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Düsseldorf, May 27th – 28th 2017

Editors:
Miran Kondrič
Michael Fuchs
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Message from the Editors

Preface

It is a great honour and pleasure for the Editors to issue this Proceedings book of the 15th International Table Tennis Sports Science Congress. This Proceedings book contains selected papers from the congress held in Düsseldorf on May 27th - 28th, 2017.

Table tennis belongs to the most popular sports in the world. Players range from youth, recreational players to the world-class elite players. Correspondingly, the number of scientific studies on table tennis is increasing. Research in every field of interest has been conducted in separate and individual areas such as physical training, physiology, psychology, medicine, dietetics, physics, and engineering. It is envisaged that this Proceedings book of the Congresses 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 German Table Tennis Association, Technical University of Munich and the Organising Committee of the World Table Tennis Championships for hosting the 15th International Table Tennis Sports Science Congress. The Congress was organized by members of Technical University of Munich, German 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 Kondric, PhD
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PART 1
Science papers

Leadership Behaviour and Satisfaction in Young Table Tennis Players

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Abstract: Several researchers have supported that the higher the satisfaction and the pleasure of athletes from participation the higher the commitment towards the sport and the team (Huang, 2002). The purpose of this study was to examine the perceptions and preferences of table tennis coaches and players and to relate them to the satisfaction young table tennis players feel from Leadership and from their Individual Performance and secondly to investigate differences related to gender, competition league and years of practice. The sample consisted of 28 table tennis coaches and their 162 young table tennis players (103 boys and 59 girls) from Greece (mean age 15.3 ± 1.52). Data was collected through LSS, (three versions) and the Athlete's Satisfaction Scale ASS. The results indicated that the most perceived and preferred leadership behaviours were *training and instructions* and *positive feedback* and the least was *autocratic behaviour*. Athletes' satisfaction had significant correlation with all four leadership behaviour dimensions in the perceived and the preferred version, while the *autocratic behaviour* had a significant negative effect on the players' satisfaction. Additionally, the girls seem to feel more satisfied by their coaches while competition league and years of practice didn't influence the satisfaction that athletes felt.

Keywords: perceived, preferred Leadership behaviour, table tennis athletes.

1. INTRODUCTION

"Leadership" is a complex term that has concerned social and sports psychologists for decades. Burns (1978) pointed out that leadership ability is one of the least understood. Is easier to give an example of success leadership than to explain what successful leadership is. According to Barrow (1977) and Stogdill (1974) leadership is defined as the process of influencing the activities of an organized group or individuals toward goal setting and achieving these goals.

Coaches' leadership abilities and behaviours influence the psychological skills of athletes such as confidence, self-esteem, their ability to perceive, exemption from worries and dealing with difficulties (Horn, 1992). Coaches' personality and behaviour also play a very important role in the personal and sport development of athletes as they affect their participation in sports and they exert a tremendous impact in the physiological and psychological prosperity of athletes and quite often detect the athletic career or even the withdrawal (Mageau and Vallerand, 2003).

A successful coach should help his athletes develop new skills, enjoy competition and learn to feel good about themselves. Moreover a successful coach should be able to teach not only sports skills but also values and ideals that will be useful for the rest of their lives (Martens, 1997).

Satisfaction

Because of the total involvement of the athlete both physically and psychologically, it becomes necessary to measure athlete satisfaction from perspectives different from those in other contexts (Chelladurai and Riemer, 1997). Daniel (1983) argues that the investigation of satisfaction is vital because "congruence of organizational goal achievement and need satisfaction of individuals within organizations is an implicit and explicit goal of a democratic society".

Satisfaction of athletes has a multidimensional meaning that is influenced by many factors, such as Leadership, individual performance, the settings, and the cohesion of the team, the facilities, and team performance in general and the performance of other teams. According to Chelladurai and Riemer (1997) athletes' satisfaction is defined as "a positive affective state resulting from a complex evaluation of the structures, processes, and outcomes associated with the athletic experience" (p. 135). The same researchers supported that the level of satisfaction is influenced by the personality of each athlete, by his personal standards, his desires, his emotions, his sense of justice, previous experience but mainly supported that there is a strong correlation between satisfaction and the leadership style of coaches. Specific leadership behaviours such as training and instructions, democratic behaviour, social support and positive feedback, are the most important predictive factors for satisfaction and performance (Chelladurai and Riemer, 1998).

According to Horn (2002), Amorose and Horn (2000) coaching behaviours that involve technical instructions, positive feedback, social support and a democratic environment, are related to efficient learning, an increase in effort, in interest and in satisfaction of young athletes.

Satisfaction and table tennis

Wen and Kong (2010) studied the training satisfaction of 257 university table tennis players and the influence it has on team support, team commitment and the intention to leave. Analysis showed that training satisfaction is proportional to team support. Moreover, sports performance, place and equipment, teammate relationships, training control and sports devotion are the actors contributing to training satisfaction that can effectively predict team support, while coach professionalism and team welfare can be used to effectively predict a tendency to quit the team.

Huang, Lin and Huang (2011) studied table tennis players and recorded the positive correlation between the perceived leadership behaviour and the satisfaction of athletes. Training and instructions and positive feedback were the dimensions of leadership behaviour that influenced statistically significantly, the satisfaction of athletes.

Therefore, the aim of the present study was twofold. Firstly to relate the perceived leadership behaviour of Greek table tennis coaches, along with the perceived and preferred leadership behaviour of their young table tennis athletes to the satisfaction these players felt from leadership and from their individual performance and secondly to investigate differences related to gender, competition league and years of practice.

2. METHODS

Participants

The participants were 28(22 male & 6 female) table tennis coaches and their 162 competitive young table tennis players from Athens and the Northern parts of Greece. There were 103 boys and 59 girls from 12 to 18 years old, with a mean age 15.3 ± 1.52 who in the year 2014-2015 played for the junior (n=89) and cadet category (n=73). All participants were table tennis players with 4.78 ± 2.07 years of practice. Table1&2

Table 1. Demographic characteristic of table tennis coaches

Gender	Male		Female	
	22		6	
Age	<40	>40	<40	>40
	12	10	3	3
Coaching Diploma	YES	NO	YES	NO
	14	8	5	1
Coaching experience	<10 years	>10 years	<10 years	>10 years
	10	12	5	1

Table 2. Demographic characteristics of table tennis athletes

	Boys	Girls
Gender	103	59
Cadet	42	31
Junior	61	28

Measures

Demographic data sheet was given to table tennis coaches and their athletes.

Leadership Scale for Sport (LSS, Chelladurai and Saleh, 1980) was used for the data collection. Leadership Scale for Sport (LSS) has 3 versions: a) Coaches' perception of their own leadership behaviour, b) athletes' perception of their coaches' leadership behaviour and c) athletes preference for their coaches' leadership behaviour. In this study the 3 versions were used. These versions were adapted into Greek by Aggelonidis, Zervas, Kakkos and Psychountaki (1996).

Leadership scale for Sport is a 40-item scale that measures 5 dimensions of leadership behaviour: training and instruction behaviour (13 items), democratic behaviour (9 items), autocratic behaviour (5 items), social support behaviour (8 items), and positive feedback behaviour (5 items) through the perceived version of coaches (I explain to each athlete the techniques and tactics of the sport), the perceived version of athletes ("My coach explains to each athlete the techniques and tactics of the sport") and the preferred version of athletes ("I prefer my coach to explain to each athlete the techniques and tactics of the sport"). Responses are provided on a 5-point Likert-type scale from 1 (never) to 5 (always). Therefore, higher scores reflect stronger perceptions of leadership behaviours.

Chelladurai and Saleh (1980) reported the internal consistency ranged from .45 (autocratic behaviour) to .83 (training and instruction) in preferred version and from .79 (autocratic behaviour) to .93 (training and instruction) in perceived version. The internal consistency (Cronbach's alpha, 1951) of the LSS-Perceived version of coaches in Greek population is: -.84, .84, .57, .61, .77 respectively for the 5 dimensions: training and instruction behaviour, democratic behaviour, autocratic behaviour, social support, and positive feedback, -.94, .83, .67, .84, .88, for the perceived version of athletes and -.84, .76, .57, .62, .76 for the preferred version of athletes (Aggelonidis et al., 1996).

Athletes' satisfaction. Athlete satisfaction was measured using 10 items in two dimensions of the Athlete Satisfaction Scale (Chelladurai, Inamura, Yamaguschi, Oinuma, & Miyauchi, 1988). The dimensions were: 1) *Satisfaction from Leadership* including 7 items, regarding how satisfied the athlete is with the leadership of his/her coach, with an example item being: "How satisfied/dissatisfied are you with your coach's ability to teach you?". 2) *Satisfaction from individual performance* with 3 items, with an example item being: "How satisfied/dissatisfied are you with your personal progress and performance?"

All of the responses from ASS are provided on a 7-point Likert-type scale anchored at the extremes by 1 (extremely dissatisfied) to 7 (extremely satisfied). The scores from the ASS demonstrated adequate internal consistency as well as content, predictive and factorial validity and in a wide variety of samples (Riemer & Chelladuarai, 1998).

The adaptation of the scale for the Greek population was made by Theodorakis and Mpempetsos (2003). The internal consistency of the scale was -.95 for the *Satisfaction from leadership* dimension and -.83 for the *Satisfaction of individual performance* dimension. Vilani and Samulski (2007), reported that the internal consistency for both Satisfaction from leadership and Satisfaction *from individual performance* in their research with table tennis players was above -.70. Cheng-Hua Huang, Li-huaLin and Chung-Hsiung Huang (2011), also in table tennis found that the internal consistency for the *Satisfaction from leadership was -.83 and* the *Satisfaction from individual performance was -.87*.

Procedure

Data was collected in the competition year of 2014- 2015 and in a time period of six months (December 2014 until May 2015). Parents of the athletes signed permission for their participation. The Demographic data sheet, the LSS an ASS questionnaires were distributed and explained to coaches and their athletes by the researcher. The researcher informed them about the purpose of the study and that participation was completely voluntary.

Statistical analysis

For the statistical analysis of the collected data, the Statistical Package for Social Science 20.1 was used. Analysis for the data was mainly conducted by statistical methods such as mean, standard deviation, Pearson correlation analysis, Independent Sample T-test, One-way ANOVA and Post Hoc Scheffe. Statistical significance was set at $p < 0.05$.

3. RESULTS

Data analysis

Research reliability was evaluated with Cronbach's alpha test. The values obtained revealed that Leadership Scale for Sports in its 3 versions (LSS) and the ASS were valid.

In the current study the internal consistency of the Leadership Scale for Sports was respectively -.83, .71, .69, .63, .72 for the 5 dimensions in the perceived version of the coaches, -.82, .74, .59, .63, .80 for the 5 dimensions in the perceived version of table tennis players and -.74, .82, .67, .68, .79 in the preferred version. The internal consistency for *Satisfaction from leadership* was -.86 and for Satisfaction *from individual performance* -.85.

Descriptive statistical analysis showed that coaches perceived very high scores of training and instructions (M=4.45) and positive feedback (M=4.41) and a satisfying social support behaviour (M=3.70). They also perceived low scores of autocratic behaviour (M=2.82). Table tennis athletes also perceived high scores of training and instructions (M=4.24) and positive feedback (M=4.29) from their coaches' leadership behaviour, a satisfying social support (M=3.46) and they perceived less autocratic behavior than their coaches did.

As for the preferred leadership behaviour, descriptive statistics showed that table tennis players prefer high training and instructions behaviour (M=4.49) and positive feedback behaviour (M=4.43), a satisfying social support (M=3.85) and democratic behaviour (M.=3.70) and they prefer from their coaches less autocratic behaviour (M=2.01) as shown in Table 3.

Table 3. Descriptive Indices of Leadership behaviour dimensions

	Leadership Scale for Sport					
	Coaches' perception (N=28)		Athletes' perception (N=162)		Athletes' preference (N=162)	
	M± S.D	α	M± S.D	α	M± S.D	α
Training & Instructions	4.45±.39	.83	4.24±.39	.82	4.49±.38	.74
Democratic behavior	3.00±.50	.71	3.19±.56	.74	3.70±.67	.82
Autocratic behaviour	2.82±.58	.69	2.20±.62	.59	2.01±.75	.67
Social support	3.70±.44	. 63	3.46±.52	.63	3.85±.55	.68
Positive feedback	4.41±.43	.72	4.29±.55	.80	4.43±.64	.79

Furthermore table tennis players seem to feel quite satisfied from Leadership (M=5.84) but they were less satisfied from their individual performance (M=5.54) Table 4.

Table 4. Means, Standard Deviations & Internal consistency of Athletes Satisfaction Scale

	Athletes Satisfaction Scale		
Dimensions	N	M± S.D	α
Satisfaction from Leadership	162	5.84 ± .87	.86
Satisfaction from individual performance	162	5.54 ± .91	.85

Analysis between Athletes Satisfaction Scale and Leadership Scale for Sport (Coaches' perception)

Pearson correlation analysis between the dimensions of Athletes Satisfaction Scale and Coaches' *perception* showed that *Satisfaction from Leadership* and *Satisfaction from individual performance* had no significant positive correlation with any dimension of Leadership Scale for Sport. Training and instructions had a very high significant positive correlation with democratic behaviour, ($r=.516$, $p<0.1$) and positive feedback ($r=.542$, $p<0.1$). Democratic behaviour had high positive statistical significance with social support ($r=.646$, $p<0.1$) and positive feedback ($r=.383$, $p<0.5$) and a negative correlation with autocratic behaviour ($r=-.268$, $p<0.5$). Finally social support had significant positive correlation with positive feedback ($r=.541$, $p<0.1$)

Analysis between Athletes Satisfaction Scale and Leadership Scale for Sport (Players' perception)

From Pearson correlation analysis between the dimensions of Athletes Satisfaction Scale and the five dimensions of Leadership Scale for Sport (Perceived version) results showed that *Satisfaction from Leadership* had significant positive correlation with *Satisfaction from individual performance* ($r=.526$, $p<0.1$) and significant positive correlation with Training and Instructions ($r=.580$, $p<0.1$), Democratic behaviour ($r=.281$, $p<0.1$), Social support ($r=.434$, $p<0.1$) and Positive feedback ($r=.320$, $p<0.1$) and a significant negative correlation with Autocratic behaviour ($=-.347$, $p<0.1$).

Moreover, Satisfaction from individual performance had a significant positive correlation with Training and instructions ($r=.291$, $p<0.1$) and Positive feedback ($r=.210$, $p<0.1$) and a negative correlation but not statistically important ($r=-.078$, Sig.=325) with Autocratic behaviour (Table 5).

Table 5. Pearson correlation analysis between Athletes Satisfaction Scale and Leadership Scale for Sport (players' Perception)

Dimensions	1.	2.	3.	4.	5.	6.	7.
1.Satisfaction from Leadership	1						
2.Satisfaction from personal training	.526**	1					
3.Training& instructions	.580**	.291**	1				
4.Democratic behaviour	.281**	.136	.249**	1			
5.Autocratic behaviour	-.347**	-.078	-.244**	-.159*	1		
6.Social support	.434**	.129	.362**	.425**	-.159*	1	
7.Positive feedback	.320**	.219**	.340**	.403**	-.79	.446**	1

p< .05 καιp< .01*

Pearson correlation analysis between Athletes Satisfaction Scale and Leadership Scale for Sport (players' preference)

From Pearson correlation analysis between Athletes Satisfaction Scale and Leadership Scale for Sport (Players' preference) the results showed that *Satisfaction from Leadership* had significant positive correlation with the *Satisfaction from individual performance* ($r=.526$, $p<0.1$), a significant positive correlation with Training and instructions ($r=.428$, $p<0.1$), Social support ($r=.283$, $p<0.1$), and Positive feedback (($r=.221$, $p<0.1$) and a negative correlation with Autocratic behaviour ($r=-.162$, $p<0.1$).

Also *Satisfaction from individual performance* had a significant positive correlation with training and instructions ($r=.244$, $p<0.1$) and Positive feedback ($r=.201$, $p<0.5$) and a negative correlation but not statistically important ($r=-.076$, Sig.=339) with Autocratic *behaviour* (Table 6).

Table 6. Pearson correlation analysis between Athletes Satisfaction Scale and Leadership Scale for Sport (players' Preference)

Dimensions	1.	2.	3.	4.	5.	6.	7.
1.Satisfaction from Leadership	1						
2.Satisfaction from personal training	.526**	1					
3.Training& instructions	.428**	.244**	1				
4.Democratic behaviour	.072**	.000	.288**	1			
5.Autocratic behaviour	-.162**	-.076	-.196**	-.015*	1		
6.Social support	.283**	.126	.488**	.3235**	-.099*	1	
7.Positive feedback	.221**	.201**	.392*	.322**	-.079	.415**	1

p< .05 καιp< .01*

Differences in satisfaction related to gender

Independent sample T-test analysis was used to assess the differences between boys and girls and Athletes Satisfaction Scale. Significant differences ($p<.01$) were found between boys and girls, only in *Satisfaction from Leadership* [$t_{(160)}=2.65$; Sig=.009; $p<.01$] with girls gaining higher scores of satisfaction. No differences were shown in the *Satisfaction from Individual Performance* [$t_{(160)}$=.74; Sig=.456] expressed by the two groups (boys & Girls).

Differences in satisfaction related to competition league

Independent sample T-test analysis was used to assess the differences between junior boys and girls and cadets boys and girls and the satisfaction they perceived on the Athletes Satisfaction Scale. The results showed no significant differences between the two categories in *Satisfaction from Leadership* dimension and also in *Satisfaction from Individual Performance* [$t_{(160)}$=.255; Sig=.799], [$t_{(160)}$=.826; Sig=.410].

Differences in satisfaction related to years of practice

Years of practice were divided into four groups a) up to 2 years, b) 3 to 4 years, c) 5 to 6 years and d) more than 7 years. One way ANOVA analysis showed no significant differences between those four categories and the satisfaction young table tennis felt [$F_{(3,158)}$=1,741; Sig=.161; p>.05] [$F_{(3,158)}$=1.871; Sig=.137; p>.05].

4. DISCUSSION

This study aimed firstly, to compare the perceptions and preferences of table tennis coaches and players and to relate them to the satisfaction young table tennis players feel from Leadership and from their Individual Performance and secondly to investigate differences related to gender, competition league and years of practice.

Coaches' perception related to players' satisfaction

The results of this study showed that coaches' perception of their own leadership behaviour is not related to Satisfaction from individual performance or the Satisfaction from Leadership. Chelladurai et al., (1988) also found that the Canadian and Japanese athletes in their study didn't relate Satisfaction from individual performance with the perceived leadership behaviour of coaches. The results of this study also are in consistence with Chelladurai (1984), who reports that satisfaction from Individual Performance is not related with leadership and the athletes shouldn't systematically relate their satisfaction from individual performance as the goals of each athlete are internal and the role of a coach peripheral. Nevertheless, coaches' perception is very important because according to the Multidimensional Model of Leadership of Chelladurai (1990), when there is congruence between coaches' behaviour and the perception and preference of athletes, then satisfaction and performance increase.

Satisfaction and Table tennis players' perception and preference

According to the results, satisfaction that young table tennis players perceived regarding their coaches' leadership behaviour had a significant correlation with all dimensions of Leadership Scale for Sport, while the satisfaction from individual performance had a significant correlation only with training & instructions and positive feedback dimensions. The preferred leadership behaviour of table tennis players had significant correlation with satisfaction from Leadership only in 3 dimensions of the Leadership Scale for Sport (training & instructions, social support and positive feedback while satisfaction from individual performance had significant correlation only with training & instructions and positive feedback dimensions. The results of the present study are in consistence with international literature that supports the high correlation between the perceived leadership behaviour and satisfaction of athletes (Chelladurai, 1984; Weiss and Friedrichs, 1986; Schliesman, 1987; Dwyer and Fischer, 1990; Bebetsos and Theodorakis, 2003; Nazarudin et al., 2009).

Huang, Lin and Huang (2011), showed that “a coach and his leadership behaviour” had a greater percentage than the “performance of athletes” regarding the perceived satisfaction of table tennis players. Training and instructions and positive feedback had the highest influence in the satisfaction of table tennis players. Researchers supported that the higher the players perceive technical instructions and positive feedback the higher were the levels of satisfaction that they felt. Chelladurai and Riemer (1998) recorded that specific coaching behaviours such as training and instructions, democratic behaviour, social support and positive feedback are consider the most predictive factors for the satisfaction and the performance of athletes. The same researchers claim that coaches should avoid autocratic behaviours in order to maximize the satisfaction of their players. Terry and Howe’s (1984) supported that athletes’ satisfaction from leadership is related to the type of sport. More specific, athletes from team sports prefer higher autocratic behaviour and less democratic behaviour from their coaches than athletes of individual sports. In individual sports such behaviours are not needed in high frequencies whereas the lack of them influences less the satisfaction from leadership.

Satisfaction and gender

The results of this study showed significant differences in satisfaction between boys and girls only in the satisfaction from leadership dimension, with girls feeling more satisfied from their coaches’ leadership behaviour compared to boys. There were no differences in satisfaction from individual performance. Barnes, (2003) found in his study, that female athletes preferred coaches who use a more democratic style of leadership, compared to male athletes with an exception to basketball female athletes. Different results were found in the study of Theodorakis and Bebetsos (2003) who found that male athletes were more satisfied than female athletes concerning their perceptions in individual performance. According to Riemer and Chelladurai (2001) gender affected 10 out of 15 aspects of athletes’ satisfaction, especially in autocratic behaviour of athletes’ preferred leadership behaviour. Male athletes preferred more autocratic behaviour than women did. These results are in consistence with previous researches (Chelladurai and Saleh, 1978; Erle, 1981; Terry, 1984). Finally, Chelladurai et al. (1988) found similar results in Canadian and Japanese athletes. Canadian athletes were more satisfied with both leadership behaviour and personal outcome, than the Japanese athletes. According to the researchers that was due to the different cultural background of the two nations.

Satisfaction in relation to competition league and years of practice

Findings also showed that neither competition league nor years of practice influenced the satisfaction that young table tennis players felt from both coaches’ leadership behaviour and individual performance. On a different note, the study of

Domali, Psychountaki, Kaloupsis and Chairopoulou (2009) found significant differences in women category compared to junior and cadet girls in synchronized swimming only in the satisfaction from Leadership dimension.

No differences in satisfaction were found between junior and cadet girls a result that complies with the present study. In the present study the two categories were very close in competition league and in years of practice and the coaches' leadership behaviour might not change, as it may occur in other categories or with more experienced players. (Men-women). Theodorakis and Bebetsos (2003) in their study found that years of practice influenced the satisfaction of the athletes, since the more experienced athletes seemed to be less satisfied from their performance and had greater expectations from their coaches and from themselves.

5. CONCLUSION

Table tennis coaches should understand the huge importance that their leadership behaviour has and how it can affect the perception, technical skills, athletes' performance and also the satisfaction that young table tennis players feel. Moreover, satisfactions from leadership and from individual performance are very important dimensions in the correct evolution and development of a child and should be seriously considered by table tennis coaches. Additionally coaches should also enhance behaviours not only suitable for the athletic environment but also relevant to their players needs and requirements in order to maximize their performance and satisfaction. The relationship between the leadership behaviour and the performance and satisfaction is a two way interaction (Chelladurai, 1993a; 1993b).

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About the Importance of "Situational Training" in High Performance Table Tennis – Empirical Study Aiming to Identify Match Situations

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Abstract: Four main aims were pursued by this qualitative, self-developed observation method: 1. To extract typical game situations. 2. To find out which competences distinguish between good and very good international players (WTTC of 1985, 1987, 1989). 3. To find psychological reasons for inappropriate situational assessments. 4. To obtain new information about the inner structure of rallies including the origins of mistakes and points. Five basic conditions or values can be defined with regard to the effect of a shot: mistake, disadvantage, stalemate, advantage and direct point. Every rally can hence be seen as a chain of interdependent values. This leads to the idea of 15 pairs of combinations/situations between two ball contacts and four main situations that include these 15 pairs: situations of 1. decision, 2. change, 3. preliminary decision and 4. stalemate. Observers were trained to assess the values. To compare the effectiveness of different players` actions, a calculation model was developed. **Results**: 1. The quality of the return distinguishes best between good and very good players. 2. Very good players reach significantly higher efficiency in dealing with a stalemate value 3. Even international top players seem to be influenced by psychological misinterpretations of game situations.

Keywords: systematic match analysis, match situations, tactics, psychology

1. INTRODUCTION

The importance of scientific match observations and psychological research in sports games has increased within the last years (see football). In contrast to this, practical training in table tennis was – and often still is - more or less mainly influenced by the idea of intensive technique training with high numbers of shot repetitions designed to allow players to ´survive` in this high speed game by means of the consistency of their movements (see Östh, G., & Fellke, J. (1992, 32, 50))**.** Of course, it works. But the idea of a higher amount of tactical training including different typical situations of rallies has been coming on strong within the last years. Additional effects like faster identification of situations, higher quality of decisions and better variation of performance are to be expected. But some questions necessarily arise, like

- What makes a situation a situation?
- How can situations be extracted?
- Are there any differences between ´objective and subjective` perceptions and assessments of situations?
- Which kind of match analysis method is more appropriate to answer these questions, a quantitative or a qualitative method?

The present study (dissertation 1999; Ludwig-Maximilians-Universität, München) will try to find answers to these questions.

2. THE STUDY

2.1. How to define a situation

Situations in ball games can be characterized as follows:

• The existence of a relatively frequent typical constellation of players, ball and table, in relation to space and time.

• The existence of different types of tasks and types of situations which can be classified.

• The beginning and the end of a situation being defined by the appearance of a new task.

• The orientation towards an aim of behaviour and its hierarchic structure including conscious and unconscious processes.

• The existence of different ways of solution.

• The different probabilities of the occurrence of different ways of task solutions.

• The interaction and partial interdependence of the actors.

• The permanent changes caused by the actions of the players.

Typical of table tennis and all racket games is the alternating task of hitting the ball. So every action of one player can be seen as a task for the other player that has to be solved by him. Nitsch (1986) points out that every action leads to a change of situation: hence a situation is created by two ball contacts (see Tessarek 1986).

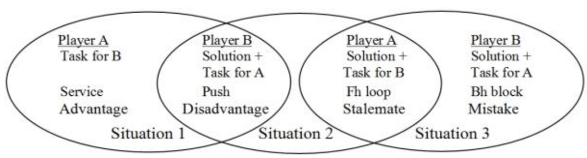

Figure 1. Situations in table tennis. Chain of overlapping pairs of different ´two-ball-contacts´ (Luthardt, Muster and Straub 2016, 49).

Following Leist (1988, 23) every perception of a situation is already guided by one`s own aim for the following action. And Nitsch (1986) assumes that the perception and assessment of a situation (definition of a situation) can be influenced either by 1. creating facts, 2. actions being regulated by hypotheses, 3. actions being oriented along certain criteria, 4. one`s personal strengths and weaknesses or environmental aspects. More research is needed to confirm these ideas. But they at least show one important fact: situations are not only manifested and created by the alternating task of hitting the ball (rules) but also by how players define, perceive and assess their actions and the actions of their opponents. Due to these psychological aspects – and the main idea that tasks create situations, one question arises: Can there also be types of situations which last longer than only two ball contacts? Leaving aside the spatial aspects of where balls are being placed or e.g. which techniques are being used – from a psychological point of view the answer must be ´yes`.

Every rally consists of actions / ball contacts that have certain effects on both players. The main aim of a player is to win a point. But there are some other steps in between winning or losing a point. One can be in a state of advantage, a state of disadvantage or in a stalemate state (with the opponent) as a result of one`s own action. So there are five basic conditions or values that can be defined: mistake (0), disadvantage (2), stalemate (5), advantage (7) and direct point (1). Since very often an advantage is followed by a disadvantage, which in turn is followed by an advantage or vice versa a disadvantage is followed by an advantage, which in turn is followed by a disadvantage, and a stalemate is followed by a stalemate and so on, we can call these three combinations ´stable situations´ of flexible length (`disadvantage – advantage-situations`, ´advantage-disadvantage-situations`, ´stalemate situations`). The first two situations mentioned can also be called ´preliminary situations`.

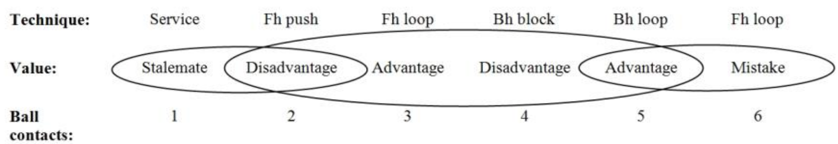

Figure 2. `Disadvantage – advantage situation` within a rally (Luthardt, Muster and Straub 2016, 50).

Deducing `normal situations` of two ball contacts from the five basic conditions or values (0, 2, 5, 7, 1) of a shot, we find 15 different value-situations, based on the three starting points:

Table 1. Value-situations in table tennis. E.g. **2 -5**: The opponent is at a disadvantage but the player cannot benefit from this and reaches a stalemate only

2 – ?	5 ?	7 ?
2 – 0	5 – 0	7 – 0
2 – 2	5 – 2	7 – 2
2 – 5	5 – 5	7 – 5
2 – 7	5 – 7	7 - 7
2 – 1	5 - 1	7 - 1

Summed up, there are four main groups of situations: situations of **1. decision** (point=?-1 or mistake=?-0), **2. change** (?-2,5,or 7), **3. preliminary decision** (2-7; 7-2) and **4. stalemate** (5-5). Main situations 3. and 4. with flexible duration.

2.2. Main aims of the present study

Four main aims were pursued by this qualitative, novel observation method:

(1) To extract typical game situations

(2) To find out which competences distinguish between good and very good international players (WTTC of 1985, 1987, 1989).

(3) To find psychological reasons for inappropriate situational assessments.

(4) To obtain new information about the inner structure of rallies including the origins of mistakes and points.

Additional aims were:

- To analyse the origin of points and mistakes.
- To calculate the probabilities of different outcomes /results of all three ´stable situations´.
- To assess the efficiency of different techniques, special techniques, placements and special placements.
- To find out the frequencies of different events e.g. techniques, placements.
- To assess the importance of different techniques, according to their frequencies and their calculated outcomes
- To find out for every ball contact combination (1⁄2; 2⁄3; 3⁄4; 4⁄5 and following) the most probable and most effective technique combinations and placement combinations.

2.3. The match observativ method

Even today qualitative interdependent match observation methods in table tennis are more or less exceptions (for review in systematic match analysis see Straub, Klein-Soetebier (2017). The present video-based method claims to cover all the important items that are necessary regarding the aims of the present study. They are analysed and noted for every ball contact. Items are: 1. Values (outcome. 0, 2, 5, 7 or 1) of a shot, assessed at a defined moment by trained observers (situational criteria e.g. height of the ball, players position to the ball, ball speed), 2. Techniques, 3. So-called ´effects` used (special techniques like side blocks), 4. Placements, 5. Special placements (deep forehand, deep backhand, placing the ball in the ´area of indecision` between forehand and backhand, playing against the direction of movement).

Four preliminary studies were conducted. Their aims were: No. 1 -3a: Development of the observation method; No.4: Extraction of hypotheses. In detail, the preliminary studies nos. 1 -3a pursued the following aims: 1. To check the category model of values devised; 2. To check the situational criteria developed to assess advantages and disadvantages (e.g. position of players with regard to the table, height of the ball, speed of the ball, position of the opponent relative to the ball); 3. To test the degree of agreement between the observers, regarding the assessment of values, effects and special placements; 4. To extract information about how to improve the extent of agreement between observers. Three groups of observers were trained and compared: a. A team of players of the Bavarian League; b. three National League players (including Lu Qui Wei – vice world champion with the Chinese team), in a sub-study Andrzey Grubba, winner of the bronze medal WC 1989 and c. the author.

Preliminary study no. 4 had the aim to gain hypotheses that later were to be checked against new data in the main study. The following matches with 2726 ball contacts in total were observed and assessed by the author:

WTTC 1985: Jiang Jialing – Chen Longcan (final); Jiang Jialing - Andrzey Grubba (team competition).

WTTC 1987: Waldner - Chen Longcan (quarter final); Waldner – Teng Yi (half final); Waldner - Jiang Jialing (final).

2.4. A calculation model for the efficiency of actions

Since qualitative studies aim for more than only extracting frequencies of different techniques, placements or points and mistakes, a calculation model was needed that is apt to assess the value or ´valency` of comparable actions (e.g. flicks and pushes or short placements of the return to the forehand or the middle zone) including the efficiency (´valency`) of the opponent`s preceding action. This method also allows you to find the origins of mistakes and direct points, which are usually hidden.

So how can the inclusion of preceding actions be realized in our situational model? Within the 15 possible basic situations we can distinguish between 7 grades of ´valencies`or efficiencies that can be reached. This idea is based on two theses:

(1) There are some expectable, stable or complementary connections between certain kinds of pairs of action ´valencies`: A stalemate is usually followed by a stalemate (5 – 5) or better, the chances of achieving a dominant status given by a preceding stalemate are about one in two for the receiving player. There are comparable connections between a preceding disadvantage and a following advantage (2 – 7) and vice versa a preceding advantage and a following disadvantage (7 – 2) in terms of a definitely better and a definitely less favourable chance.

(2) Steps / differences between mistakes, disadvantages, stalemates, advantages and direct points are by definition equal.

These two theses lead to the first step of the calculation model. Since the value (´valency` or efficiency) of reactions within the three situations mentioned 5 – 5, 2 – 7 and 7 – 2 are expectable, we will call them neutral. Neither a step in the direction of a positive development towards winning the point and nor a fall back into a negative direction is to be noticed. Based on this ´zero-step` idea, we can find seven possible gradations altogether - three in the positive direction, three in the negative direction and additionally the above mentioned zero-step. This is due to the fact that in basic situations only three different ´valencies` can precede the reaction: disadvantage (2 - ?), stalemate (5 - ?) and advantage (7 - ?). Their distances to the positive endpoint (direct point=1) and the negative endpoint (mistake=0) define the number of possible steps, as can be seen in table 2. Table 3 shows all 15 situations listed according to their steps` gradation. Point values from 1 to 7 are assigned to them. They built the basis of all following calculation steps.

Table 2. Seven possible gradations / steps of negative, neutral or positive values

Situations		Steps	Situations		Steps	Situations		Steps
	1	**+1**		**1**	**+2**		**1**	**+ 3**
2 -	**7**	**0**		**7**	**+1**		**7**	**+ 2**
	5	-1	**5 -**	**5**	**0**		**5**	**+ 1**
	2	-2		**2**	-1	**7 -**	**2**	**0**
	0	-3		**0**	-2		**0**	-1

Table 3. Categories of situations sorted by their step values

Steps	Included situations	Point values
+ 3 steps	**7 - 1**	**+ 7**
+ 2 steps	**5 -1; 7 - 7**	**+ 6**
+ 1 step	**2 - 1; 5 - 7; 7 - 5**	+ 5
0 step	**2 - 7; 5 - 5; 7 - 2**	+ 4
- 1 step	**2 -5; 5 - 2; 7 - 0**	+ 3
- 2 steps	**2 - 2; 5 - 0**	+ 2
- 3 steps	**2 - 0**	+ 1

To be able to compare two or more different situation solutions, we now need to adjust every solution to their given conditions. In a first step we calculate, on the basis of all the situations played (by all players), the so called ´expectation factors` of all three preceding ´valencies` 2 - ?; 5 - ? and 7 - ?. By counting the frequencies of each of the fifteen possible disadvantage situations, stalemates and advantage situations and multiplying them with their respective step values, we extract two numbers for each of the three conditions: the sum of situations and the sum of step values. Dividing the latter by the first, leads to the ´expectation factor`.

Table 4. Calculation of ´expectation factors` e.g. 2 - ?

	2 - ?	Frequencies	Point values or step values	Multipl. point values
	2 - 0	60	1	60
	2 - 2	2	2	4
	2 - 5	27	3	81
	2 - 7	201	4	804
	2 - 1	34	5	170
Total:		324		1119
			1119/324 =	
Expectation factor:			3.45	

The same calculation process may now be applied to the objects of study e.g. *special placements* and *normal placements*. The extracted data are the ´raw scores`.

Table 5. Calculation of raw scores, here of *special placements*

Step value or point value:	**4**	**4**	**4**	**5**	**5**	**5**	**3**	**3**	**3**	**6**	**6**	**2**	**2**	**7**	**1**	**Total:**	**Raw score**
Situations:	**5-5**	**7-2**	**2-7**	**5-7**	**7-5**	**2-1**	**2-5**	**5-2**	**7-0**	**5-1**	**7-7**	**5-0**	**2-2**	**7-1**	**2-0**		
Frequencies:	**14**	**9**	**33**	**38**	**7**	**17**	**2**	**5**	**1**	**7**	**6**	**2**	**0**	**4**	**7**	**152**	**4,44**
Multiplied point values:	**56**	**36**	**132**	**190**	**35**	**85**	**6**	**15**	**3**	**42**	**36**	**4**	**0**	**28**	**7**	**675**	

These ´raw scores` now have to be adjusted to those values that should be expected on the basis of the expectation factors (results of all players in the same proportional distribution – see above). The formulas for these calculation steps are the following:

Table 6. Calculation formula: expectation values or probability values by dividing:

$$\frac{(\text{Sum of all 2 - ? x 3.45}) + (\text{sum of all 5 - ? x 3.86}) + (\text{sum of all 7 - ? x 4.08}) = \text{intermediate expectation value}}{\text{Total number of all included situations (2-? + 5-? + 7-?)}}$$

Normal placements as example:

$$\frac{\text{Intermediate expectation value: } (265 \times 3.45) + (522 \times 3.86) + (356 \times 4.08) = 4384.14}{(265 + 522 + 356) = 1143}$$

Expectation value = 4384.14 / 1143 = **3.84**

Now both values (raw score and expectation value) have to be divided and in a last step be transformed to a percentage value that shows the different ´valencies` or efficiencies of the objects of study (solutions of situational tasks) that were to be compared.

$$\frac{\text{Raw score}}{\text{Expectation value}} = \text{provisional percentage value}$$

Examples:

Special placements

Raw score: / Expectation values: $\frac{4,4408}{3,7428} = 118.66\ \%$

Normal placements

Raw score: / Expectation values: $\frac{3,7425}{3,8356} = 97.58\ \%$

Adjusted to the 100 percent limit the final values now are:

Special placements:	18.66 %
Normal placements:	-2.42 %

2.5 Main study

To check the hypotheses which were extracted in preliminary study number 4, new data was needed. Eight randomly gained sets out of four matches of the WC 1989 with a total of 1586 ball contacts were analysed by a group of well trained observers. The matches were:

Team competition (final): Waldner – Jiang Jialiang; Waldner – Teng Yi; Persson – Chen Longcan.

Men`s single (final): Waldner – Persson.

Since this was a pilot study, a level of significance of 0.10 was chosen. In the very most cases this limit had clearly been exceeded with higher significance. Non-parametric tests like the chi square test, the sign test, the binomial test and the Wilcoxon rank-sum test (Mann-Whitney U-test) were used (latter for testing point values or valencies).

2.6 Main results

(1) Rare, and therefore unusual events (7 – 7; 2 – 2) lead significantly more often (yes: 10; no: 9) to a direct end of the rally (0, 1) compared to the sum of all other ´normal` situations (yes: 160; no: 494). (p = 0.05; ES: 0.66).

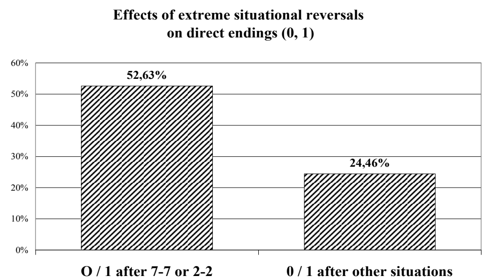

Figure 3. Endings of a rally (0, 1) directly after extreme situational reversals compared to ´normal situations`

(2) Identical given conditions are resolved with different efficiencies (valencies) according to the valency of the ball contact that precedes the given condition. The examples examined were: 2 - 5 - ? compared to 7 - 5 - ?. The first ´stalemate condition` shows a weak action of the opponent who did not take advantage of the weakness (2) of the player in the way that should be expected. The second example, in contrast, shows a strong performance (a stalemate, not a disadvantage that should be expected) of the opponent after the preceding advantage (7) of the player. Both end in a stalemate. Nevertheless the weak action of the opponent leads to a higher efficiency of the following ball contact of the player. Similar effects can be seen in ´advantage-disadvantage situations` and ´disadvantage-advantage situations`. Although all three hypotheses could not be significantly proved, their tendencies show a strong need for further research. It seems that ´Druck ist nicht gleich Druck (pressure does not equal pressure` (Straub, 2008). Or more specifically: weak actions - either by the player or his opponent – seem to have a greater impact than strong actions.

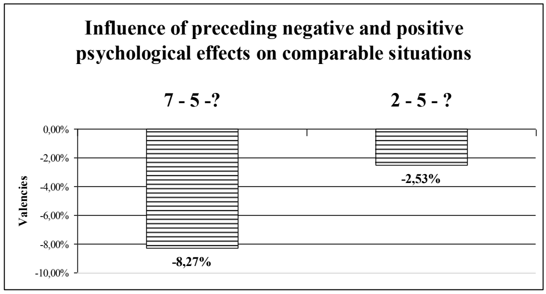

Figure 4. Influence of preceding negative and positive psychological effects on utilization of comparable situations

(3) ´Special placements` result in significantly better valencies (18.66%) than ´normal placements` (-2.42%). See data above, table 5; (p=0.01).

a) Services placed in the short forehand zone gained significantly worse conditions for the returning players compared to services placed in the short middle zone. Valencies for serving players are: 0.43% and -6.82%. The frequency of services in the short forehand zone is definitely lower than the number of services in the middle zone (p=0.10).

(4) The superiority of very good players compared to good players is first and foremost due to the fact that they reach significantly higher efficiency (valency) in dealing with a stalemate value (5 -?); p=0.01. This superiority cannot only be seen from the return but also from the subsequent ball contacts.

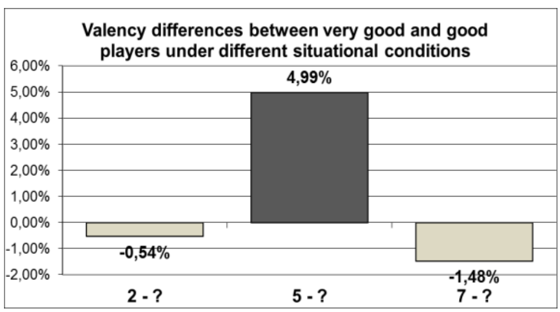

Figure 5. Comparison of situational utilization between very good and good players under different given conditions: disadvantages, stalemates and advantages

(5) The quality of the return is the best and most significant distinguishing feature between good and very good players (see also Sialino 1988, 128); p=0.01. The valency differencies between very good and good players are: ball contacts (bc) 1/2: +7.54%; bc 2/3: +1.57%; bc 3/4:-1.48%; bc 4/5: +7.32%; bc5/6: 0.82%.

