and Files	6	10
2) Equity	8,2	8,2
2A) One vote per member	7,5	5
2B) Rules for Votes and Members Registration	8,3	10
2C) Conflict of Interests in General Assembly	10	10
2D) Electoral Process	5	5
2E) Projects Distribution	10	10
3) Accountability	8,5	9,2
3A) Approval Process	10	10
3B) Audit	5	10
3C) Reports	10	6,7
3D) Fiscal Council Performance	10	10
3E) Internal Controls	6,7	10
4) Integrity	2,9	8,8
4A) Stakeholders Relationship	0	7,5
4B) Code of Conduct	0	10
4C) Anticorruption Practices	3,3	10
4D) Sustainability in Projects	6,7	10
4E) Economic Dimension	5	7,5
5) Modernization	3,3	7,1
5A) Professionalization	3,3	6,7
5B) Administrative Council	4,3	6,4
5C) Role of Advisory Councils	5	5
5D) Managers Salary	0	10
Final Grade	5,8	8,5

So, the grow in 4 years were about 46% in governance index. Emphasize the understanding of the need for change within a traditional organization. This poses even greater challenges. Despite the pressure exerted by the media and society for change, one must also show the internal will. Without which it would not be possible to implement these processes.

With this agenda created by “Sou do Esporte”, there was a broad movement that impacted both the Brazilian Olympic Committee (COB) and the Brazilian Paralympic Committee (CPB). In COB, the Governance, Ethics and Transparency (GET) program was created, which monitors monthly the performance of the confederations within an electronic platform, which ranks organizations in 5 levels of maturity since 2017. In this regard, CBTM ended the year 2018 with an evaluation of 3.3 points out of 5

possible - this indicator, compared to the performance of the other confederations of the System, will become part of the criteria for the distribution of resources of lottery funds made by the COB to affiliated entities. From CPB, a partnership with the Instituto Ethos, an entity that, since the 1990s, evaluates private companies in terms of social responsibility and governance. The analysis generated the Rating Integra rating index, which went through an electronic questionnaire followed by in-loco evaluation of a specialized consultant to search for evidence on governance issues.

4. CONCLUSIONS

Social and public pressure, followed by the evaluation of sports entities by means of indicators, contributed to putting the term governance in the daily life of these organizations. In the case of CBTM, the issue is taken with extreme seriousness, being absorbed as a parallel competition, which creates a positive agenda for the entity.

The next steps to make the changes even more consistent involves creating an enabling and disseminating knowledge environment for internal stakeholders and affiliated members. At present, this knowledge is restricted to the top management of the organization, not reaching the base.

By creating a culture of governance that is achieved in the long term, it will be possible to better work the management processes of the entity. The impact will be on the agility of decision-making and on the impersonality of decisions, since these should be supported by clear and objective regulations.

REFERENCES

Clarke, T. (2004). *Theories of corporate governance: The philosophical foundations of corporate governance.* London: Routledge.

Hoye, R., & Cuskelly, G. (2007). *Sport governance.* Oxford: Elsevier.

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SplitT-Pong as an easy tool to select talents for table tennis

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Abstract: To find and select table tennis talents is not an easy job. First of all, organize an event either at your club or in schools. The appropriate advertising and needed equipment are very important. SplitT-Pong is an afloat table with measurements of 200cm X 120cm. With SplitT-Pong you can play ping-pong in the water.

You can easily move the table and transport it by car. Getting started with SplitT-Pong is equally easy: you put the table into the water, start to play and many children will want to join you. The rackets of SplitT-Pong are glove-paddles which give you a feeling of playing with your palm. The diameter of the SplitT-Pong's ball is about 5 cm, and it is made from rubber or sponge. The shape of the paddles and the ball makes it possible to learn SplitT-Pong in no time. The real talents can play after 2-3 minutes and enjoy the game. The rules are much simpler than in table tennis. You play outside and not in the hall, with large balls allowing you to play in the wind (up until 5 m/s). Another advantage of SplitT-Pong, that you can adjust the high of the table in the water. Despite the differences between SplitT-Pong and table tennis, the same qualities are needed for both types of entertainment. We make recruitment for table tennis mainly in the summer and in the leisure time of children. This is much more effective than the conventional recruitment.