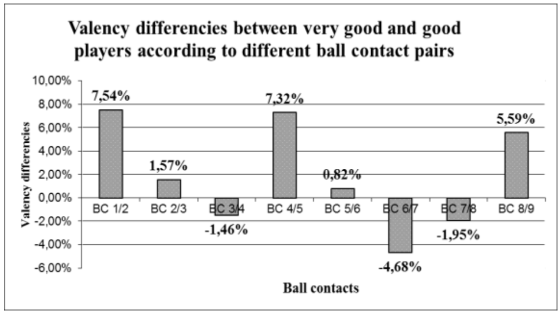

Figure 6. The quality of return as a distinguishing criteria between very good and good players

(6) There are significant tendencies as to which of the placement criteria (to forehand, to backhand; diagonal, parallel; ´opening` direction – change from diagonal to parallel placement or vice versa, ´not opening` direction – a diagonal shot is followed by a diagonal one (a parallel is followed by a parallel) and which ´direction combinations` are chosen according to the given valency of the opponent. In contrast to the other two respective conditions: Stalemate conditions (5 - ?) mainly lead to a ´not opening` placement from the backhand back to the backhand, whilst advantage conditions (7 - ?) surprisingly tend more to a placement to the forehand of the opponent who had the advantage. Disadvantage conditions (2 – ?) seem to lead a player more often to use an ´opening direction`. Dependent on the phase of the rally different placements and ´direction combinations` are to be expected.

Table 7 Tendencies towards certain placement criteria and ´direction combinations` according to the given valency condition of the opponent

Placement criteria	Direction or combinations
5 - ?	**5 - ?**
Not opening; p: 0.025; ES: 0.33	**From backhand (bh) to bh – back to bh; p: 0.025**
Direction backhand; p: 0.025; ES: 0.31	
7 - ?	**7 - ?**
Direction forehand; p: 0.025; ES: 0.29	**From bh to bh – parallel to fh; p. 0.005**
Parallel; strong trend	
2 - ?	**2 - ?**
Opening; strong trend	**From bh parallel to fh – diagonal to fh; p: 0.025**

a) There seems to be a trend towards growing frequencies of the three rare placement criteria (to forehand, parallel, ´opening` direction) from situations of ´stalemates` to ´change` to preliminary decisions´ to ´decision` (point or mistake).

(7) A strategy of patience seems to be the most successful way for the player being in the stronger position of dealing with an ´advantage – disadvantage – situation`. The longer these situations last, the better the solution valencies of these players (no significance but strong trend).

(8) At least half (54.48%) of all mistakes, direct points or the origins of both are located within the first three ball contacts of main study (no such hypothesis was made in preliminary study number 4).

(9) So called ´opening techniques`, in this case forehand and backhand loops against pushes, reach weaker valencies than the sum of all ´open ball techniques` (counter, blocks, shots, loops); p=0.10.

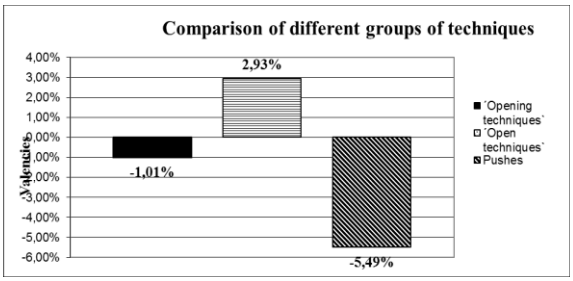

Figure 7. Comparison of ´opening techniques` (in this case forehand and backhand loops against pushes) and normal techniques.

(10) The significantly most frequent´3-step-technique combination` of the first three ball contacts is ´service – push – loop` (27.24%) followed by ´service – push – push` (10.98%); p=0.01; and ´service – loop` – block (10.57%).

(11) The number of ´decision situations leading to a mistake` is significantly greater (79.16%) than the number of ´decision situations leading to direct points`; p=0.01; ES: 1.92. Additionally: the number of direct points or mistakes that happen with preceding ´advantage situations` or ´disadvantage situations` (no matter if there is a connection) is significantly higher (67.14%) than those without.

(12) Two ´direction combinations` (from backhand (bh) to bh – back to bh; from bh to bh – back to forehand) total more than 50 percent of all eight combinations found in 5% of standard situations; p=0.01.

(13) With the exception of ball contacts 1/2 (service and return) and ball contacts 5/6 and 6/7 no other ´direction combination` apart from `backhand to backhand - back to the backhand` could be found on a level of a 10 percent frequency.

a) Service and return were mostly placed from the backhand side to the short middle zone followed by placements in the backhand zone and then by placements to the short forehand zone.

b) As second most frequent ´direction combination` in ball contacts 5/6 with a frequency of more than 10 percent, a parallel placement from backhand side to forehand side could be found, followed as second most frequent ´direction combination` in ball contacts 6/7 (more than 10 percent frequency) by a placement from the forehand side parallel to the backhand side.

c) None of all eight possible ´direction combinations` within ball contacts 3/4 could reach the 10 percent hurdle. Hence, ball contacts 3/4 can be called the ´phase of highest unexpectancy` in terms of placement.

2.7 Discussion

(1) Even international top players seem to be influenced by psychologically induced misinterpretations of game situations. One tendency could be the overestimation of weak actions.

(2) Very good players cannot be distinguished from good players by better performance in all areas of game. In this study they showed significantly better valencies in how to play **the return** and in the way they solved **´stalemate conditions**`.

(3) Different situational tasks (2, 5, 7) lead in many ways to different tendencies of placements.

(4) Table tennis can additionally be described e.g. by the following criteria:

- The majority of the sum of mistakes, direct points and origins are situated within the first three ball contacts (only main study).
- The importance of the return, especially the push as a return technique and loops with forehand and backhand as ´opening techniques`.
- The weaker valencies of ´opening techniques`, their frequent existence at ball contacts 2 and 3.
- The better valencies of surprising actions like e.g. special placements or certain ´effects` e.g. side rotation variations.
- The majority of points are won by means of preparing actions or after situations of change. Hence table tennis can be described as a game where players are mainly driven to mistakes and not as a game being characterized by actions that merely lead to direct points (see the importance of patience in ´preliminary situations`).
- The dominant role of direction combination number 1 (from backhand side to backhand side), with the exception of ball contacts 1/2 and 3/4.

There are several reasons to assume that the psychological connections mentioned above exist in other fast racket games, too. Research in this area should be conducted and communication with scientists of other games should be intensified. As can often be seen, frequent and clear misinterpretations of situational contexts are also a very big hindrance in the development from a beginner to a good or very good player. Hence methodological ways must be chosen or discovered that provide more correct assessments of match situations. As a side effect of faster and more precise processes of situation identification and assessment, a higher level of mental stability can be expected.

2.8 Conclusions for practical training with players of good to very good level

Training efforts can be carried out in several fields: A. Perception of opponent`s behaviour / anticipation training / situational acting; B. Acting under surprising conditions / stimulation of mental and motor flexibility and creativity; C. Training of / in four main and 15 special situations of valencies; D. Training of ´direction

combinations`; E. Combinations of exercise types C and D; F. Training of placement precision; G. Service-return training; H. Special difficulties.
Some Examples:

(1) As a combination of different aims (first to improve the special placements: "placing the ball in the ´area of indecision`; ´playing against the direction of movement` and secondly to learn how to act efficiently in ´preliminary situations`) one of the two players is given a disadvantage: Within his first three ball contacts he is only allowed to use the forehand side of his racket. This will force him to very intensive footwork leading also to situations of permanent ´open areas` on his side of the table, rapid movements and unfavourable positions in relation to the ball. Special placement options will be increasing for his opponent the same as ´preliminary situations`, with their inherent chances to improve abilities like patience and (for the other player) willpower to ´come back`. Similar effects could be gained by a restriction of the zone that one player is allowed to place balls in within e.g. the first three ball contacts from the whole side of the table to only the backhand side.

(2) Increasing the proportion of ´service-return-phase-exercises`. Here, apart from tactical variations and decision training steps by means of using alternatives, the coordinative and the perceptive aspects should be brought into focus. For example, by increasing the precision of placements and special placements, by inventing and testing several new individual techniques of returns and effects, by obstructions to perception like closing one`s eyes for a very short time, e.g. directly before the server hits the ball or before the ball hits the table for the first time. Other means are returning services with permanent changes of rackets of different kinds of sponge thickness or tuning the fastest rackets by adding glue.

(3) Using exercises which are able to create certain ´value situations`. For example ´change situations` by gaining an alternating right for irregular placements within one exercise e.g ball contacts 1/3 for player A; ball contacts 4/5 for B.

(4) Using exercises that train to assess ´value situations` and combine this process with decision making (in this case placement decisions). E.g. if the player on top of the drawing sees himself being in a disadvantage or stalemate he places (in this case) in forehand; if he sees himself in an advantage he places (in this case) in the backhand side (Figure 8).

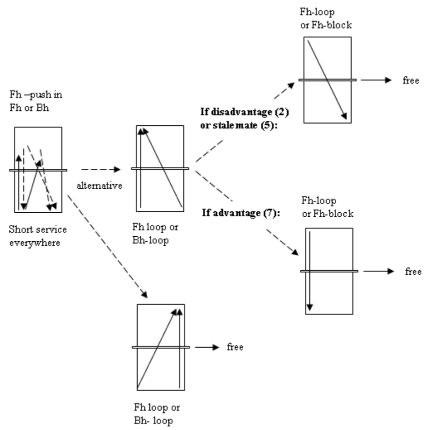

Figure 8. Decision training dependent on the assessed situational conditions

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Development of System of Table Tennis Game Analysis Using Ultrasonic Sensor

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Abstract: It is a common perception that reconsideration of games after making statistical analysis based on game records is important for future games. It has been desired in table tennis to get data of every bound of the ball on the table for statistical analysis. However, it is not easy to collect such data, because table tennis is a speedy sport. Several methods have been proposed in previous studies, but not yet in practical use.
In this work, we tried to develop a system and software of recording the bound points by using ultrasonic sensors. This system is called “Ultrasonic Sensor Globe Characteristics Analysis System". The principle of measurement is to make use of difference in arrival time of collision sound waves coming from different sensors set up at different places. The coordinate of the bound point can be calculated from those signals. The reason to use the ultrasonic sensor, not audible sound sensor, is that the collision sound has high frequency and the accuracy of the ultrasonic sensor is superior to that of the audible sound sensor. We developed the software which connects bound coordinates and displays a locus of rally by white lines

Keywords: pattern of course distribution, ultrasonic sensor, collision sound, coaching

1. INTRODUCTION

It is a common perception that reconsideration of games after making statistical analysis based on game records is important for future games. It has been desired in table tennis to get data of every bound of the ball on the table for statistical analysis. However, it is not easy to collect such data, because table tennis game pace is speedy. Several methods have been proposed in previous studies, but not yet in practical use. In this work, we tried to develop a system and software of recording the bound points by using ultrasonic sensors.

2. METHOD

2.1 Structure of system

A globe characteristic analysis system using a sound sensor is a system in which a sound sensor is arranged on a table and the coordinates of the falling position of the ball are calculated from the difference in time until the falling sound of the ball reaches the sound sensor, and displays it on the screen of the computer.

The structure of audible sound sensor is roughly divided into a microphone and a transistor. The structure of the ultrasonic sound sensor consists of three parts: a microphone, a transistor, and an FET.

For measurement of the time difference when calculating the coordinates, a multichannel counter consisting of three structures of a comparator, CPLD, and CPU is used.

2.2 Research method

Using two types of sound sensors, an audible sound sensor and an ultrasonic sound sensor, we perform precision experiments on a straight line and accuracy tests in situations close to the game site. Comparing the obtained results and a more accurate sound sensor is adopted. For the adopted sound sensor, we will conduct experiments to further improve the accuracy.

In the precision experiment on the straight line, we arrange the sound sensor and the ball falling position on a straight line, and drop the ball from the height of 16 cm. After calculating the error between the average value and the actual distance, we judged that smaller error sound sensor has higher accuracy.

Accuracy experiments in the situation close to the competition site pick up two purposes; ①only the signal without being influenced by the external sound even at the competition scene filled with external sounds (noise) such as cheering, footsteps, playing sounds from the surrounding table’ s ②How accurately six sound sensors can record the locus of the rally on table.

3. RESULTS

In the accuracy test on the straight line, the maximum error of the audible sound sensor was 47 cm at a distance of 90 cm. Also, at distances up to 90 cm, the error increases as the distance between the sound sensor and the falling position increases, and the error tends to decrease over 90 cm. The maximum error of the ultrasonic sound sensor was 6 cm at a distance of 60 cm. At each distance, although there was some variation of about 2, 3 cm, it was possible to calculate the distance more stably.

In the accuracy test in the situation close to the competition site, six sound sensors were set up on the table during the activity hours of the table tennis club of Niigata University, and the forehand rally and the back hand rally were measured.

Figure 1 is a scatter chart of the calculated coordinates using Excel.

① In an experiment on whether or not only the signal can be picked up without being influenced by the external sound even in the competition scene where the external sound (noise) such as cheering and footsteps, playing sounds in the surrounding table are overflowing, It was found that the ultrasonic sound sensor is less susceptible to external noise (noise) than the audible sound sensor. Frequency problem is considered as a cause. Ultrasonic sound sensors are not affected by relatively low frequency sounds such as footsteps and voices. Next, with the surrounding play sound, the audible sound sensor has omnidirectional (omnidirectional), whereas the ultrasonic sound sensor has a sharp directivity, and the ultrasonic sound sensor is thought to be less affected by noise. With the falling sound of the ball to the floor, the ultrasonic sound sensor is thought to be less affected because the ultrasonic sound sensor is disposed on the top surface of the table while the audible sound sensor is installed on the back of the table. Finally it is about hitting sound. The hitting sound has a relatively high frequency, and in many cases, sound is generated at a higher position than the position of the sound sensor. Therefore, the ultrasonic sound sensor sometimes detected the sound. And then as a countermeasure, we include a correction in the program of the multichannel counter for judging the first sound as the falling sound of the ball when a sound is detected twice consecutively in the same coat.

②In an experiment on how accurately the locus of the rally of the entire table can be recorded by operating the six sound sensors, trajectory of the rally obtained by using the audible sound sensor has variation when compared to ultrasonic sensor. In addition, most of the coordinates of the bound point obtained by the audible sound sensor was corrected, and we could not see the difference of the small drop point. While y coordinate of the track of the rally got from the ultrasonic sound sensor alternately comes and goes to the coat on the minus side and the coat on the plus side, at the track of rally of the audible sound sensor, there was a time when the bound sound was detected continuously on the same coat. If falling sound is detected on the minus side coat, originally, the sound to be detected next is the sound falling on the plus side coat. However, since the audible sound sensor sometimes was not be able to detect the falling sound, such a locus was recorded.

Based on these results, we decided to adopt an ultrasonic sound sensor which has little error between the calculated coordinates and the actual coordinates and is not easily influenced by noise.

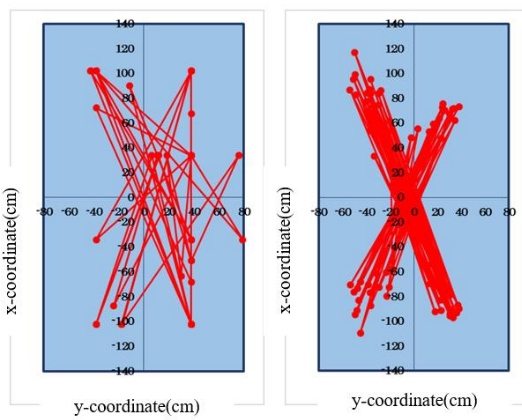

Figure 1. Audible sound sensor and ultrasonic sound sensor, we perform precision experiments on accuracy tests in situations close to the game site.

Next, experiments on the directivity of the ultrasonic sound sensor and precision experiment of the ultrasonic sound sensor were carried out. In experiments on directivity, the purpose was to investigate the extent of directivity of the ultrasonic sound sensor and to examine the number of sensor heads. Table was divided at an interval of 30cm×30cm, and a table tennis ball was dropped from a height of 15 cm 3 times to 44 falling points and the voltage of the sound generated at the time of falling was measured with an oscilloscope. The position of the sound sensor was placed in the center near the end line of the table in order to check the range of the directivity to the front direction of the sound sensor. Figure 2 shows the range of the directivity when the threshold voltage is set to 1.5v and 1.3v. Outside numerical values indicate coordinates, inside numerical values indicate average threshold voltages of falling sounds. The darker the color, the stably they were detected.

As a result, although the coordinates of the sound of the ball dropped in the central part of the table could be detected stably, the error of the coordinates of the sound of the ball dropped on the edge part of the table was large and unstable.

In the precision experiment, six ultrasonic sound sensors are placed on the table, and the accuracy test is performed on the entire table. Since there are variations in the sensitivity of the sound sensor, the experiment was advanced while adjusting the sensitivity (threshold value) one by one as seen from the result of the experiment. Also, as it is necessary to adjust the sensitivity (threshold) while confirming the influence of noise, measurements are carried out within the activity time of the Niigata University table tennis club, just as in the case of accuracy experiments in the situation close to the competition site did. Drop a ball from a height of 15 cm three times to 40 falling points at an interval of 30 cm × 30 cm. Using the simulator to calculate the coordinates of the falling point from the count value obtained by the multichannel counter. The actual coordinates were compared with the calculated coordinates, and it was investigated how many error was seen. As a result, the accuracy when the ball dropped to the center of the table was good, but there was a tendency that the accuracy of the edge part of the table was not good. These results showed many parts in common with the results of experiments on the directivity of the ultrasonic sound sensor. From this, it was suggested that the directivity problem of the ultrasonic sound sensor is the main factor. From these results, in order to ensure the stability of the sensitivity of the edge part of the table, the number of sensor heads was set to two for each sensor.

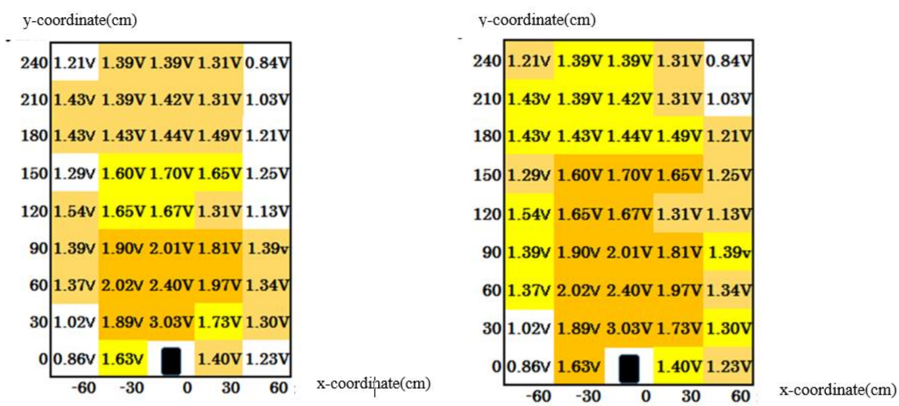

Figure 2. The range of the directivity when the threshold is set to 1.5 v and 1.3 v

The software that displays the calculated coordinates on the screen of the computer was created using C # which is a programming language on "Microsoft Visual Studio Community 2015" which is a development environment on Windows. Figure 3 is the fall position display software displayed on the screen of the personal computer. The falling position display software currently has the following functions.

· Function to communicate with multi-channel counter
· Function to display the trajectory of rally
· Function to display game count and score
· Function to register player information
· Function to display scoring rate
· Function to save rally trajectory, player information, scorer in file

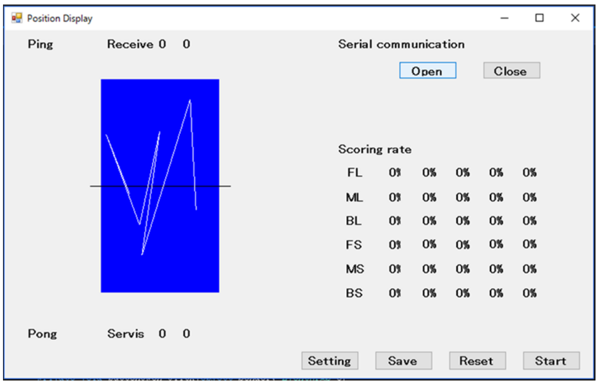

Figure 3. The falling position display software

Setting six ultrasonic sound sensors (two sensor heads) on the table tennis table, activating the falling position display system, asking two examinees to play one game. The game contents are taped with a video camera, and the error is verified by comparing the obtained data with the taped actual picture. As a result, it was impossible to obtain accurate data due to operational mistakes or deviations of the open and close buttons of the fall position display system. In addition, the locus of the rally was not displayed on the screen of the falling position display system.

4. CONCLUSION

In the system that calculates the coordinates of the falling position of the ball, we decided to use a sound sensor with high precision by conducting an accuracy experiment using two sound sensors, an audible sound sensor and an ultrasonic sound sensor.

In the system that calculates the coordinates of the falling position of the ball, the accuracy test is conducted using two sound sensors, the audible sound sensor and the ultrasonic sound sensor; the error between the calculated coordinates and the actual coordinates is small; the effect of noise it is decided to adopt an ultrasonic sound sensor which is also difficult to receive.

Next, we conducted a precision experiment on the adopted ultrasonic sound sensor. The directivity of the ultrasonic sound sensor was sharp, suggesting that it is necessary to install two sensor heads for each sensor. In the accuracy test on the entire table of the ultrasonic sound sensor, the error of the peripheral part of the table was large, so the problem of the ultrasonic sound sensor was considered as the factor of the error.

In the falling position display software, the function of communicating with the multichannel counter, the function of displaying the track of the rally, the display of the game count and the score, the score ratio and the player information, and the function of storing these information in the file are added and so on. As a result of the verification experiment using the system, it was thought that it approaches practical use by modifying the program.

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Understanding Hysteresis in Discrete Multi-Articular Action Performed by Skilled and Novice Table Tennis Players

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Abstract: From a dynamical systems perspective, self-organization is a key tenet in understanding human movement and may be examined via phenomena at the phase transition point. Amongst the phenomena is hysteresis. Hysteresis refers to the influence of previous experience on the next movement pattern. The aim of this study is to examine hysteresis through the investigation of movement patterns in a table tennis task. Skilled (n=10) and novices (n=10) were required to return balls delivered in a scaling manner by a feeding machine to nine locations back to a target. 3D kinematic data of the upper body was captured and digitised and results were obtained using the cluster analysis approach. A six point nominal scale was used to record performance. Cluster analysis resulted in two movement patterns for skilled and seven for novices. Hysteresis region for novices were notably larger, spanning over eight locations as compared to the skilled participants' two locations. This highlights the inability of novices in utilising the most suitable task solution at any particular location and further supports the trait of heightened exploration in novices. The numerous variations of movement patterns adopted by novices indicate their exploration for the most suitable task solution and infers the presence of meta-stability and degeneracy expected from a discrete multi-articular task. Results for hysteresis indicate that this phenomenon may be a function of skill levels therefore, it may be used as a tool to dichotomise skill levels. In that regard, coaches should adopt training sessions that encourages players to practice a variety of spatial locations that may improve their decision-making skills.

Keywords: hysteresis, dynamical systems theory

1. INTRODUCTION

Hysteresis refers to a primitive kind of memory where the history of system behaviour affects the current state (Kelso, 2014). It has been observed in many contexts like magnetism, weather, economics as well as human motor behavior. From the Dynamical Systems Theory (DST) perspective, hysteresis is amongst the key phenomena observed at a transition point observed as a result of self-organisation. As a system 'organises' from one attractor to another, a transition occurs. The occurrence of hysteresis corresponds to other DST features like "multi-functionality (different behavioural patterns for the same parameter values) and switching or 'decision making' (one behavioural pattern is selected over another at critical parameter values)

(Kelso, 2014, pp. 31).

Unfortunately, hysteresis has received little attention over the years, especially, with regards to discrete multiarticular tasks. This is largely due to the pertinent issue in DST-based studies where a majority of studies have investigated coordination of lab-based cyclical movement tasks than discrete multiarticular tasks (Button, Wheat, & Lamb, 2014; Rein, Davids, & Button, 2009) and as a result, it has been implied that there is a lack of theoretical understanding (Rein et al., 2009). This includes the understanding of the hysteresis phenomenon and of particular interest to this article, how different skill levels may correspond to the occurrence of this phenomenon.

Over the years, a number of studies have applied DST on discrete multiarticular actions and although hysteresis could be identified, few had reported this phenomenon as a function of skill (e.g. Lamb, Bartlett, & Robins, 2011) in a golf-chipping task and Southard (2002, 2006) in a throwing task). The relatively small sample size coupled with the use of a single skill level preclude generalizations of findings.

In human motor behaviour, the difference between skill levels is apparent. Novices tend to display non-specific movement patterns as they undergo a period of exploration and this may result in a myriad of movement patterns. Conversely, expert behaviour is often termed as having the capacity to both reproduce a specific movement pattern consistently and to increase the automaticity of movement (see Seifert, Button, & Davids, 2013). Additionally, experts typically characterize subtle, refined variations in movement patterning as their attractor stability is probed to strengthen its adaptability in different circumstances (Liu, Mayer-Kress, & Newell, 2006). In relation to the concept of perceptual-motor landscape, even at the skilled level, the process of exploration is still evident and skilled participants are expected to continually attempt to improve the functionality of behaviour (Davids, Button & Bennett, 2008). Therefore, it would be reasonable to expect skilled performers to make subtle changes to their movement pattern, without sacrificing performance. To clarify, these subtle changes (may be seen as variability in movement) are both functional and flexible to adapt to various task constraints. In table tennis, a skilled player may execute a similar stroke technique (e.g., forehand) but coupled with varied magnitudes of power and dexterity, may result in “spins” or “chops” that would consequently deceive an opponent and score a point. However, this may not necessarily be detected as different movement patterns. Concerning hysteresis, it may be inferred that since skilled participants may have a lesser number of movement patterns and as their movement patterns do not differ as much due to their “subtle exploration”, skilled participants may display a narrow hysteresis region with two different movement patterns occupying one ball delivery location. From our knowledge, there is a lack of empirical investigation on discrete multi-articular tasks to provide such insights at this point in time.

To summarise, the aim of this study was to investigate hysteresis in skilled and novice participants via their movement patterns in a discrete multi-articular task. It was hypothesised that skilled participants would display few movement patterns and this may result in a narrow hysteresis region demarcated by two movement patterns on one ball delivery location. Conversely, novices would display more movement patterns that may result in a larger hysteresis region.

2. METHODOLOGY

2.1 Participants

Twenty right-handed participants (age: 23±2.5 years) were assigned to a “skilled” or a “novice” group equally. The skilled participants have at least 10 years’ experience of playing competitive table tennis and trained for at least six hours per week. The novices had never played table tennis or another racket sport on a regular basis.

2.2 Task and apparatus

Participants were required to return table tennis balls projected from a table tennis robot (Newgy Robo-pong 2050) accurately to a demarcated target (0.51m x 0.46m). The balls were delivered in a scaled manner from right to left and left to right of the participant towards nine different locations (see Figure 1). The balls were delivered at 12 balls per minute with the ball velocity at 3.5m/s.

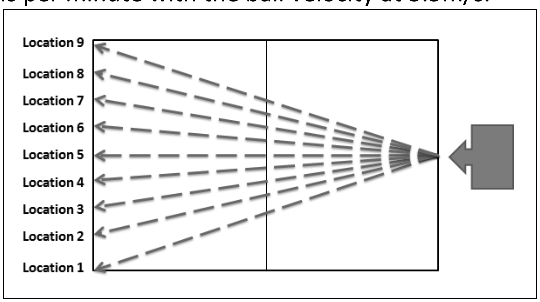

*Figure 1***.** Location of Ball Delivery

A kinematic model of the upper body was constructed using nine spherical reflective markers that were placed on key anatomical points (see Williams, Schmidt, Disselhorst-Klug & Rau, 2006). Three-dimensional Euler joint angles of flexion and extension were derived for the wrist, elbow, shoulder, clavicle and trunk from the respective segments as defined by the marker sets. Five 14mm diameter reflective markers were placed on the participant’s bat. Body and bat kinematic data were captured by ten MAC cameras and connected to the MAC system (CA, USA), and data was recorded at 100 Hz. The Visual3d software (C-motion) was used to construct a five-segment upper body model.

Performance of the task was assessed by how accurately the shots landed on the target. Outcome scores were determined from a 6-point rating scale (see Table 1).

Table 1. Performance Scores

Points	Description
0	Participant missed the ball completely.
1	Participant successfully hits the ball but the ball did not land in any of the scoring zone.
2	Participant successfully hits the ball; ball hits the net and did not land in any of the scoring zone.
3	Participant successfully hits the ball; ball hits the net but lands in any of the scoring zones except the target zone.
4	Participant successfully hits the ball; ball crosses the net successfully and lands in any of the scoring zone except the target zone.
5	Participant successfully hits the ball; ball hits the net and lands in the target zone.
6	Participant successfully hits the ball; ball crosses the net successfully and lands in the target zone.

3. RESULTS

The mean performance points for all participants are shown in *Figure 2*.

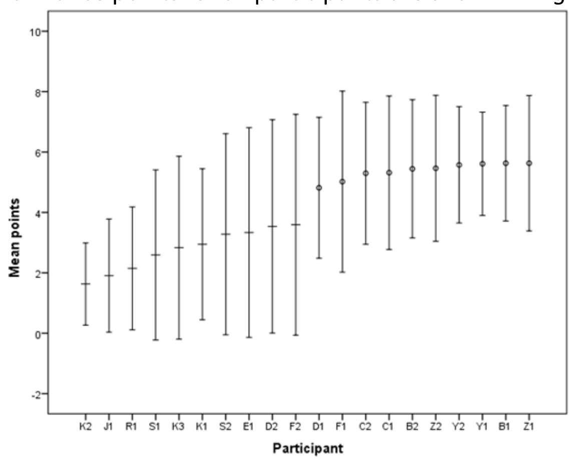

Figure 2. Mean +/-2 SE of performance scores each participant arranged in ascending order. Circles represent the skilled participants whereas dashes represent novices.

Cluster analysis was applied on all trials across both sets of participants as a whole. The results of the cluster validation using the silhouette coefficient (see *Figure 3*) indicated that the number of clusters across all participants was five.

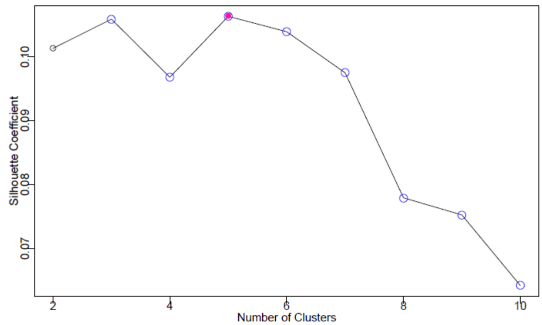

Figure 3. Cluster validation. Results of the silhouette coefficient. Pink circle indicates the most suitable number of clusters detected.

The distribution of clusters may be seen in Table 2.

Table 2. Frequency distribution for all trials in condition 1 for each cluster identified.

Cluster No.				
1	2	3	4	5
291	606	131	10	42

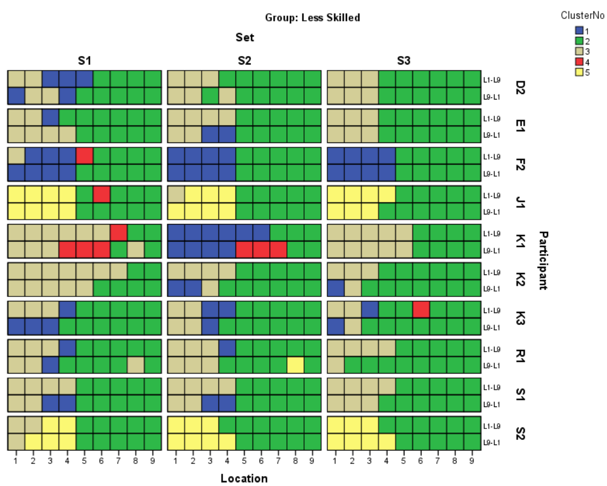

Figure 4. Cluster occurrence for every trial and participant (novice only).

It can be seen from *Figure 4* that all novices adopted either a 3 or 4 movement solution as compared to the skilled participants who displayed a dominant two- cluster solution (see *Figure 5*). Interestingly, at the third set, eight out of ten novices adopted a two-cluster solution. In addition, no participant adopted the same set of cluster solution (movement repertoire) from the first to the last set. Finally, six out of ten of the skilled participants repeated the same movement repertoire with three of the participants (C2, F1 and Y2) adopting the same movement repertoire throughout the three sets.

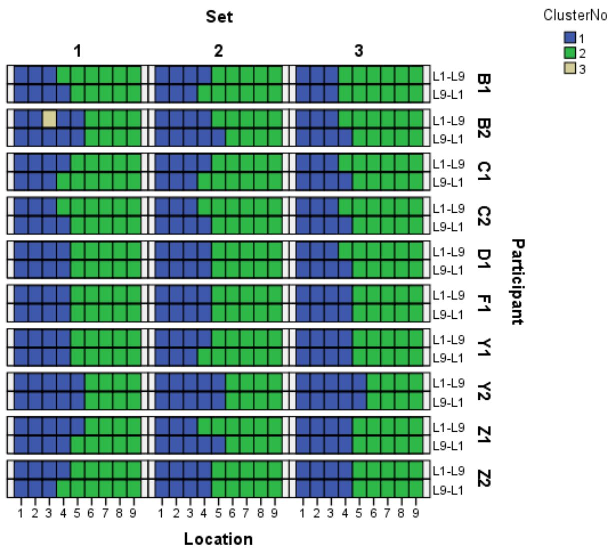

Figure 5. Cluster occurrence for every trial and participant (skilled only).

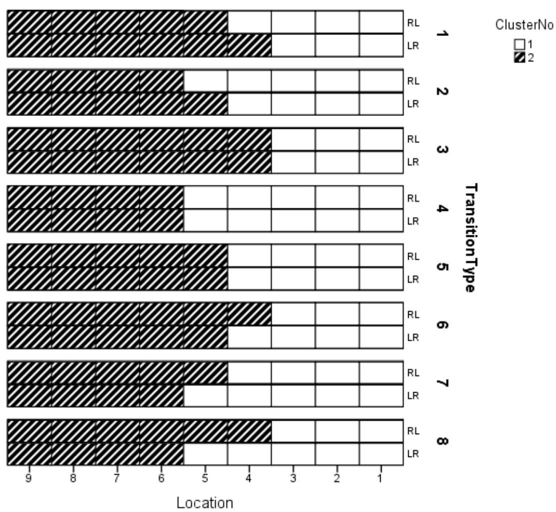

*Figure 6***.** Summary of cluster occurrence according to type of cluster transition for skilled participants. Types 1 and 2 are examples of *Hysteresis*. Types 3, 4 and 5 are examples of fixed transition points and types 6, 7 and 8 are examples of negative hysteresis. RL and LR represent the ball delivery direction; right to left and left to right respectively.

From *Figure 6*, it may be suggested that there are three broad types of scenarios where cluster switching occurs that may suggest *Hysteresis*. The first type observed were the ones with a fixed transition point (e.g. Transition types 3 and 4). For example, in type 3, when the ball was delivered from L1 to L9, cluster 1 was adopted till location

3 and when the direction was reversed, cluster 1 was re-adopted at location 3. This fixed location for pattern switching, results in the absence of *Hysteresis,* as there is no reference point at which the influence of direction would drive the cluster beyond the transition point. The second type is the occurrence of *Hysteresis* (see type 1). In this example, when the ball was delivered from L1 to L9, cluster 1 was adopted until location 4 and when the direction was reversed cluster 1 was re-adopted at location 3. This difference in transition point coupled with the influence of the direction to 'push' the cluster adoption beyond its transition point results in an occurrence of *Hysteresis*. The third type of occurrence is particularly interesting. With reference to type 6, it may be observed that cluster 1 was utilised for only three trials when the direction was reversed, cluster 2 was utilised for only five trials in the opposite direction. This suggests that the influence of direction on the cluster is "weak" as it is clear that in both directions the initial cluster was 'dropped early' before a new cluster was adopted. This phenomenon is termed as *Negative Hysteresis* and will be elaborated further in the discussion section.

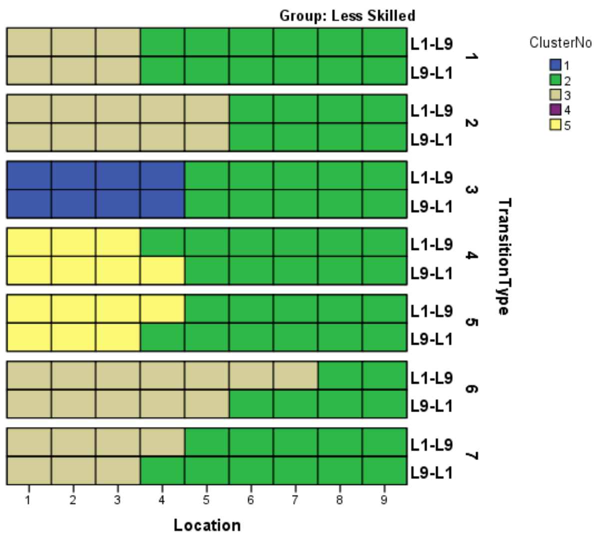

Figure 7. Summary of cluster occurrence according to type of cluster transition for novices. Types 1, 2 and 3 are examples of fixed transition point. Type 4 is an example of negative hysteresis and types 5, 6 and 7 are examples of *Hysteresis*.

From *Figure 7*, fixed transition point (type 1 and 2) which may be observed in set 2 and 3 for participant F2 and set 3 for participants D2, E1, and K1, interestingly, occurred four out of ten of the final (third) sets. Negative hysteresis (type 4) was observed twice throughout all sets and was observed in the same participant S2 at sets 2 and 3. *Hysteresis* (types 5, 6 and 7) was observed thrice in set 1 of participant K2 and set 3 of participants J1 and S1. In summary, it is notable to highlight that the occurrence of fixed transition point throughout this study for novices was 16.67%, *Hysteresis* was 6.67% and the negative hysteresis was 10% (with the remainder being multiple-states with no single transition point) as compared to skilled participants who displayed 50% fixed transition, *Hysteresis* at 20% and the negative hysteresis at 30%. Notably, unlike the skilled participants where there were three broad types of scenarios of cluster switching, it is difficult to ascertain for the novices. The main reason is due to multi- and meta- stable states within the system (see *Figure 8*).

From *Figure 8*, the multi-stable (where more than one attractor may be observed at one ball delivery location) and metastable (where an attractor emerges without influence from prior states) nature is apparent thus resulting in the difficulty in identifying Hysteresis. Interestingly, except for location 9, all other locations have at least three clusters occupying the same space (location). This result is particularly interesting when compared to the skilled participants' (see *Figure 9*).

From *Figure 9*, it can be observed that the locations where clusters 1 and 2 overlap are restricted to two locations (location 4 and 5). The *Hysteresis* region was determined by first identifying the dominant cluster for each position. From *Figure 9*, it can be seen that beginning from location 1, clusters 1, 3 and 5 may be seen at that location. As these clusters progress (from location 1 to 9), only cluster 3 persisted until location 8. From the other direction, only cluster 2 may be seen from location 9 and this cluster persisted until location 2. Taken together, the *Hysteresis* region spanned from location 2 to location 8. This wide Hysteresis displayed by the novices was in stark contrast to the skilled participants' Hysteresis region.

4. DISCUSSION

Adopting table tennis as a vehicle for discrete multiarticular task and operationalising spatial location as the control parameter, the presence of *Hysteresis*, was examined. As the ball delivery scaled from right to left and vice versa, past the transition point, a switch between movement patterns were observed. Through cluster analysis and validation via silhouette coefficient, five clusters were identified across all participants. Clusters 1, 3 and 5 are variations of the forehand stroke with cluster 1 being a forehand with a backswing whereas clusters 2 and 4 are variations of the backhand stroke. Skilled participants showed a strong two-cluster solution (cluster 1 and 2) whereas the novices displayed a combination of clusters. Interestingly, cluster 1 was adopted consistently by only one novice (F2) and cluster 2 was adopted consistently by all novices. Although cluster 2 was adopted by both skilled and novice participants as the preferred backhand stroke, they differed in terms of performance scores as well as the angular velocity of clavicle, elbow and wrist at ball-bat contact. This highlights the ability of skilled participants to manipulate the finer aspects of movement coordination (Davids et al., 2008, 2014).

A two-cluster solution was observed in the last set for eight out of ten novices. However, only one novice (participant F2) displayed a two-cluster solution that is comprised of clusters 1 and 2 (preferred clusters adopted by skilled participants); and this was observed in two out of three sets. Interestingly participant F2 was also the best novice in terms of mean performance points.

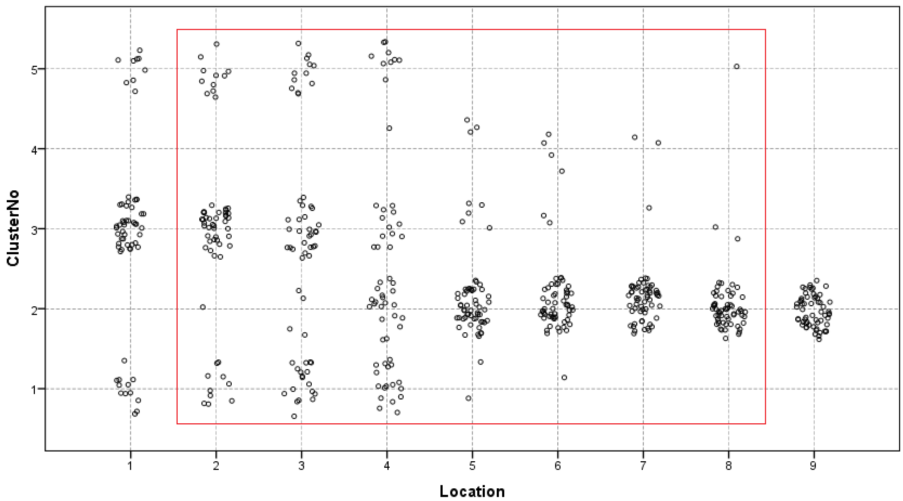

Figure 8. Cluster distribution (with jitter applied) of all novices. Red box demarcates the *Hysteresis* region.

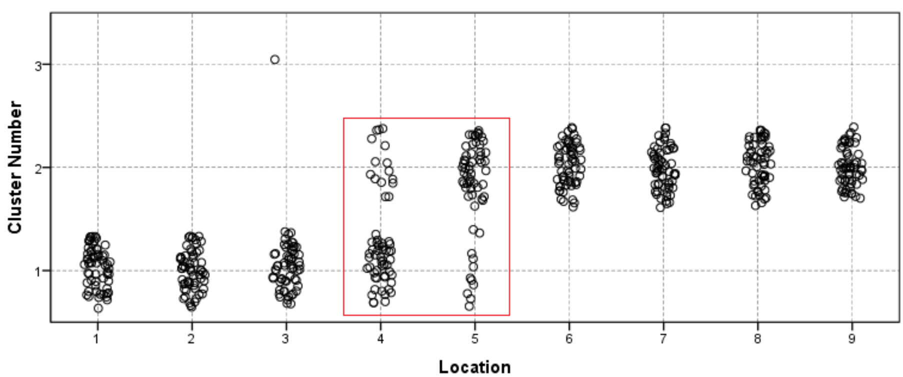

Figure 9. Cluster distribution (with jitter applied) of all skilled participants. Red box demarcates the *Hysteresis* region.

This suggests that a two-cluster solution may be a function of skill as this feature was observed in 29 out of 30 sets executed by the skilled participants. One reason may be due to the skilled participants' familiarity (through years of practice) in adopting the most suitable task solution (Davids et al., 2008, 2014). Indeed, a secondary qualitative finding revealed that the participant (F2), although never a competitive player, was exposed to the game more than twelve years ago during his primary school as part of an introductory programme. This may have influenced his performance during the test session. From a DST perspective, it can be further elaborated that the perceptual-motor landscape for participant F2 contained this prior experience and when the task constraint was presented to the participant, the competition between the task constraint and the intrinsic dynamics resulted in minimal variation and therefore better performance scores (than the other novices) (Davids et al., 2008).

As for the rest of the novices, most adopted either a 3 or 4 movement solution as compared to the skilled participants who displayed a dominant two-cluster solution. As reported earlier, at the third set, eight out of ten novices adopted a two-cluster solution. In this regard, it is also possible to infer that a two-cluster solution might be the ideal 'final' or 'stable' solution for this task. The myriad of movement patterns displayed by the novices also demonstrate the concept of degeneracy. Degeneracy essentially concerns the capacity to make use of structurally different components to achieve the same functional outcomes (Davids et al., 2006, 2008; Edelman & Gally, 2001; Hong & Newell, 2006). This property expresses the flexibility and adaptability to fit task constraints for performance goal-achievement (Davids et al., 2006, 2008; Edelman & Gally, 2001). Clearly, the five movement patterns are structurally different, yet they were able to achieve the same task goals especially at locations 4 where all the five clusters were adopted by the novices (see *Figure 8*).

For the skilled participants, the transition points were fixed between location 4 (slightly right of centre) and 5 (centre) regardless of the direction of ball delivery (i.e. Except for location 4 and 5, all other locations elicit one movement cluster). Additionally, all other locations displayed a dominant single cluster solution respectively – locations 1, 2 and 3 were forehand drives whereas locations 6, 7, 8 and 9 were backhand drives. In this phase of study, most of the novices (except for participant F2) displayed either a four or a five-movement cluster solution and in most sets, a three-cluster solution was often adopted. This results in multiple transition points when the ball is scaled in both directions (see Figure 10 for an example).

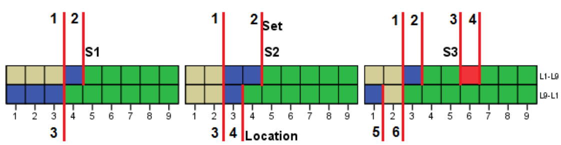

Figure 10. Cluster occurrence for participant K3 (a novice) across all sets. Red lines indicate the transition points whereas the numbers beside the lines indicate the number of transition points in each set.

Due to this high number of transition points, it was found that determining hysteresis was challenging. Fixed transition point for novices were 16.67%, hysteresis was 6.67% and negative hysteresis was 10% (with the remainder being multiple-states with no single transition point) as compared to skilled participants who displayed 50% fixed transition, *hysteresis* at 20% and negative *hysteresis* at 30%. Interestingly, it was found that the fixed transition points exhibited by the skilled participants resulted in better performance scores and participant F2 who is the best performing novice adopted a two-cluster solution with a fixed transition point for two out of three sets. Regarding the lack of phase transition behaviour generally observed in the novices, the results support previous studies where different strategies between participants were observed (Buchanan, Kelso & de Guzman, 1997; Limerick, Shemmell, Barry, Carson, & Abernethy, 2001; Sorensen et al. 2001).

It was found that the skilled participants displayed a *Hysteresis* region that spanned no more than one location; indicating a narrow region of instability, whereas, the novices displayed a wider *Hysteresis* region that spanned across seven locations. From a DST perspective, the *Hysteresis* region highlights the system instability where skilled participants are able to adopt the most suitable task solution at every other location whereas the novices who are unfamiliar to the task may be searching and exploring with the most suitable task solution – which explains for the myriad of movement pattern undertaken (Kostrubiec et al., 2012; Liu et al., 2006, 2010; Zanone & Kelso, 1992, 1997).

A key point when examining the cluster map for the novices was the amount of remnants or 'ghosts' attractor states (Kelso, 2012). In a metastable performance region as displayed by the novices, one or several movement patterns are weakly stable (when there are multiple attractors) or weakly unstable (when there is only attractor remnants) and switching between two or more movement patterns occurs according to interacting constraints. Ideally, a metastable system can simultaneously realize a number of different competing patterns and thus has the potential to exhibit novel and independent solutions (i.e. creativity) as well as stable, coordinated behaviour.

Essentially, understanding the Hysteresis region should encourage the practitioner to appreciate the adoption of a similar (DST based) task setup for their practice sessions. In this context, through the manipulation of ball delivery location (control parameter), a cluster map of the movement solution (attractors) adopted by the leaner may be further analysed. It may be implied that the Hysteresis region is a function of skill and may be used to segregate and identify different skill levels so that intervention that is more meaningful may be designed and presented.

Finally, another notable discovery when looking at the phase transition behaviour is that only three of all the participants adopted the same set of movement solution from set 1 to set 3 in condition 1. This implies that regardless of skill, both sets of participants continue to search for the most suitable task solution (Chow et al., 2008a, 2008b; Davids et., 2008; Kelso, 2012, 2014, Kostrubiec et al., 2012; Liu et al., 2006, 2010; Zanone & Kelso, 1992, 1997).

5. CONCLUSION

The results of this study highlight a number of notable differences between skill levels with respect to hysteresis. The results suggest that hysteresis is a characteristic inherent in skilled behaviour and may be used to dichotomise skill levels.

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A Network Analysis of Table Tennis Matches Played in Italy

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Abstract: This study proposes a network analysis of the complete set of table tennis matches played in a Country. A wide dataset concerning all results registered by the Italian Table Tennis Federation (FITET) is considered. In the resulting network, players are represented by nodes and matches by undirected arcs labelled by weights between nodes. We investigate the main features of the network, which shows scale-free and small-world properties, typical of a "complex network". The degree distribution indicates that few athletes played a relatively high number of matches, while most players with few matches are in the long-tail. In addition, most nodes are connected by very few edges: the degree of separation between two athletes is 3.37. Assortative mixing is positive, to indicate that players often play against similar opponents. A second analysis focuses on the correlation between ranking position and centrality measures. The favorable position of an athlete in the network is positively correlated with the position in final ranking. This underlines the importance of the adversaries and the kind of tournament an athlete is playing. Finally, we investigate the main topological features by applying community detection algorithms to visualize groups and structural patterns.

Keywords: match analysis, social network analysis, data mining

1. INTRODUCTION

Sport performance prediction of athletes usually refers to individual features such as preparation, posture, food, attitude, behavior and so on. While common sense well recognizes the importance of the type of opponents against which an athlete plays during the season, it is difficult to experimentally demonstrate the role that network measures play.

This article explores the topological features of a large network of matches. We focus on the complete dataset of the Italian Table Tennis Federation (FITET). Our research questions are: 1) What are the characteristics of that network (i.e., sparse or dense graph, how many communities, complexity)? 2) Does role and position of players in the graph matter? In other words: while the number of matches played in a season seems to be an important indicator in shaping performance, what about the centrality of an athlete: is it important to be close to many others, or is it better to have an intermediary position between different groups of players? To answer these questions, we explore a large dataset of ten years of table tennis matches played in a Country by using Social Network Analysis techniques, in order to find some suggestions between final ranking and network metrics. Our analysis initially provides some practical evidence about the usefulness of considering the network measures to improve players' performance.

In the following of the paper, section 2 introduces dataset and methodology, while section 3 describes the results of the analyses. Finally, section 4 draws some concluding remarks.

2. DATASET AND METHODOLOGY

2.1 Dataset

The complete dataset includes about 1 million matches played by 26k Italian table tennis players. These matches occurred in all official competitions, both tournaments and championships. In Italy, players are at least 8 years old, with four youth categories divided by age (up-to-10, 11-12, 13-14, and 15-17 years old). Athletes older than 18 are called "seniores". Players of both categories (youth and "seniores") can participate in championships, while some tournaments are reserved (i.e. for younger, Paralympic or elderly athletes). While tournaments separate genders, women can participate in the men's championships. At the beginning of a season, each player gets a score from the previous year final ranking, which increases or decreases depending on the number of matches in which the player won or lose. Finally, the ranking position is based on this score at the end of the season.

After a manual inspection of the complete dataset, we opted to remove "doubles games", in order to consider only games. By considering each individual game between two players, the number of matches between them increases the weight of the arcs. Moreover, we focused our attention on last 10 agonistic years, from 1996/97 to 2015/16. We finally obtained a dataset of 25,727 players and 811,958 matches.

We model last 10 years matches as a network whose nodes represent the players. An edge in the network connects two athletes if they met at least once. The edge's weight represents the overall number of matches between two players. Here we focus on the undirected graph of the largest connected network component, after the removal of small groups of isolated nodes, as we are interested in the social structure based on the presence of links.

2.2 Social Network Analysis

We consider a wide range of techniques and measures from Social Network Analysis (SNA). A first kind of interest concerns the overall network, i.e. *diameter, density*, *connectivity*. First of all, we investigate if the table tennis graph is a complex network taking in exam the scale-free distribution of the nodes degree, *small-world* property, and positive *assortative mixing* (see section 3.1).

Focusing on nodes, we test the strength of their connections, as well as their relevance in the network. While the main node measure is degree, which indicates the number of athletes encountered by a player, other measures describe the position in a network (i.e. *centrality* measures), as well as different features (*clustering coefficient, diversity*, *constraint).* Centrality seems promising to our goals, as the measure indicates which nodes have a more relevant role in connecting others. We mention here *betweenness centrality* to represent athletes which occupy a favorable position in connecting different groups of players, as well as *closeness centrality* which indicates the nodes closest to the others. In order to test the relevance of SNA measures in the exam of the players' performance, we compute the correlation index between such network metrics and the final ranking position of the player in the season (section 3.2).

2.3 Data Mining

Large datasets can be explored by using machine learning algorithms to find and extract useful information. A relevant task is finding hidden structures in the network, such as groups of nodes that are more densely interconnected among themselves rather than with others (communities). Among the existing techniques for the detection of communities in a network, we exploit the algorithm based on *modularity*. This measure corresponds to the number of edges falling within groups minus the expected number in an equivalent network with random edges. A positive value indicates the possible presence of community structure. This study adopts the *modularity* algorithm implemented in "Gephi" "an" open-source software for visualizing and analysing large networks (section 3.3).

3. RESULTS

3.1 Main features of the network

The complete, weighted and undirected network (henceforth referred to as TT-Net) includes 701,300 edges. The latter are obtained from 811,958 matches, as two athletes may have played against more than once, connecting together 25,727 nodes (i.e. table tennis players).

Table 1 describes the main features of the network. The diameter (Diam) is 33, with an average shortest path length (AvPL) of 4.37, corresponding to 3.37 intermediaries or "degrees of separation". This is less than the famous "six degrees of separation" theory of the sociologist Milgram. Interestingly, this value is similar in other large social networks, such as Facebook (4.74, computed on 800 million users) or the movie actor's collaboration network (3.65). The measure reveals that any two players of the Italian Table Tennis Federation are on average separated by just 3.37 matches (or intermediate connections).

Table 1. Network metrics of TT-Net.

	Dens	Diam	AvPL	AvCC
TT-Net	0.0022	33	4.37	0.35674

We further investigate the nature of TT-Net. In order to test the *small-world* property, we computed AvCC and AvPL on an equivalent network (TT-Ran) with random edges. Results state how AvCC measures are significantly higher in TT-Net (0.35674) than expected by random chance in TT-Ran (0.00176). Vice versa, AvPL is small both in TT-Net (4.37) and in TT-Ran (2.92). The clustering coefficient value (AvCC) indicates the existence in the whole network of well-connected groups of players, more than in the corresponding equivalent random graph.

In addition, the degree distribution on log-log scale (see Figure 1) shows points lying approximately along a line, as in power-law distribution. This means that very few players have a high number of connections, acting as "hub". On the contrary, the long tail indicates that most players have few connections.

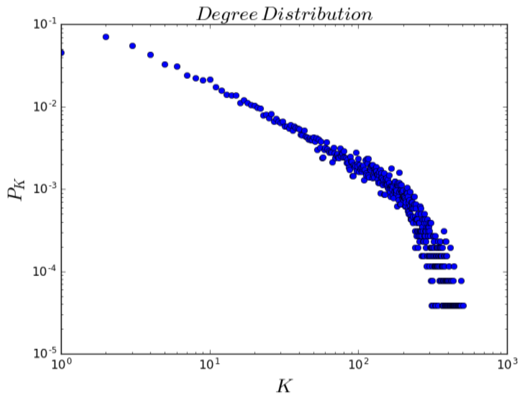

Figure 1. TT-Net degree distribution on log-log scale

Finally, the positive value of *degree assortativity* (0.374) well describes the preference for network nodes to connect with nodes having similar characteristics. In particular, this means that players prefer to play against similar players in term of experience (in fact, degree approximates the number of games played by an athlete in the considered seasons), revealing the *homophily* property for the whole network. These experiment results indicate that we are dealing with a complex network.

3.2 Correlation between centrality and ranking

After a manual inspection of centrality measures, we noticed they are not in agreement with a normality distribution. Thus, we computed Spearman correlation coefficient between SNA measures in TT-Net and the final position in the ranking of the season (2015/2016). Results seem conforming to our expectations. The relevance of SNA metrics with respect to positive outcomes is stated by a correlation index r=0.84, with a *p-value* < 0.01 (*closeness*), as well as r=-0.61, with a *p-value* < 0.01 (*betweenness)*. The negative correlation means higher the values of *betweenness*, lower the position in final ranking.

3.3 Community Detection

In order to automatically detect communities in our graph, we applied *modularity* (ModTT), a measure proposed by Mark Newman. Table 2 shows the percentage distribution of nodes in the resulting eight groups. After a manual inspection, we clearly identified geographical patterns in 7 clusters over 8, while the remaining group includes only female players. In fact, group 1 includes athletes from Italian central regions (most of all Lazio, Umbria, Abruzzo, Marche, Sardegna, Campania), group 2 from Toscana, group 3 from Piemonte and Liguria, group 4 from Veneto – TAA – FVG, group 6 from Lombardia, group 7 from Calabria and Sicilia, and finally group 8 from Emilia Romagna. Finally, group 5 includes only women, as they mostly play together in gender-specific tournaments and championships.

To give an idea of the accuracy of *modularity*, we state how the 96% of all women are assigned to the same group of players.

Table 2. Distribution (%) of nodes in ModTT groups.

	1	2	3	4	5	6	7	8
ModTT	26	7	17	11	7	16	7	9

Figure 2 provides a graphical representation of the large connected component of nodes having a degree greater than 150, including about 3k players and 205k edges. This network includes athletes which have played against 15 other players, on average in last ten years. The visualization exploits a force-directed graph drawing algorithm in which the color corresponds to a class of nodes *modularity*.

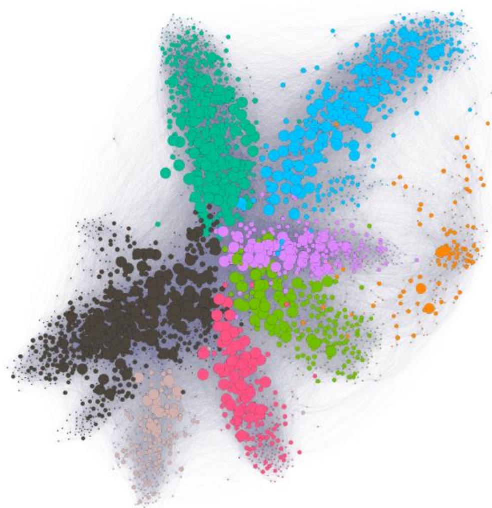

Figure 2. Network of athletes (nodes) and matches (edges). Colors indicate 8 communities by *modularity*.

4. CONCLUSIONS

This work explores a large network of athletes, where a player is connected to others if they have ever met in a game. We focused on the complete Italian Table Tennis Network of last ten seasons. Like some other networks in the real world, TT-Net exhibits a complex nature. The exam of the graph clearly detects communities, while a first correlation analysis suggests the role of centrality measures. Given this intuition, we plan to use a machine learning framework to approach three different problems: namely, talent identification, prediction of a player's performance-driven class, and prediction of the final ranking. Expected results are that combining profile, activity metrics and topological features will give consistently the best performance across tasks and seasons.

These observations have potentially an impact on defining innovative methodologies to model performance in sports, and to encourage national federations to develop specific projects with a multidisciplinary and integrative perspective. For instance, the relevance of network metrics like centrality may suggests to enhance opportunities for players to participate in higher-quality tournaments, i.e. encouraging table tennis federations to organize tournaments at the national level, as well as to facilitate and increment the participation of players. Similarly, societies might provide incentives to their most promising athletes to play in such venues.

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Studies of the Influence of Ball Size and Net Height on Table Tennis Trajectory Distributions

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Abstract: One possible measure to increase the medial appeal of table tennis is to slow down the game by using bigger balls or higher nets. In this work, the equations of motion for table tennis balls are solved numerically on GPUs (Graphics Processing Unit) by CUDA (Compute Unified Device Architecture). This allows analyzing five billion different initial conditions for systematical, statistical studies of the impact of ball size and weight as well as of net height on the distribution functions of successful strokes. Hitting locations, initial spins and velocities in terms of values and directions are varied by Monte Carlo sampling and the resulting distributions of successful trajectories were analyzed. The analysis confirms the empirical observation that the change of the ball in the year 2000 from a 38-mm to a 40-mm ball can be compensated with other parameters such that their resulting trajectory distribution functions are nearly identical. A larger ball of 44 mm with small weight is one option for suppressing high velocities, coupled also to a reduction of the influence of spinning. Alternatively, an increase of the net height is possible.

Keywords: rule changes, GPU computing, Monte Carlo methods

1. INTRODUCTION

The medial appeal of table tennis seems to go down in terms of TV hours, at least outside Asia. One of the reasons is the fact that the speed of the game is nowadays so high that it is very hard for spectators to follow the balls (Nelson, 1997; Djokic, 2007). Possible counteractions to slow down the game are to use bigger balls or higher nets. Usually, empirical studies are used to study the effect of such changes on the players and the game. An alternative approach, followed in this work, is the use of computer simulations. The equation of motion for table tennis balls is solved numerically to allow systematical, statistical studies of the impact of ball size and weight as well as of net height on the distribution functions of successful strokes. One intention of possible rule changes is to reduce the impact of spin on the game. Another goal is to reduce the speed of the balls to allow a better visual tracking during the rallies (Djokic, 2007). Some rule changes, like a larger ball, different counting system, stricter limits for rubbers or new service rules, were already implemented and new modifications are under discussion (Djokic, 2007). For the players all rule or technical changes have strong impacts on their techniques and strategies, requiring usually adaptations of their individual training programs. Therefore, players are rather hesitant to new rules.

The 40-mm ball played today is 2 mm larger and 0.2 grams heavier than the 38-mm ball used before. It has a larger air drag due to its larger cross sectional area reducing the maximum velocities (Bai, 2005). The mass distribution of the larger ball is shifted further away from the center compared with the 38 mm ball. This creates a larger inertial moment and reduces the spin. The larger 40-mm ball results in a velocity and spin reduction of about 5 to 10 percent (Li 2005; Iimoto, 2002). However, the larger ball had practically no impact on the characteristics of table tennis, because larger exertions of forces by the players compensated the effects of the size increase (Liu, 2005; Li, 2005). As a consequence of the modified technique, the fitness of the individual player got more important. In modern table tennis the forces for a stroke are created not only by the arms but the whole body is used to support this. A stronger athletics allows more pronounced use of the legs producing larger forces on the ball, which are needed to compensate the size increase. In addition, the wrist has to be used more effective to produce spin. For the larger ball only the use of the forearm is no longer sufficient for spin, as it was the case for the 38-mm ball. The needs for larger exertion of forces amplify possible technical mistakes, because the individual movement execution gets extended (Kondric, 2007).

One obvious strategy to reduce the maximum velocity in table tennis rallies is to increase the net height. However, such a change will have a severe impact on the characteristics of table tennis, because this will limit very directly fast spins, shots and service. Therefore, up to now this change of rule was avoided and ball size was the preferred correction action. Nevertheless, a scientific data base is still missing for a decision.

In this work the impact of larger balls or higher nets on table tennis trajectories is studied using computer simulations. A data base is created to quantify the influence of such changes. Modifications in technique, tactics, strength and fitness are not considered in this analysis. For a huge number of initial conditions the effect on successful strokes is studied. This delivers the maximum amount of possible strokes for different conditions in terms of statistical distributions which can be compared and analyzed. This represents already the best possible adaptation to the changes, independent of what this would mean for the players in terms of changes in their training. In particular the impact of the changes on the ball velocity distributions will be discussed as motivated before.

After a short discussion of the effects of larger balls and higher nets as measures to slow down table tennis, the forces acting on a moving ball are introduced. The computer code solving the equation of motion is described and statistical analysis of trajectory distribution functions for different balls and net heights is done. Using for this a GPU (Graphics Processing Unit) by CUDA (Compute Unified Device Architecture, CUDA 2013) coding gives a very large speed-up compared to CPUs. Results for different cases are compared and analyzed. Finally, the results are summarized and discussed.

2. SPECIFIC SCOPE OF THE STUDY

For a quantitative analysis of ball size and net height effects a computational approach is followed. The basic element of the simulation is the solution of the equation of motion for table tennis balls. The equation of motion needs a mathematical description of the acting forces. The flight trajectory of a table tennis ball is determined by the gravitational force of the earth and aero dynamical forces.

The gravitational force

$$\overrightarrow{F_G} = -m\vec{g} \qquad (1)$$

alone results in a parabolic trajectory. This force acts towards the center of the earth and depends on the mass m of the ball and the gravitational constant g (9.81 m/s²). The aero dynamical forces modify the simple parabola by air drag and lift. Air drag acts as friction force against the direction of the movement of the ball. It scales with the cross sectional area. The mathematical expression is

$$\overrightarrow{F_D} = -\frac{1}{2}C_D\rho A v\,\vec{v}, \quad (2)$$

with the density of air ρ, the cross sectional area A for a ball with radius r

$$A = \pi r^2, \qquad (3)$$

the ball velocity v and an air drag coefficient C_D. This coefficient can be measured, e.g. in wind tunnel experiments.

The second important aero dynamic force is the air lift. The so-called "Magnus effect", named after his discoverer Heinrich Gustav Magnus (1802-1870), is the reason that a rotating ball experiences a deviation from its flight path. The Magnus effect is a surface effect, because around the spinning ball a co-rotating air layer is formed at the surface of the ball. The flying and spinning ball induces a pressure imbalance, because on one side the ball is rotating with the air flow created by the movement of the ball in the air, the other side opposite to it. On the side where counter-rotation exists, the total velocity of the air flow is reduced, because both velocities compensate partly. On the co-rotation side a larger flow velocity is created, because both velocities add up. Higher velocity in a flow means lower pressure and the pressure differences on the two sides lead to the deviating Magnus force, mathematically expressed with an air lift coefficient C_L as

$$\overrightarrow{F_D} = \frac{1}{2}C_L\rho A v\overrightarrow{e_\omega} \times \vec{v}. \qquad (4)$$

The air lift force acts perpendicular to the axis of rotation $\overrightarrow{e_\omega}$ and to the velocity $\vec{v}$ (see Figure 1).

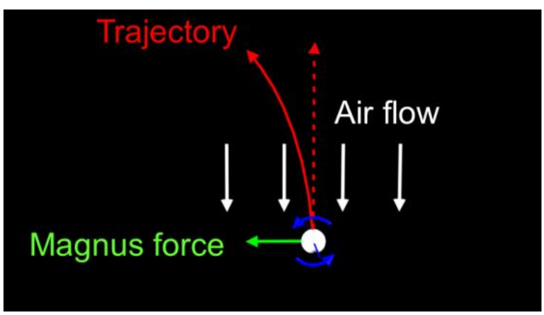

Figure 1. Movement of a rotating table tennis ball.

Air drag and lift coefficients of a rotating ball as a function of the ratio of spinning velocity to translational velocity are implemented into the computer code as a fit of experimental data (Achenbach, 1972; Bearman, 1976; Davies, 1949; Maccoll, 1928; Mehta, 1985). The computer code solves the equation of motion of table tennis balls for given initial positions, velocities and spins using CUDA on a GPU. Details can be found in (Schneider, 2013).

One example of a table tennis ball trajectory is shown as a red line in Figure 2. The table tennis table region is marked in green, the net is blue. The orange sphere is the initial point of the trajectory, where the ball is hit. The spinning of the ball is taken constant during the flight. x and y are the spatial coordinates within the plane of the table tennis table. z is the height coordinate over the table. A time step of 0.0001 seconds was used.

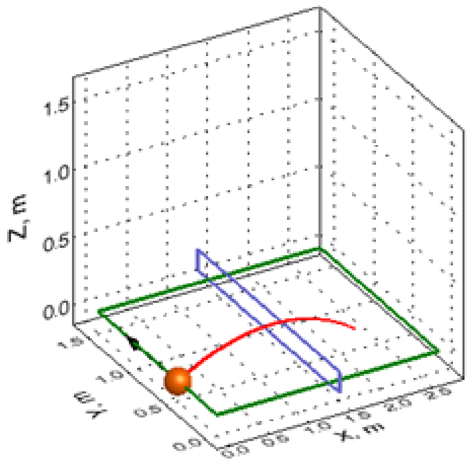

Figure 2. 3D trajectory of a table tennis ball

The ball in Figure 2 is hit at the baseline (x=0 m) in the forehand part of the table (y=0.6 m) on the height of the table (z=0 m). The black arrow shows the rotation axis of the ball, which is here purely pointing into positive y-direction: the ball was a pure topspin without any sidespin.

3. RESULTS

For a statistical analysis of the effects of ball sizes and net heights on trajectories of table tennis balls a Monte Carlo procedure was used. Many different initial conditions were solved: x was varied between 0.3 m to -3 m, representing hitting locations from 30 cm above the table to 3 m behind the table. y was kept constant at 0.381 m, which is ¼ of the width of the table tennis table. This was chosen as a representative position, the exact location of the hitting point in y (forehand or backhand position) is not important for this numerical test. Initial height z was sampled from 0.4 m to -0.4 m. The direction of the initial velocity was determined in the following way: the horizontal angle was sampled between the limiting angles of the starting point to the net posts, the elevation angle was chosen randomly. The spin axis was also sampled randomly, that means topspin, backspin and sidespin were included.

The analysis was particularly aiming at fast shots. Therefore, only balls passing the net within 30 cm height distance were accepted. The absolute values of the translational velocities were limited from 20 to 200 km/h, the spinning velocities from

0 to 150 turns/s (which is equal to 9000 turns/min). These values were determined empirically before as limits for 38 mm balls (Wu, 1993). A ball is counted as a successful ball if it passes the net within the height limit and hits the other side of the table tennis table.

Monte Carlo studies using random numbers were done for the 38-mm ball with a weight of 2.5 g, used in tournaments until end of 2000, the actual 40-mm ball with 2.7 g and a 44-mm ball with a weight of 2.3 g, which was tested already in Japan. For the 40-mm ball an increase of the net height for 1 and 3 cm was analyzed, too.

The sampling of such a large number of initial conditions guarantees to cover all possible combinations of initial parameters (positions, translational and spinning velocities) for the different cases creating a successful stroke. Clearly, for different balls and net heights the parameter space of initial conditions leading to successful strokes will be different. The database created in this study allows also an analysis of this effect.

For each case half a billion initial conditions were sampled and trajectories calculated. Initially this was done on a Linux Cluster with 32 cores. The run-time for each core was 20 hours resulting in a total run time of 640 hours. Alternatively, GPU computing with CUDA was used on a Dell Precision T7500 Desktop with NVIDIA Quadro FX3800. Here, only 3 hours for the same calculation are needed (Schneider, 2013).

Figure 3 shows as a function of initial kinetic energy the number of successful trajectories. There is a clear ranking of the different scenarios visible: the largest number of successful hits for the same initial kinetic energy is produced by the 44-mm ball, because it has lighter weight and higher air drag. The 40-mm ball is very similar to the 38-mm ball. Changes of the balls are compensated by other parameter changes. A higher net affects strongly the balls hits above the table limiting there the number of successful trajectories.

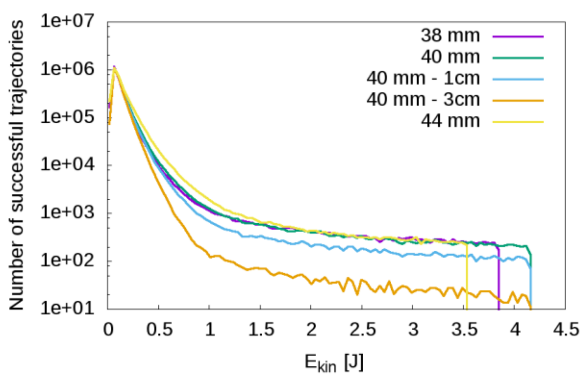

Figure 3. Number of successful trajectories as a function of initial kinetic energy for the different cases studied.

The differences in the rotational energy distributions (Figure 4) show larger rotational energies for the 44-mm ball, then the 38-mm and 40-mm balls, followed by the cases with higher nets.

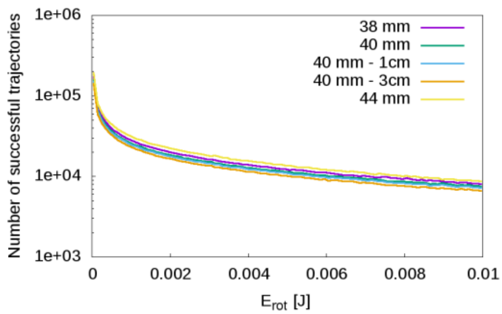

Figure 4. Number of successful trajectories as a function of rotational energy for the different cases studied.

This is better understandable if one looks at the 2D distributions of successful hits in dependence of topspin and sidespin (Figure 5). The 44-mm ball occupies in this 2D distribution plot a larger area with increased successful hits compared to the 40- and 38-mm balls. The cases with increased net height are also nearly unchanged to the 38-mm and 40-mm cases. That means, that one needs larger spins to influence the trajectories of the 44-mm ball, whereas 38- and 40-mm balls are very similar. Increasing the net height does not change much the influence of rotation.

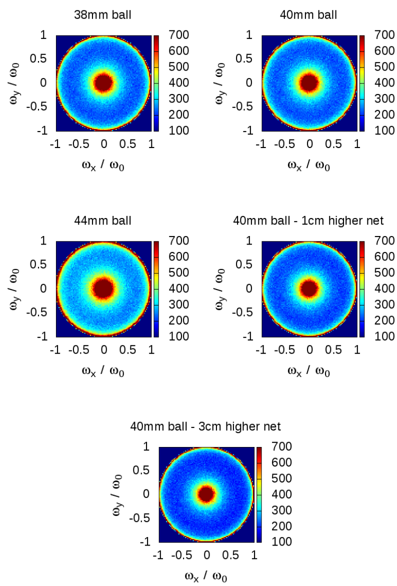

Figure 5. 2D contour plots of the number of successful trajectories as a function of spin in y- (topspin) and x-(sidespin) direction. The rotation vectors are normalized to the maximum of the spinning velocity (150 turns/s).

In Figure 6 the number of successful trajectories as a function of final velocities are shown.

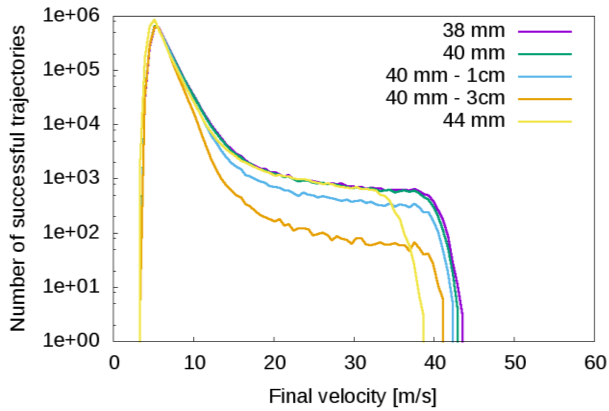

Figure 6. Number of successful trajectories as a function of final velocity of the balls

Again, the results for the 38 and 40 mm ball differ only marginally. For the 44-mm ball one gets more successful trajectories compared to the 38 and 40-mm ball for higher initial velocity (see Figure 7), the distributions for the final velocities are nevertheless very close again. Very high velocities above 35 m/s are suppressed earlier for the 44-mm ball. A stronger influence is visible for the 40-mm ball increasing the net height. Already for smaller initial and end velocities of about 10 m/s a reduction of successful trajectories shows up being equivalent to a slowing-down of the game. For very low velocities the impact of the air drag is not yet important resulting in larger number of successful trajectories.

Looking at the 2D distribution of successful trajectories as a function of the initial velocities and height of the ball at the net (see Figure 7) a clear tendency appears: from 38-mm balls to 40-mm and 44-mm balls more successful trajectories are possible for larger initial velocities. This is understandable, because the effect of drag forces increase with larger size. As soon as the net height is increased the initial velocities are reduced.

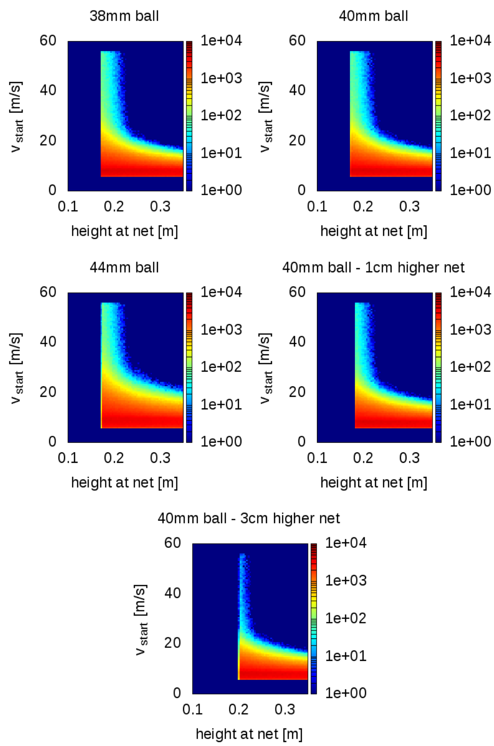

Figure 7. 2D contour plots of the number of successful trajectories as a function of start velocity and height of the ball above the net.

In addition, the code was also used to study differences of the balls for a typical top-spin shot. Initial conditions were chosen as starting point (0.8, -0.7, 0.1) m, velocities (0.1, 10.0, 2.0) m/s and spins (120, 10, 10) 1/s. The difference between a 38-mm and a 40-mm ball is rather small: the 38-mm ball flies only 3 mm shorter. In contrast, the difference between a 40-mm and a 44-mm ball is more pronounced (see Figure 8), because the 44-mm ball is lighter and experiences stronger friction forces due to its larger size.

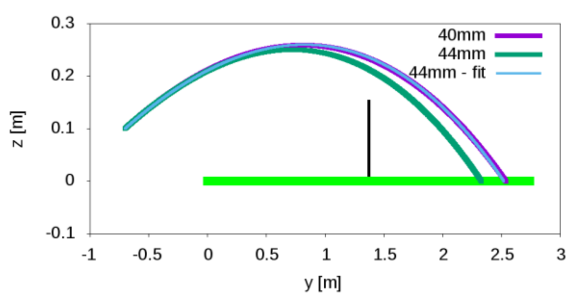

Figure 8. Trajectory of a 40-mm and a 44-mm ball for the same initial conditions. Using a fit algorithm the starting velocities and rotation velocities of the 44-mm ball are modified to get as close as possible to the 40-mm trajectory.

Trying to get to the same trajectory with the 44-mm ball requires – as expected – a larger initial velocity of (0.1, 10.7, 2.1) m/s. The rotation velocities are unchanged. Therefore, in terms of necessary force for the player to execute the same shot, the smallest force is needed for the 38-mm ball, followed by the 40-mm ball (because it is heavier). Due to the large change in initial velocities, despite of its smaller mass, the 44-mm ball requires even more force.

4. INTERPRETATIONS

Statistical analysis of the influence of ball size and net height on the number of successful table tennis trajectories using computer modelling is used to quantify the effects on trajectory distribution functions. The analysis confirm the empirical observation that the change of the ball in the year 2000 from a 38-mm to a 40-mm ball can be compensated such that their resulting trajectory distribution functions are nearly identical. This was achieved in reality by adaptations of the technique and the material. A larger ball of 44 mm with small weight is one option for suppressing high velocities, resulting also in a reduction of the influence of spinning. As an alternative option an increase of the net height is possible, where a reduction of the higher velocities is obtained without changing the influence of spinning on the trajectory.

One should note that modifications of basic rules in table tennis like ball size and net height can reduce the maximum velocities, but such modifications will always be linked with severe changes in the characteristics of table tennis: dynamics, technique and strategy will change strongly, too.

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Analysis of Anthropometric Characteristics in Young Table Tennis Players

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Abstract: The purpose of this study is to analysis of anthropometric characteristics in young table. 41 players took part in this study (12 female and 29 male) all of whom underwent control and evaluation for a period of four years (between the ages of 9 and 12). Anthropometric evaluation was conducted following the International Society for The Advancement of Kinanthropometry protocol. Data collected for body variables were: weight, height, BMI, skinfolds (biceps, triceps, subscapular, supraspinale, iliac crest, mid-thigh and calf), perimeters (contracted/relaxed arm and leg), and diameters (humerus, styloid and bicondyle of femur). Body composition was calculated using percentage of body fat, bone and mass percentage, following De Rose and Guimaraes' tetra compartmental model. Carter's method was used to obtain somatotype. Consent form was signed by all participants prior to fore-mentioned processes being carried out.

Analysis of variance for repeated measures of a single factor showed statistically significant differences for BMI (p=0.029) and for total value of six skin-folds (p=0.015), increasing in both cases with age. No statistically significant differences were found in reference to muscle and fat mass percentages.

Total value of six skin-folds and BMI are extremely interesting variables to keep in mind when managing the evolution of an athlete's biotype due to the direct accumulative effect of specific training sessions after several years.

Evaluating body composition in young players may be of interest when it comes to managing their progression, maturation and both physical and sports performance.

Keywords: anthropometric characteristics, young, body composition, training

1. INTRODUCTION

Anthropometry and somatotype values have previously been used as sports talent detection criteria (Bustamante, Maia and Nevill, 2015; De Hoyo, Sañudo and Carrasco, 2008). Several studies show that a specific training regime carried out on a long term basis produces morphological changes and adaptations as a direct consequence of such practice (Aragonés and Casajús, 1991).

Recent research work carried out with top-ranked players (Yáñez-Sepulveda, Barrz, Soto, Báez and Tuesta, 2015; Pradas, González-Jurado, Molina and Castellar, 2013) and lower age groups (Pradas, Carrasco, Martínez and Herrero, 2007; Nikolić, Furjan-Mandić and Kondrič, 2014; Sattler et al., 2015) have allowed us to re-allocate table tennis player's biotype.

The purpose of this study is to analysis the measured anthropometric characteristics in young table tennis players.

2. METHODS AND MATERIALS

A total of 41 players took part in this study (12 female and 29 male) all of whom underwent control and evaluation for a period of four years (between the ages of 9 and 12). All included athletes trained at least eight hours per week and regularly competed and national level at the time the study was concluded.

The material used to evaluate the different anthropometric variables was a SECA 714 (SECA, Hamburg, Germany) scale with a precision of 100 g and a range of 0.1-130 kg, with a built-in measuring rod with a precision of 1 mm and a range of 60-200 cm, a plicometer (Holtain Ltd, Dyfed, UK), with a constant pressure of 10 g / mm2, with a precision of 0.2 mm and a range of 0-48 mm, a pachymeter with a precision of 1 mm and a range of 0-14 cm (Holtain Ltd, Dyfed, UK), measure tape of inextensible material with precision of 1 mm and range of 0-150 cm, and demographic pencil.

Analysed variables were: body mass (kg), height (cm), 8 skin folds (biceps, triceps, subscapular, suprailiac, supraespinal, abdominal, front thigh and medial leg), 4 perimeters (relaxed arm, contracted arm with flexed elbow, mid-thigh and leg) y 3 diameters (biepicondylar humerus, bistyloid wrist and bicondylar femur). Each measure was taken following the International Society for the Advancement of Anthropometry's protocols (ISAK) and after obtaining signed consents. For under aged players, consents were also signed by parents/tutors. All measurements were taken by an ISAK-approved and certified expert. While carrying out the study, indications included in Helsinki's declaration (2013) were always taken into consideration. The study was approved by the Government of Aragon's Ethical Committee in Spain.

Body Mass Index (BMI) was calculated using Quetelet's formula. Calculations for body composition were those proposed by De Rose and Guimaraes (1980), based on the tetracompartimental model. Body fat (Faulkner, 1868), bone (Rocha, 1975), muscular (Mantiegka, 1921) and residual (Wurch, 1974) components were calculated. The Heath-Carter method (1990) was used to analyse somatotype and obtain value for each of three components: endomorphic, mesomorphic and ectomorphic.

Statistical analysis:

For the statistical analysis, IBM's SPSS 21 software was used. Descriptive statistics Mean and Standard Deviation were calculated. A Confidence Interval of the mean values was obtained at 95% to estimate measurement reliability. As for inferential statistics, a Multivariate General Lineal Model was applied to analyze differences between groups (sex and category). Differences in comparisons by pairs (pairwise comparisons) were analyzed using Bonferroni correction. Value for p was calculated for general comparison. When significant differences $p<0,05$ were found among the various categories of any variable, every individual was compared against all others and also by pairs, adjusting with the Bonferroni method with which very precise differences may be established.IN the pairwise comparison, groups with statistically significant differences appear with the same superscript letter by the corresponding variable. Likewise, in order to determine the magnitude of the differences between groups, the effect size was measured through partial Eta squared.

3. RESULTS

Table 1 shows comparison results by categories. Analysis of variance for repeated measures of a single factor showed statistically significant differences for BMI (p=0.029) and for total value of six skin-folds (p=0.015), increasing in both cases with age. No statistically significant differences were found in reference to muscle and fat mass percentages.

Table 1. Comparison of anthropometric variables for different age groups

TOTAL (N= 41)	9 YEARS (N= 19)		10 YEARS (N= 38)		11 YEARS (N= 33)		12 YEARS (N= 23)		p	Eta parcial^2
	Mean±SD	$CI_{95\%}$	Mean±SD	$CI_{95\%}$	Mean±SD	$CI_{95\%}$	Mean±SD	$CI_{95\%}$		
BMI	17.3±4.6	13.1-19.9	17.6±3.6	13.5-20.5	18.3±4.1	13.8-21	18.8±4.3	14.4-21.7	0.029	0.656
TRICEPS	12.1±5	8.9-14.5	13±5.1	9.3-15.9	13.2±5.1	9.6-16.9	13.1±5	9-15	0.459	0.264
6 Skin Folds	83.2±42.7	52.9-100.7	80.4±35.4	55.5-102	85.1±37.8	59.2-114.5	98.1±44.1	79.6-132.7	0.015	0.710
%Fat	13.2±4.7	9.6-15.3	13.3±4.4	9.3-15	13.9±5.1	10.2-16.8	13.9±4.9	9.8-16.7	0.112	0.508
%Muscle	41.2±9.7	31-47.8	41±9.2	25.9-47.5	41.7±8.1	31.8-48.1	40.4±11.6	33.5-47.6	0.552	0.220

p< 0.05 indicate significate difference

In female players, no statistically significant differences were found for any of the variables (Table 2). Height, body mass and BMI all increase with age. The six skinfold value is higher than 73 mm, and muscle % muscular higher than 46. The mesomorph component is predominant in females with respect to somatotype.