Keywords: table tennis, SplitT-Pong, water ping-pong, select talents, recruiting

1. INTRODUCTION

SplitT-Pong (Sport like Table Tennis) is a series of ping-pong tables with different measurements. They are games for leisure activities. The elements of the SplitT-Pong series are:

- SplitT-Pong "MINI"- standing table with measurements 200cm X 120cm
- SplitT-Pong "PROFI"- 2 SplitT-Pong "MINI" tables 1 m apart with the net between them
- SplitT-Pong "SWIM" ("VIP") - floating tables without standing construction.

1.1 SplitT-Pong "MINI"

SplitT-Pong table with measurements 200cm X 120cm X 7cm. The standing construction is made of plastic.


1.2 SplitT-Pong "PROFI"

This table is the largest table of the SplitT-Pong family. 2 SplitT-Pong "MINI" tables are placed from each other in 1 meter distance. The net is located between these 2 "MINI" tables.


1.3 SplitT-Pong "SWIM"

The polystyrene table floats in the water.


1.4 SplitT-Pong "VIP" (Valuable Inflatable Pingpong)

The inflatable table fits into the bag with measurements 75cm X 35cm X 35cm

The floating tables with the smallest size are SplitT-Pong "SWIM" (EPS-Expanded Polystyrene version) and SplitT-Pong "VIP" (inflatable table version). They are most suitable to select talents, because of their easy transport and installation.

2. WHILE WE USE THE FLOATING SPLITT-PONG TABLES?

The SplitT-Pong "SWIM" ("VIP") are most suitable devices to discover talents. The SplitT-Pong "SWIM" table consists 4 polystyrene pieces with measurements of 100cm X 60cm (building bricks). Several tables with measurements 200cm X 120cm can be delivered by a normal car. The SplitT-Pong "VIP" (Valuable Inflatable Pingpong) table fits into the bag with measurements 75cm X 35cm X 35cm. The weight of the bag is about 10 KGs (inclusive net, 2 paddles, balls). It is easy to travel with floating tables everywhere to make "recruitment".

3. SPLITT-PONG AS AN EASY-TO-LEARN LEISURE ACTIVITY

3.1 The paddle type racket

The SplitT-Pong racket is a "glove type" paddle. You have to pull it on the hand and gives a feeling as if you hit the ball with your palm. It is easier to control the ball as by the racket with handle.

3.2 The size of the balls

You can play SplitT-Pong with different balls depending on the environment and the playing skills of the players. We play with spiked rubber balls (diameter 3-5 cm) in the water. We use sponge balls on land (grass, sand, hall, etc…). You can play mainly with the balls with diameter about 5 cm. The beginners can start with the larger balls (8-10 cm). Advanced player can play ping-pong ball-sized sponge ball.

3.3 Easy rules

The SplitT-Pong rules are simpler than the table tennis rules. No complicated service rule. Edge ball is not a point (should be replayed). The rally is let, when the net is touched by the ball.

4. WHY IS BETTER TO DISCOVER TALENTS BY SPLITT-PONG?

4.1 Physical characteristics

The depth of the water can be adjusted to the height of the children.
The height difference between children can be compensated by the sloping ground.
It is possible to play in the small wind. It is possible to play with the large sponge ball by the wind until 5 m/s.

4.2 Human parts

The children have no stress. They come to play voluntarily.
Only the child who is interested in the game comes to play.
The real talents can play after 2-3 minutes and they are fully enjoy the game.

5. SUMMARY

Despite the differences between SplitT-Pong and table tennis, the same qualities are needed for both types of games:

- Timing
- Coordination
- Hit the ball between body and table
- Ball placement
- etc…

A fundamental difference between SplitT-Pong and table tennis is, that you can't give a big spin to the ball by SplitT-Pong. So, we can't observe clearly how the kids can handle the spin of the ball. To make topspin by SplitT-Pong practically is not possible.

However, we usually do not teach the topspin at the beginning of the children's learning process.

REFERENCES

URL: www.splitt-pong.com, www.splitt-pong.eu, www.splittpong.com, www.splittpong.eu, www.facebook.com/splittpong

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