Table 2. Comparison of anthropometric variables for different age groups in female players

Female (n= 12)	9 YEARS		10 YEARS		11 YEARS		12 YEARS		p value	Eta parcial^2
	Mean±SD	$CI_{95\%}$	Mean±SD	$CI_{95\%}$	Mean±SD	$CI_{95\%}$	Mean±SD	$CI_{95\%}$		
HIEGHT	139±3	100.3-177.8	142.8±3.6	98.4-189.2	148.8±3	144.9-152.6	154.8±0.3	150.9-158.6	0.1	0.976
BODY MASS	33.9±4.4	22-107.9	38.1±5.5	31.7-107.9	41.8±1.8	18.9-64.6	46.7±3.2	5.4-88	0.163	0.936
BMI	17.5±1.5	1.7-36.6	18.5±1.7	3.6-40.7	18.9±0.7	9.5-28.2	19.5±1.3	3.2-35.8	0.133	0.957
TRICEPS	14.2±1.1	0.2-28.2	13.3±0.3	10.1-16.4	13.4±0.9	1.9-24.8	15.4±1.1	2.1-28.8	0.610	0.331
BICEPS	6.2±0.1	4.9-7.5	7±0	7.0-7.0	6.8±0.7	2-15.9	6.3±0.2	4.3-8.1	0.079	0.985
6 Skin Folds	80±15.6	118.2 -278.2	73±8.5	35-181	83.7±3.7	36.1-181	84.3±3.4	41-127.5	0.820	0.078
%Fat	14.4±0.6	6.2-22.7	12.1	12.1-12.1	15.1±2.7	19.7-50	13.2±0.2	10.7-15.7	0.172	0.929
%Muscle	46±2.4	15.5-76.5	48.3±0.5	46.3-50.2	45.6±2.1	18.9-72.3	48.1±1.6	27.8-68.4	0.500	0.220
Endomorphy	3,4±0.2	1.4-5.2	3.0±0.1	1.7-4.3	3.4±0.3	0.4-5.3	3.4±0.1	2.1-4,7	0.395	0.662
Mesomorphy	4.4±0.1	3.1-5.6	4.0±0.1	2.7-5.2	4.5±0.4	1.1-10.2	4.1±0.0	4.1-4.1	0.742	0.100
Ectomorphy	2.9±0.6	2.3-11.2	2.6±0.7	6.2-11.4	2.8±0.4	2.2-7.8	2.9±0.7	2.2-11.7	0.09	0.980

p< 0.05 indicate significate difference

Table 3 shows comparison results by categories in males with significant differences in height, body mass, six skinfold and in endomorph. All with a value for p<0.5, as seen from the table. Height increases with age, showing significant differences between 9-year olds and 11-year olds, 9-year olds and 12-year olds and between 10-year olds and 12-year olds. Weight also increases with age with significant differences between 9-year olds and all others. Skinfold values at biceps and triceps increase with age from 9 to 11 years.6 skinfold sum increases with age, while significant differences were found exclusively between 9-year olds and 11-year olds. Fat % increases with age though differences were not significant. As for somatotype, there are significant differences only in endomorphy between 9-year olds and 11-year olds with p=0.021. The mesomorph component is predominant in all groups.

Table 3. Comparison of anthropometric variables for different age groups in male players

Male (n= 29)	9 YEARS		10 YEARS		11 YEARS		12 YEARS		p value	Eta parcial²
	Mean±SD	$CI_{95\%}$	Mean±SD	$CI_{95\%}$	Mean±SD	$CI_{95\%}$	Mean±SD	$CI_{95\%}$		
HIEGHT	142.9±3[ab]	135.6-150.3	147.5±2.9[c]	140.2-154.8	152.6±1.4[a]	149.1-156.1	159.4±4.2[bc]	149.1-169.7	0.042	0.846
BODY MASS	36.8±3.2[abc]	28.8-44.8	40.5±3.1[a]	33-47.9	44.2±3[b]	36.7-51.6	50.4±3.2[c]	42.5-58.3	0.023	0.887
BMI	17.9±1.2	15.1-20.8	18.5±0.9	16.3-20.7	18.9±1.1	16-21.8	19.8±0.7	18-21.5	0.140	0.712
TRICEPS	11.9±1.6	7.9-15.9	13.4±2	8.4-18.5	14.4±2.3	8.9-20	11.9±1.7	7.7-16	0.398	0.488
BICEPS	6.3±1.6	2.2-10.4	7.1±1.1	4.3-10	7.2±1.5	3.2-11.1	6.8±0.7	4.9-8.6	0.418	0.141
6 Skin Folds	79.4±16.2[a]	39.8-118.9	86.2±15.1	49.3-122.9	94.8±18.3[a]	49.9-139.5	122±14.7	86.1-157.9	0.048	0.836
%Fat	12.9±1.5	9.1-16.7	13.1±1.6	9.2-17.1	14.2±1.9	9.6-18.7	14.4±2.1	9.4-19.4	0.109	0.748
%Muscle	42.3±0.8	40.2-44.4	43.1±1.2	40.2-45.9	43±1.4	39.5-46.5	42.7±0.7	40.8-44.5	0.609	0.100
Endomorphy	3,4±0.7[a]	1.6-5.2	3.8±0.7	2.1-5.6	4±0.8[a]	2.1-5.9	3.9±0.5	2.7-5.1	0.071	0.799
Mesomorphy	5.1±0.4	4-6.2	4.5±0.5	3.2-6.2	4.5±1.4	3.7-6	4.9±0.2	4.3-5.4	0.389	0.452
Ectomorphy	3.1±0.6	1.5-4.7	3.0±0.5	1.7-4.7	3±0.5	1.7-4.3	3.1±0.4	2-4.2	0.771	0.224

4. DISCUSSION

In the age ranges studied here, this sport does not represent an intense enough stimulus to cause analysed variables to be significantly affected. Nevertheless, there are modifications in BMI for the whole population of our study, as well as in the six skinfold sum value, showing clear anaerobic attributes from the very beginnings. Table tennis, from a physiological point of view, is an intermittent sport with alternating bouts of aerobic and anaerobic effort where 40-50% of the time is aerobic, 10-20% lactic anaerobic and the rest alactic anaerobic (Faccini et al., 1989).

Height increases with age for both sexes although this characteristic is not a deciding component in this sport. Long joint levers together with a good intramuscular coordination and a low body mass all play in favour of an efficient development of maximum explosive strength and thus the possibility of performing very fast footwork actions at very high speeds which favour athletic performance, as shown by Pradas et al., 2003.

For both sexes, six skinfold sum value increases with age, whereas endomorph only increases with age in males with mesomorph actually decreasing with no changes in fat or muscle % (despite a slight increase of the former). If we compare fat % from our study for males: from 12.9±1.5 to 14.4±2.1 and for females from 12.1 to 14.4±0.6 with other studies such as Pradas 2013, male 12±2.7 adult male and 14.7±1.5 adult females, or with Allen's 1991, male 12±1.07 and female 18.55±0.7 %, our study provides higher values due to children in our study having a higher fat% and not so lean bodies.

In our study, males showed a clearly predominant mesomorph somatotype, datum which agrees with Pradas et al. (2007) and Martínez et al., 2009). In Astrand's study, (1992) muscle and fat components balanced out over ectomorph.

As can be seen from the comparison for females, we find no significant differences whereas for males there are differences, maybe due to differences in the nature of their games. Males' is a faster and more explosive game when compared to the females' slower and longer-rallied game (Picabea, Cámara and Yanci, 2017).

Muscle % in our study is higher than 42%. A good muscle % in agreement with other studies which show that athletes from this sport usually show a favourable muscular development, especially evident in lower limbs (Matytsu, 1994).

Data included in this study indicate a low physical and physiological impact, as athletes have been training for a short time and their game still needs to be defined; full biological maturity has yet to be reached in order to define their game further. However, these variables are not relevant for the assessment of future performance with other variables such as technique and game materials and equipment becoming more predominant.

5. CONCLUSION

Total value of six skin-folds and BMI are interesting variables to keep in mind when managing the evolution of an athlete's biotype due to the direct accumulative effect of specific training sessions after several years.

Evaluating body composition in young players may be of interest when it comes to managing their progression, maturation and both physical and sports performance.

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Developing of a Flipped Classroom Learning Satisfaction Scale on University Table Tennis Program

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Abstract: Flipped classroom is an innovative teaching method that helps teachers to move away from direct instruction as their primary teaching tool toward a more student-centered style. The purpose of this study was to develop a satisfaction scale for teaching and learning in university table tennis teaching program based on flipped classroom method. 144 National Chung-Hsing University students (90 males and 54 females, mean age 18.76 ± .731) have participated in the pre-test. The questionnaire was summarized and drafted using the concept of "flipped classroom" as the main axis and complemented with relevant PE teaching methodological literature. 20 questions were screened out and selected for the preliminary questions after the item analysis. Then five dimensions were extracted by factor analysis and became the formal scales. The name of each scale and its Cronbach's Alpha were as follow: Film Preview (α=.816), Program Design (α=.817), Self-correcting (α=.771), Assignment (α=.755) and Cooperative Learning (α=.500). This study showed that the scale of learning satisfaction, when applied to a flipped classroom, had a good reliability and validity. It is an important reference for table tennis teachers in the teaching design of the "flipped classroom."

Keywords: table tennis, program design, innovation teaching, Likert scale

1. INTRODUCTION

1.1 Research background

An ancient Chinese proverb says that "a learned person does not need to step outside his/her gates to know the happenings under the sun." This proverb not only is taken to mean that ancient scholars were knowledgeable, talented, and outstanding but at the same, it also highlights the quite conceited side of learned scholars with respect to their social standing. Nevertheless, times have changed and this is no longer the case. In today's Internet era, everyone is capable of becoming a learned person, because as long as you know how to get to the Google website, the knowledge you want is at your fingertips. This demonstrates that the arrival of the Internet and digital age has brought many innovations and much convenience for human societies. As educators standing at the front lines, more than ever we must also keep up with the trend of the times. How to make good use of the power of high technologies to generate innovations and benefits for our teaching is also the most important research topic in the current physical education teaching reforms. In recent years, when it comes to innovative teaching methods, one of the highlights is the rise of Flipped Teaching. In Taiwan, the most famous advocate of flipped teaching is none other than Professor Ping-Cheng Yeh, professor of Electrical Engineering at the National Taiwan University. Professor Yeh has been organizing the Flipped Teaching Workshop since the end of 2013, attracting the participation of more than 700 teachers the first time the workshop was held. In just one year, he gave more than two hundred talks, which inspired countless local and foreign teachers interested in innovation (Yeh, 2014). The authors also had the fortune to become involved in transforming boom through the Internet platform, and began to apply the flipped teaching method in a university table tennis program for the first time in 2014.

Flipped classroom originated in 2007 with Bergmann and Sams, two high school chemistry teachers from the Woodland Park High School in the state of Colorado, United States (Bergmann & Sams, 2012). Flipped teaching refers to self-regulated learning concept proposed by Bergmann and Sams. The lecture in lessons was recorded to film. The students will watch the film before the lesson. The interactive teaching such as practice, problem solving, or discussion will be implemented in the limited time of the lessons. At the beginning, the idea was simply to let absent students to be able to make-up class by watching videos at home, but then it had evolved into an instructional strategy of "pre-study before class, discussion and exchange in class." This type of cooperative learning model among students not only improves the passive instructional method of traditional group teaching, but also enhances students' interest in learning, thus promoting the internalization of knowledge (Baker, 2000; Bergmann & Sams, 2012; Lage, Platt & Treglia, 2000). Nevertheless, the concept of "flipped classroom" has become widely known and used thanks to an invited TED talk by Salman Khan in 2011, who mentioned that "teachers can use Khan Academy's resources to assist in flipping the classroom" (Khan, 2011). Khan's TED presentation also explained the core issues and advantages of the flipped classroom. It was believed that many enthusiasts who care for educational circles, might heard the speech of the Khan Academy founder, Salman Khan in TED Talks. He explained the important concept of "Films can change education". As mentioned earlier, the authors have always adhered to the ideal that physical education teaching needs to be innovative. Thus during our first "flipped the classroom" experiment in 2014, we not only discovered that university students learning table tennis forehand drive loop by "flipped teaching method" had better learning achievement than those taught by "traditional teaching method", but we were also able to identify three summary findings that support the advantageous application of this method in physical education teaching. The three findings were as follows: 1. Learning through film videos can continuously strengthen one's cognition and subsequently affect one's skill level; 2. Time used by teachers for explanation and demonstration has shortened, while students' practice times have lengthened; 3. Students are better able to understand their own learning situation, and learn by cooperating with other students in accordance with their own style and progress (Hsu & Chen, 2017). This result not only confirms that flipped teaching is a new trend in current educational reform, at the same time it also improves upon the traditional physical education pedagogy, which places too much emphasis on “exercise skill” and “teacher-centered” mode of teaching. Traditional methods hinder innovations in teaching, limit the enhancement of interests in activities, and thereby influence students’ learning outcomes and their willingness to enrol in the class (Hung & Chen, 2011). Thus, flipped classroom is very suited for physical education teaching.

Although the first phase of our flipped classroom experiment in 2014 was quite successful, then we were only conducting exploratory research on 59 students enrolled in an advanced-level table tennis program. Whether it is the number of students or the classification of participating groups (only advanced-level), the authors felt that data were not enough to make inferences to all table tennis programs for the entire university, or even push for its universal implementation in other universities. As we all know, the most important thing in physical education curricular design at schools is to be able to meet current teaching trends as well as student interests and needs. Therefore, how to let students learn something and improve their level of satisfaction with physical education teaching are the primary tasks of physical education teachers. And to understand students’ satisfaction with physical education teaching, we must rely on the use of objective tools and methods, strengthening the credibility and accuracy of obtained results so that they can be used as basis for teaching and instruction (Hung & Chen, 2011). This idea triggered the authors into developing a learning satisfaction scale that uses “flipped classroom” as the main concept. The teaching method is a continuation of flipped teaching mode used in 2014 (that is, pre-study teaching videos and fill out feedback forms before class; achieve course learning through discussion, cooperation, and games during class; and work on practice exams online or upload self-made videos). We also increased the number of experiment participants from 59 to 150, and expanded the group of students to include beginner-level students as well as advanced-level students. The authors hope that through the learning responses from more participants and from students of different skill levels, these can be used to improve the teaching of table tennis in the future. This is the main motivation behind the present study.

1.2. Purpose

According to the research motivation described above, the main purpose of this study was to develop a student satisfaction scale with a university table tennis program. Through this scale, the study seeks to understand student feelings of various factors toward the use of "flipped classroom" teaching method, using them as reference for improving the teaching of table tennis.

2. METHODS

2.1 Collection of Data

The development of the pre-test scale was based primarily on the concept of “flipped teaching” proposed by Sams & Bergmann (2013). It combined the concept of autonomous learning commonly used in Mosston’s theory of teaching spectrum (Hsu & Chen, 2017), and integrated the feedback provided by students to an open questionnaire in 2014 during which the authors used the flipped classroom teaching method for the first time. The pre-test questionnaire had a total of 24 questions, and used a Likert five-point scale, ranging from 1 for "strongly disagree", to 5 for "strongly agree".

2.2 Test Subjects

The test subjects were 150 National Chung-Hsing University students (3 class sections) enrolled in a table tennis program during the second semester of 2015. A total of 144 valid questionnaires were collected (90 males and 54 females with a mean age of 18.76 ± .731 years), for a response rate of 96%.

2.3 Test Method

The use of flipped classroom method in a table tennis program is still in the exploratory stage. Thus, we only programmed 9 weeks out of an 18-week semester for flipped teaching so as not to cause a backlash from enrolled students who could not adjust to the new instruction method. After 9 weeks of implementing flipped teaching, the authors posted the pre-test questionnaire online in the Satisfaction Survey section of the "National Chung-Hsing University Table Tennis Teaching System" website (http://tt.sim.nchu.edu.tw/index.php) that they themselves had developed, in which the students may fill the online questionnaire on their own after entering their account names and passwords. The questionnaire response period was 2 weeks, beginning on November 23, 2015 and ending on December 6, 2015.

2.4 Analytical Tool

The scale was developed using IBM SPSS Statistics 20.0 as data analysis tool, and went through item analysis, factor analysis, reliability testing, and other procedures before becoming a formal scale.

3. RESULTS AND DISCUSSIONS

3.1 Item Analysis

Item analysis primarily treats each questionnaire item of the scale as a test object, and analyzes the extent of its usability item by item. Item analysis of the pre-test scale uses comparison of extreme groups-critical ratio (abbreviated as CR value) test, and homogeneity of variance test. The CR value criterion is such that if the group's t value from the t-test for difference between means did not reach .05 significant level, the item must be deleted. A second criterion is that if t value achieves a .05 significant level, but its value is less than 3.00, the item is also best deleted. There are two types of homogeneity tests. The first is to calculate the product-moment correlation between each item of the scale and the total scale score—the higher the correlation coefficient ($r \geqq .400$), the better the individual item reflects level of satisfaction with learning. The second is to determine the scale's internal consistency, or it's α coefficient. The type of test consists in judging the quality of an item through changes in the scale's α coefficient after the item had been deleted. If the scale's α reliability coefficient increases a lot after the item had been deleted, then the item should be considered for deletion. Table 1 listed all the 24 pre-test scale items. Table 2 presented the results of the item analysis. From the results of the extreme group comparisons, the CR value for each of the 24 items is between 1.199 and 11.807, and among the 24 items, only that of item 20 did not reach significant level ($p > .05$). Additionally, the CR value for item 2 ($t=2.689$), item 9 ($t=2.676$), and item 20 ($t=1.199$) were less than the critical value of 3.00. From the homogeneity test, it was found that the correlation coefficient between the 24 items and the total scale did not reach the critical value of .400 or above for item 2 ($r=.322$), item 9 ($r=.304$), item 12 ($r=.353$), and item 20 ($r=.102$). The corrected item-total correlation coefficient did not reach the critical value of .400 and above for item 2 ($r=.238$), item 5 ($r=.353$), item 7 ($r=.376$), item 9 ($r=.222$), item 12 ($r=.267$), and item 20 ($r=.012$). For items, 2, 9, 12, and 20, the scale's α reliability coefficient after deleting each of these individual items was greater than the α reliability coefficient of the total scale ($\alpha=.886$). According to the four item analysis above, items 2, 9, and 20 did not reach critical values 4 times, and for item 12, on 3 occasions. Hence, these 4 items will be deleted from the formal questionnaire. As for item 5 and item 7, only one indicator did not reach criterion, thus both items will be retained. Normally, poor item discrimination is caused by "items being too polarized" or "the meaning of items not very clear." Due to this study's limited experiment time, these four items will be temporarily deleted. In the next revision of the scale, we may consider them again for pre-test after re-interpreting their item contents.

Table 1. Pre-test Items

No	Item
1	I feel that to learn from watching the film to be more relaxing and comfortable.
2	I feel pressure to pre-study from the film before the lesson.
3	Learning from the film is helpful for me to understand thoroughly about the cognition of skills and rules of table tennis.
4	I feel that learning from the film can give me deeper learning impression.
5	If I have pre-studied before the lesson, it is not necessary for the teacher to explain the motion in details again in the lesson.
6	I feel that pre-studying online conforms to the current teaching trend.
7	I feel that in the traditional physical education teaching model, the teacher spends too much time "explaining the motion".
8	I am still interested in e-learning even if the teacher does not force me to watch the film online
9	If the film had more storylines, I would be more interested in e-learning.
10	I feel that handing in the pre-study homework (feedback form) is helpful for me to understand the learning key points.
11	I feel it is acceptable to hand in homework after pre-studying a topic in the film.
12	Sometimes, I feel that I am unable to bear for too much homework before (after) the lesson.
13	I like doing the warm-up exercise with different groups of music.
14	It is happy to achieve the learning task with the peers.
15	The "Flipped Classroom Method" increases the quantity and quality of interaction between my peers and me.
16	I feel that the learning strategy (such as multi balls training, hula hoop, passing the challenges, cooperation, feedback form) arranged in the lesson is helpful for me to increase the learning pleasure.

(continued)

No	Item
17	I am able to complete the learning task by myself or with my peers arranged by teacher.
18	When I am unable to achieve the task, I still hope that the teacher could help me to complete it.
19	If I need assistance from peers or teacher, I will tell them actively.
20	When I am performing poorly, I always feel that my peers would be kind of impatient.
21	I feel fresh and interesting to watch myself playing table tennis in the film.
22	I can find out my shortcomings of motions clearly by watching my own film.
23	I like watching my own film to correct my motion and get the learning achievement.
24	If there is chance, I am willing to continue applying “flipped classroom” to physical education lesson.

Table 2. Item Analysis Summary Table

Item	Comparisons of extreme groups	Homogeneity of Variance			Times not reached critical value	Delete Item
	CR value	Item-Total Correlation	Corrected Item-Total Correlation	Cronbach α if Item Deleted		
1	10.306***	.731***	.696	.876	0	
2	2.689**	.322***	.238	.888	4	v
3	10.872***	.693***	.654	.877	0	
4	8.883***	.700***	.665	.878	0	
5	4.539***	.432***	.353	.885	1	
6	11.807***	.666***	.623	.878	0	
7	5.086***	.447***	.376	.884	1	
8	5.522***	.514***	.445	.882	0	
9	2.676**	.304***	.222	.889	4	v
10	5.430***	.555***	.496	.881	0	
11	5.116***	.490***	.426	.883	0	
12	3.338**	.353***	.267	.888	3	v
13	8.693***	.583***	.529	.880	0	
14	5.772***	.531***	.475	.882	0	
15	9.386***	.671***	.624	.878	0	
16	6.111***	.562***	.502	.881	0	
17	9.409***	.673***	.636	.878	0	
18	5.130***	.530***	.475	.882	0	
19	5.165***	.499***	.446	.882	0	
20	1.199	.102	.012	.895	4	v
21	5.603***	.555***	.496	.881	0	
22	11.671***	.715***	.675	.877	0	
23	8.003***	.584***	.518	.880	0	
24	9.841***	.753***	.716	.875	0	
Judgment Criteria	CR≧3.00	r≧.400	r≧.400	α<.886		

*p<.05 ***p<.001 α=.886

3.2 Factor Analysis

After conducting item analysis on the scale, the study carried out a factor analysis. Factor analysis mainly seeks to determine the construct validity of a scale. Factor analysis can be used to extract common factors between variables, with fewer constructs representing the more complex data structures. As to whether the scale is suitable for factor analysis, the test indicator commonly used by researchers is the KMO-MSA (Kaiser-Meyer-Olkin Measure of Sampling Adequacy) (Kaiser, 1970, 1974). The higher the KMO value, the higher the correlation and the more suited is the scale for factor analysis. It was known from Table 3 that the KMO value for the scale was .847, which indicated that its suitability for factor analysis was good (Meritorious). There were common factors between the variables in the scale, for which factor analytical procedures were suitable.

The scale's factor analysis uses the principal component analysis method with the Varimax Method as the Orthogonal Rotation. From Table 4, there were five factors with eigenvalues greater than 1. The eigenvalue of these five factors was 3.077, 2.978, 2.859, 2.384, and 1.68, respectively, and the corresponding explained variance was 15.384, 14.89, 14.297, 11.919, and 8.402, respectively. The cumulative variance of the five factors was 64.893%.The number of items and factor loadings extracted by each factor (dimension) were approximately as follows: Factor 1 (6 items, .429 ~ .794), Factor 2 (6 items, .420 ~ .722), Factor 3 (3 items, .594 ~ .784), Factor 4 (3 items, .719 ~ .820), and Factor 5 (2 items, .573 ~ .760).

Table 3. KMO & Bartlett's Sphericity Test

Kaiser-Meyer-Olkin measure of sampling adequacy	.847
Bartlett's Sphericity Test χ^2	1370.803
df	190
Sig.	.000

*Table 4.*Factor Analysis Structure Summary Table for the Learning Satisfaction Scale

Item	1	2	3	4	5
5	.794	.038	.015	-.107	.043
3	.641	.123	.457	.187	.113
8	.629	.113	-.082	.174	.374
6	.602	.367	.314	.164	-.126
4	.571	.144	.378	.243	.295
1	.429	.356	.403	.275	.108
14	.024	.722	.204	.038	.243
13	.141	.698	.101	.243	.126
7	.131	.647	.034	-.103	.316
15	.458	.637	.244	.199	-.204
24	.365	.473	.471	.272	.004
17	.313	.420	.405	.067	.385
23	.168	.153	.784	.017	.119
21	-.083	.094	.765	.319	.171
22	.380	.240	.594	.109	.221
11	.198	.055	.072	.820	-.026

(continued)

Item	1	2	3	4	5
10	.161	-.017	.230	.725	.290
16	-.132	.500	.171	.719	.022
19	.152	.257	.192	-.005	.736
18	.052	.160	.254	.356	.573
Eigenvalues	3.077	2.978	2.859	2.384	1.680
% of Variance	15.384	14.890	14.297	11.919	8.402
Cumulative %	15.384	30.275	44.572	56.491	64.893

3.3 Factor Naming

The formal scale's item numbers shown in Table 5 were rearranged according to the magnitude of factor loadings listed in Table 4. By the contents of each factor item (in Table 5), the topic of the first factor is mostly related with pre-studying film videos online or learning about the course through the web platform; therefore, the factor was named "Film Preview." The contents of the second factor are roughly related to the arrangement and design of program content (such as doing warm-up exercises with different groups of music, enhancing the interaction between peers), so the facto was named "Program Design." The contents of the third factor are generally related to watching films of oneself to achieve self-correcting and self-learning of table tennis related motions and techniques, so the factor was named "Self-Correcting." The fourth factor is primarily related to students handing in assignments after pre-studying film lessons, thus it was named "Assignment." Because pre-studying films online is an important part of flipped teaching, teachers usually would use "assignments" or random quizzes to understand whether students are learning through online films, and to assess their knowledge level with regard to film content after viewing. The contents of the fifth factor are related to how students in the class, over the course of learning about table tennis techniques, complete tasks through teamwork with their peers or by asking for teacher's assistance; hence, it was named "Cooperative Learning." The authors believe that, after performing the factor analysis, the fact that the fifth factor was only extracted from two items is a blemish; a more appropriate action would be to delete the items or increase or revise the item contents. Yet considering that the implementation of the flipped classroom concept in physical education teaching is still at a preliminary experimental stage, coupled with the fact that cooperative learning (Factor 5) is an important learning process in physical education teaching, we chose to temporarily retain items related to Factor 5. At the same time, we look forward to further revise item contents the next time we implement flipped teaching, so that the scale has more power.

Table 5. Formal Flipped Classroom Learning Satisfaction Scale for a University Table tennis Program

Item Description	Score
Film Preview	
1. If I have pre-studied before the lesson, it is not necessary for the teacher to explain the motion in details again in the lesson.	□5 □4 □3 □2 □1
2. Learning from the film is helpful for me to understand thoroughly about the cognition of skills and rules of table tennis.	□5 □4 □3 □2 □1
3. I am still interested in e-learning even if the teacher does not force me to watch the film online	□5 □4 □3 □2 □1
4. I feel that pre-studying online conforms to the current teaching trend.	□5 □4 □3 □2 □1
5. I feel that learning from the film can give me deeper learning impression.	□5 □4 □3 □2 □1
6. I feel that to learn from watching the film to be more relaxing and comfortable.	□5 □4 □3 □2 □1
Program Design	
7. It is happy to achieve the learning task with the peers.	□5 □4 □3 □2 □1
8. I like doing the warm-up exercise with different groups of music.	□5 □4 □3 □2 □1
9. I feel that in the traditional physical education teaching model, the teacher spends too much time "explaining the skill".	□5 □4 □3 □2 □1
10. The "Flipped Classroom Method" increases the quantity and quality of interaction between my peers and me.	□5 □4 □3 □2 □1
11. If there is chance, I am willing to continue applying "flipped classroom" to physical education lesson.	□5 □4 □3 □2 □1
12. I am able to complete the learning task by myself or with my peers arranged by teacher.	□5 □4 □3 □2 □1
Self-correcting	
13. I like watching my own film to correct my motion and get the learning achievement.	□5 □4 □3 □2 □1
14. I feel fresh and interesting to watch myself playing table tennis in the film.	□5 □4 □3 □2 □1
15. I can find out my shortcomings of motions clearly by watching my own film.	□5 □4 □3 □2 □1
Assignment	
16. I feel it is acceptable to hand in homework after pre-studying a topic in the film.	□5 □4 □3 □2 □1
17. I feel that handing in the pre-study homework (feedback form) is helpful for me to understand the learning key points.	□5 □4 □3 □2 □1
18. Sometimes, I feel that I am unable to bear for too much homework before (after) the lesson.	□5 □4 □3 □2 □1
Cooperative Learning	
19. If I need assistance from peers or teacher, I will tell them actively.	□5 □4 □3 □2 □1
20. When I am unable to achieve the task, I still hope that the teacher could help me to complete it.	□5 □4 □3 □2 □1

3.4 Reliability Analysis

After the factor analysis, to further understand the reliability and validity of the questionnaire, it is necessary to conduct reliability tests. Higher reliability and validity values are two major characteristics of an appropriate scale. When using the internal consistency α coefficient to test the scale, if the reliability coefficient of the total scale is greater than .800, then its reliability is good; if the reliability coefficient of the total scale is greater than .700, then its reliability is acceptable. For each dimension, a reliability coefficient greater than .700 means that its reliability is good; a reliability coefficient greater than .600 means that its reliability is acceptable. From the reliability test summary table in Table 6, it could be seen that the α coefficient for each of the five sub-scales were “Film Preview” (α=.817), “Program Design” (α=.817), “Self-Correcting” (α=.771), “Assignment” (α=.775), “Cooperative Learning” (α=.500). The α coefficient of the total scale was .906, which indicated that this scales reliability is very good (Gay, 1992). In terms of the five factor dimensions, with the exception that the reliability coefficient of the fifth factor dimension was less than .600, the reliability coefficients of the remaining 4 factor dimensions were all greater than .700. As mentioned above, although the reliability coefficient of Factor 5 was less than .600, considering that cooperative learning is an important part of physical education teaching and instruction, we still temporarily keep the scale items related to Factor 5. We look forward to the next revision of the scale, in which the item contents can be improved or number of items increased, so that the flipped teaching scale becomes more perfect.

Table 6. Results Summary Table for Internal Consistency Analysis of Satisfaction Scale (N=144)

Subscale	Item Number	Cronbach α
Film Preview	1,2,3,4,5,6,	.816
Program Design	7,8,9,10,11,12	.817
Self-Correcting	13,14,15	.771
Assignment	16,17,18	.755
Cooperative Learning	19,20	.500
Total Scale	Total 20 items	0.906

α= .906

4. CONCLUSIONS AND SUGGESTIONS

The questionnaire was summarized and drafted using the concept of "flipped classroom" as the main axis and complemented with relevant PE teaching methodological literature. The scale underwent through item preparation, pre-testing, item analysis, factor analysis, and various reliability and validity test procedures. The resulting flipped classroom learning satisfaction scale consists of 20 items, and was composed of the following five factors: Film Preview, Program Design, Self-correcting, Assignment, and Cooperative Learning. The cumulative variation explained was 64.893%, which indicated that the scale has construct validity. In terms of reliability, Cronbach's α was used to test the reliability of the scale in the study. The results showed that the internal consistency coefficient of the total scale and each subscale is quite high, indicating that the reliability of this scale is quite good. Flipped classroom method is a new teaching trend that has emerged in recent years, but its use in physical education teaching remains a minority. Although the authors began to get involved with flipped teaching in 2014 and had actually applied the method in table tennis programs, the overall experience with flipped teaching remains lacking. Moreover, because this study is still in the exploratory stage, there is a lot of room for improvement in scale preparation and development. Follow-up researchers are recommended to collect more extensive data and incorporate other variables according to research needs, before conducting analysis. In addition, the study used participating university table tennis class students only to set an example for others to follow. The authors greatly anticipate that once the development of flipped classroom satisfaction scale has become more mature, it can be extended to table tennis club training and other sports fields. Proper use of the study's results in teaching implementation and instruction is the ultimate goal of the scale's development.

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A Study of Students Motivation and Flow Experience on Participating Table Tennis

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Abstract: The purpose of this study was to investigate the motivation and the flow experience of students on participating Table Tennis Exercise. The participants were university students who select table tennis as their PE interest course from midland of Taiwan. To meet the objective of this study more closely, we use "participatory motivation and flow experience scale" as our research tool and utilize descriptive statistics, independent sample T-test, one-way analysis of variance, and Pearson Product-Moment Correlation Coefficient to make statistic calculation and analysis. The results of research are summarized as follows:

1. Students who participated in a table tennis class before have a higher motivation to participate in table tennis.
2. Students who had participated in the table tennis competition have higher flow experiences.
3. Students who had the experiences of representing the team had higher flow experiences than those who didn't have experience.
4. Students who participated twice weekly in average have higher motivation then those who participate once a week.
5. There was a high positive correlation between the positive emotions and the voluntary fun in the flow experiences scale.

Keywords: table tennis, participation motivation, exercise flow experience

1. INTRODUCTION

As a result of the change in the era, the values of the people change. People begin to watch their physical health. Participating in the sport is one of the important ways to improve health which is also the high-quality one of other options. (Sport Administration, Ministry of Education, 2005) Sport Administration aggressively promote "sport island" project, following up the project to promote sports activities in Taiwan from year 2016. The purpose of this project is to encourage the population to become voluntary sport participants; to lead the exercise fashion so that the whole citizen can enjoy the fun of sports; to build perseverance exercise habits, to enhance personal physical and mental health, and to improve quality of life.

The development of habits in sports begins in young age. Per the 2006 study of the Sports Administration, showed that about 50% of the students in the elementary school had reached the habit of exercising three times a week (excluding physical education) and reduced to less than 40% of the students maintaining this standard when they reached the middle school, and only 25% of the students maintaining the habit of regular exercise to the high school and only about two percent of the students in university still exercise. (Ministry of Education, 2006). Therefore, in order to respond to the concept of the government's national endeavor, school sports are a very important part of the physical training. Through the physical training classes, students developed the habits, skills, fun, and understanding of the way the body works. Also through creative and interesting activities which broaden students vision, and made kids love to exercise (Chieh, 2012). If the habit of exercise could be established or a skill of sports could be developed while being a student, you could expect the exercise habits extended to social life (Chen, 1998), and then developed a lifelong habit.

The physical education in university is the final stage of individual physical education and is also considered to be the last key stage to develop and keep exercise in life. In the current university system, physical education courses in most school are either a two-year requirement plus two years elective or one-year requirement plus one-year elective. In order to establish good habits of exercise in the final stage of student life, each university develops different physical education curriculum according to the school characteristics and students Interests. The study of Hsu & Wu (2007), shows that students are more motivated and loyal for their favorite sports and they stay in the spots after graduate. The motivation for this repetitive activity without external rewards perhaps can be explained from the “flow experiences” report by the psychologist Csikszentmihalyi (1975). Because the “flow experience” is very good, and it is a reward of its own, it can make participants desire to achieve a flow state, to get more fun and achievements (Jackson & Csikszentmihalyi, 1999).

Therefore, the implementation of the option of selective courses per students’ interest in physical education will help students to have a deeper understanding of the sport. Through the learning of sport techniques, students will have a better understanding of the sport and turn into an interest, resulting in the flow experience of the sport, then developing good sports habits; further establishing proper leisure activities and physical and mental balance. However, the reason why students participated in the sports after school was closely related to the level of their value recognition, and the motivation of the participation was one of the most important issues that affect their willingness to be involved in the sport. If students had a strong interest in a sport, and were fascinated by this sport, this would directly affect the student's continuous involvement in the sport. If the student was willing to continue to be involved in the sport, he would see the sport as a hobby (Venkatraman, 1990). This study took the university students who shown interests in table tennis and participated in the class after school. What were the experiences of these students? What were the experiences of the students who were willing to participate in the table tennis after class? The results were provided to the instructor and the practitioner as references in the implementation of physical education or teaching to stimulate students' interest in sports, and then cultivate the habit of students’ lifelong sports.

2. METHODOLOGY

2.1 Research Object

The study object was the university students who selected table tennis class in the central area of Taiwan. 300 persons agree to participate in the study, and 292 of them returned valid questionnaires.

2.2 Research Tools

This study was based on the “participatory motive scale” of Wu (2006) and the “flow experiences scale” of Yang (2006) which were adapted for “university students to participate in table tennis motive and flow experiences scale” and participatory scale. The items in “Participation in motive scale” were extracted into four factors: "physical needs", "psychological needs", "social needs" and "achievement needs". “Flow experiences scale” were used to extract the 10 factors: "Immediate Feedback", "Clear Goals", " Challenges and Skills "," Behavior and Consciousness "," Concentration "," Potential Manipulation "," Temporarily Unconscious "," Twist of Time "," Voluntary Fun "and" Positive Emotion ".

2.3 Data Processing

After the questionnaire was collected, the invalid questionnaires were removed and then balance were registered and coded. The computer software SPSS 18.0 for Windows was used for statistical analysis. The following statistical methods were used according to the purpose of the study:

2.3.1 Recorded the basic information describing the statistical analysis.

2.3.2 The independent sample used T- test and one-way ANOVA to test differentiate between the motives and the flow experiences of the students in the table tennis. If the results of the single factor analysis are significant, the Scheff’e procedure was used to compare the results.

2.3.3 Use of “Pearson's product-moment correlation” to test the motives and flow experience of the relevant factors of the situation.

2.3.4 The significant level of statistical test in this study was defined as α <.05.

3. RESULTS

3.1 The motives and flow experiences of university students participating in table tennis

The motives and flow experiences of university students participating in the table tennis are shown in Table 1 and Table 2. The scores of "psychological needs" in the four facets of the Participation Motives Scale are the highest and it is learned that the "physical needs", "social needs" and "achievement needs" are lower for the students who participate in table tennis after school. However, one study made by Wu (2013), Peng (2010) and Chen (2008), shows that one of the important influencing factors involved in motives is the “health fitness”, which is different from the results of this study. To conclude, the motives of different age groups to participate in the sport were different, and releasing the stress was the most important factor for the group of students.

Table 1. The motives of the Student Participation in Table Tennis

	Average Score	Position
Social needs	3.67	3
Physiological (health and fitness) needs	3.88	2
Psychological needs	3.94	1
Achievement needs	3.76	4

It is understood from Table 2 that the scores of "positive emotions" in the ten facets of university students participating in the flow experiences of table tennis is the highest, followed by challenges and techniques, and the lowest score is “potential manipulation”. Because of the great interest in table tennis, participating in table tennis will have a positive impact and concentrate more on learning which benefits from learning the skills and thus enhance their flow experiences. The study of Hoffman and Novak (1996) mentions that when the user has higher flow experiences, the user has more positive subjective experience, resulting in a higher level of satisfaction and more motivation to learn. We learned that the motives in participation and flow experiences are complementary. When students had a higher motivation and more time to participate in table tennis, the better flow experience was created.

Table 2. The flow experience of the Student Participation in Table Tennis

	Average Score	Position
Immediate feedback	3.6	3
Clear objectives	3.4	7
Challenge and skill	3.62	2
Behavior and consciousness	3.11	9
Concentration	3.24	8
Potential manipulation	3.03	10
Temporarily unconscious	3.41	6
Distortion of time sense	3.55	5
Voluntary Fun	3.59	4
Positive emotions	3.75	1

3.2 The difference between the motives and flow experiences of university students participating in table tennis

The differences in the motives and flow experiences of university students participating in the table tennis are shown in Table 3, Table 4 and Table 5. The motivations for the students who had participated in the table tennis class was higher, but there was no difference between the genders. This result was different than the study of Wang (2009) and Wu (2013). We learned that there were no differences in the motives of students participating in table tennis. Table tennis is quite popular and not restricted by the venue. It is a sport suitable for boys and girls, so there is no difference between the genders participating in table tennis.

Table 3. The table of t test on motivation for different background variables students participate in the table tennis

Background variable	group	M	SD	t	p
Gender	Male	3.83	0.63	0.47	0.64
	Female	3.79	0.53		
Have participate in table tennis	Yes	3.89	0.56	-2.51	0.01*
	No	3.71	0.60		
Have compete	Yes	4.21	0.55	-1.62	0.1
	No	3.81	0.60		

*p<.05

It is clear from the Table 4 that students who had participated in the table tennis competition show a difference in the flow experiences. They had a better experience than the students who had not participated.

Table 4. The table of t test for different background variables students flow experience in the table tennis

Background variable	group	M	SD	t	p
Gender	Male	3.45	0.54	0.97	0.32
	Female	3.38	0.44		
Have participate in table tennis	Yes	3.47	0.52	-1.43	0.15
	No	3.38	0.51		
Have compete	Yes	3.85	0.50	-2	0.04*
	No	3.42	0.51		

*p<.05

It was observed that the students who have been practicing in the table tennis class are better than the students who have not had the class. Students who had this experience have better self-confidence in class, accept new challenges and learn new skills. Those students have higher flow experiences participating in table tennis. Lin (2002) mentioned in his research that when athletes are in peak performance, they can experience a higher flow experience. It is recommended that if the school physical education course has a two-year compulsory program, when planning school physical education courses, students should be allowed to take table tennis class in the first year. If students can take two-year of table tennis training, they will have a more solid basic skill of table tennis. It will be beneficial to improve their motives to participate in table tennis in the future.

Students who had participated in table tennis competition did elect table tennis courses and believed that they had a good flow experience in the competition, great interest and clear goals for the technique of learning table tennis. Students who have competed have a better experience with table tennis. And this study shows no difference in the flow experience between genders. This result is different from the study of Hsu (2008), Liu (2005) and Wang (2011). The reason should be deduced that in recent years, with the implementation of the national sport programs, more and more people recognize that exercise does improve health. In conclusion, table tennis is a good sport for everyone, so women participating in table tennis has gradually increased, their techniques are gradually improving, and the flow experiences have also increased.

From Table 5 we learn there is a difference in motives and flow experiences between the university students who had the experience of participating in different teams and the students who participated weekly in the diversity of table tennis. After the comparison, we find the students who participate in the team competition have more motives and better flow experience than the students who did not have those experiences. The students who played twice a week had better motives and flow experiences than the ones who played only once a week. The results are similar to that of Wang (2011). Students who had the chance to compete had better flow experiences, were also more willing to take the time to engage in the sport and improved their techniques. The results of this study agree with Jackson, Kimiecik, Ford and Marsh (1998), which argued that when the individual has a flow experience in a sport, the internal self-motivation will significantly improve.

Table 5. The table of one- way ANOVA for different Background variables students' motive and flow experience participate in the table tennis after school

Background variable	Group	Motive	Flow experience	Scheffé Post Hoc Comparison
Grade	1. Second grade 2. Third grade 3. Fourth grade	0.42	0.16	
Experience	1. No 2. Class team 3. Department team 4. School team	0.01*	0.00*	Motive: 2>1 Flow Experience :2>1
Frequency of participation weekly	1. Once every week 2. Twice Every week 3. Three times Every week 4. Four times Every week	0.01*	0.0 1 *	Motive: 2>1 Flow Experience :2>1

*p<.05

3.3 The correlation on motives and flow experience of university students participating in table tennis

Table 6. The table of the correlation on motives and flow experiences in the table tennis

	social needs	physical needs	psychological needs	achievement needs	immediate feedback	clear goals	Challenges and Skills	Behavior and Consciousness	Concentration	Potential manipulation	Temporarily Unconscious	Twist of Time	Voluntary Fun	Positive Emotion
social needs	1	0.479**	0.476**	0.662**	0.567**	0.556**	0.548**	0.383**	0.425**	0.483**	0.410**	0.371**	0.440**	0.412**
physical needs	0.479**	1	0.670**	0.728**	0.530**	0.526**	0.569**	0.200**	0.373**	0.338**	0.425**	0.432**	0.515**	0.520**
psychological needs	0.476**	0.670**	1	0.682**	0.575**	0.407**	0.545**	0.256**	0.354**	0.358**	0.447**	0.471**	0.557**	0.565**
achievement needs	0.662**	0.728**	0.682**	1	0.716**	0.632**	0.633**	0.359**	0.427**	0.492**	0.490**	0.473**	0.587**	0.597**
immediate feedback	0.567**	0.530**	0.575**	0.716**	1	0.699**	0.754**	0.487**	0.501**	0.612**	0.614**	0.562**	0.646**	0.590**
clear goals	0.556**	0.526**	0.407**	0.632**	0.699**	1	0.737**	0.470**	0.497**	0.643**	0.505**	0.439**	0.506**	0.487**
Challenges and Skills	0.548**	0.569**	0.545**	0.633*	0.754**	0.737**	1	0.488**	0.458**	0.612**	0.591**	0.542**	0.632**	0.583**
Behavior and Consciousness	0.383**	0.200**	0.256**	0.359**	0.487**	0.470**	0.488**	1	0.564**	0.626**	0.443**	0.315**	0.294**	0.208**
Concentration	0.425**	0.373**	0.354**	0.427**	0.501**	0.497**	0.458**	0.564**	1	0.597**	0.529**	0.438**	0.436**	0.389**
Potential manipulation	0.483**	0.338**	0.358**	0.492**	0.612**	0.643**	0.612**	0.626**	0.597**	1	0.623**	0.450**	0.517**	0.414**
Temporarily Unconscious	0.410**	0.425**	0.447**	0.490**	0.614**	0.505**	0.591**	0.443**	0.529**	0.623**	1	0.661**	0.629**	0.552**
Twist of Time	0.371**	0.432**	0.471**	0.473**	0.562**	0.439**	0.542**	0.315**	0.438**	0.450**	0.661**	1	0.643**	0.602**
Voluntary Fun	0.440**	0.515**	0.557**	0.587**	0.646**	0.506**	0.623**	0.294**	0.436**	0.517**	0.629**	0.643**	1	0.767**
Positive Emotion	0.412**	0.520**	0.565**	0.597**	0.590**	0.487**	0.583**	0.208**	0.389**	0.414**	0.552**	0.602**	0.767**	1

*p<.05

Table 6 shows that there are positive correlations between participation motives and flow experiences. The results of the study are related and in agreement to Jackson, Kimiecik, Ford and Marsh (1998). They found that when the individual experiences the flow experience, that relative intrinsic motives will be improved. There is a positive correlation between the positive emotions and the voluntary fun aspect. It can be seen that when the students had fun with table tennis, they had positive emotions while engaged in the sport, challenges vs skills, and result in immediate feedback in a second-high positive correlation. Challenges vs skills and clear goals exist in the third high positive correlation. We can see that when students in the process of learning table tennis, their skills will be improved and they will have better flow experiences in practice or competition, ultimately feeling positive feedback. When students are more familiar with basic techniques, they will have more clear learning objectives and want to challenge themselves for a higher level skill. Table tennis is a sport that can be played fast or slow. Beginners only need a simple push action to practice with each other and can even have effective competitions.

Therefore, it is recommended that when teachers design a selective curriculum, students should test, or compete to validate the basic skills taught. Students will be filled with a great sense of accomplishment and produce positive emotions when these milestones are achieved. After Students have fun playing table tennis, they improve the motivation to participate and even create positive habits for playing table tennis outside of the structured environment.

4. CONCLUSION AND SUGGESTIONS

4.1Conclusion

The purpose of this study was to explore the motives and flow experiences of university students participating in table tennis, targeting the students who play table tennis in the central area of Taiwan. The results found that the most important motive factor is “psychological needs”, and the students who have trained in a table tennis class are more motivated to participate in independent practice after school. In the flow experiences, the “positive emotions” scored the highest. Students who participated in the table tennis competitions had better flow experiences than the students who had not participated in the competitions. University students who participated in table tennis twice a week had better flow experiences than those participating once a week. Finally, by the Pearson product correlation analysis, it was found that there was a positive correlation between the motives and the flow experiences.

4.2 Suggestions

It is found that the requirement of “psychological needs” and “positive emotions” score the highest in the motive and flow experience of university students' participating in table tennis.

Therefore, the selective of physical education is one of the important steps to inspire students to continue their lifelong sports. It is suggested that the sport class should be based on the interests of the students and even promote the selective course in high school so that students can participate in their favorite sport at an early age. The teachers should also engage students within their talents which would increase the fun of the sport, promote the flow experiences to enhance the motives of participating in sports after school, further creating a positive habit of lifelong sports and promoting the national health fitness.

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The Effects of Social Loafing on Table Tennis: The Moderating Effect of peer Leadership and Sport Confidence

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Abstract: In the learning environment of sport settings, young athlete's interaction produces learning outcomes, personality, and psychological development, and it plays a key role. Therefore, the purpose of this study was to explore the effects of social loafing on the forehand spin performance for table tennis, and examined the moderating effect of peer leadership and sport confidence. Fifty young athletes were recruited from five high schools in Taipei. The participants completed Peer Leadership Scale, Sports Confidence Scale, and the Sport Forehand Spin Performance of Table Tennis. The methodological design consisted of four experimental groups. Individual performances were compared in individual versus group conditions. During a first session, participants carried out forehand spin of table tennis in the individual condition. During a second session, one of the four experimental groups was equivalent to a group condition without inter-group competition, whereas the three others competed against fictitious opponents which had same or different levels of group performance. Prior to the second forehand spin of table tennis session, members of the three experimental groups were individually asked to assess their team score as well as that of their opponent. A Two-way Mixed Design ANOVA was used to analyze in study. Two ANOVAs with repeated measures and Scheffé post hoc pair comparisons were used to analyze in study. The results indicated that, under identifiability conditions, the participants improved their forehand spin performance on table tennis, peer leadership and sport confidence were affected as a moderating role, and they perceived less social loafing in their teammates. This study shows that the competitive context, social interaction, and confidence for group outcomes have an impact on social loafing.

Keywords: loafing, peers, confidence, perceived, performance

1. INTRODUCTION

Athletic competition is a show of personal skill and tactic but also emphasizes the importance of teamwork. Social psychologists define groups as the interaction of two or more members or the impact between each other. (Aronson, Wilson, & Akert, 2002). Such phenomenon is also known as the "Ringelmann effect", that is, the occurrence of social loafing phenomenon (Rune et al., 2006). According to studies by Latane, Williams and Harkins (1979), the tendency that an individual tends to pay less effort in a team situation than he/she does in an individual one is so called social loafing. Most works to be done through efforts, either physical or mental endeavor, are prone to appear a social loafing phenomenon, which has been proved by studies as a ubiquitous situation. Such as: shouting and clapping (Latane' et al., 1979), and solving puzzles (Jackson & Williams, 1985); in exercise settings, such as 30M relay (Rune et al., 2006) and tug of war (Inghamet et al., 1974), also found such phenomenon. In order to avoid social loafing phenomenon, whether the team members have perfectly cooperated and gone all out is a major influencing factor; since the effectiveness of a team's cooperation must rely on leaders to integrate different backgrounds, interests and ideas of members to pursue common goals and work towards team objectives, thus, the interaction among members of the group will directly and indirectly affect the performance of the entire team, especially the psychosocial factors (George & Feltz, 1995).

In addition to social loafing phenomenon, the coach's leadership style often plays a key role in the performce of sport team. Previous studies (Westre and Weiss, 1991) pointed out that the coach's leadership behavior is a key determinant to player's personal result and team's performance. However, except the important factor of leadership model of a good coach for the team, the members of the group can also become a leading role. Peer-led behavior are frequently found in sport teams during the competitions, in which Kozub and Pease (2001) suggesgted that each athlete can display leadership in the team. Peer leadership in a group may display the function that does not demonstrate in formal leadership, and it is suggested that it may be able to replace formal leadership as another source of leadership in the group. Moreover, Carron, Hausenblas and Eys (2005) also pointed out that, whatever fucntion of the role played by the peers, it would affect the operation, atmosphere and cohesion of the team. The fomation of such role is the result contributed by various factors of their roles and situations or the assigned responsibilities they are to bear in the team. According to the above, when the team needs, the peers with better ability can be regarded as peer leadership, and the other members of the team will assist and listen to his/her instructions accordingly, resulting in efficient peer leadership as well as higher work and social cohesion. In this case, it may also improve the collective effectiveness.

Another factor that could affect social loafing may be the player's self-confidence (Weinberg and Gould, 1995). However, it is also an important factor that affects athlete's performance in prusuing sport goal under highly intensive competition. Athlete with self-confidence usually has positive emotional reaction and better concentration which can lead the game rhythm and have better game strategies. Many excellent athletes tend to have a better level of self-confidence in a highly competitive game. In this regard, Vealey (1986) also believed that sport self-confidence refers to the individual's belief in the success of athleticism and the degree of certainty. Many studies on sports self-confidence were mainly based on the conceptual model of Vealey (1988), trying to clarify the relevant issues of athletes' self - confidence from the view of social cognition. The organizational culture and athlete characteristics presented in this framework would affect the source and level of sport self-confidence. Team organization culture includes the level of competition, the motive atmosphere, and the specific goals of sports training, etc., that is, an excellent sports team's organizational culture may be different under the social loafing situation.

According to above studies, the main reason of social loafing is from lacking or losing stimulation of motivation, in other words, even if the number of athletes increased in the team, the extent of its efforts still decline, which indirectly affects the sport performance. While pursing sport performance in the game settings, the condition of athlete's mental quality and self-confidence level are often the key determinates of outcome. Therefore, the coach must understand that, in the sport settings, what are the sources of athlete's self-confidence and peer leading status, so that to build an appropriate training methods and team cohesion to enhance the sport performance. In the past, most studies of social loafing mainly focused on team sports, less paid attention to explore that individual could also be a related object in team sport research. Thus, this study targeted on table tennis players as the research object and selected the forehand spin, a currently main scoring technique for the opponents in the game, to conduct tests in order to explore the impact of social loafing on sport performance. The purpose of this study aimed to explore the effect of social loafing as well as to analyze the interaction situation of peers' leadership, sport self-confidence and social loafing on the forehand spin performance of table tennis.

2. METHODS

2.1 Participants

This study recruited a total of 50 players of men's table tennis teams from five high schools as research objects. Those players were receiving long-term table tennis training in the schools and had participated in all levels of games in this field on behalf of their own schools.

2.2 Research tools

(1) Peer leadership scale: this scale was developed by Xu Wei-Min (2010), mainly used to measure the leadership of the peers' leader in a sports team. The scale contains four items, namely, 6 questions of task leader, 6 questions of social leadership, 4 questions of external leadership and 6 questions of personal skills, a total of 22 questions. At the time of the development of this scale, the consistency of Cronbach's α of each sub-scale were .87, .90, .83, .90, respectively, and the total interpretation of variance was 52.50%. The questionnaire was designed by a four-point Likert-type scale, in which 1=rarely, 2 = occasionally, 3=sometimes, 4=often so, with 1 to 4 points in sequence. The larger the number checked, the higher the frequency of peer leadership's presence; the smaller the number checked, the lower the frequency of peer leadership's behavior.

(2) Sporting self-confidence scale: this scale was translated by Chen Ying-Ji (2010) from the sporting self-confidence scale of Vealey and Knight (2002), which is mainly used to measure the athletic self-confidence level on his/her own ability to be successful in technique, decision making and recovery. This scale contains three subscales, where 5 questions of confidence in physical skills / training, 6 questions in cognitive efficiency of confidence, and 3 questions in restoration confidence, a total of

15 questions. It's Cronbach's α value was .97 with good internal consistency. This scale adopted 7-point from 1 (completely impossible) to 7 (absolutely certain).

(3) Multi-functional table tennis smart tutor: the machine of WLP-CRACK/V-989E used in the experiment presented a ball out frequency of 50s one minute, where the rotations include 8 top spins and 2 down spins up, and the location of ball placement were set between point 4 and 9. The experimental data of this tutor was the adjusted results of more than 10 times pre-tests carried out prior to the experiment.

2.3 Experimental design

The participants were agreed by each school coach and filled in the informed consent, the peer leadership scale and the exercise self-confidence scale 10 minutes before the commencement of this experiment. Participants were asked to complete a one-minute forehand spin test in four different situations alone. First of all, the participants were told that the test would be the ranking of personal performance. In the second time, they were told that this test was a grade ranking of total 10 people plus high strength group. In the third time, they were told that the test was a grade ranking of total 10 people plus equal strength group. Finally, they were told that the test is for total 10 people plus low strength group.

2.4 Data processing

This study used 2 x 4 (groups: personal effort and team group vs tests: four social loafing conditions) two-way ANOVA mixed design analysis, in which the test was repeated measures to analyze the variation effect of four different social loafing situations. In the part of the repeated measures, this study first checked whether it violated the spheric assumption in order to determine the truth of hypothesis. If the interaction reaches a significant level of statistics, this study then conducted the simple main effect test and post-hoc analysis in order to test the difference situation of peer leadership and sports self-confidence on sport performance. The statistically significant levels of this study was set to α=.05.

3. RESULTS

3.1 The impact of social loafing on sport performance

The findings of dependent sample One-way ANOVA showed that, the average difference between means of the four groups was significant at F (2.245,109.989)=39.99*, p= 0.01<0.05. Thus, this study conducted a post hoc pair comparison, and the results were shown in Table 1.

Table 1. Summary table of post hoc pair comparison on sport performance in social loafing situation

(I) Social loafing	(J) Social loafing	Average difference (I-J)	Stand Error	Significance (a)	The difference between 95% CI (a) Lower Limit	Upper Limit
1. Situation 1. (Personal effort)	2	.041(*)	.004	.000	.034	.048
	3	-.020(*)	.007	.005	-.034	-.007
	4	.044(*)	.007	.000	.029	.058
2. Situation 2 (Group v.s high strength)	1	-.041(*)	.004	.000	-.048	-.034
	3	-.062(*)	.007	.000	-.076	-.047
	4	.002	.008	.751	-.013	.017
3. Situation 3 (Group v.s equal strength)	1	.020(*)	.007	.000	.007	.034
	2	.062(*)	.007	.000	.047	.076
	4	.064(*)	.009	.000	.046	.082
4. Situation IV (Group v.s low strength)	1	-.044(*)	.007	.000	-.058	-.029
	2	-.002	.008	.751	-.017	.013
	3	-.064(*)	.009	.000	-.082	-.046

$^{*}p < .05$

3.2 The impact of peer leadership on sport performance in social loafing situation

The variables of mission leadership, social leadership, external leadership and personal ability of participants in this peer leadership scale were separately divided into two groups of high and low grades. The results showed that the social loafing of each variant was as follows: high mission leaders (*M*=3.0733) were higher than those of low mission leader (*M*=2.3267); high social leaders (M=3.5435) were higher than those of low social leaders (*M*=2.9383); high external leaders (M=3.4063) were higher than those of low external leaders (*M*=2.7426); high individual talents (*M*=3.4931) were higher than those of low individual talents (*M*=3.0000).

The sport performances of peer leadership in different situations were shown in Table 2. The analysis showed that Mauchly's W coefficient of mission leadership was .459 ($\chi 2$=36.356; p<.05). After correction, the interaction between social loafing and mission leadership showed no significant level at $F_{(2,\ 82)}$=2.416, p=.87> .05. The Mauchly's W coefficient of social leadership was .457 ($\chi 2$=36.545; p <.05) and, after correction, the interaction between social loafing and social leadership reached a significant level, $F_{(2.196,\ 105.416)}$=3.042 *, p=.04 < .05, as shown in Figure 1. Hence, this study conducted the simple main effect test and the results showed that there were significant differences in the sport performance of high/low social leaderships in the social loafing situation, in which the low society was $F_{(2.17,\ 105.416)}$ =15 *, p=1.8E-06 and the high society $F_{(2.076,\ 105.416)}$ =23 *, P=5.2E-09, both p values were less than .0083 with significant differences. After the post hoc pair comparison, the study found that the social loafing situations of low society was 1, 3>2 and 4, and those of high society was 3>1>2 and 4. The Mauchly's W coefficient of external leadership was .463 ($\chi 2$=35.937; p <.05). After correction, the interaction between social loafing and external leadership showed no significant difference, $F_{(2.258,\ 108.381)}$=0.799, p=>.05. The Mauchly's W coefficient of personal talent was .449 (χ2=37.450; p<.05) and, after correction, the interaction between social loafing and personal talent showed no significant difference of $F_{(2.237,\ 107.361)}$=0.309, p=.759 > .05.

Table 2. The description statistics table of sport performance of peer leadership in social loafing situation

Variable of peer leadership		Situation 1	Situation 2	Situation 3	Situation 4
High mission	*M*	.70	.67	.74	.68
(*n*=25)	*SD*	.09	.09	.08	.08
Low mission	*M*	.74	.69	.75	.70
(*n*=25)	*SD*	.09	.09	.08	.10
High society	*M*	.71	.67	.75	.67
(*n*=23)	*SD*	0.08	.08	.07	.09
Low society	*M*	.74	.69	.74	.68
(*n*=27)	*SD*	.10	.09	.09	.10
High external	*M*	.73	.69	.75	.70
(*n*=16)	*SD*	.06	.06	.06	.08
Low external	*M*	.72	.68	.74	.67
(*n*=34)	*SD*	.11	.10	.09	.10
High personal	*M*	.75	.70	.76	.70
(*n*=24)	*SD*	.08	.08	.07	.09
Low personal	*M*	.70	.66	.73	.66
(*n*=26)	*SD*	.10	.09	.08	.10

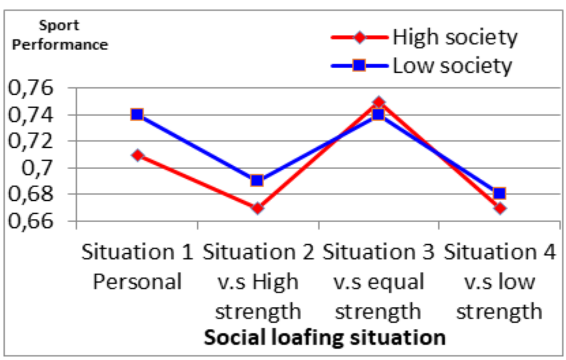

Figure 1. Analysis diagram of the variances of sport performance of high and low social leadership

3.3 The impact of sport self-confidence on sport performance in the social loafing situation

The variables of physical skills / training confidence, cognitive efficiency confidence, restoration confidence, self-confidence of this study's participants in sport self-confidence scale were divided into high and low grades according to the median of each group, respectively. As a result, the social loafing of each variable was: those with high physical skills / training (M=5.1167) was higher than that of low physical skills / training (M=3.8615). Those with high cognitive efficiency (M=5.2716) was higher than that of low cognitive efficiency (M=4.1522). Those with high restoration confidence (M=4.8500) was higher than that of the low restoration (M=3.6300). Participants with high self-confidence (M=4.8613) was higher than that of low self-confidence (M=4.0400).

After the analysis of the sport performance of sport self-confidence in different situations shown in Table 3 demonstrated that, the Mauchly's W coefficient of physical skills / trainings was .511 (χ2=31.390; p<.05) and, after correction, the interaction between social loafing and physical skills / trainings was significant at $F_{(2.347,112.644)}$=5.631 *, p=.003 <.05, as shown in Figure 2. Thus, this study conducted a simple main effect test, and the results showed that the sport performance of high and low physical skills/trainings in social loafing situation reached a significant difference, in which the low society was $F_{(2.408, 112.644)}$=190 *, p=1.0E-36 and the high society was $F_{(2.181, 112.644)}$=560 *, P=4.8E-59, both *p* values were less than .0083 and reached significant differences. After the comparison, this study found that social loafing of low-skill / training was 1, 3> 2, 4, and society loafing of high-skill / training was 1, 3> 2> 4. The Mauchly's W coefficient of cognitive efficiency was .508 (χ2=31.640; p<.000). After correction, the interaction between social loafing and cognitive efficiency showed a significant level with $F_{(2.322,111.472)}$=5.631 *, p=.002 < 0.5, as shown in Figure 3. Therefore, this research conducted simple main effect test. The results showed that the high and low cognitive efficiency in the social loafing situation was significantly different, with the low cognitive of $F_{(1.910, 111.472)}$ =25 *, p = 2.15E-06 and high cognition of $F_{(2.018, 111.472)}$=61 *, p=1.34E-07, both P values were less than .0083 with significant differences. After the comparison, we found that the social loafing phenomenon of low cognition was 1, 3> 2, 4, while the high cognition was 1, 3>2>4. The Mauchly's W coefficient of restoration force was .455 (χ2=36.745; p <.05). After correction, there was no significant interaction between social loafing and restoring force with $F_{(2.245, 107.775)}$=082, p=.938> .05. The Mauchly's W coefficient of self-confidence was .504 (χ2=32.005; p<.05) and, after correction, the interaction between social loafing and self-confidence showed a significant level with $F_{(2.337, 112.188)}$=5.216 *, p=.005 <.05, as shown in Figure 4. Hence, this study conducted a simple main effect test and the results showed that the sport performance of high and low self-confidence in the social loafing situation were significantly different, in which the low self-confidence was $F_{(2.365, 112.188)}$=18 *, p=1.6E-07 and the high self-confidence was $F_{(2.222, 112.188)}$=55 * = 2.2E-07, both p values were less than .0083 with significant differences. After the comparison, this study found that the social loafing situation of low self-confidence was 1, 3> 2> 4 and that of high self-confidence was 1, 3> 2, 4.

Table 3. The descriptive statistics table of sport performance of sport confidence in social loafing situation

High/low skill		Situation 1	Situation 2	Situation 3	Situation 4
High skill (*n=24)*	*M*	.73	.69	.76	.67
	SD	.08	.08	.07	.10
Low skill (*n=26)*	*M*	.72	.67	.73	.69
	SD	.10	.10	.08	.08
High cognition	*M*	.72	.69	.75	.66
(*n=23)*	*SD*	.09	.08	.07	.09
Low cognition	*M*	.72	.68	.74	.07
(*n=27)*	*SD*	.11	.10	.09	.10
High restoration	*M*	.74	.69	.76	.69
(*n=25)*	*SD*	.07	.07	.07	.08
Low restoration	*M*	.71	.67	.73	.67
(*n=25)*	*SD*	.11	.11	.08	.11
High self-confidence	*M*	.73	.69	.76	.67
(*n=25)*	*SD*	.07	.06	.07	.09
Low self-confidence	*M*	.71	.67	.72	.69
(*n=25)*	*SD*	.11	.11	.09	.10

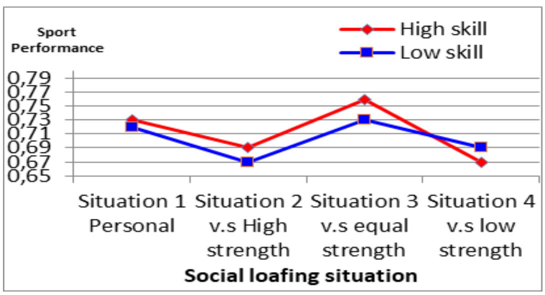

Figure 2. The ANOVA diagram of sport performance of high, low skills/trainings

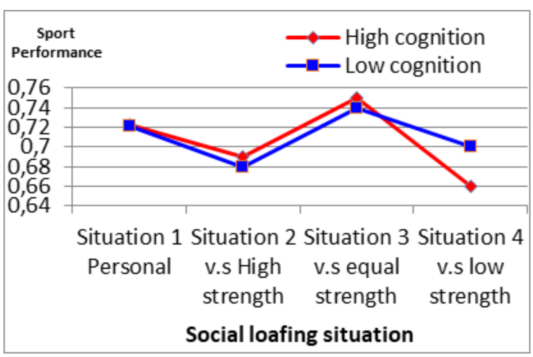

Figure 3. The ANOVA diagram of sport performance of high, low cognitions

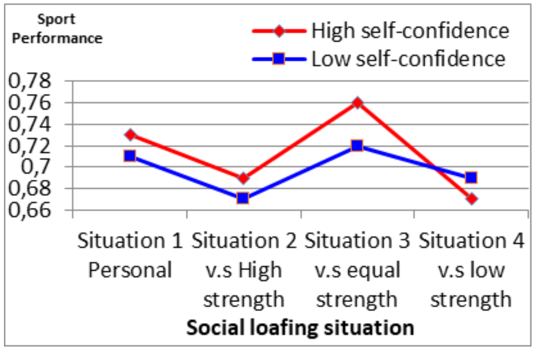

Figure 4. The ANOVA diagram of sport performance of high and low self-confidence

4. DISCUSSION

The results of this study showed that athlete's sport performance would indeed be different in different social loafing situations. After post hoc pair comparing with each other, it was found that, except situation 2 (group vs high strength) and situation 4 (group vs low strength), others all were significant and the results showed that 3> 1> 2, 4, in which situation 3 (group vs equal strength) was the highest, indicating that when athletes tended to inspire individual sport performance when encountering players with equal strength. In the situation 2 (group v.s high strength) and the situation 4 (group vs. strength low), the movement performance is poor, that when the athletes encounter high strength and low strength of the players, the more reluctant to make every effort to play. This is consistent with Heuze and Brunel's findings (2003) of when facing with player(s) of same level, an individual performance would increase, while facing with player(s) of better level, the individual performance tended to decline. In addition, the study also found that when athlete faced encounter with lower strength, a social loafing condition would also occur and the sport performance would decline accordingly.

This research not only found that, in each variable of the peer ledership only social leadership and social loafing generated interaction, but the high, low socail leadership exerted impact on the sport performance in the four situations of social loafing, which indicated social leadership could demonstrate social support as well as encouragement and care to team members that ehhanced the team's sport performance. The results of this study supported the findings of Carron et al., (2005), suggesting the role of social leadership orientation could provide support for some tension relationships, promoting team solidarity, and emphasizing team cohesion, which might have some impact on sport performance. This paper also supported the findings of Bednarek, Benson, and Mustafa (1976), suggesting that peer leadership might use different leadership style under different situation. The possible reason for this might be because the coach believes that athletes' leadership and team efficiency and performance could be interacted.

This study showed that the interaction of levels of skill / training, cognitive efficiency, self-confidence with social loafing would affect sport performance, that is, the sport performance would be affected by different situations and the levels of skill /

training, cognitive efficiency and self-confidence. Zhou Wen-Xiang (1995) pointed out that in the process of skill learning or sport competition, lack of self-confidence will affect individual's attention and generate self-doubt and thereby affect the sport performance. The results of this study also showed that sport performance in social loafing situation was affected by self-confidence as well, which is consistent with the inference of relevant literatures and shows the importance of sport self-confidence to sport performance.

Study findings discovered researchers may refer that players tend to have a bitter fighting scenes when encountering with competitors with less strength. Many of the reasons of such condition are generated from social loafing, that means, individual concentration under the mentality of expected victor would be more relax which results in less effective performance in technique. Or when encountering opponent(s) with high strength, the athlete might surrender earlier and ultimately under the expected mentality of lose. The spirit of unyielding confrontation till the end will only display when facing opponent with equal strength.

Through social loafing, this study not only understood the enhancement of sport forehand spin performance of table tennis as well as the interaction between peer leadership and sport self-confidence, but also verify the literature and theory of past empirical researches; however, there are also some limits in this study. In the past, the study of social loafing focused on the the size, effectiveness and identiablilty of team, and the laboratory research also distinguished the size of teams based on teme project, and then conducted sport test in team work situations from each team to serve as the way to identify the social loafing. However, this study was based on individual projects and used virtual sport competition as a sport situation of social loafing to carry out experiment. Therefore, it is recommended that there should have more practical research to be conducted in order to strengthen the conclusions of this study. In addition, the coach shall be able to timely, focusng on the player's own psychological factors, personal characteristics and the status of the scene during the time of training, before and after the game, provide counselings and reminders, in order to avoid social loafing generation that affects the overall performance.

The topic concerned in this study was how the sport forehand spin performance of table tennis is affected by social loafing as well as how such impact affects the interaction between peer leadership and sport self-confidence. The conclusion of this study confirms that the peer leadership and sport self-confidence in social loafing situations will affect the sport performance, and find that, through the test of different situations of individual athlete participating team competition, psychological factors, the same as external factors, will also affect social loafing.

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The Current Situation and the Developmental Prospects of the Public Table Tennis Rating Game in China

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Abstract: The Public Table Tennis Rating Game (PTTRG) has become increasingly popular in China. This paper investigates the current status of the PTTRG in China via research based on a literature review, interviews of experts, questionnaires, mathematical statistics, comparison analyses research methods, based on the rating game mode and sport E-marketing as the theoretical foundation for the study. Comparisons are made between various periods of the developmental process, the findings outline the influential factors of the PTTRG and make an analysis of it in the end. The developmental strategies and suggestions are put forward.
The conclusions are as follows: 1) Although the number of people and matches of the PTTRG in China have been largely elevated, they are also staying at their developmental stages. The PTTRG has experienced the process that is originally introduced by China Table Tennis Association (CTTA), and have been well developed within the public. Furthermore, this is accepted at an official level. The PTTRG is progressively developing at the bottom level of the pyramid. However, there are still many existing dormant members. 2) The PTTRG are currently individually operated by online platforms. 3) The influential factors of the PTTRG include: systems and standards; basic conditions, social support and cooperation, participants, online platforms and organizers and qualifications.

Keywords: table tennis, public, rating game, PTTRG, current situation, developmental prospects

1. INTRODUCTION

Even though the performance of American Table Tennis is not competitive in the world, its rating game, starting during the 70s, has become increasingly successful and systematic. Currently, all the levels of competition in American table tennis are using this rating system to record the changes of individual rating.

There are huge table tennis fans based in China. However, because a lack of a scientific competition model, the scale of competition and participation is low (Guo, 2009). Meanwhile, for the purposes of enhancing public fitness and sport for all, a series of governmental policies and regulations were published (General Administration of Sport of China, 2011; 2014). In 2006, the CTTA introduced the American rating game into China as a PTTRG to better attract participants and to manage public competitions. However, the previous PTTRG cannot be widely developed because of a lack of liquidity and unfair groupings based on age and gender (Sun, 2009). In 2009, many internet companies, such as Kaiqiu.cc in Beijing, Happypingpang.com in Suzhou, Aijuwang.net in Shanghai, Bokett.com in Hebei and so on, introduced rating systems and launched PTTRG online platforms. They gradually collaborated with local table tennis clubs and sponsors to promote PTTRG in China. These platforms aim to increase the website viscosity and the participation of the PTTRG through the rating system and membership system, and to create a popular table tennis tournament brand that can attract table tennis enthusiasts. According to the rating system, members are graded by their initial levels and changed along with the results of the game. With the further support of CTTA and local table tennis associations, PTTRG was developed on a larger scale. Researches (Ding, 2010; Li, 2004; Liang & Ji, 2011) focused on the developmental prospects of PTTRG in some districts but there is no research study on PTTRG on a nationwide scale. Therefore, this paper focuses on the developmental strategies and suggestions for PTTRG in China.

2. METHODS

Taking three online platforms, Kaiqiu.cc, Happypingpang.com and Aijuwang.net as examples, three research methods were applied to investigate the PTTRG organization model and the developmental prospects in China.

2.1 Interviews

Ten people including 3 CEOs of table tennis internet companies, 3 PTTRG organizers, 2 table tennis club managers and 2 players on PTTRG in China were interviewed to obtain the current situation of PTTRG at various stages of the developmental process.

2.2 Questionnaires

A questionnaire was designed with two sections: Personal Information and the influential factors Scale. The study randomly selected nine matches (three on each online platform). The duration of the survey was thirteen days. The total number of participants were 300 and 297 questionnaires were returned. 279 valid questionnaires were collected with a 99% response rate and 93.9% efficiency.

2.3 Statistical Analysis

The data has been processed by using the SPSS 16.0 software. The basic statistical parameters have been calculated to reveal the (mean, standard, deviation, frequency of answers). To ascertain key influential factors for the developmental process of PTTRG in China, the factor analysis and Principal Component Analysis were employed.

3. RESULTS AND DISCUSSION

3.1 Cooperation and management system analysis

From 2010, the PTTRG experienced a process that was introduced at official level (CTTA). It was well-developed at grass-roots and then gradually accepted again at the official level. The structure of the cooperation and management system of PTTRG in China is presented as a pyramid below (see *Figure 1*).

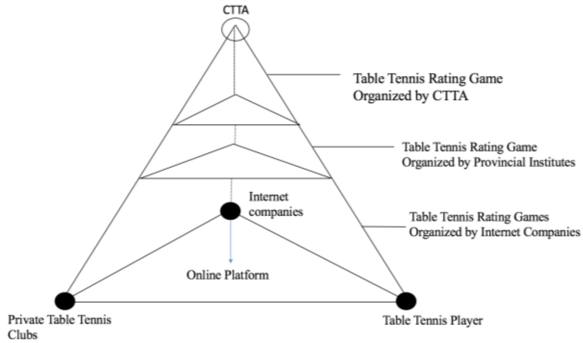

Figure 1. Cooperation and management and the structural analysis of the PTTRG in China.

CTTA stands at the top of the pyramid. As an authority, CTTA has limitations in its organization of competitions because of insufficient staff. That is to say, a nationwide PTTRG also needs to be associated with the provincial and local table tennis associations. However, provincial and local table tennis associations are not affiliated to CTTA. This situation results in low efficiency cooperation and poor promotion. The PTTRG is organized by the city and the provincial levels are in the middle level of pyramid. It is also a small portion of the market. The majority of participants stay at the bottom level of the pyramid. The PTTRG in this level is jointly organized by internet companies, amateur table tennis clubs and competition organizers within an online and offline mode.

3.2 The function and status quo of the platform of PTTRG

The online platforms of PTTRG are implemented, operated and managed by internet companies. It is mainly served as a Social Network Site (SNS) for promoting PTTRG and also for providing information on table tennis competitions, activities, table tennis equipment, facilities, coaching information and so on.

1) The rating recording function of the platform of PTTRG

The online platforms are used to better manage and supervise the PTTRG. Its functions include setting up the role of the rating system, publishing the competition information, promoting competitions and recording ratings. Moreover, the platforms are also an online community where participants can publish and share competition information, blog, share pictures and videos. Besides, as self-media platforms, it is also an important marketing tool for PTTRG (Dubosson-Torbay, Osterwalder, & Pigneur, 2002).

The rating system of PTTRG is based on the rules of the USA Table Tennis Leagues. The ratings in China started from 400 and the higher the table tennis skill of the participant, the higher the rating is. *Table 1* explains the rating variation mode. The total points won or lost will be calculated for each player based on the ratings chart. Players will gain or lose points based on this new rating.

Table 1. The standard of rating score in China.
Source: Happypingpang.com

A	B	C
0-12	8	8
13-37	7	10
38-62	6	13
63-87	5	16
88-112	4	20
113-137	3	25
138-162	2	30
163-187	2	35
188-212	1	40
213-237	1	45
238 and up	0	50

A: Point Spread Between Players
B: Expected Result (Higher Rated Player Wins: number of points exchanged)
C: Upset Result (Lower Rated Player Wins: number of points exchanged)

2) The Status quo of the online platform of PTTRG

Even though different online platforms use the same evaluation criteria and the same calculation system, the rating distribution is varied. Taking Happypingpang.com and Kaiqiu.cc as a comparison (See *Figure 2*), the rating range of Kaiqiu.cc approaches the normal distribution and reaches the peak of the rating between 1601-1800. The top rating of Happypingpang.com remains the same as the range for Kaiqiu.cc. However, the members of Happypingpang.com have less high level skilled players and more players with low ratings than Kaiqiu.cc.

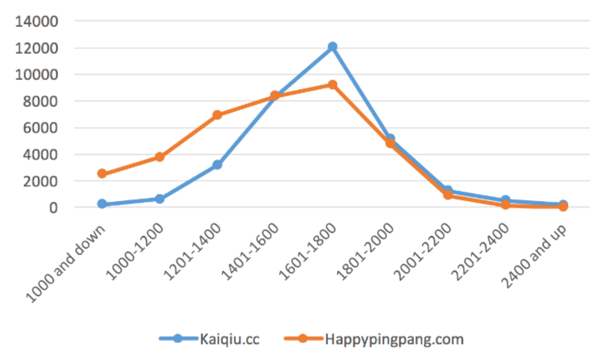

Figure 2. Rating distribution for Kaiqiu.cc and Happypingpang.com

In the rating range for 1401-1600, Happypingpang.com and Kaiqiu.cc have the same number of participants. Kaiqiu.cc has more participants above this range while Happypingpang.com has more participants below this range. The two platforms exploit the same rating system but with relative independence. The rating range of two platforms are different based on different participants.

3.3 Participation rate and dormant members

Based on the statistical analysis on the online platforms (see *Table 2*), there is a huge number of registered members, about 230,000, including 154,200 males and 75,800 females. This number includes those people who have only registered online and not played any match, the so-called dormant members. They can also participate in the online activities, such as posting messages, discussing and browsing the latest news. Only registered players who played matches can get rated. Dormant members on website platforms reach over 130,000. The participation rate of PTTRG is only 41%. With a majority mass base of males, the participation rate of females is higher than that of males.

Table 2. Participation rates and dormant members
Source: Happypingpang.com, Kaiqiu.cc and aijuwang.net

	Platform Members (Numbers)	Participants (Numbers)	Participation Rate (%)	Dormant Members (Numbers)
Male	154,200	62,400	40	91,800
Female	75,800	32,600	43	43,200
Total	230,000	95,000	41	135,000

a. Participation Rate= Participants/Platform Members
b. Dormant Members= Platform Members - Participants

3.4 Primary influential factors of impacting the development of PTTRG in China

In order to investigate the influential factors of the development of PTTRG in China, an instrument was designed and 24 measurement items were confirmed by experts (See *Table 3*). The influential factors were graded on a 5-point Likert scale (5 – Strongly agree, 4 – Slightly agree, 3 – Agree, 4 – Slightly disagree, 1 – Strongly disagree). The main influential factors were reduced dimensionally from a Principal Component analysis using a varimax rotation.

Table 3. Potential listed Influential Factors

	Potential Influential Factors
1.	Competition rules
2.	Reward and punishment systems
3.	Table tennis mass base
4.	Rating rules
5.	Website construction of public rating game
6.	CTTA attach importance to the development of public rating game
7.	The efficiency of rating publishing
8.	Rating group
9.	The power of propaganda
10.	Registration, sign up and transportation
11.	Cooperation between stakeholders
12.	Level of participants
13.	Standard of participants
14.	The ability of Competition organizers
15.	Entry costs

(continued)

	Potential Influential Factors
16.	Competition facilities and services
17.	Referees
18.	Information delivery and communication between players
19.	Ambience
20.	Censorship of Qualification
21.	Registration with ID
22.	Type of competition
23.	Sponsor support
24.	National integration

As noted by Thang (2004), the values of KMO are used to quantify the degree of inter-correlations among the variables and the appropriateness of factor analysis; taking values from 0 to 1 as guidelines: (1) 0.80 or above, meritorious; (2) 0.70 or above middling; (3) 0.60 or above, mediocre; (4) 0.50 or above, miserable; and (5) below 0.50, unacceptable. It helps to predict whether data is suitable to perform factor analysis. In this study, the KMO measure was 0.81, meaning it is located in the category 0.80 or above, meritorious (See *Table 4*). Another test employed was Bartlett's test of the Sphericity Correlation Matrix. The Bartlett test for all runs of factor analysis showed a non-zero correlation existing at the significant level of 0.000 (Bartlett's Test of Sphericity = 3566.637). In brief, the statistical results provided a very sound support for the suitability of the factor analysis in this case.

Table 4. KMO and Bartlett`s Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.81
Bartlett`s Test of Sphericity	Approx. Chi-Square	3566.637
	df	276
	Sig.	.001

Table 5 lists the eigenvalues associated with each linear component. There are two options to obtain principal components: 1) the cumulative is higher than 80% and 2) total eigenvalues are higher than 1. Finally, six principal components were extracted with a total cumulative rate of over 66.55%. The principal components can basically reflect the original data. The six influential factors are the factors of Systems and standards, the factor of basic conditions of PTTRG, the factor of social support and cooperation, the factor of participation, the factor of online platforms and organizers and the factor of qualifications. The following paragraphs explain the main influential factors separately.

Table 5. Total Variance Explained

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	8.369	34.872	34.872
2	2.296	9.566	44.438
3	1.498	6.243	50.681
4	1.407	5.861	56.542
5	1.247	5.197	61.74
6	1.155	4.812	66.552
7	0.834	3.476	70.028
8	0.819	3.411	73.439
9	0.745	3.104	76.543
10	0.674	2.809	79.351
11	0.653	2.72	82.071
12	0.576	2.399	84.47
13	0.551	2.297	86.767
14	0.534	2.224	88.991
15	0.435	1.812	90.803
16	0.38	1.582	92.385
17	0.364	1.516	93.901
18	0.314	1.307	95.208
19	0.278	1.16	96.368
20	0.238	0.993	97.362
21	0.203	0.847	98.209
22	0.178	0.742	98.95
23	0.136	0.566	99.517
24	0.116	0.483	100

1) *The factor of systems and standards*

Based on the principal component analysis, the Reward and punishment system, Referees, Types of competitions, National integration, Competition rules, Rating rules and Rating groups are seen as key factors that impact the factors of the system and equity norm.

The regulations and criteria are disregarded in order to facilitate the operation of the competitions and a systematic development. The most attractive point of PTTRG is the rating system. The rating system can measure the level of participation, which is widely approved by participants. It is important to keep the system and regulations objective. The more accurate the original rating, the less impact of inaccurate ratings for new participants. The more matches they play, the more accurate the ratings are given. Furthermore, more support systems are needed to make the competition more attractive. Currently, the match rules are not formulated by the online platform. Instead, the organizers of PTTRG can make them themselves.

2) *The factor of the basic conditions of PTTRG*

The components of Registration, the signing up process, the Convenience of transportation, Entry costs, Competition facilities and services, and Ambience, decide the developmental trends of PTTRG. All participants want to pay less entry fees while playing more matches. It is important to balance these two. Convenient transportation and good facilities can attract more participants. Currently, the clubs are small with tightly spaced tables. Moreover, only a few stadiums are air-conditioned and the venues are far from the city center.

3) The factor of social supporting and cooperation

The power of propaganda shows that CTTA attaches importance to the development of PTTRG, Cooperation between stakeholders and Sponsor support are recognized as the key factors for social support and cooperation.

The well and long term operation of PTTRG in China need social support and cooperation. Key stakeholders, such as CTTA, local clubs, social platforms, competition organizers and participants, closely work together, monitoring each other. This will play an important role of operating the PTTRG in China.

4) The factor of participants

The factor of participants involves, the table tennis mass base, the Level of participants and the Standards of participation. The participants are the main body of PTTRG. The participation rate has direct impacts upon the development of PTTRG. The participation rate depends on individual participants and it is difficult to control. The competition is often impacted by participant's personal reasons, such as being late, leaving early and even match-fixing. In 2015, there were only two participants that attended the competition while three players could not attend due to their personal reasons. Based on the rules and regulations of the competition, the least number of participants is five people. Hence, the matches tend to be cancelled, which has negative impacts on the PTTRG in China.

5) The factor of online platforms and organizers

The factor of online platforms and organizers includes the efficiency of rating the publishing, the website construction of the public rating game and the ability of competition organizers. The online platform is the main body responsible for monitoring the operation of PTTRG. The standard of operating PTTRG is simplified and run automatically through the online platform. It can be clearly shown by participants in terms of the process of PTTRG, from the launching of the competition, registration, dividing the groups, and publishing the updated ratings. Participants want to see their updated ratings as soon as they play a match. However, the process of rating the inputs is always delayed.

6) The factor of qualifications

The factor of qualifications includes the Censorship of Qualifications and Registration with ID. Traditional competition has censorship forms meant to identity the qualifications of participants. The qualification of PTTRG ignores the traditional categories such as age and gender. Instead, participants are divided into groups according to their ratings. Some participants with high ratings would play with low rating players to gain big bonus. The unfair phenomenon is caused by disorderly management systems. Sometimes participants have the same name in the system or one participants has more than one rating in an online platform. A complete monitoring and management system is extremely urgent for PTTRG in China.

4. CONCLUSIONS AND SUGGESTIONS

Although the number of people and matches of the PTTRG in China have been largely elevated, they are also staying at their early developmental levels. The PTTRG has experienced the process that was originally introduced by the CTTA, and well developed among the public. Furthermore, it is accepted at official level. The PTTRG is progressively developing at the bottom level of the pyramid. However, there are many existing dormant members. The PTTRGs are individually operated by online platforms. The influential factors of the PTTRG include: systems and standards, basic conditions, social support and cooperation, participants, online platforms and organizers and qualifications.

There is a long way to complete the system and regulations on a nationwide scale. The CTTA should communicate with online platforms to ensure a well-organized management system and surveillance mechanisms in China. The CTTA and online platforms should promote incentive mechanisms to attract more brand sponsorships to further involve potential participants and expand the network of PTTRG in China. The online platforms should be developed and explored to better serve participants. Meanwhile, the online platform also needs to be designed to have complete functions and Apps for mobile phones and for attracting more members. Furthermore, the online platforms should further enhance cooperation within middle – large sized stadiums to intensify the facility utilization ratio and to better serve PTTRG in China.

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Quantization Analysis of Deviation Propagation Effect Results from Error-Estimated Table Tennis Players' Ratings

~ A Monte Carlo Simulation Approach

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Abstract: USATT rating system, initiated since 1970s, had been the most well-known sports rating system in the world. The rating system uses single parameter logistic model derived from Item Response Theory (IRT) to quantize a table tennis player's playing strength. Because it is easy to perform, including ITTF, the system had been widely adapted with some deviations all over the world. As a computer programmer and table tennis enthusiast, I wrote a computer program and devoted in table tennis players rating calculation for the past decade in Taiwan (TWTT Rating System). There had been 36,737 table tennis players registered in our database while 3,147 events and 522,101 matches were recorded for calculating and analysis. A Mote Carlo simulation program was developed in this research to analyse the effect of error-estimated ratings problem. Each simulated player has two rating scores, one represents his real playing strength and the other imply the observation from computer program which might be equal or deviated from his real ability by manipulation. The outcome of all simulated matches were determined by two opponent's real playing strength using single parameter logistic probability model while the observation rating score will be re-calculated according to the outcome above in every simulated match. Deviation between real playing strength and observation rating for error-estimated players and whole population could be thus analysed iteratively. We hope that this simulation can help us for the development of the automatic rating adjustment process for the error-estimated players in the future.

Keywords: TWTT rating system, Monte Carlo simulation, item response theory, standard error of measurement

1. INTRODUCTION

USATT-Style rating system, unlike traditional sports ranking system, is a rating system based on statistics and probability theorem. It presume that each player has a playing strength defined by a score, the so-called rating, and will change over time as the player gets better or worse. When 2 players play in a game, the one with higher rating score will defeat the one with lower rating score more likely as expected result. But there is still chance that the lower rating player will defeat the higher one which was called the upset result. The lager the difference between 2 opponents' rating score, the more likely that no upset result would happen. Because it is easy to perform, including ITTF, the system had been widely adapted with some deviation all over the world. We started to create Taiwan's table tennis rating system since 2004 (http://www.cybertabletennis.com/TWTTRating/). Since then, 3,147 events, including ITTF Pro Tour Chinese Taipei Open or some regional rating games, had been included while 36,737 players' 522,101 matches had been recorded for rating calculation. To fully utilize the computer program automation, we also proposed a new algorithm to determine players' initial rating by using least square sense optimization approach to estimate the most likely initial rating of a new player according to his first event matches record which had been also submitted to 9th ITTF Sports Science Congress. Being elected as the director-general of both Taiwan Veteran Table Tennis Association (TVTTA) and Chinese Taipei Table Tennis Association for College Alumni (TTACA), we are now focusing the rating calculation on aging and veteran table tennis players in Taiwan.

According to the past 10 years' experience, there is always an annoying problem in rating calculation. Since the computer program estimates players' playing strength only by their matching records in the first event, there might be always over- or under-estimated table tennis players in the rating process. Theoretically, we assumed that those error-estimated players' ratings could saturate to a stable rating score representing their playing strength after more events, but we have no idea how those error propagated in the whole population. A Mote Carlo simulation program was developed to address this problem. Each simulated players had two rating scores, one represents his real playing strength and the other imply the observation from computer program which might be equal or deviated from his real ability by manipulation. The difference between these 2 scores is defined as the measurement error. The outcome of all simulated matches were determined by two opponent's real playing strength using logistic probability model while the observation rating score would be re-calculated according to the outcome above. Deviation between real playing strength and observation rating for error-estimated players and whole population could be thus analysed through simulation. We calculated the standard error of all measurement errors for every players after simulation and illustrated the error propagation effect via histogram bar chart so that the uncertainty of the rating system could be examined due to the initial error estimated players.

2. THEOREM

2.1 USATT-Style rating system

The USATT Rating System's rating table is listed as *Table 1*.

Table 1. USATT Rating Chart

Rating Difference between 2 Opponents	Expected Result	Upset Result
0 ~ 12	8	8
13 ~ 37	7	10
38 ~ 62	6	13
63 ~ 87	5	16
88 ~ 112	4	20
113 ~ 137	3	25
138 ~ 162	2	30
163 ~ 187	2	35
188 ~ 212	1	40
213 ~ 237	1	45
> 238	0	50

Consider that if two opponents' rating scores have saturated to their real playing strength, assume that their playing strength won't change in the future, the rating transaction rule according to the rating table shall not change their rating scores after "infinite" matches. That is, the overall expected rating for those two players will gain from this rating table shall be zero after they have played many games. Therefore, the rating table actually imply the odds for expected results and upset results as Table 2.

Table 2. Odds for expected results and upset results.

Rating Difference	P_1	P_2
0 ~ 12	0.5000	0.5000
13 ~ 37	0.4118	0.5882
38 ~ 62	0.3158	0.6842
63 ~ 87	0.2381	0.7619
88 ~ 112	0.1667	0.8333
113 ~ 137	0.1071	0.8929
138 ~ 162	0.0625	0.9375
163 ~ 187	0.0541	0.9459
188 ~ 212	0.0244	0.9756
213 ~ 237	0.0217	0.9783
> 238	0.0000	1.0000

P_1: Odds for lower rated player to defeat the opponent, the expected result.
P_2: Odds for lower rated player to be defeated by the opponent, the upset result.

In the Item Response Theory (IRT) for modern test statistics, we use Rasch Model (one-parameter logistic model) to express the probability for a student with ability θ who can answer a question with difficulty *b* correctly.

$$P(\theta,b)=\frac{e^{D(\theta-b)}}{1+e^{D(\theta-b)}} \quad (1)$$

D : constant ~ 1.7, $\Rightarrow P(\theta,b)$ ~ (0,1)

θ : student's ability, normal distribution ~ (0,1)

b : question's difficulty, normal distribution ~ (0,1)

Similarly, we can find that the USATT-style rating system use the same manner to express the probability function of rating difference for the match results. When D was set to 0.01637, θ and b represent the rating of two opponents, the Equ. (1) becomes the probability function for the odds for expected result of rating difference (θ-b) as Equ. (1*). *Figure 1* is a demonstration of the rating table and the continuous probability function.

$$P(\theta,b)=\frac{e^{0.01637\times(\theta-b)}}{1+e^{0.01637\times(\theta-b)}} \quad (2)$$

θ: Player's real playing strength

b : Opponent's real playing strength

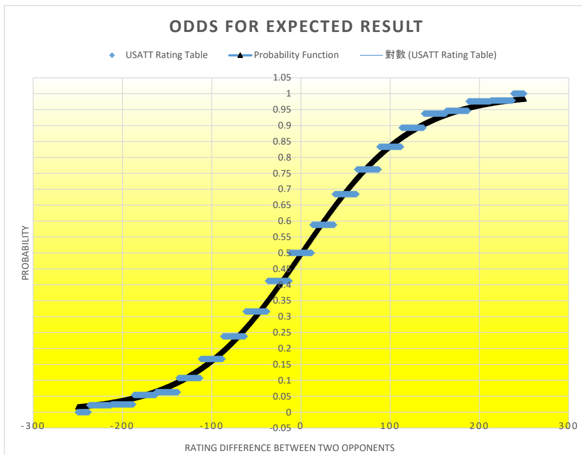

Figure 1. The rating table imply the logistic probability function for the odds of the expected result.

2.2 Standard error of measurement, $SE_{meas.}$

If $R_{\text{playing strength}}$ implies a player's real ability, let $R_{\text{observation}}$ denotes his current rating in the real world, the difference between $R_{\text{playing strength}}$ and $R_{\text{observation}}$ will be the measurement error E. Equation (3) shows this relation.

$$R_{\text{observation}}=R_{\text{playing strength}} + E_{\text{measurement error}} \quad (3)$$

Traditionally, it is normal to assume that the distribution of $E_{\text{measurement error}}$ could be a Gaussian distribution. The standard error of the measurement error ($E_{\text{measurement error}}$) for all population, $SE_{meas.}$, is then defined as the standard error of measurement of the rating system.

$$SE_{meas.}=\sqrt{<E_{measurement\,error}{}^{2}>-<E_{measurement\,error}>^{2}} \quad (4)$$

3. METHODOLOGY

The Monte Carlo simulation program was coded by C++ programming language. As mentioned above, 1,000 players with 2 rating scores (one denotes the real playing strength and the other represents the observation rating score) range from 1,000 to 2,100 with Gaussian distribution were generated in the program. Initially, the observation rating scores were set to be identically the same as the real playing strength. Custom-made measurement error of different distribution was then added to the observation rating scores for different simulation purposes. Arbitrary two players were selected randomly 20,000 times for simulation match and the match result was determined by their real playing strength difference using the continuous probability function (Equ. (2)) while the observation rating scores were then re-calculated according to the USATT rating table separately (Table 1). Measurement errors for each players were calculated and histogram was drawn for all population for each simulation. Standard error of measurement, $SE_{meas.}$, was calculated also to represent the precision and accuracy of each simulation.

There are 4 kinds of simulations discussed in this article to see the rating accuracy and precision in different conditions.

1. No measurement error was added into players.
2. Only 1 under-estimated player was simulated.
3. Only 1 under-estimated player played 100 matches with other accurate players.
4 30% of error-estimated players with Gaussian measurement error were simulated.

4. RESULTS

4.1 No Measurement error was added

Figure 2 shows the rating distribution histogram.

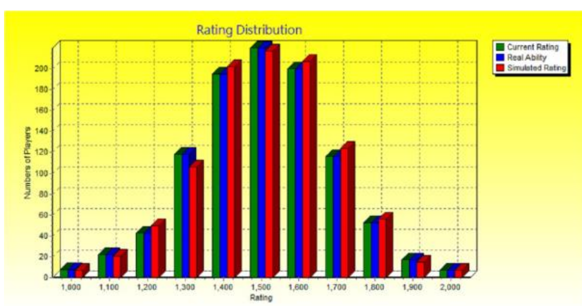

Figure 2. Rating distribution histogram for condition 1.

As the legend displayed in the right upper corner of the figure, the blue bar represents the real playing strength (Real Ability), the green bar represents the current rating (observed rating score), while the red bar represents the observed rating score after 20,000 times of simulation matches. Because no measurement error was added, the blue bar was identical as the green bar. We can see some slight change in the rating distribution after the simulation. *Figure 3* shows the error histogram before and after the simulation.

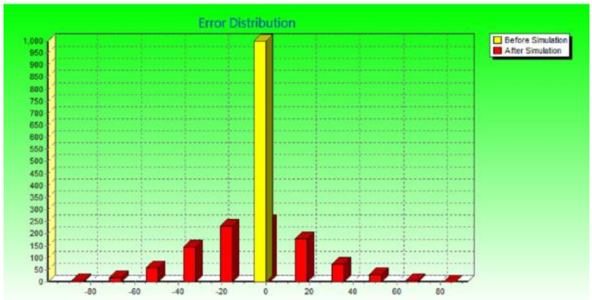

Figure 3. Error distribution histogram for all population before and after simulation in condition 1.

The standard error of measurement, $SE_{meas.}$, was equal to 26.703 after simulation (0 before simulation) which means that the rating system shows great accuracy and precision for different abilities players.

4.2 1 under-estimated player was simulated

Just like *Figure 2*, *Figure 4* shows the rating distribution histogram in condition 2 while Figure 5 shows the error distribution histogram before and after simulation.

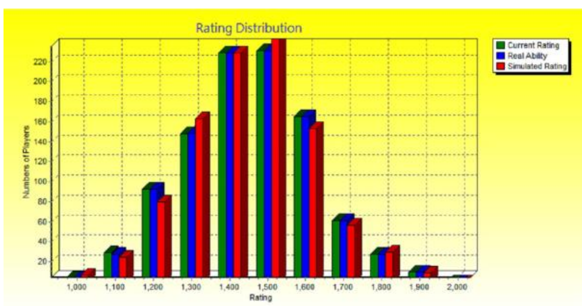

Figure 4. Rating distribution histogram for condition 2.

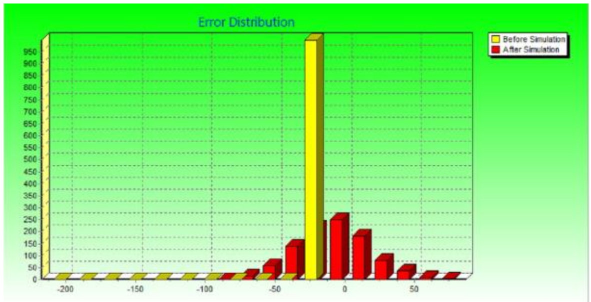

Figure 5. Error distribution histogram for all population before and after simulation in condition 2.

The standard error of measurement, $SE_{meas.}$, was equal to 27.106 after simulation (6.321 before simulation due to the only one under-estimated player) which means that the rating system shows great accuracy and precision even there is an under-estimated player with 200 rating score error.

4.3 Only 1 under-estimated player played 100 matches with accurate players

Neither of the above two kinds of histograms cannot show the rating evolution trend of the under-estimated player. Thus we simulated another situation for the under-estimated player. We randomly assign 100 accurate players to play with the under-estimate player and see if the under-estimated rating can be self-calibrated. *Figure 6* & *7* shows that an under estimated player's rating evolution trend after 100 matches with other accurate player was simulated.

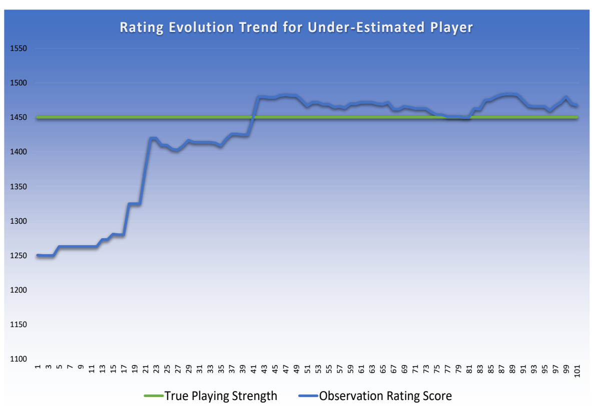

Figure 6. Rating evaluation trend for the 200 rating score under-estimated player.

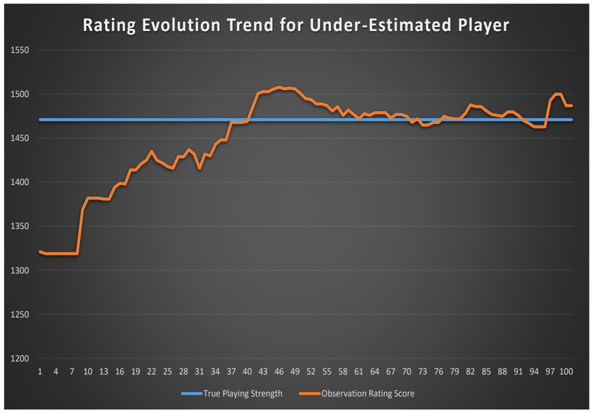

Figure 7. Rating evaluation trend for the 150 rating score under-estimated player.

4.4 30% of error-estimated players with Gaussian measurement error

Consider an extremely worse case that there are 30% error-estimated player where the error might be in Gaussian distribution. Figure 8 and Figure 9 are the rating distribution and error distribution histogram separately. The original standard error of measurement was 92.449 which is not acceptable while after 20,000 simulated matches, the standard error of measure meant drop to 42.747 which is in the acceptable region (< 50). Since there are so many error-estimated players in condition 4, you can see that the rating distribution for real playing strength and observation rating score are quite different in shape. But, it is also obviously that after the 20,000 simulated matches, the distribution of the observation rating scores of all players became much similar to the distribution of the ideal playing strength with Gaussian distribution.

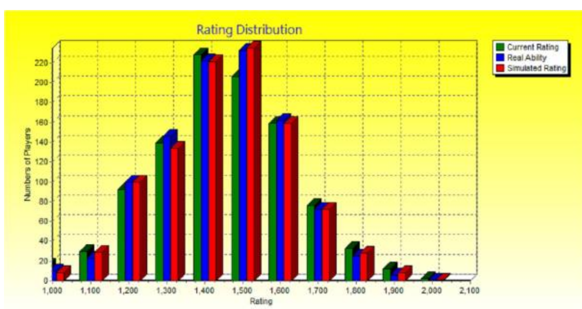

Figure 8. Rating distribution histogram for condition 4.

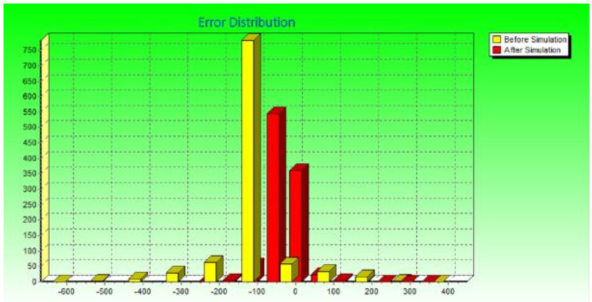

Figure 9. Error distribution histogram for all population before and after simulation in condition 4.

5. DISCUSSION & CONCLUSION

A novel approach to examine the USATT-Style rating system was proposed. The concept of standard error of measurement, $SE_{meas.}$, was adapted to quantize the accuracy and precision of the rating system. According to our simulation, for those well-estimated players, the USATT-Style rating system's standard error of measurement is about 26.703, while for those where there might be 30% of error-estimated players group, the rating system's standard error of measurement could be dramatically reduced to 42.747 from 92.449 after 20,000 matches. Nevertheless, according to *Figure 6* & *7*, it takes nearly 40 matches for the player with 150~200 rating score under-estimated to saturate to his real playing strength. And this is in the assumption of 1. The player's real playing strength will not change and, 2. Opponents'' observation rating scores are all accurate and with less measurement errors. If neither of the above assumption sustains, the rating calibration mechanism might be much worse and result in more and more measurement error to all populations.

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Comparative Analysis of the Table Tennis Plastic Ball and Celluloid Ball in Terms of Racket Angle

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Abstract: On July 1, 2014, the ITTF started implementing the use of the plastic ball in all ITTF sanctioned and World Title events, instead of the traditional celluloid ball. In addition to the material change from celluloid to plastic, there was also a slight change in the diameter and the weight of the ball from 39.50mm-40.50mm to 40.00mm-40.60 mm and from 2.67g-2.77g to 2.65g-2.82g.

The change in material, together with the change in diameter and weight, can greatly affect the game of table tennis and how it is viewed and played. Since this is a new and recent change and development in the sport, there are still a lot of areas to be looked into and studied.

The purpose of this study was to determine if there is a significant difference between the racket angles among the Philippine Men's Table Tennis National Team Players when using the plastic ball compared with that when using the celluloid ball. A quantitative, experimental, and within subject research design was used in this study. All 3 subjects were tested for both the plastic ball and the celluloid ball and repeated racket angle measurements were taken for all participants.

Results showed that among the group, there was a statistically significant difference between the racket angle measurements for the celluloid ball and plastic ball. Significant differences were also found in each one of the three player's racket angle measurements for the celluloid ball when compared to each one's own individual racket angle measurements for the plastic ball.

Keywords: table tennis, plastic ball, celluloid ball, speed, spin, racket angle, ITTF

1. INTRODUCTION

1.1 Background of the Study

On July 1, 2014, the International Table Tennis Federation (ITTF) started implementing the use of the plastic ball/poly ball in all ITTF sanctioned and World Title events, instead of the traditional celluloid ball. These events include the World Championships, the ITTF World Tour, ITTF Junior Circuit, and ITTF sanctioned continental events. Plastic balls and celluloid balls are both legal, however, the ITTF world title events and ITTF sanctioned events will use exclusively the plastic balls, whereas all other events are free to choose the type of ball they wish to use. Domestic tournaments can choose to use any approved ball, either celluloid or plastic.

The reason behind the switch to the plastic ball is two-fold. Initially, the reason given was that celluloid is increasingly becoming difficult and expensive to obtain, due to dangers in production and increasing regulatory restrictions. However, ITTF President Adham Sharara revealed in an interview in February 2014 that another purpose was to slow down the game by changing balls from celluloid to plastic for less spin and bounce. The ITTF took the view that by slowing the game down, the length of the rallies would increase, which in turn would make the game more appealing to television viewers.

In addition to the material change from celluloid to plastic, there was also a slight change in the diameter and the weight of the ball. Celluloid balls were required to be between 39.50mm and 40.50mm in diameter while the new plastic balls need to be between 40.00mm and 40.60 mm. The acceptable weight for the celluloid ball is between 2.67g and 2.77g while the allowable weight for the plastic ball is between 2.65g and 2.82g.

1.2 Statement of the Problem

In the Philippines, majority of the table tennis players still use the traditional celluloid ball in playing the sport. There are some table tennis associations and clubs, however, which have already started implementing the use of the plastic ball in some of their tournaments. This has caused some confusion and uncertainty to a lot of Filipino table tennis players and coaches alike on which ball they should use and on which techniques, styles, and strategies they should adopt, adapt, and employ in training, playing, and in coaching.

The Philippine national table tennis team and national table tennis players, as well, are also fazed by the same problem when they compete internationally since international events sanctioned by the ITTF (e.g., SEA Games, Asian Games, World Table Tennis Championships) all use plastic balls while majority of the table tennis events and tournaments in the Philippines (e.g., UAAP, NCAA, Palarong Pambansa) still use the traditional celluloid ball.

A difference in the material of the ball can lead to a different production of speed and spin on the ball. There is a common view and belief that the plastic material used on the plastic ball would decrease the ball speed and would make the game slower. There is also an assumption that the increase in diameter and weight would decrease the speed and the spin the ball can generate. This, in turn, could lead to some changes in the player’s technique such as increasing the racket angle to compensate for the decrease in the speed and spin of the plastic ball compared to the celluloid ball.

1.3 Objectives of the Study

The study would like to determine if there is a significant difference between the racket angles among the Philippine Men’s Table Tennis National Team Players when using the plastic ball compared with that when using the celluloid ball.

The study would also like to determine if there are significant differences individually for each of the 3 players when comparing each one’s own racket angle measurements using the plastic ball with each one’s own racket angle measurements using the celluloid ball.

In the case that significant differences are found, another thing the study would like to find out is if there is a large effect size or if there is high practical significance of the use of the plastic ball compared to that of the celluloid ball.

1.4 Scope and Limitations

The study focused only on the racket angles generated when hitting the plastic ball compared with that when hitting the celluloid ball. The study was conducted in the Philippines and was conducted on Philippine Men's Table Tennis National Team Players. The study is limited by resources such as money, time, venue, instruments, and equipment. The result and extent of this study was dependent on the availability of these resources.

2. METHODOLOGY

2.1 Research Design

An experimental, quantitative, and within subject/repeated measures research design was used in this particular study. Quantitative because it deals with empirical and numerical data such as the measurements of speed, spin, and racket angle, which were subjected to computational, mathematical, and statistical techniques and analyses. The study is also experimental in nature since some conditions are controlled and one of the variables are manipulated to determine its effect on a dependent variable. The independent variable in this study is the ball type which can be categorized into two: (1) plastic/poly ball – heavier and larger; (2) celluloid ball – lighter and smaller. The dependent variable that was measured depending on the ball type is racket angle.

2.2 Participants

The participants in this study are 3 of the Top 5 Male Philippine National Table Tennis Players from the Men's Philippine Table Tennis National Team. These are 3 of the top 5 male players in the Philippines based on the TATAPHIL (Table Tennis Association of the Philippines) National Selection Tournament which gathers the top players from all over the country to get the best of the best in Philippine Table Tennis. These are also the players who represent the Philippines in International tournaments and ITTF sanctioned events like the SEA Games, Asian Games, and the World Table Tennis Championships.

Player 1 is a defensive player and is a multiple medallist at the Southeast Asian Games in Table Tennis, winning Silver and Bronze medals in the Men's Singles Events and Men's Doubles Events. Meanwhile, Player 2 is a former Junior Philippine Table Tennis National Team Player and an up and coming table tennis player who has now transitioned to the Philippine Men's Table Tennis National Team even at a very young age. He has won bronze medals in the Southeast Asian Table Tennis Junior Championships 15-U Singles event and also took the Philippines boys 15-U team its first bronze medal. On the other hand, Player 3 comes from the Philippine Navy and has won several local and national competitions in the country. Player 1 plays a defensive style while both Players 2 and 3 play an aggressive offensive style of table tennis. All 3 players use an inverted rubber on the forehand side of their racket which they used to hit the ball with a forehand topspin.

2.3 Sampling

The subjects were primarily chosen due to their expertise in the skill that would be tested for the comparison of the plastic/poly ball and the celluloid ball, which is the forehand table tennis topspin stroke. These athletes are highly skilled and are considered the best table tennis players in the country. They are presumed to have accuracy, consistency, and mastery when it comes to executing the skill. These players were also chosen due to their experience in using both the plastic/poly ball and the celluloid ball in both local and international competitions. These help ensure that the data gathered would be reliable, appropriate, and accurate, both in terms of relevance and depth, especially since there is a lack of empirical evidence in the subject area.

Additionally, the subjects were also chosen on the basis of their specialist knowledge of the research issue and their capacity, availability, and willingness to participate in the research. The sampling techniques that were used in this study include purposive sampling, homogenous sampling, expert sampling, and convenience sampling.

2.4 Setting

The study was conducted in the TATAPHIL (Table Tennis Association of the Philippines) National Training Center in Rizal Memorial Sports Complex, Adriatico St., Malate, Manila. The setting was chosen primarily due to its availability, location, and accessibility to the participants of the study who train in the facility almost every day. This venue is considered to be one of the best table tennis centers in the country which would provide the necessary space, conditions, facilities, and equipment for conducting the study.

2.5 Equipment

ITTF approved 3-star plastic/poly balls and 3-star celluloid balls, all color white, were used in this study. The participants also played on an ITTF approved Table Tennis table with an ITTF approved net assembly using their individual ITTF approved table tennis rackets which all have inverted rubbers on the forehand side.

High-speed cameras which could record at frame rates of 30fps (frames per second), 60fps, and 120fps such as the GoPro Hero 4 Silver were used in shooting videos of the participants while they are executing the forehand topspin stroke using the plastic/poly ball and the celluloid ball. Three cameras were used in taking the videos simultaneously, one for the frontal view, one for the sagittal view/side view, and one for the top view. Tripods were used to mount the cameras and to hold them in place stably and steadily.

A Newgy Robo Pong Ball Feeding Machine was also used to feed both the plastic/poly balls and the celluloid balls to the players with consistent speed, spin, trajectory, height, position, ball frequency, and interval, to ensure accurate and reliable results. The speed was set at 15 (around 40mph), simulating an incoming topspin attack from an opponent.

2.6 Research Instruments

The primary research instrument that was used in this study to measure and compare racket angles produced using the plastic/poly ball and the celluloid ball is the Forehand Topspin Multiball Test. The Forehand Topspin Multiball Test is a test based on a table tennis drill or exercise called the multiball drill/exercise/training, wherein a player is continuously fed with multiple balls by a ball feeder which could be a coach, co-player, or a ball feeding machine also called robo pong. The test was adopted from the Forehand Topspin Multiball Drill/Exercise where the player hits the ball with a topspin using the forehand topspin stroke.

For this particular study, each player was asked to hit 20 balls using a moderate or medium power forehand topspin stroke with as much consistency as possible from a distance of 60cm away from the table for each trial. Each player was given 2 trials each for both the plastic/poly ball and the celluloid ball, respectively. After one trial for the celluloid ball, the player is then given a corresponding trial for the plastic/poly ball. A rest interval of 5 minutes in between trials was given to each player to give them time to rest and recover and also to eliminate the factor of exhaustion or fatigue. Players were not informed on what ball they are being fed with as this may affect their performance and execution. White balls were used for both plastic and celluloid ball to eliminate the possibility of identifying which ball they are being fed with.

Out of the 20 balls, only the middle 15 successful ball returns were taken into account and recorded for racket angle measurements. The first 3 balls were not taken into account to give the players an adjustment period to get used to the ball feed of the machine. On the other hand, the last 2 balls were not taken into consideration to eliminate the factor of fatigue or exhaustion.

A Newgy Robo Pong Ball Feeding Machine was used to feed both the plastic/poly balls and the celluloid balls to the players with consistent speed, spin, trajectory, height, position, ball frequency, and interval, to ensure accurate and reliable results. The speed was set at 15 (around 40mph), simulating an incoming topspin attack from an opponent.

Other research instruments that were used in this study are video analysis and biomechanical analysis. Simultaneous videos of the players while performing the test were recorded from 3 aspects: frontal view, sagittal view/side view, and top view. Biomechanical Analysis software such as Kinovea, Tracker, and Skill Spector were also used in analyzing these videos and in measuring racket angles in each of the tests performed by each player.

2.7 Procedure

Upon approval of the thesis proposal, the researcher sent a letter of intent to TATAPHIL (Table Tennis Association of the Philippines) President Ting Ledesma, seeking permission to conduct the study on the Philippine Men's Table Tennis National Team Players in their National Training Center. The researcher would like to thank Pres. Ting Ledesma and the TATAPHIL for being very much willing to participate in the study and for subjecting their players to testing and even going as far as lending their venue, center, facilities, and equipment for the conduct of the research.

The venue was set up with chroma key or blue screen backgrounds for better visibility of the ball and racket leading to more accurate measurements and analyses. Three high speed cameras were set up to take the videos, one for the frontal view, one for the sagittal view/side view, and one for the top view. These cameras were synced with each other using a feature of the Go Pro Hero which allowed it to shoot and record videos for all 3 cameras/aspects simultaneously. The camera for the frontal view was placed on top of the table just in front of the net facing the player, the racket, and the ball. The one for the sagittal view was mounted on a tripod and was positioned on the racket hand side of the player from a distance which would record the racket angle upon contact and the trajectory/path of the ball. The last camera was mounted on a tripod positioned above the player and the table to record the trajectory/path of the ball from the top view.

These videos were then transferred to a laptop/computer and were subjected to video analysis and biomechanical analysis using biomechanical analysis software such as Kinovea, Tracker, and Skill Spector. Racket angles were measured with the aid of video analysis and biomechanical analysis and a special feature in these software which allowed the measurement of the degree of angulation of the table tennis racket for each of the shots for each ball.

2.8 Data Gathering

Data was gathered using video analysis and biomechanical analysis. Videos of the players while performing the Forehand Topspin Multiball Test were recorded in May 2016 right after major local and international tournaments joined by the Philippine National Team. The racket angle produced using the plastic/poly ball and the celluloid ball were recorded and measured using these videos and biomechanical analysis software. Collection of data and data gathering was done from May 2016 to June 2016. After all the measurements and data have been collected and gathered, the data was then subjected to statistical analysis.

2.9 Analysis of Data

Descriptive measures such as the mean and standard deviation were used in this study to analyze and establish the reliability of the data. To analyze and interpret the gathered data even further, statistical analysis techniques such as the Repeated Measures T-Test was used with levels of significance at 0.01 to test for differences for racket angle measurements produced when using the plastic/poly ball compared to with that when using the celluloid ball. The researcher also used the Cohen’s d statistical technique to test for the effect size of using the plastic/poly ball compared to using the celluloid ball.

3. RESULTS

Results of data analysis are presented in this chapter. First, all racket angle measurements of all the 3 players in all of their trials for both the celluloid and plastic ball were combined and all taken together as one sample and tested for significant difference. Secondly, the measurements for the 2 trials for each player using both the celluloid and plastic ball respectively, were combined and taken as one to test for significant differences individually for each of the 3 players when comparing each one's own racket angle measurements using the plastic ball with each one's own racket angle measurements using the celluloid ball.

The researcher then looked for significant differences between the 2 types of balls in terms of racket angle in both conditions by computing for their means, mean differences, standard deviations, t-values, and confidence intervals. Aside from significant difference, the researcher also computed for the effect size, which is the magnitude of the effect of changing the ball from celluloid to plastic.

The study was conducted among 3 Philippine Table Tennis National Players: Player 1; Player 2; and Player 3. Each player was given 2 trials each to hit 20 celluloid balls and 20 plastic balls, respectively, with a moderate power forehand topspin stroke. The last 15 balls for each trial were taken into account and were recorded for racket angle measurements produced with each shot.

Table 1 and table 2 below show that among the 90 celluloid balls (n=90) and 90 plastic balls (n=90) hit by Players 1, 2, and 3 (30 celluloid balls and 30 plastic balls each), there was a statistically significant difference between the racket angle measurements for the celluloid ball (M=44.98, SD=5.79) and plastic ball (M=57.23, SD=6.56), t(89)=18.15, p<0.0001.

Table 1. Group Descriptive Statistics

Player Number	Ball Type	n	Mean	SD	Mean Difference	95% Confidence Interval
	Celluloid	90	44.98	5.79		
Players 1-3	Plastic	90	53.87	7.02	8.89	7.92-8.96

Table 2. Group Difference and Effect Size

Player Number	Ball Type	t-value	p	Difference	Cohen's d	Effect Size
Players 1-3	Celluloid vs. Plastic	18.15	p < 0.0001	Significant	1.38	Large

Table 3. Individual/Within Subject Descriptive Statistics

Player Number	Ball Type	n	Mean	SD	Mean Difference	95% Confidence Interval
	Celluloid	30	48.73°	7	8.5°	6.68-10.32
Player 1	Plastic	30	57.23°	6.56		
	Celluloid	30	43.53°	4.66		7.76-11.37
Player 2	Plastic	30	53.1°	7.53	9.56°	
	Celluloid	30	42.67°	3.12		6.97-10.16
Player 3	Plastic	30	51.27°	5.66	8.6°	

Table 4. Individual/Within Subject Differences and Effect Sizes

Player Number	Ball Type	t-value	p	Difference	Cohen's d	Effect Size
Player 1	Celluloid vs. Plastic	9.58	p < 0.0001	Significant	1.25	Large
Player 2	Celluloid vs. Plastic	10.84	p < 0.0001	Significant	1.53	Large
Player 3	Celluloid vs. Plastic	10.94	p < 0.0001	Significant	1.8809	Large

Further, Cohen's effect size value (d=1.38) showed large effect size, meaning that the use of the plastic ball compared to the celluloid ball led to a big increase in the racket angle used by the players to hit the ball. There is also a 95% confidence interval that that the mean difference lies between 7.92 and 8.96.

Results show that the 3 Philippine Men's Table Tennis National Team Players, when taken as a group, elicit a statistically significant difference between the racket angles when using the plastic ball compared with that when using the celluloid ball. From here, we could generalize that in the Philippine Men's Table Tennis National Team, there is indeed a big increase in the racket angles they use to hit the ball when using the plastic ball compared to that when using the celluloid ball. This shows that even elite players experience a need to compensate and adjust to the slightly heavier and larger plastic ball by opening their racket or increasing the racket angle.

After establishing a statistically significant difference between the racket angles among the Philippine Men's Table Tennis National Team Players when using the plastic ball compared with that when using the celluloid ball, the researcher then looked into possible differences individually for each of the 3 players when comparing each one's own racket angle measurements using the plastic ball with each one's own racket angle measurements using the celluloid ball.

As seen in tables 3 and 4 above, among the 30 celluloid balls (n=30) and 30 plastic balls (n = 30) hit by Player 1, there was a statistically significant difference between the racket angle measurements for the celluloid ball (M=48.73, SD=7) and plastic ball (M=57.23, SD=6.56), t(29)=9.58, p<0.0001.

Further, Cohen's effect size value (d=1.25) showed high practical significance or large effect size, meaning that the use of the plastic ball compared to the celluloid ball led to a big increase in the racket angle used by the players to hit the ball. There is also a 95% confidence interval that that the mean difference lies between 6.68 and 10.32.

On the other hand, based on tables 3 and 4, Player 2 who also hit 30 celluloid balls (n=30) and 30 plastic balls (n=30), also displayed was a statistically significant difference between the racket angle measurements for the celluloid ball (M=43.53, SD=4.66) and plastic ball (M=53.1, SD=7.53), t(29)=10.84, p<0.0001.

The Cohen effect size value (d=1.53) for Player 2 also showed high practical significance or large effect size, even higher than Player 1, suggesting that the use of the plastic ball compared to the celluloid ball for Player 2 led to an even bigger change in the racket angle. The 95% confidence interval for Player 2 shows that the mean difference between the celluloid ball and the plastic ball lies between 7.76 and 11.37.

Meanwhile, also basing on tables 3 and 4, Player 3 who likewise hit the same number of celluloid balls (n=30) and plastic balls (n=30), respectively, yielded the highest Cohen effect size value (d=1.88), exhibiting the largest effect size or the highest practical significance among the 3 players. This suggests that the use of the plastic ball compared to the celluloid ball had the biggest impact on Player 3 in terms of having to change or increase his racket angle when hitting the ball.

Among the 30 celluloid balls and 30 plastic balls hit by player 3, there was a statistically significant difference between the racket angle measurements for the celluloid ball (m=42.67, sd=3.12) and plastic ball (m=51.27, sd=5.66), t(29)=10.94, p<0.0001.

4. DISCUSSION

An experimental, quantitative, and within subject/repeated measures research design was used in this particular study.

In addition to the finding that there is a significant difference between the racket angles when using the plastic ball compared with that when using the celluloid ball among the Philippine Men's Table Tennis National Team Players when taken as a group, results also showed that there are also significant differences individually in the racket angles used by each player in hitting the plastic ball and the celluloid ball. Results showed that the racket angle measurements for the plastic ball for each individual player were higher compared to each one's own racket angle measurements for the celluloid ball. This means that the Philippine Men's Table Tennis National Team Players felt the effect of the change of the ball not only as a group or as a team but also individually.

These significant differences in the racket angle measurements among all 3 players individually and among all players taken together as a group can be attributed to the perceived and presumed decrease in the speed and spin of the plastic ball compared to the celluloid ball. Studies by Zhang and Wu (2000); Tang, Mizoguchi, and Toyoshima (2002); and Wei, Chuan, and Zhi (2002) showed that, indeed, a larger and heavier ball has less speed and spin compared to a smaller and lighter ball, thereby creating the need for the players to adjust their technique or style of play (i.e., increasing the racket angle).

The same can be assumed of the plastic ball which also has a larger diameter and a heavier weight compared to the celluloid ball, thereby generating less speed and spin and requiring a higher racket angle. According to Tang et al. (2002), it is estimated that there will be some changes in the playing style and the game tactics because of the new ball. It can be assumed that the changes of the diameter and weight of the ball will have some influence on player's performance. Celluloid balls were required to be between 39.50 and 40.50mm while the new plastic balls are required to be between 40.00 and 40.60mm. The acceptable weight for the celluloid ball is between 2.67 and 2.77g while for the plastic ball, the acceptable weight is between 2.65 to 2.82g (ITTF Technical Leaflet, 2014).

Speed and spin are two primary factors that play an important role in winning table tennis matches (Wu, Qin, Xu, and Xi, 1992). As seen in the 4th Phase in a Topspin Curve, if an incoming ball has a lot of topspin, the ball jumps upwards and the player is forced to compensate for the topspin by adjusting the angle of his/her racket by closing the racket or by decreasing the racket angle. Since the plastic ball is assumed to have less speed and spin compared to the celluloid ball, it is expected that the player would have to open his racket more or to increase the racket angle. This increase in the racket angle can be considered as a compensatory mechanism to the lesser spin coming from the plastic ball compared to the celluloid ball. As an adjustment to the lesser spin coming from the plastic ball, the player then naturally opens and increases the racket to a higher angle so that the ball would bounce off higher on the racket and would cross the net going to the other side of the table. If the player uses the same racket angle for the plastic ball as with the one he uses for the celluloid ball, there's a tendency that the ball would not cross the net as it would not bounce as high off the racket due to less spin.

Aside from the presumed decrease in speed and spin in the plastic ball, the significant differences in the average racket angle measurements for the plastic ball compared to the celluloid ball could also be due to other factors such as the speed and force of the stroke, length of backswing, contact point, contact timing, and follow through, which could all affect the racket angle used by the player in hitting the ball. According to the study by Wei et al. (2002), the extent of reduction of speed and spin with a heavier and larger ball is different for different players and different techniques. But despite the differences in measurements, attributes, and styles of play, Players 1, 2, and 3 all showed significant differences, individually and as a group, in the racket angles they used to hit the plastic ball compared with that to hit the celluloid ball which could be attributed to the perceived and presumed decrease in speed and spin of the plastic ball due to its larger diameter and heavier weight.

The ITTF took the view that by increasing the diameter and the weight of the ball, the new ball would have less speed and less spin, thereby slowing the game down and prolonging rallies, making table tennis more interesting and more attracting to spectators (Wei et al., 2002). The increase in racket angle due to the perceived decrease in speed and spin, therefore, aids in this vision of the ITTF of slowing the game down and making rallies longer to attract more spectators to watch the game as a higher racket angle would also mean a higher chance for the shot to get in and to cross the net. The increase in the racket angle also slows down the ball as the ball has to travel a farther distance and trajectory compared to hitting the ball with a lower racket angle. The change to plastic ball can favor high loopers because they are already accustomed to hitting the ball with a high racket angle. The plastic ball can also be advantageous to defensive players as the ball is slower, thereby giving the defensive player more time to react and prepare for his/her defensive tactics. On the other hand, the plastic ball can be a disadvantage to offensive players who are used to hitting the ball with a closed racket angle and with a forward hitting stroke. Overall, the change from celluloid to plastic ball can lead to significant changes to the sport of table tennis, not just in terms of the racket angle, but also in the force and speed of the stroke, contact point, contact timing, strategies, techniques, and playing styles.

5. CONCLUSION

Table tennis is a fast-growing sport drawing more and more attention from more players, enthusiasts, and spectators especially with the recent changes and developments to the game. With the advent of the new table tennis plastic ball which is slightly bigger and heavier than the traditional table tennis celluloid ball, it is expected that there will be some slight changes in the game and how it is played.

It is for this reason that the researcher chose to conduct this study to determine if there really are significant differences in the racket angles when hitting the plastic ball compared to that when hitting the celluloid ball. The researcher also looked for practical significance and the magnitude of the effect of the change from celluloid to plastic ball if significant differences are found.

The study was conducted on 3 Philippine Men's Table Tennis National Team Players and they were chosen due to their availability and their expertise and consistency in the skill or technique that was tested to yield more accurate and reliable results. The research design is a within subject/repeated measures design wherein the racket angle measurements for each player for the celluloid ball were compared to his own racket angle measurements for the plastic ball. The statistical techniques used were paired t-test/dependent t-test and Cohen's d effect size.

The results of the study revealed the following conclusions: (1) There is a statistically significant difference between the racket angles among the Philippine Table Tennis National Team Players when using the plastic ball compared with that when using the celluloid ball; (2) There are statistically significant differences individually for each of the 3 players when comparing each one's own racket angle measurements using the plastic ball with each one's own racket angle measurements using the celluloid ball.

6. RECOMMENDATION

After conducting a quantitative study on the subject matter, the researcher recommends further and more extensive quantitative studies in the sport of table tennis and in the field of biomechanics and sports science here in the Philippines. Despite the lack of testing means, facilities, and equipment, the researcher highly encourages other sports science students, faculty, players, coaches, trainers, and researchers to conduct quantitative studies in the field of sports science as it provides scientific bases and evidences to different changes, developments, claims, and findings in the area of sports and exercise. The researcher would also like to recommend the University of the Philippines Diliman College of Human Kinetics to acquire more sports science research and testing equipment for the students and the faculty to be able to conduct more quantitative research and to yield more practically significant and relevant findings that can be applied to improve the performance of athletes and to improve the health and fitness of humans.

Based on the results of this study, the researcher also recommends table tennis players, coaches, and trainers to look into experimenting and adjusting the racket angle by making it higher or more open when using the plastic ball. As seen in the study which was conducted on 3 of the top 5 male Filipino table tennis players in the country, there was an extremely significant difference between the racket angles when using the plastic ball compared to that when using the celluloid ball and there was also a high practical significance or big effect in the change or increase of the racket angle when using the plastic ball.

Additionally, the researcher recommends future studies to take into account and record measurements of the speed and spin of the ball coming from the ball feeding machine and also the speed and spin of the ball after it was hit by the player to help in clearly identifying the specific factors that lead to the increase of the racket angle when using the plastic ball compared to that when using the celluloid ball.

Furthermore, a bigger population and a bigger sample size is recommended to validate the results of this study and for more ideal, accurate, and statistically significant results. A pretest-posttest design with an intervention program can also be done in order to test for significant differences between the playing properties of the celluloid and the plastic ball and in order to test the effects of the intervention program. Future studies to be conducted on the difference between the celluloid and plastic ball can also consider and look into other adjustments, adaptations or factors applicable to the new ball such as contact point, contact timing, speed and force of the stroke, type of racket/blade used, type of rubber used, techniques, strategies, and playing styles.

As regards to which ball we should be using more for training and for competitions and tournaments here in the Philippines, the researcher recommends the Table Tennis Association of the Philippines to start implementing the use of the plastic ball in local and domestic tournaments so that we could keep up with international competition and so that the local players could already get used to the new ball because it requires a lot of time, effort, and a practice to adjust and transition to the newer plastic ball. This will also benefit and help the Philippines in its dream and goal of winning its first Olympic Gold, particularly in the beautiful and exciting sport of table tennis.

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A Method of Estimating Ball Drop Area using AE Measurement

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Abstract: To develop a system for analyzing the hitting position of a table tennis player in real time, the authors propose a method of estimating the position at which the ball hits the table, which is called the drop position of the hereafter, based on its acoustic emission (AE). Previous studies using small AE sensors have indicated that the drop position can be reliably estimated if it is less than 50 mm away from a sensor. However, the practical application of this method requires a large number of sensors, making the signal processing rather complex.

Therefore, in this study, we investigated a method of estimating the drop position of a ball more efficiently by using broadband AE sensors instead of small sensors. Specifically, we utilized four AE broadband sensors to estimate the drop position of a ball by applying a processing method using contour lines and found that it is possible to estimate the position within the range available for actual tactical analysis. Furthermore, in the processing method using contour lines, it takes about 0.05 s to estimate the drop position of the ball, indicating that tactical analysis could be performed in real time.

Keywords: ball drop position, estimate, AE senor, real time

1. INTRODUCTION

In today's competitive sports, objective analysis via scientific data collection is becoming an important method of improving the competitive skills of players. In ball sports in particular, it is useful to analyze the ball delivery pattern and play characteristics of the opponent in preparation for the game (Iizuka et al., 2013; Yang et al., 2010). Data collection is mainly performed using videos. Nowadays, it is also possible to formulate tactics and modify the performances of players during the game using tablet terminals in addition to video cameras. A system that can provide feedback about specific scenes by tagging captured images has been developed for use in table tennis also (Yoshida et al., 2004). However, since the rallies in table tennis are much faster than those in other ball game, a system that is capable of instantaneously calculating temporal and spatial indicators such as the area in which the ball strikes the table and the rotational speed of the ball has not yet been developed (Kamijima et al., 2017). In addition to video analysis, if a system that can instantaneously quantify the content of the game could be developed, it would be possible to devise tactical planning and training programs based on scientific rationale.

The authors are therefore working on developing a system that can instantaneously identify the position at which the ball hits the table, which is called the drop position of the ball hereafter, using acoustic emission (AE) sensors and quantitatively analyze the distribution pattern. AE is a phenomenon in which the energy stored inside a material is released as an elastic wave when deformation or cracks occur in the material and is used for monitoring and diagnosing the conditions of various mechanical system and buildings (Hase, 2012). When a table tennis ball hits the table, elastoplastic deformation occurs instantaneously and an AE wave (elastic wave) is generated. In the previous report, the possibility of identifying the area in which the ball hits the table, which is called the drop area hereafter, by measuring AE waves using the small AE sensors employed in earlier research is demonstrated (Kamijima et al., 2013). However, the use of small AE sensors is problematic because several of them are required for practical application, which complicates the signal processing.

In the present study, the AE waves generated when a ball hit a table were measured over a wide range using broadband AE sensors and a method of estimating the ball drop area more efficiently than is possible by using small AE sensors was examined.

2. METHOD

2.1 Experimental method

As shown in Figure 1, a coordinate system was created on one side of a table tennis table (VR-VERIC10-310; 25-mm-thick tabletop, SAN-EI), and a table tennis ball (Nittaku40+***) was dropped onto it three times from a height of 16 cm at each of 56 designated points. The grid of 56 points was created using all possible combinations of seven x-coordinates and eight y-coordinates in 20 cm increments. The distances of the coordinate system from the edges of the table were as follows: 5 cm from the end line, 6.25 cm from the side line, and 12 cm from the net. AE sensors were mounted at four locations on one side of the table, and the experiments were conducted using two sets of sensor positions, which are referred to herein as Sets1 and 2 and are depicted in Figure 1.

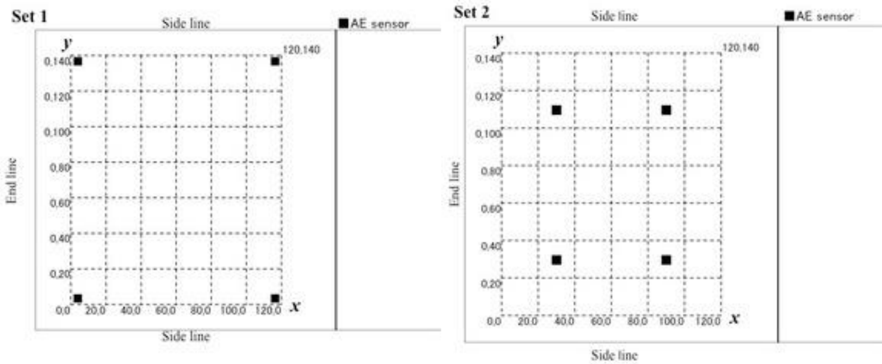

Figure 1. Area and coordinates

2.2 AE measurements

Figure 2 depicts the configuration of the AE measurement system, which consisted of an AE sensor (AE-901S, NF Corporation, Japan) that detected AE waves and converted them into electric signals, a preamplifier (9913, NF Corporation) that amplified the electric signals, and an oscilloscope that displayed and stored the data. The AE sensors were fixed onto the underside of the table using Vaseline, as shown in Figure 3. The AE wave generated when the ball hit the table was amplified by the preamplifier, and the output was measured and recorded by the oscilloscope after being filtered. The average of the three maximum amplitudes measured at each point was used to estimate the ball drop area.

2.3 Ball drop area estimation

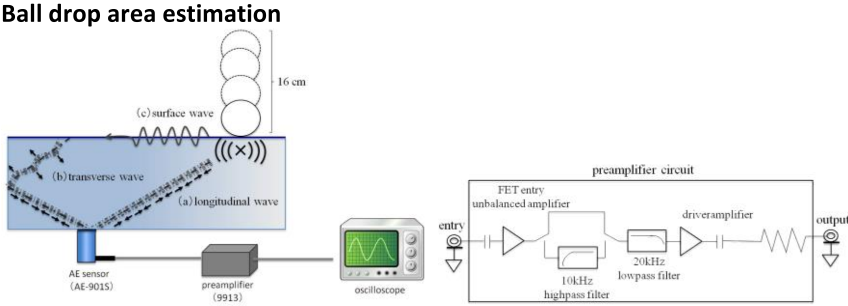

Figure 2. AE measurement system configuration

Figure 3. Installation of an AE sensor

The AE wave generated when a ball hits a table propagates as (a) a longitudinal wave, (b) a transverse wave, and (c) a surface wave, in that order, as indicated in Figure 2. The propagation speed is determined by the material and structure of the table, and viscous damping and distance attenuation occur in a composite manner during propagation. Viscous damping is the temporal damping caused by the viscosity of the material. Distance attenuation is the spatial attenuation caused by the distance between the position at which the AE occurs and is measured (Hase, 2012). If the ratio of the propagation distance to the attenuation of the AE wave remains constant, then, when three or more AE sensors are installed on the table, the drop position of the ball can be estimated based on the point of intersection between the concentrically propagating amplitude lines (Figure 4 (a)). However, although the amplitude of the AE wave and its arrival time at each sensor are generally consistent, they tend to differ in actual measurements due to the uneven structure of the table and the influences of reflection and transmission at the surface. In such cases, since the radii of the equal-amplitude circles do not coincide, it is difficult to estimate the drop area of the ball (Figure 4 (b)). Therefore, in this study, we marked a wide area that included the equal-amplitude curve and estimated the drop area of the ball based on the region in which the areas detected by all of the sensors overlapped (Figure 4 (c)). The area estimation was performed using the contour data provided by the sensor, and the center of gravity of the estimated area was defined as the drop position of the ball. To improve the estimation accuracy, four sensors were used, and they were installed uniformly to cover the range of positions at which the ball hit the table. The estimation procedure is shown below, taking Set 1 as an example in this paper. The estimation method was the same for Sets 1 and 2, and the program was created and run using MATLAB.

2.3.1 Creation of equal-amplitude contour lines
2.3.2 Extraction of the estimated ball drop area
2.3.3 Determination of the region in which the sensor estimates overlapped and drop position estimation

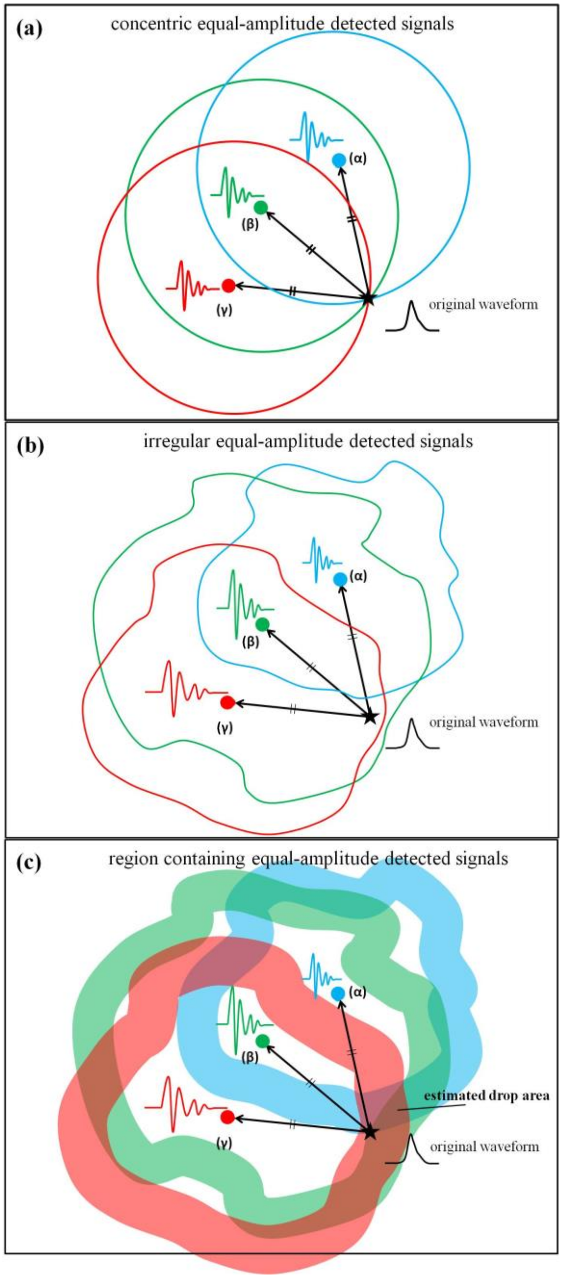

Figure 4. Schematic diagrams of the signals detected by an AE sensor (a) ideal situation, (b) actual situation, (c) concept of estimation. ★ represents the position of the AE sensor and ● represents the drop position (α), (β), (γ) of the ball.

2.3.1 Creation of equal-amplitude contour lines

To obtain the amplitude distribution across the table, contour lines were created based on the amplitudes output by the sensors when the ball was dropped at each of the points. Figure 5 shows the contour lines thus created. The interval between the contour lines was set to 1 V. The red and blue regions are those with high and low amplitudes, respectively. In Figure 5 (a), since the sensor was attached near the point (0, 0), the amplitude is high near (0, 0) and decreases gradually with increasing distance from the sensor. However, as described in the previous section, distance attenuation varies depending on the region, and, hence, the shape of each contour line is complex. In Figure 5 (a), the amplitude is somewhat high near (40, 40). Similarly, in Figure 5 (b)-(d), the amplitude is higher closer to the sensor and decreases with increasing distance from the sensor and the contour shapes are different in different areas.

2.3.2 Extraction of the estimated ball drop area

In this study, the region containing equal-amplitude curves was approximated by a contour region containing the amplitudes provided by the sensors. Figure 6 presents the contour regions obtained using the individual sensors when the ball hit the table near (20, 40). The white area in each image represents the estimated ball drop area. Since the sensor that was the closest to the point (20, 40), which is where the ball was dropped, was the one at (0, 0), a small region relatively close to (0, 0) was selected by that sensor, as shown Figure 6 (a). Furthermore, since the other three sensors were farther from the drop position of the ball, they yielded comparatively wider estimated areas, as illustrated in Figure 6 (b)-(d).

2.3.3 Determination of the region in which the sensor estimates overlapped and drop position estimation

In this study, the area in which the four regions indicated in Figure 6 overlapped was used as the estimated ball drop area. Figure 7 shows the final estimated region obtained when the ball hit the table near (20, 40). The center of gravity of the estimated area was taken to be the estimated drop position and is indicated by a small gray dot.

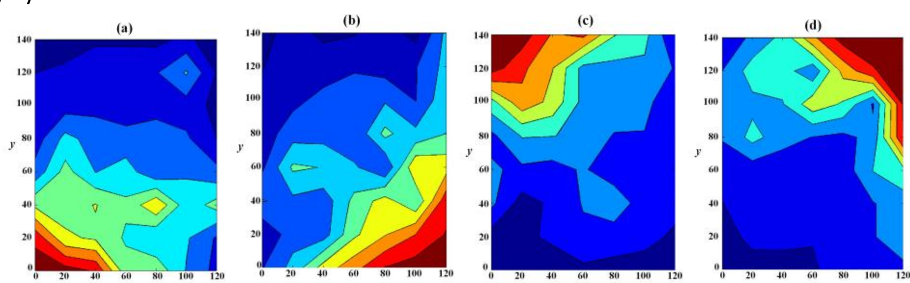

Figure 5. Contour lines for each sensor in Set 1

Contour lines obtained when the sensor was attached at (a) (0, 0), (b) (120, 0), (c) (0, 140), and (d) (120, 140).

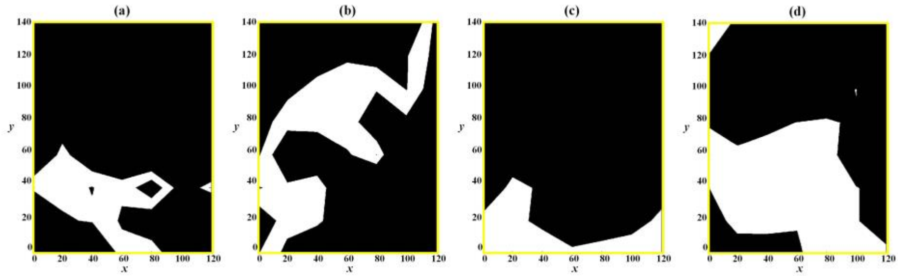

Figure 6. Drop areas estimated using the individual sensors

Areas estimated using the sensors near (a) (0, 0), (b) (120, 0), (c) (0, 140), (d) (120, 140). The frame surrounded by the yellow line shows on the coordinate.

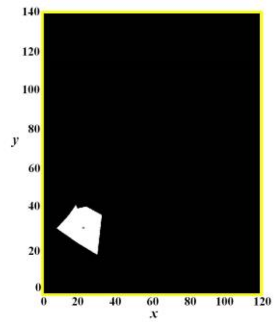

Figure 7. Final estimated ball drop area

3. RESULT

Figure 8 depicts the positions at which the ball was made to hit the table and the estimated positions obtained using Set 1. Table 1 lists the distance errors, i.e., the distances between the actual and estimated drop positions of the ball. The average distance error is about 10 cm, and the maximum is about 77 cm. Figure 9 depicts the actual and estimated drop positions obtained using Set 2, and Table 2 lists the distance errors. The average distance error for Set 2 is about 8 cm, and the maximum is about 35 cm. Set 2, in which the AE sensors were located closer to the center of the table than they were in Set 1, is believed to yield more accurate drop position estimates than Set 1. Based on the results of previous studies that have demonstrated the utility of tactical analysis by focusing on the hitting course, the estimates obtained in the present study are considered to be sufficiently accurate to be used in actual tactical analysis. Furthermore, the processing time necessary to conduct the procedures described in Sections 2.3.2 and 2.3.3 is about 0.05 s (processor: Core i3-3110 @ 2.4 GHz), suggesting that real-time analysis may be feasible.

The plot obtained using Set 1 reveals that the sensor positions yielding distance errors of more than 30 cm mainly occur when the y-coordinate is 20 or 120 and are particularly numerous when it is 60, when the center is far from the sensor. This finding is believed to be a result of the fact that the range estimated by each individual sensor was wide, preventing the actual drop position from being determined even based on the overlap between the regions yielded by the four sensors. Further supporting this conclusion, in the plot obtained using Set 2, although there is position (60, 60) at with distance error is more than 30 cm, while the distance errors in the center of half court are smaller than those in the plot obtained using Set 1. This difference could be a result of the fact that the sensors were closer to the center of the table in Set 2, where the distance errors were large for Set 1, so it was easier to detect the AE waves using Set 2, and hence, the drop position could be estimated more accurately. It might be thought that moving the sensors closer to the center would reduce the distance errors near the center, but doing so is actually expected to increase the errors near the outside of the table. This characteristic suggests the necessity of adding another sensor in the center in Set 2 to improve the estimation accuracy.

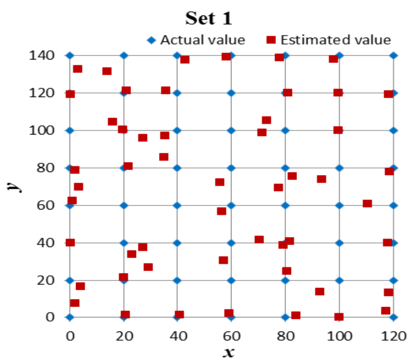

Figure 8. Actual drop positions and those Estimated using Set 1

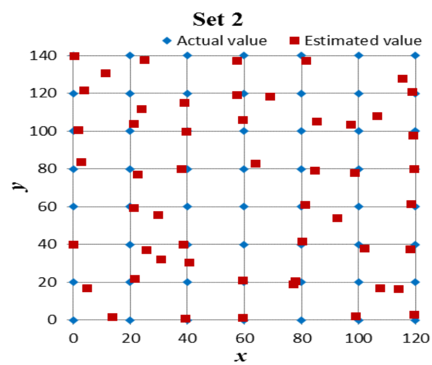

Figure 9. Actual drop positions and those estimated using Set 2

Table 1. Distances between actual drop position and those estimated using Set 1

					x			*(cm)*
		0	20	40	60	80	100	120
	140	7.88	10.61	3.60	1.96	2.39	2.83	20.67
	120	0.92	1.83	4.39	40.76	0.84	0.37	1.83
	100	19.85	5.96	5.30	14.17	8.64	0.34	19.48
	80	2.50	1.99	7.46	9.07	5.41	8.87	2.63
y	60	2.75	47.46	38.82	4.97	77.27	10.52	9.56
	40	0.31	7.18	17.09	10.56	1.64	18.38	1.74
	20	5.33	1.58	21.46	30.04	4.68	9.51	7.11
	0	7.80	1.57	1.63	2.55	4.31	0.19	4.29

Table 2. Distances between actual drop positions and those estimated using Set 2

		x						(cm)
		0	20	40	60	80	100	120
y	140	0.72	5.96	30.09	3.95	3.59	32.84	13.13
	120	4.45	9.45	5.16	2.52	10.86	20.87	1.15
	100	2.13	3.99	0.69	5.81	7.45	3.92	2.84
	80	4.52	4.09	1.93	4.89	5.24	2.44	0.52
	60	34.79	1.98	10.98	30.28	1.74	9.71	1.79
	40	0.27	13.92	1.19	27.50	1.38	15.43	3.40
	20	6.10	2.18	10.27	0.78	1.97	17.62	6.72
	0	13.82	6.36	0.69	0.92	32.48	1.81	2.40

In this study, the region containing equal-amplitude curves was approximated based on contour regions including the amplitude outputs of the sensors. Since this method does not necessarily yield the region in which the amplitude is its median value, it is quite likely that it does not include the regions in which the possibility of the ball hitting the table is high. Therefore, it may be possible to estimate the drop position more accurately by performing processing using the region whose amplitude is the median value.

Moreover, in the experiments performed in this study, the same data were used to calculate the contour lines and to estimate the drop positions. To confirm the effectiveness of the proposed processing method, it is necessary to verify the estimation accuracy by employing data different from that used to calculate the contour lines.

4. CONCLUSION

In this study, we installed broadband AE sensors on a table tennis table and investigated whether the drop position of a ball could be estimated based on the AE wave generated by the ball upon hitting the table. We found that the drop position of the ball could be estimated by employing a processing method using contour lines. Furthermore, the error and processing time of this method indicate that it may be usable for actual tactical analysis in real time.

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Analysis of the Duration of Rally and Rest Time in Standing Para Table Tennis Official Tournaments

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Abstract: This study aims at analysing and comparing the match characteristics of standing Para table tennis classes that played by the men's team events (class 6, 7 and 8) at the Rio2016 Paralympics. Eight table tennis matches of each selected class (6, 7 and 8) were analysed. Duration of rally (DR) and rest time (RT) were measured as match characteristics. The DR classes 6, 7 and 8 corresponded to 4.6±1.8, 5.4±2.8, 4.6±1.7 seconds, and RT to 12.4±3.7, 12.6±3.5 and 11.3±3.3 seconds. In the DR of classes 6 and 8 there were no significant differences, but they were found in class 7 between class 6 and 8 ($p < 0.05$). RT in class 6 and 7 found no significant differences, but significant differences in class 8 were observed ($p < 0.05$). The results indicate that the DR time in class 6 was short due to physical limitations, class 8 by the athletes have more agility and power to execute the strokes and class 7 had longer rallies for having all-round style athletes. The RT of class 8 was significantly different compared to classes 6 and 7 due to physical limitations in both classes to catch the ball to start a new rally. These characteristics of Para table tennis should be used by coaches to check the disadvantages of athletes who have more physical limitations when playing team tournaments.

Keywords: Para table tennis, standing classes, rally, rest time

1. INTRODUCTION

Analysis of the game has been studied in table tennis, tennis and badminton (Martin, Ambrosini, Mousset, Brault, Zouhal and Prioux, 2015; Fernandez, Villanueva, Garcia and Terrados, 2007; Cabello Manrique and González-Badillo, 2003). Indicating that the table tennis matches have as a characteristic intermittent effort, with a short duration at effort and rest (Morel and Zagatto 2008; Zagatto and Gobatto 2010; Sperlich, Koehler, Holmberg, Zinner and Mester, 2011). The Para table tennis is an adapted sport of table tennis is grouped in standing, wheelchair and intellectual. Athletes from disability groups can take part. Standing table tennis (STT) receive classifications Class 6-11 (ITTF, 2012). STT is an adapted sport presenting rules equal table tennis different from wheelchair athlete slight modifications.

The intermittent nature of the sport in a STT match means that the players have intermittent exercise bouts and a multitude of rest periods over a long duration. In this sense studies about sport of rackets have verified specific characteristics (Zagatto, Papoti and Gobatto, 2008; Fernandes, Mendez-Villanueva, Pluim, 2006; Smekal et al., 2005; Roy, Menear, Schmid, Hunter and Malone, 2006; Filipčič, et al., 2009; Sánchez, Torres and Sanz-Rivas, 2016).

The activity patterns and the specific characteristics of the match Standing Para table tennis classes should be used in the exercises to improve the training sessions to check the possible disadvantages of athletes who have more physical limitations (Class 6 and 7) presents when they play the team tournament together with class 8, because it has been studied relating the effectiveness of footwork with stroke in table tennis (Malagoli, Lobietti and Merni, 2007; 2009; 2010). However, there is no study in Para table tennis that measured the match characteristics. Thus, the purpose of this study was to analyse and compare the match characteristics of Standing Para table tennis that played by the men's team events (class 6, 7 and 8) at the Rio2016 Paralympics Games.

2. MATERIAL AND METHODS

2.1 Determination of Characteristic of Para table Tennis Matches

Eight official Para table tennis matches men's class (6, 7, and 8) were analysed. All matches were recorded with fixed Sony Handycam HDR-PJ380 video camera. The analyses were performed by the same experienced researcher. Each match was monitored and recorded for subsequent analysis. The DR and RT of Standing Para table tennis classes that played in the team tournament at the Rio2016 Paralimpics was analysed using free software for video analysis (KINOVEA). Rallies duration and the shots per rally were measured individually in all matches using Dartfish note app was used for periods of effort and recovery in the rally were similar in other studies (Zagatto et al., 2010; Sánchez et al., 2016). From these data, the following variables were calculated for the eight matches analysed:

Rallies duration, from the time the service player hit the ball at the first serve to the moment the point finished in seconds;

Resting time, was determined by the sum of the break time between points (obtained by subtracting the start time of the point from the finish time of the previous point) in minutes.

2.2 Statistical analyses

Results are shown as mean and standard deviation. Before using nonparametric tests, the assumption of normality was confirmed using the Kolmogorov-Smirnov test. The nonparametric Kruskal Wallis were used to compare the DR and RT between the classes that played in the team tournament at the Rio2016 Paralympics. Results were analyzed using STATISTICA 7.0 In all cases, statistical significance was set at $p < 0.05$.

3. RESULTS

The characteristics of all Para table tennis matches are shown in Table 1. In observing the characteristics of the matches in classes 6, 7, 8 corresponded to 4.6±1.8, 5.4±2.8, 4.6±1.7 seconds, and RT to 12.4±3.7, 12.6±3.5 and 11.3±3.3 seconds. In the DR of classes 6 and 8 there were no significant differences, but they were found in class 7 between class 6 and 8 ($p < 0.05$). RT in class 6 and 7 found no significant differences, but significant differences in class 8 were observed (p <0.05).Figures 2 and 3 show the frequency of occurrences of the DR and rest time, respectively. The highest activity periods were found between 3 and 4 seconds for DR and the for rest time between 10 and 14 seconds (Figure 2 and 3).

Table 1. Characteristics of Para table tennis obtained in all matches.

Classes	DR Mean (±SD)	RT Mean (±SD)	Range (DR)	Range (RT)
Class 6	4.6±1.8	12.4±3.7	2 – 14	3 – 24
Class 7	5.4±2.8*	12.6±3.5	1 – 23	2 – 26
Class 8	4.5±1.7	11.3±3.3#	2 – 11	5 – 25

Results are mean, (±SD) and range. Significant differences (p< 0.05) in relation:
**: class 6 and 8;*
#: class 6 and 7.
DR: Duration of rally; RT: Rest time.

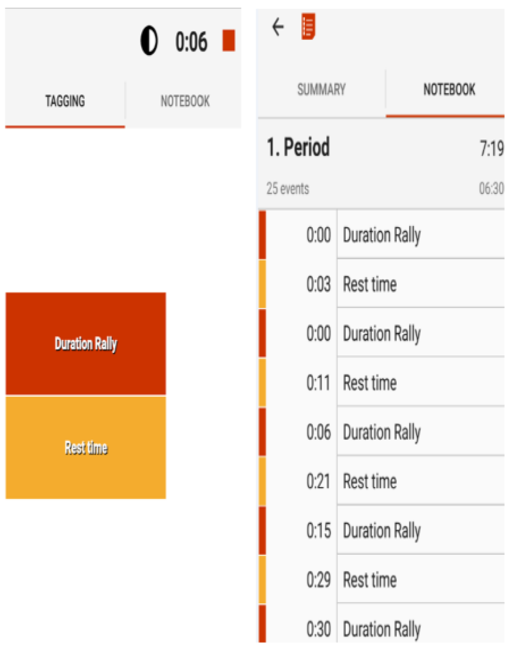

Figure 1. Dartfish note app with tagging and summary.

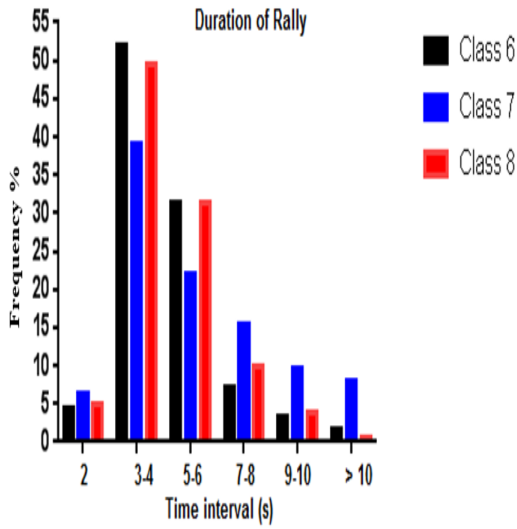

Figure 2. Distribution of rallies duration during the matches.

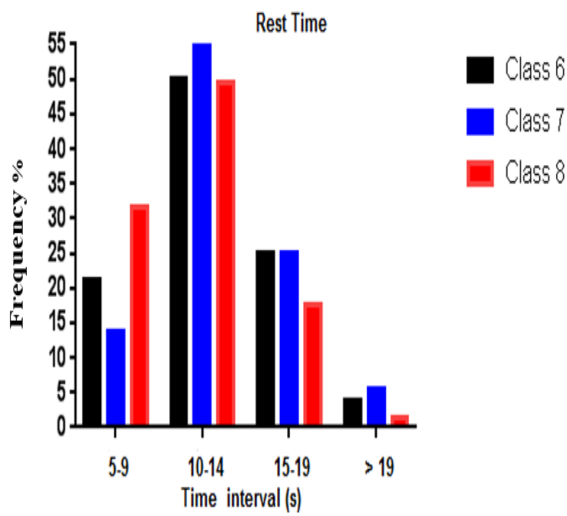

Figure 3. Distribution of the rest time between rallies.

4. DISCUSSION

The principal purposes of the study were analyse and compare the match characteristics of Standing Para table tennis classes that played in the team tournament at the Rio2016 Paralympics. To the best of our knowledge, the present study was the first to undertake such a thorough Para table tennis. The main findings are that the DR of classes 6 and 8 there were no significant differences, but they were found in class 7. RT in class 6 and 7 found no significant differences, but significant differences in class 8 were observed.

Regarding the rally duration and rest time, the data from this study show a mean per point of each class (Table 1). The frequency of the rally distribution and the rest time are shown in Figure 1 and 2.

Thus according to the results of the study the differences of the DR in class 6 was due to severe impairments of legs and arms (physical limitations), class 8 have moderate impairments of the legs or of playing arm, more agility and power predominating in this way short rallies and class 7 had longer rallies as a result of having more athletes in the all-round style (balance between attack and defense). The RT of class 8 was significantly different compared to classes 6 and 7 due to severe and very severe impairments of legs (poor static and dynamic balance) in both classes to catch the ball to start a new rally. These characteristics of Para table tennis should be used to check the disadvantages of athletes who have more physical limitations when playing team tournaments because the game requires repeated powerful strokes, agility, rapid footwork involvement breaks between the rallies, making players perform short bursts of high-intensity exercise interspersed with periods of rest or low-intensity.

The disability of the players of class 6 influences directly when it has to hit the ball during the rally, because players have limitations severe impairments of legs and arms having poor static. In class 7 combination of arms and legs impairments less severe than in class 6 providing better adjustments in your footwork and hit the ball during the rally and the class 8 moderate impairments of playing arm and leg enables athletes to have more agility and power in the strokes for short rallies during matches as can be seen in the results.

This way the rest time present a significant difference because to start a new rally the athletes of class 6 and 7 need to move to catch the ball and their severe and very severe impairments of legs (poor static and dynamic balance) delays to start a new rally.

Therefore players class 8 when playing the team tournament may have some advantage in the rally dispute for having advantages in the execution strokes. In this way the characteristics of the Para table tennis obtained from this study should be used by coaches to plan training prescriptions between classes would aim at achieving better sport performance in training procedures for coaches (Martin et al., 2015; Zagatto et al., 2010; Katsikadelis & Pilianidis, 2007,2010). Because in general the amount hours and time of exercise in the Standing Para table tennis training sessions are similar to the conventional table tennis, due to the limited number of research and lack scientific information for coaches. Additional studies are needed to analyze of the total playing time effort and rest time ratio, effective playing time and influence of playing style.

4. CONCLUSION

Based on the findings from the present study, we can conclude that:

- The duration of the rally in class 7 is longer than class 6 and 8.
- The rest time is longer in the players of class 6 and 7 by having influence of their physical limitations to start the new rally.

• The disability influence the duration of the rally and rest time in the Standing Para table tennis.

• Finally, class 7 had longer rallies for presenting all-round athletes style, the strategy of game and physical condition (disability) were determinants for similarity in the duration of the rally of class 6 and 8.

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Evaluation of Physiological Response on Table Tennis Multiball Training with Different Loads

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Abstract: Background: There are the three basic energy pathways of the human body, ATP-PC system, lactic acid system, and oxygen system. Table tennis match is mainly in the ATP-PC system. Multiball training has always been one of the major training methods of table tennis, but the intensity has not been determined. *Purpose:* Evaluation of physiological response on table tennis multiball training with different loads. *Method:* Twelve outstanding male college table tennis players (age 20.42±1.56 years, height 175.33±4.59 cm, and weight71.17±8.64 kg) were recruited in this study. Average training year-time was 10.33±1.26 years. Method of balance sequence is adopted to test 12 subjects which were required to accomplish 9 balls a repeated (each rep consisted of 9 balls, 1 rep interval 10 sec rest, 9-10), 18-20 and 30-33 training. 1 set consisted of 90 balls, and a total of 180 balls. The frequency was 55 balls per minute by robot. The test type was the Falkenberg footwork. Lactate (La) level and Heart rate (HR) in baseline (R), during test (1 Set), and end of test at 1, 3, 5 min (E1, E3 and E5) were determined. Ammonia (NH_3) level in R and E5. Rating of perceived exertion (RPE) in R, 1 set and E1. The three tests proceed in an interval of one week. By one-way ANOVA Repeated Measures and LSD used in the Post hoc Comparison, differences in the all dependent variables were analyzed. *Results:* In baseline is no difference. 30 balls-33 group exhibited higher heart rate, Ammonia and RPE in post-test immediately compared to the other tests ($p<.05$). The level of lactate in 9-10 group was not over 4 mmol/L lactate threshold at the beginning of test to post-test 5 min and lower than the other group tests ($p<.05$). *Conclusions:* The major finding in this study was that the multiball training of table tennis using the Falkenberg footwork test in 9 balls group was reasonable to reflect the energy utilization during competition.

Keywords: lactate threshold, interval time, non-oxygen supply

1. INTRODUCTION

The table tennis match can be divided into three parts: 1.Multi-quick-and-strong ball-playing activities (ex. serving, receiving, looping and hitting). 2. Short-time no-ball activity with low, middle or high intensification (ex. standby situation or alerting situation) 3.Short-time intervals (ex. stop or holding). There are the three basic energy pathways of the human body: The phosphagenic (ATP-PC) system, lactic acid (La) system, and oxygen system. According to the studies on sporting energy metabolism system, table-tennis energy supply system differs with different condition: ATP-PC system or no-oxygen and non-lactic-acid system (Hsu, Lee, 2010), or ATP-PC and no-oxygen energy lactic acid system (Peng, Liang, 1994), and a system of 70% ATP-PC, 20% lactic acid and 10% oxygen (Lin,1997), and in elite junior table tennis have been documented demonstrating low cardiorespiratory and metabolic demands during Table Tennis training and match play in internationally competing juniors (Sperlich et al., 2011). In addition, table tennis matches present the aerobic system as a principal output energy, the phosphagenic system being the most important during efforts. Both ATP-PC and aerobic system are important. (Zagatto et al., 2010; Kondric et al., 2013).

Match sporting training differs from one to another. The training method of table tennis mainly belongs to multiball training. The so-called multiball training refers to putting lots of balls into one basket and constantly and repetitively serving to the player on the fore-end table. The repetitively flopping and hitting balls can quickly intensify the player's frequencies and intensification and improve his basic training, correct his errors and better his skills.

General speaking, the training could not guarantee the good effect, but the scientific training could bring the greatest effect. Moreover, the key issue of the multiball training is the moderate intensified training, too many servings may increase the physical loads. However, the relative researches don't provide the solid proof. Lee et al. (2005) gives us an example of three different serving modes: 60 balls each 40 seconds interval, 80 balls each 50 seconds interval and 100 balls each 60 seconds interval, and perform it for twenty times. The result shows that the frequency and sporting volume of the 80 balls each 50 seconds interval are suitable to the outstanding female table tennis players: it means this mode can bring the greatest intensification, meet the mass training volume and keep a high-rated nice ball hitting. Chang (2007) provides the other mode: the younger players with 3-5 year experiences, 36/60/100 balls each time by manual side-end serving. Getting their heart rate (before the test and the time of 1 and 3 min during recovery). The 36 balls each time prove to be the best. Kao and Shih (2008) suggest 30 balls each 20 seconds every time, 3-4 rounds as a unit. Easy to say, each mode of training has its solid proof.

The stimulation causes the physical response, and the heart rate and blood lactic acid are the two obvious phenomenon of physical fatigue. By observing the index of physical fatigue, we can make sure the trainee's loads. For example, while the lactic acid amassment is 4mmol/1, in the condition of this physical stimulation, the same rate of the lactic acid exclusion and production, the amassment point with the same rate reveals the Body state is not in fatigue and still in sporting. NH3 is the product of the protein metabolism; it is also an index of the fatigue. Yuan (2000) pointed out the testing index of the NH3 can be used to evaluate the exercise loads, the player's physical state, fatigue and training loads. Another physical index is the rating of perceived exertion (RPE), an easy-to-collect physical parameter index, it can be used to evaluate the sporting intensity by collecting the players' physical senses (heartbeat, breathing, sweat draining, and muscle fatigue).

The multiball training is very common in China or Taiwan. The coach always demands the trainees to constantly practice until they feel very exhausted. There are no training principals and samples, so it is very difficult to know if the trainee's loads are enough. Since the coach cannot make sure the proper training index and stimulating point, the trainees are hard to get improved. The scientific training is very important. By using the chemical index, one can observe the trainees' physical state and provide the efficient help. Based on the energy supply system, game rate, multiball dosage, physical observation index, the goal of this study is as follows: the various multiball training loads, 9 serving-10 seconds interval (9-10), 18 serving-20 second intervals (18-20) and 30 serving-33 second intervals (30-33), 180 servings as a group (2 examinations), to explore the excellent players' lactic acid index, heart rate, NH3 index, and RPE.

2. METHODS

2.1. Subject

Twelve outstanding male college table tennis players [age 20.4 (±1.6) years, body height 175.3 (±4.6) cm, and body mass 71.2 (±8.6) kg] were recruited in this study. Average training year-time was 10.3±1.3 years. All had over seven years of systematic regular training and participated in competitions, being technically representative samples of table tennis players. All research was undertaken at the National Taiwan Sport University. All participants signed a letter of informed consent and were advised of their right to withdraw from the study at any time.

2.2. Experimental Procedures

Each subject performed 2-4mmol/l Lactic acid threshold test (Mader, Lisen, Heck, Philippi, Rost, Schurch and Hollmann, 1976). A protocol consisted of incremental 5-min periods of exercise until the subject's [La-] reached or exceeded 4.0mmol/l. Each exercise period was separated by 5 min, and each subsequent run increased by 0.5m/s. Initial treadmill velocity was either 2.0 m/s as determined by the investigators in an attempt to ensure that all the subjects began the protocol at similar relative intensities. By using lactic acid threshold, we can get the players'aerobic threshold and anaerobic threshold. According to the average sort based on anaerobic threshold, we divide it into Group A, Group B and Group C, 4 players for each group. The study time is for 3 every other weeks, 9/18/30 ball for Group A, 18/30/9 ball for Group B, and 30/9/18 ball for Group C. Each protocol separated by 7 days. The order of protocols was counter-balanced to eliminate an order effect.

The testing method: by shoving, edging and hitting (backhand on the left, forehand on the left, and forehand hitting on the right, Figure 1), the serving frequency is 50 balls by a robot (akkadi TW-2700-V2, Taiwan). The playing time for each player is 2 sets, 180 balls, one minute interval rest. The collected physical parameter [blood lactate (La, EKF BIOSEN C_line, Germany), Heart rate (HR, Polar S625, Finland), blood ammonia (NH3, PocketChem BA PA-4140, Japan), Rating of perceived exertion (Rpe, Borg, 1970)] point is as follows: Lactate data were extracted at before the test, the 1st set end, the 2nd set end and the time of 3 and 5 min during recovery. Ammonia data were

extracted at before the test and the time of 5 min during recovery. Heart rate and Rpe data were extracted at before the test, every repeated interval rest end and the time of 5 min during recovery.
La: Baseline(R), 1st set, 2nd set, End 3min(E-3), E-5.
Ammonia (NH3) index: R, E-5.
HR: R, one Rep interval rest, E-5.
Rpe: R, one Rep interval rest, E-5.

Table tennis-specific procedure (ST)
The ST was applied on table tennis court simulating backhand shoving and forehand offensive hitting in ball shots from a mechanical ball thrower robot. This ST refers to the study of Zagatto (Zagatto et al., 2012). The robot had also adjustments for ball speed and lateral ball oscillation. Ball speed and lateral ball oscillation were maintained constant, corresponding to setting 4 (approximately 35 km.h-1). Balls were shot systematically on two locations of the table (laterally at 30-40 cm from the central line - maximal equipment range), so that the ball contacted the table between 50 and 60-cm away from the net, simulating the stroke of an opponent (Morel and Zagatto 2008, Zagatto et al., 2011).

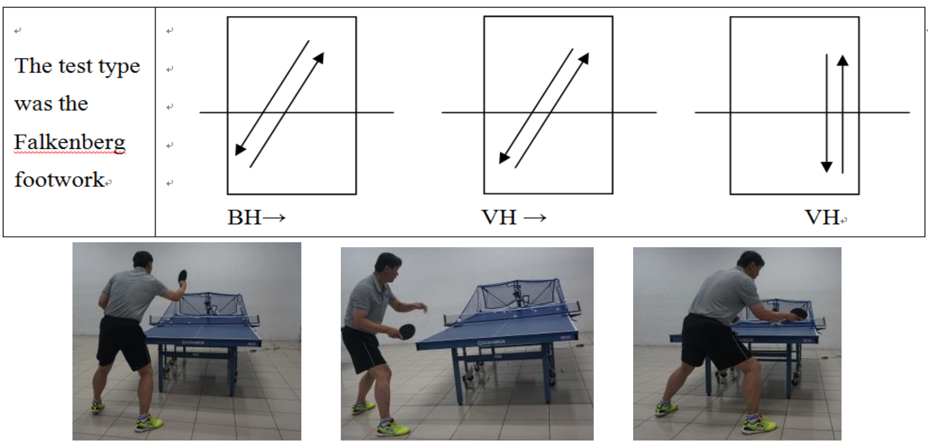

Figure 1. The test type by the Falkenberg footwork (1.backhand on the left; 2.forehand on the left, and 3. forehand hitting on the right)

2.3. Statistics
This was a method of balance sequence is adopted to test assessor. There were 4 separate outcome variables (blood lactate, Heart rate, blood ammonia, Rating of perceived exertion), with repeated measures over four points [Baseline and 9balls- 10 sec (each rep consisted of 9 balls, 1 rep interval 10 sec rest, 9-10), 18balls- 20sec, and 30balls-33sec]. We go on the analysis by using SPSS Software (version 20; IBM SPSS Inc, Chicago, IL). By repeated number ANOVA, we go on the physical parameter analysis of the multiball training with various loads and compare it by LSD post-test. The obvious level of the study it set to be α = .05 (The alpha level was set at $P < 0.05$ for all

analyses.)

3. CONCLUSION

3.1 test of homogeneity

The physical parameter data analysis before multiball testing in Table 1 showed no obvious difference ($p>.05$). The participants shows no differences in the physical metabolism before testing (3 times)

Table 1. The basic physical parameter before the multiball testing

	9 balls	18 balls	30 balls	Levene	p
Blood Lactate (mmol/L)	0.90± 0.24	1.11 ± 0.29	1.0 ± 0.2	.648	.530
Heart Rate (min^{-1})	77.2 ± 6.7	76.3 ± 5.4	77.8 ± 4.9	1.126	.378
Ammonia index (u mmol/l)	23.83±11.41	22.83± 7.92	22.8± 6.9	2.748	.079
RPE	6.58 ±0.51	6.75± 0.45	6.58± 0.7	2.914	.068

3.2. The physical parameter after the multiball testing

After the test, in the part of lactate, at the 1^{st} set, the 9-ball group was 3.5 (± 1.1) mmol / l, the 18-ball group was 4.5 (± 0.7) mmol / l, the 30-ball group was 6.9 (± 1.0) mmol / l, have significant differences ($p <.05$), the accumulation of lactate in the 30-ball group was greater than 9 and 18- ball group. In the 2^{nd} set, the 9-ball group was 4.4 (± 1.3) mmol / l, the 18-ball group was 6.8 (± 1.5), the 30-ball group was 10.3 (± 1.8) mmol / l, have significant differences ($p <.05$), in the 18-ball group was higher than the 9-ball group, and the 30-ball group was higher than the 9-ball group and the 18-ball group. The time of 3 min during recovery, the 9-ball group was 4. (± 1.4) mmol / l, the 18-ball group was 6.9 (± 2.0), the 30-ball group was 9.3 (± 2.0) mmol / l, have significant differences ($p <.05$), as 2^{nd} set. The time of 5 min during recovery, the 9-ball group was 3.8. (± 1.2) mmol / l, the 18-ball group was 6.7 (± 2.0), the 30-ball group was 8.5 (± 1.9) mmol / l, have significant differences ($p <.05$), the 18-ball and 30-ball group was higher than the 9-ball group.

In the part of heart rate, at the 1^{st} set, at the 1^{st} set, the 9-ball group was 151.4 (± 2.2) min^{-1}, 18 and the group was 151.8 (± 1.8) min^{-1}, 30 and the group was 158.9 (± 7.7) min^{-1}, which was significant ($p < 05$), the heart rate of the 30-ball group was greater than 9 and 18-ball, and in the 2^{nd} set, the 9-ball group was 158.4 (± 2.2) min^{-1} and 18-ball was 160.0 (± 2.3) min^{-1}, and 30-ball group was 167.3 (± 3.6) min^{-1}, and the heart rate of the 30-ball group was greater than 9 and 18-ball group. The time of 5 min during recovery, the 9-ball group was 77.8 (± 6.7) min^{-1}, and the 18-ball group was 77.8 (± 5.0) min^{-1}, and the 30-ball group was 76.3 (± 5.4) min^{-1}, did not reach significant ($p> .05$).

In the part of ammonia value, the time of 5 min during recovery, 58.5 (± 17.2) μ mmol / l for the 9-ball group, 59.3 (± 15.7) μ mmol / l for the 18-ball group and 86.0 (± 18.4) μ mmol / l for the 30-ball group, which was significant ($P <.05$). The 30-ball group was greater than 9 and 18- ball group.

In the part of RPE, at the 1^{st} set, at the 1^{st} set, the 9-ball group was 13.0 (±1.5), 18 and the group was 13.0 (± 1.5), 30 and the group was 14.0 (± 1.1), which was significant (p < 05), the 30-ball group was greater than 9-ball group, and in the 2nd set, the 9-ball group was 14.3 (± 1.0) and 18-ball was 15.0 (± 1.9), and 30-ball group was 17.0 (±0.0), have significant differences (p <.05), and the 30-ball group was greater than 9 and 18-ball group.

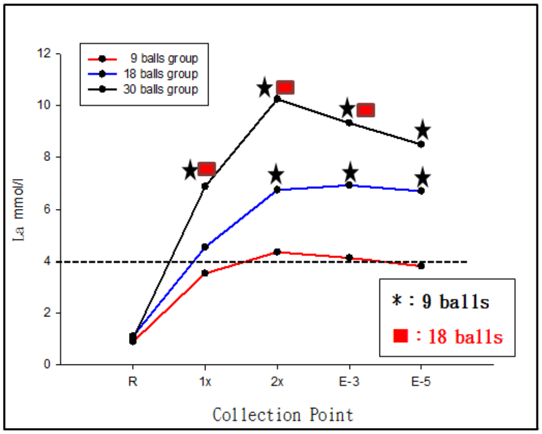

Figure 2. The accumulation of lactate under different loads

Table 2. Changes (mean ± SD) physiological response of the blood lactate (La), heart rate (HR), blood ammonia and RPE before (Pre), immediately after 90 balls, and 180 balls , End-3min and End-5min after 9 balls- 10 sec rest group, 18-20 group and 30-33 group, (n= 12).

		Pre	90 balls	180 balls	End-3min	End-5mn
	9 ball G	0.9± 0.2	3.5 ± 1.1	4.4± 1.3	4.1 ± 1.4	3.8 ± 1.2
La	18 ball G	1.1 ± 0.3	4.5 ± 0.7	6.8 ± 1.5*	6.9 ± 2.0*	6.7 ± 2.0*
	30 ball G	1.0 ± 0.2	6.9 ± 1.0*#	10.3 ± 1.8*#	9.3 ± 2.0*#	8.5 ± 1.9*
	9 ball G	77.2 ± 6.7	151.4 ± 2.2	158.4 ± 2.2		77.2 ± 6.7
HR	18 ball G	76.3 ± 5.4	151.8 ± 1.8	160.0 ± 2.3		76.3 ± 5.4
	30 ball G	77.8 ± 4.9	158.9± 7.7*#	167.3± 3.6*#		77.8 ± 4.9
	9 ball G	23.8± 11.4				58.5 ± 17.2
NH3	18 ball G	22.8 ± 7.9				59.3 ± 15.7
	30 ball G	22.8 ± 6.9				86.0 ± 18.4*#
	9 ball G	6.6 ± 0.5	13.0 ± 1.5	14.3 ± 1.0		
RPE	18 ball G	6.8 ± 0.5	13.0 ± 1.5	15.0 ± 1.9		
	30 ball G	6.8 ± 0.7	14.0 ± 1.1*	17.0 ± 0.0*#		

An asterisk (*) indicates a significant (P<0.05) difference from the 9 balls Group value.
An asterisk (#) indicates a significant (P<0.05) difference from the 18 balls Group value.

4. DISCUSSION

In table tennis there are few studies that compared results measured in specific and conventional tests (Morel and Zagatto, 2008; Zagatto et al., 2008), being found more studies in rackets sports such as tennis and badminton. Table 3 includes two data: the date of the players' heart rate and lactic acid in the Germany DTTB (2002), Hsu (2012) and Zagatto et al. (2010) games and the analytic data of this study. There are no obvious differences on three type loading heart rate in the testing, but the lactic acid index shows obvious high, especially in the 30-ball group, higher than 8mmol/1. According to Liese and Baum (1997) study, the training items with high skills (e.g. Badminton and Table tennis). In the training, the lactic acid index stays below 8 mmol/l, so as not to cause the movement coordination problem due to the muscle fatigue. If the blood lactic acid index is 4mmol/1 in describing the anaerobic threshold index, that will be the most stable lactic acid (Maximal lactate steady-state, $MaxLa_{ss}$). That is, the participant under the strong stimulation will produce lactic acid massing and exclusion. The balance point is 4mmol/1. In the other words, there is no fatigue phenomenon in this condition and the training is allowed to go on.

Table 3. The postgame heart rate and lactic acid index of the Germany professional table tennis players and Taiwan Sports University players (DTTB, 2002), Taiwan Sports University players (Hsu and Lee, 2008) and Brazil Regional and national experience players (Zagatto et al., 2010)

Degree (Country)	Heart rate	Lactic acid index	remarks
Degree 1 (Germany)	159 min^{-1}	1.9mmol/l	38mm ball, 21 points, 5 game 3 set
Degree 5 (Germany)	152 min^{-1}	2.6mmol/l	38mm ball, 21 points, 5 game 3 set
Sports University (Taiwan)	146 (±15) min^{-1}	1.49 (± 0.5) mmol/l	40mm ball, 11 points, 5 game 3 set
Regional and national experience (Brazil)	164 (±14) min^{-1}	1.80 (± 08) mmol/l	40mm ball, 11 points, 7 game 4 set

The study shows that the heart rate, blood lactic acid , blood ammonia index and RPE is obviously higher in Group 30 balls; that is, in the about-30- second multiball training, the player seems like to dash 75-100 meters with all his might. Under this condition, the physical parameter is surely higher than normal. Due to the stimulation of the high intensity, the lactic acid amass causes physical fatigue. If the training keeps going on, it would be hard to get the skill improved and even causes sports injury. On the contrary, in the group 9 balls loads, the player is set to get 10-second training with the same distance, we find his physical parameter is low and the efficient stimulation and activated individual ATP-PC system fits in the games situation.

Generally speaking, there are many kinds of training. If we follow the successful mode, we would save many experimental process. China leads in the global table tennis games, many countries try to follow his mode. Of course, many Chinese coaches and trainers take videos for demonstration and imitation, including multiball training videos. By videos and references observation on the games and statistics, it takes 7 balls from serving to the round, usually taking 3-6 balls or 3-5 second (Leite et al., 2017; Zagatto et al., 2016; Zagatto et al., 2010). Although one game may last for more than 10 minutes, the one-round time is within the 10 seconds. We can surely to say the most of the energy comes from the ATP-PC system (Kondric et al., 2013; Hsu and Lee, 2012; Zagatto et al., 2010), not from the other two systems. The time to picking up the ball could be classified as an active rest. According to Saltin (1986), the excellent players' ATP regeneration rate could be 4.4 mmol/l every minute (it may be influenced by individual aerobic endurance). The ball-picking time is the time to restore ATP. When the round restarts, the players would refresh again. The viewpoint comes to be the same as Kondric et al. (2013) observation: the energy generated from the anaerobic ATP-PC system and fits in the games situation.

5. CONCLUSION

According to my study, in the condition of the 9 ball/10 second loads within 10 seconds, the data of the heart rate, blood lactic acid index , blood ammonia index and RPE is < Group 18 ball and Group 30 ball, it also fit with the real game situation. So, the study result is very worthy to be consulted to the table tennis coaches and players.

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Anthropometric Characteristics of Top-Class World and European Male Table Tennis Players

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Abstract: The purpose of this study was to compare anthropometric profiles of top 100 ITTF Rank male table tennis players and to set up a set of reference values useful for future investigations on athlete selection, talent identification, and training programme development. Seventy-five best world players, ranked in the top 100 at the ITTF Rank list (male) were analyzed. The following data were taken: Body high, Body weight, Body mass index, age, Continent affiliation and playing hand. Players were distributed in groups according to performance level. Descriptive statistics parameters were calculated for all analyzed players according their performance level. Differences between groups (performance level, Asian and European players, Right-handed vs. left-handed; different age categories) were analysed with One-way ANOVA test (p<.05). Anthropometric characteristics of best World players were: Body high: 180.0±6.8 cm, Body weight: 73.99±7.93 kg, Body mass index: 22.80±1.81 and Age: 29.3±5.6. Asian players have: Body high: 175.0±5.3 cm, Body weight: 68.57±6.49 kg, Body mass index: 22.36±1.84 and Age: 27.4±4.3 and European players: Body high 183.9±5.6 cm, Body weight 76.70±6.5 kg, Body mass index 22.96±1.74 and Age 30.5±6.1 years old. Results of ANOVA showed that there are no statistical significant differences in anthropometric characteristics according performance level, while that there is in Body high and Body weight between continental affiliations. These reference data should be useful to practitioners and researchers, providing useful information for talent identification establishing the model of top table tennis player and development for the assessment of training progression in table tennis.

Keywords: table tennis, body weight, body high, body mass index, age

1. INTRODUCTION

Anthropometry has been shown to play an important role in athlete selection and performance criteria in sports. It is a known fact that the determination of the somatotype is especially supportive in sports in which the body may impact on the biomechanics of movement and the resulting performance (Vucetic, Matkovic and Sentija, 2008; Massidda et al., 2013). Also, anthropometric profile may indicate whether a player would be suitable to participate at the highest level in a specific sport (Bourgois et al., 2000; Bourgois et al., 2001; Claessens at al., 1999).

The interest in anthropometric characteristics, body composition and somatotype from different competitive sports has increased over the last decades. The quantification of morphological characteristics of elite athletes sometime can be a key point in relating body structure to sports results. During the past 17 years, great changes have taken place in table tennis with respect to technique and tactics, according change of rules. Most of the scientific literature has focused on physiological and biomechanical variables, physical performance and prevention of injuries. Analysis of the specific table tennis literature has shown that there is a lack of information explaining the developmental pattern of high profile athletes in relation to different expressions of the anthropometric characteristics.

Analysis of the literature comparing anthropometric variables and somatotypes related to table tennis shows that the authors were mostly interested in analyses of anthropometric and somatotype profiles of top level players (Pradas de la Fuente et al., 2013) and young players (Carrasco, Pradas & Martínez (2010). The others were oriented in findings in relation between some anthropometric characteristics with performance level and gender (Zagatto et al., 2016) or the influence on competitive success (Munivrana, Pausic & Kondric, 2011; Limoochi, 2007).

Therefore, the purpose of this study was to determine the anthropometric characteristic profiles of top 100 ITTF Rank male table tennis players and to set up a set of reference values useful for future investigations on athlete selection, talent identification, and training programme development.

2. METHODS

2.1 Sample

Seventy-five best world players, ranked in the top 100 on the ITTF Rank list (February 2017) (male) were analyzed.

Table 1. Sample of analyzed players

Continent	N	Percent (%)
ASIA	26	34.7
EUROPE	44	58.7
S AMERICA	3	4.0
AFRICA	2	2.7

2.2 Variables

The following data were taken:

1) BH - Body high,
2) BW - Body weight,
3) BMI - Body mass index.

Analyses were done considering players' age, continent affiliation and playing hand. Also, players were distributed in groups according to performance level (1-20; 21-50; 51-80; 81-100).

2.3 Statistical analyses

Descriptive statistics parameters were calculated for all analyzed players according their performance level. Differences between groups (performance level, Asian and European players, Right-handed vs. left-handed; different age categories) were analysed with One-way ANOVA test (p<.05).

3. RESULTS

In Table 2 are presented results for a complete analysed sample of players.

Table 2. Anthropometric characteristic of all analysed sample

	N	Min	Max	Mean
BH	75	1.62	1.96	1.80±.067
BW	75	51.0	93.0	73.99±7.92
BMI	75	18.67	27.16	22.79±1.81
AGE	75	19.0	45.0	29.28±5.58

In Table 3 and 4 are presented results of anthropometric characteristics for the continent affiliation of players and according their position on the ranking list.

Table 3. Anthropometric characteristics according continent of players

	N(78)	BH	BW	BMI	AGE
Asian	27	175.0±5.3	68.57±6.49	22.36±1.84	27.4±4.3
European	46	183.9±5.6	76.70±6.5	22.96±1.74	30.5±6.1
South America	3	1.77±.064	75.00±12.53	23.76±2.95	28.67±6.65
Africa	2	1.88±.11	83.00±14.14	23.37±1.18	27.50±2.12

Table 4. Anthropometric characteristics according ranking position of players

Ranking	N(75)	BH	BW	BMI	AGE
1-20	20	177.0±.06	70.45±7.27	22.42±1.54	28.25±5.40
21-50	25	1.81±.063	74.12±7.68	22.45±2.04	28.72±5.02
51-80	21	1.80±.066	75.85±7.40	23.17±1.30	30.19±6.32
81-100	9	1.80±.068	77.11±9.49	23.68±2.47	31.00±5.80

- Among the top 20 players there are: 13 players from Asia (65%), 6 players from Europe (30%) and one player from South America (5%). 15 players are right-handers (75%) and 5 are left-handers (25%).
- Among 30 analyzed players ranked from 21-50 places there are: 10 from Asia (33.3%), 18 from Europe (60%) and 2 from Africa (6.7%). 20 players are right handers (66.7%) and 10 left handers (33.3%).
- Among 30 analyzed players ranked from 51-80 places there are: 9 from Asia (30%), 20 from Europe (66.7%) and 1 from South America (3.3%). 24 players are right handers (80%) and 6 left handers (20%).
- Among 20 analyzed players ranked from 81-100 places there are: 9 from Asia (45%), 9 from Europe (45%) and 1 from South and North America (10%). 14 players are right handers (70%) and 6 left handers (30%).

In Table 5 are presented frequencies of playing hand, according continent affiliation and position on rank list.

Table 5. Playing hand frequencies according continent and ranking position

	N	Right handed	%	Left handed	%
Whole sample	100	73	73.0	27	27.0
Asian	41	31	75.6	10	24.4
European	54	38	70.4	16	29.6
South America	3	1	33.3	2	66.7
Africa	2	2	100.0	0	0.0
1-20	20	15	75.0	5	25.0
21-50	30	20	66.7	10	33.3
51-80	30	24	80.0	6	20.0
81-100	20	14	70.0	6	30.0

3.1 Results of ANOVA

Results of ANOVA showed that there are no statistical significant differences in anthropometric characteristics according performance level, while that there are in Body high and Body weight between continental affiliations ($p < .001$).

4. DISCUSSION

The objective of the research was to study an anthropometric profile of top 100 male players. In top 100 players there are most of the European players. The average body high is 1.80±.067, weight 73.99±7.92, BMI value 22.79±1.81 and the average age is 29.28±5.58.

Asian players are smaller with lower BMI values instead others, and younger of them, and mostly ranked in the top 20. Considering ranking position, body weight and BMI increase.

In ranking position from 20-81 European players dominate. While right-handers dominate, the only ranking positions where the lowest ratio between left-handers and right-handers are 21-50.

In this research there were no observed differences according performance level, like Zagatto et al., (2016) , while Pradas et al., (2013) find out the differences in sample of elite female table tennis players and concluded that bio typology data that represent a better and suitable reference for selection and prediction of the competitive success. And Munivrana, Pausic & Kondric (2011) concluded that there was no relation between performance and somatotype as a factor that directly influences the competitive success.

There are no statistical significant differences in anthropometric characteristics according performance level, as Limoochi (2007) concluded on sample on an 32 top women table tennis players at the Athens 2004 Olympic Games and their world ranking, while that there are in Body high and weight according continental affiliations.

At the end we can conclude that anthropometric characteristics don't represent a factor which directly influences performance, and that possible that some other factor of body composition can increase chances for success. But, we get some anthropometric profiles of top players, and those which are in the middle and last third position among best 100 World players.

5. CONCLUSSION

There is a light difference in body mass index values (as a measure of relative weight) between best ranked players and lower ranked players. Among the top 20 players dominate players from Asia instead European players and right-handers prevailed in the age of late 20-ties. By contrast, significant differences were observed in body high and body weight between continental affiliations. These differences could influence the playing style and success of the players.

These reference data should be useful to practitioners and researchers, providing useful information for talent identification establishing the model of top table tennis player and development for the assessment of training progression in table tennis.

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Blood Pressure Response to Exercise in Table Tennis Varsity Athletes

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Abstract: The aim of the study was to examine changes in blood pressure during exercise and to identify blood pressure abnormalities in female and male table tennis collegiate players. Twenty-one athletes (female=8, male=13) completed the Queens College Step Test to determine their response to exercise. Systolic (SBP) and diastolic blood (DBP) pressure markers were measured before, immediately after, and 1,2,3-minute post (recovery) exercise. On average, SBP of female and male athletes significantly change after exercise but no significant differences were found between genders on all blood pressure variables. However, individual results revealed 48% of the players had SBPmax of < 140mmHg and one player has DBPmax of > 100mmHg suggesting blood pressure abnormalities. The findings support a similar study in Filipino collegiate racket sport players that showed evidence of irregular systolic and diastolic blood pressure responses to exercise. The current study provides further insights about the importance of exercise blood pressure markers to diagnose athletes at risk of developing hypertension or cardiovascular disease and to evaluate players' metabolic fitness. However, more research is needed particularly which blood pressure parameter would noticeably detect exaggerated blood pressure response to exercise in athletes.

Keywords: hypertension in athletes, hypertensive response to exercise, abnormal blood pressure, Filipino athletes

1. INTRODUCTION

Blood pressure is described as the force of the blood circulating on the walls of blood vessels in the body. It consists of the systolic blood pressure (SBP), which is the pressure in the arteries when the heart contracts, and the diastolic blood pressure (DBP), which is the pressure in the arteries when the heart relaxes in between beats. It is considered one important vital signs of the body and systolic and diastolic blood pressure readings between 90-120mmHg and 60-80mmHg respectively, signify a “healthy” resting (American Heart Association) range for adults. However, resting blood pressure measurements above these ranges categorized as: prehypertension (120-139/80-89mmHg), high blood pressure stage 1 (140-159/90-99mmHg), high blood pressure stage 2 (160+/100+mmHg), and hypertensive crisis (>180/>110mmHg) (American Heart Association, 2017) are considered abnormal and could be warning signs of prevalence of hypertension that is found to be a significant factor in predicting future cardiovascular morbidity and mortality (O’Donnell et al., 1995; Sieira, Ricart, & Estrany, 2010).

Similarly, exercise blood pressure (ExBP) is another alternative way of evaluating blood pressure to detect existence of hypertension and/or to prognose risk of future cardiovascular diseases including left ventricular hypertrophy and hypertension (Miyai et al., 2002; Tzemos, Lim, & MacDonald, 2002). In a normal situation, SBP rises as exercise intensity increases and may reach up to 225-240mmHg in trained subjects, while DBP only displays slight changes or not at all in spite of exercise intensity (Cruz, 2016; Palatini, 1988; Sieira et al., 2010). However, in a review study by Sieira and colleagues (2010), they suggested that blood pressure response during exercise is deemed abnormal when maximum SBP values >210 and >190mmHg in men and women respectively, DBP values >100-105mmHg or increase of >10mmHg at any time during the test, reduced SBPdelta (SBPmax-SBPrest) to below 45mmHg, low SBP max (<140mmHg), and slow SBP recovery (SBP 142+- 19 at 3'; SBPrec 3'>1'; SBPrec >195mmHg at 2'). Thus, normal and exercise blood pressure measurements should be taken into consideration in one's health evaluation because of its potential to diagnose hypertension as well as to predict chances of developing left ventricular hypertrophy and hypertension (Sieira et al., 2010; WHO 2017).

The use of normal and exercise blood pressures is often conducted with the general or high risk (unhealthy) population when evaluating their health. However, recent studies are suggesting the inclusion of these blood pressure measurements to individuals who are known to be in good health and in low cardiovascular risk population such as athletes (Cruz, 2016; Miyai et al., 2002; Munoz et al., 2009). For instance, Munoz et al. (2009) found seven percent (7%) of the collegiate athletes in their study had SBP > 130mmHg, while Tucker et al. (2009) found 13.8% and 64.5% of their sample football players were in the hypertension and prehypertension categories respectively. These results suggest prevalence of hypertension in athletes and therefore be included in the pre-participation screening and/or regular fitness testing of athletes. Although elevated blood pressure studies in sports players using resting blood pressure are available (Berge, Isern, & Berge, 2015; Bruno, Cartoli, & Taddei, 2011) reports using blood pressure response to exercise in athletes are still lacking (Caselli et al., 2014; Cruz, 2016). Therefore, the aim of the study was to examine changes in blood pressure during exercise and to identify blood pressure abnormalities in female and male table tennis collegiate players. Identifying athletes' high blood pressure response to exercise will help coaches assess the effects of their training program on athletes' fitness. Furthermore, understanding exercise blood pressure can assist medical practitioners or health care providers to pinpoint individuals who have hypertension or who are susceptible to future risk of hypertension and other cardiovascular diseases so that proper treatment and preventive measures are given.

2. METHODS

2.1 Participants

Twenty-one table tennis athletes (female=8, male=13) with age ranging from 17 to 20 years and with 4–12 years of table tennis experience, voluntarily participated in this study. Participants were informed about the testing protocol before undergoing fitness testing. All participants provided written informed consents before testing, which was performed according to the Declaration of Helsinki for human experiments.

2.2 Anthropometric measurements

All measurements were taken by trained research assistants to ensure reliability. Body weight to the nearest 0.1 kg was measured using a calibrated digital Bioelectric Impedance Analysis scale (i.e., Tanita Inner Scan Body Composition Monitor, Model BC541, Tokyo, Japan). Standing height, waist girth, and hip girth were measured according to ISAK protocols (ISAK, 2011).

2.3 Blood pressure measurements

Blood pressure was recorded using a portable digital blood pressure machine (iCare model CK802, UK, London) with adult cuff size for average upper arm circumference (22-32cm). Prior to the test, the participants rested for 5 minutes while sitting on benches before their resting heart rate was measured. Resting blood pressure was measured twice and recorded the average. Immediately after the exercise test, blood pressure was recorded as SBPmax and DBPmax and 1-,2-,3-minute post exercise as recovery blood pressures.

2.4 Exercise protocol

The Queen College Step test (QCST) (Meyers, 1969) was performed to measure athletes' effort. This is a valid submaximal exercise test in predicting maximum oxygen uptake. Participants were instructed about the test procedure before commencement. Each participant stepped up and down on the step for 3 minutes following a metronome with a rate of 24 steps/minute and 22 steps/minute for males and females respectively. Blood pressures were recorded immediately after, and at 1,2,3-minutes post-tests.

2.5 Statistical analyses

A mixed factorial design (2-gender × 4-time) was used to determine differences between and within subject factors. Statistical significance was set at $p < 0.05$.

3. RESULTS

Means and standard deviations of anthropometric values of the athletes are shown in Table 1. Collegiate male and female table tennis players differed only in height and % body fat suggesting that male athletes were significantly taller and with less body fat than their counterparts. However, no significant differences were found in athletes' weight, waist, and hip measurements.

Table 1. Demographic and anthropometric values of athletes.

Variable	Female		Male	
	Mean	SD	Mean	SD
Age	18.62	1.302	18.00	1.00
Experience	8	1.309	6.92	2.660
Height(cm)*	161.812	6.611	172.854	6.578
Weight(kg)	55.075	7.742	62.877	11.277
Waist(cm)	76.938	7.880	74.431	6.825
Hip(cm)	93.500	6.071	90.615	6.779
% fat*	24.725	3.444	9.146	3.280

$p<0.05$

Means and standard deviations of blood pressure markers of the athletes are shown in Table 2. There was no main effect of gender on blood pressure between groups. Conversely, there was a main effect of time on blood pressure within groups. Further analyses revealed significant differences in the systolic pressure variables were observed within groups but not diastolic pressure. Pairwise comparisons for the SBP revealed the following results for males and females:

1. Female $Systolic_{peak} > Systolic_{rest}$
2 Female $Systolic_{peak} > Systolic_{Rec2}$
3. Female $Systolic_{Rec1} > Systolic_{Rec2}$
4. Female $Systolic_{Rec1} > Systolic_{Rec3}$
5. Male $Systolic_{peak} > Systolic_{rest}$
6. Male $Systolic_{Rec1} > Systolic_{rest}$
7. Male $Systolic_{peak} > Systolic_{Rec2}$
8. Male $Systolic_{peak} > Systolic_{Rec3}$
9. Male $Systolic_{Rec1} > Systolic_{Rec3}$

Table 2. Blood pressure parameters of athletes

BP mmHg	Female		Male	
	Mean	SD	Mean	SD
$Systolic_{Rest}$	117.13^{a}	11.79	119.38^{ae}	12.65
$Diastolic_{Rest}$	70.75	4.65	68.84	9.59
$Systolic_{Peak}$	139.25^{ab}	20.478	136.85^{abf}	24.372
$Diastolic_{Peak}$	79.50	9.149	82.77	19.524
$Systolic_{Rec1}$	127.62^{cd}	13.866	129.54^{de}	14.158
$Diastolic_{Rec1}$	72.38	6.346	74.38	10.898
$Systolic_{Rec2}$	115.25^{bc}	8.225	126.08^{b}	18.432
$Diastolic_{Rec2}$	70.62	6.927	72.15	17.214
$Systolic_{Rec3}$	114.50^{d}	15.232	121.77^{df}	11.461
$Diastolic_{Rec3}$	71.25	4.527	67.769	10.940

$p<0.05$

4. DISCUSSION

The aim of the study was to examine changes in blood pressure during exercise and to identify blood pressure abnormalities in female and male table tennis collegiate players. Results showed significant gender effect for height and % body fat suggesting that male athletes were taller than female athletes, whereas female athletes had more body fat than male athletes. The current study supported previous studies that found gender differences in table tennis athletes (De la Fuente, Gonzales-Jurado., Sotomayor, & Castellar, 2013; Zagatto, Milioni, Freitas, Arcangelo, & Padulo, 2016).

For the blood pressure variables, results revealed significant changes in the SBP of males and females as a function of time, but not diastolic pressure. No gender differences were also found between groups. In the current study, resting SBP and DBP are within the normal range category indicating the athletes' status of good health.

During exercise, SBP normally increases as intensity increases while DBP remains the same or slightly changes despite of exercise intensity (Cruz, 2016; Palatini, 1988; Sieira et al., 2010). The findings showed that while DBPs changed after and post exercise, no substantial differences were found within and between groups and supported previous studies (Becker, Chaves, Silva , Moreira , & Victor, 2007; Cruz, 2016; Sieira et al., 2010). On the other hand, peak SBP, although significantly increased prior to exercise, barely reached 140mmHg. This low SBPpeak response might be attributed to the exercise protocol, which only stimulates effort in a submaximal state. It is probable that the exercise intensity of the test was not adequate to affect blood pressure to greatly increase. Meanwhile, recovery blood pressures of both genders in all time intervals were within the normal range. Nonetheless, the SBPpeak not reaching 140mmHg indicates abnormal blood pressure during exercise for both male and female table tennis players.

In addition, individual blood pressures showed 48% of the table tennis players (male=7, female=3) had SBPpeak of < 140mmHg and one player has DBPpeak of > 100mmHg suggesting blood pressure abnormalities. These results were similar to the study done in badminton athletes (Cruz, 2016) wherein poor SBP and high DBP responses after exercise were found in several players.

5. CONCLUSION

The present finding provides further evidence about the existence of abnormal blood pressure response to exercise in athletes as well as offers support concerning the importance of exercise blood pressure markers to diagnose athletes at risk of developing hypertension or cardiovascular disease and to evaluate players' metabolic fitness in addition to the normal resting blood pressure. However, more research is needed particularly which blood pressure parameter would noticeably detect exaggerated blood pressure response to exercise in normotensive athletes.

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Case Study: Using Video Analysis of Matches to Track Player Performance and Inform Training

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Abstract: This case study describes how video analysis of table tennis matches was used to track player performance and inform training. Over a two week training camp, two-highly trained junior players competed four times in a 'best of five sets match' against a player of similar age and ability. Two key performance indicators (KPIs) were tagged live for each player to be reviewed by the player, coach and video analyst together after each match. After two matches the coach modified training, concerned by increasing KPI (error) counts. Improvements in KPI counts post-intervention appear to be associated with improved match results. This case study shows that the simple but effective review of video analyses can help an experienced coach identify and track KPIs for a player's style of play. By reviewing analyses of all matches, a coach can feel when training needs to be modified to improve short-term match performance.

Keywords: table tennis, video analysis, tracking, performance

1. INTRODUCTION

Video analysis has been a widely utilized performance enhancement tool in high-level sport for over a decade (Lees, 2003). In table tennis, video analysis of matches has been successfully used to improve physical performance of players (e.g. Glynn et al., 2013) but mainly to inform the tactical / technical performance of players in matches (Malagoli-Lanzoni et al., 2011). Analysis of matches can help to identify player strengths and weaknesses for his / her style of play and therefore Key Performance Indicators (KPIs) can be established (Hughes & Bartlett, 2002). Video analysis software and mobile devices for 'live tagging' have enabled information to be shared quickly and easily with coaches and players following each match. Whilst competition analysis is commonplace, video analysis of practice matches could further inform training and accelerate performance gains.

This case study describes how video analysis of table tennis matches was used to track and review player performance and inform training for two highly-trained junior players. Additionally, this work demonstrates how an experienced coach can work effectively with a video analyst to enhance player performance.

2. METHODS

Over a two week training camp, two-highly trained male junior players competed four times in a 'best of five sets match' against a player of similar age and playing ability from an opposition team. All players were informed to adopt their usual styles of play for each match that would give them the best chance of winning. Player 1 was

16.0 years old with a World Junior U18 ranking of 244. Player 2 was 15.3 years old with a World Junior U18 ranking of 271. In addition to several other actions of interest (based on the player's style) previous video analyses identified two KPIs for both players. For Player 1 selected KPIs per set of total unforced errors and service return errors were video tagged and noted. For Player 2 KPIs of total unforced errors and footwork errors were video tagged and noted. Matches were tagged live on a mobile device using dartfishnote^{TM} by an experienced video analyst who knew the players well and was able to identify a KPI with relative ease. Following each match the tagged video was edited by trimming, including colour-coded coaching comments and collating clips of the same action using dartfishanalyzer^{TM}. The video storyboard was then uploaded to dartfishtv^{TM} to be jointly reviewed by the player, coach and video analyst the day after each match.

Between each match there were two days of training with two tactical / technical training sessions each of those days. Each training session was of two hours duration with twenty minutes devoted to physical preparation and cool-down. The physical loading of each two-day period prior to a match was similar to negate the impact of physical fatigue and mental readiness. Prior to Match 1 and Match 2 these training sessions consisted mainly of traditional technique drills with sparring partners and many-balls sessions with the coach. Post-review following Match 2, the coach modified training drills with more focus on match situations with players starting every drill with a serve or return as opposed to an arbitrary stroke. Additionally, 'many balls' training was replaced with service / return practice and 'first ball' situations with an emphasis on reducing unforced errors. For example, the first shot against passive return was highlighted.

KPI counts were normalized to the average set size across four matches of 19 points for each player to account for sets having different numbers of points.

3. RESULTS

High counts for both players in each KPI (negative performance connotation since KPIs refer to errors) were noted after Match 1 (Table 1). These KPI counts increase by + 14 to 90% after Match 2. With the exception of total unforced errors (+ 24%) for Player 2 in Match 3, all KPI counts were reduced from Match 2 to Match 3 (- 32 to 40%) and reduced further to the minimum values in Match 4 (- 23 to 72%).

Table 1. Tracking of player KPI's over four matches

Player	KPI count / set	Match			
		1	2	3	4
1	Total unforced errors	3.7	4.7	3.0	2.3
	Serve return errors	2.3	2.7	1.6	0.8
2	Total unforced errors	2.0	3.8	4.7	1.3
	Poor footwork	2.0	2.5	1.7	1.0

Table2. Match results sets won – sets lost

Player	Match result 1	2	3	4
1	2-3 (L)	1-3 (L)	3-1 (W)	3-1 (W)
2	1-3 (L)	1-3 (L)	3-2 (W)	3-2 (W)

L = Match lost; W = Match won

4. DISCUSSION

In all eight matches at least one set was won by a player (Table 2) confirming the similar playing abilities. Whilst there are multiple factors which can influence the result of a table tennis match, in this case study the selected KPI counts appear to be directly related to the match result. Relatively high KPI counts per set in Match 1, which increased in Match 2, were associated with a 'lost' outcome. Conversely, decreased KPI counts were associated with a 'won' outcome. This suggests that when playing an opponent of similar ability, there is a threshold for errors which should not be exceeded to win the match when adopting your usual style of play. The anomaly of total unforced errors increasing (+ 24%) for Player 2 in Match 3 can potentially be explained by a more aggressive (riskier) approach during a couple of sets. Additionally, as 2 sets were won convincingly with 15 points in total then the normalised KPI count becomes higher than the absolute value.

Improved performance (a reduction in KPI counts and matches won) occurred after Match 2 when the coach decided to change the training content. With more emphasis on match situations, the players devoted more time and attention to the areas they were making mistakes and relatively quick improvement was achieved. One might expect moderate performance improvements following video review sessions without distinct changes to the training content. However, the clear changes to KPI counts and associated improvements in match results confirm that the training content modifications were the main driver in bringing about the positive changes. This case study highlights the importance of analysing all matches and modifying training accordingly to improve performance in the next match. In this way the coach is effectively closing the training – match – analysis – training loop for player improvement. (Figure 1).

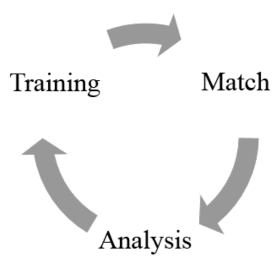

Figure 1. The training – match – analysis – training loop for player improvement.

For two highly-trained players, an experienced coach and video analyst were able to facilitate a positive change in performance in a relatively short period of time. Clearly when considering the long-term development of a player training must include specific technique drills to address weaknesses and many-balls routines to refine technique. However, when looking to optimise training in the short-term to get the best match results, video analyses can help an experienced coach to identify how training could be modified for an individual player to reduce weaknesses and maximise strengths.

5. CONCLUSION

The simple but effective review of video analyses can help an experienced coach to identify individual player KPIs and track them with the aid of a video analyst. By applying this approach systematically for all matches, a coach can use the information gleaned to modify training to enhance player performance and win a match against an opponent of similar playing ability.

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Factor Structure of Morphological and Motor Characteristics of Young Table Tennis Players

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Abstract: The aim of this study was to determine the latent structure of morphological characteristics and motor abilities of young table tennis players (N=101) at the age of 9-11. What was measured were the 15 standard anthropometric measurements for the assessment of four latent morphological dimensions: longitudinal dimensionality, transversal dimensionality of the body, volume and body mass, as well as the subcutaneous adipose tissue. The selected measurements evenly reflect an existing model of the morphological space established by the International Biological Programme. For the assessment of motor skills, 24 tests were measured which best define latent dimensions: coordination, agility, frequency of movement, flexibility, explosive strength, speed, repetitive strength and endurance. Factor analysis was applied according to the method of principal components, selection of eigenvalues by the Kaiser criterion and an orthogonal (varimax) rotation matrix of factor loadings. The obtained results indicate that two factors were extracted in morphological space of young table tennis players: the factor of skeletal dimensionality and the adipose body volume factor. Six factors were isolated in the motor space: the agility factor, the factor of explosive strength and frequency of movement, the factor of the whole body coordination, the factor of the shoulder and hip flexibility, repetitive strength factor and the lower extremities flexibility factor. The obtained results will enable trainers to be more objective when directing the long term development of young players, especially the development of specific motor skills in sensitive phases.

Keywords: table tennis players, morphological characteristics, motor abilities, factor analysis

1. INTRODUCTION

Since table tennis falls 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. What affects the development of technical skills is the level of children's motor abilities, and those are speed, coordination, agility, precision, balance, and strength (Kondrič et al., 2003). By determining the factor analysis of table tennis players' children (Faber, Nijhuis-van der Sanden, Elferink-Gemser and Oosterveld 2015), a two-dimensionality in the motor skills assessment that seems to cover the most important necessary perceptual-motor skills in elite table tennis was obtained. The "ball control" factor's main task load seems to be coordinating and controlling the ball, while the "gross motor function" factor's task is to combine strength, speed and agility.

In the available literature of research dealing with the determination of the latent structure of morphological and motor space of table tennis children players have not been found, compared to some other sports whose latent structure of morphological and motor space is known. In the theory of table tennis, the obtained results will show the latent space of morphological and motor characteristics of table tennis children players, and in practice will help trainers in programming the training process with younger age.

The aim of the research is to determine the structure of latent variables in morphological characteristics and motor abilities of young table tennis players in order to be able to form rational procedures for optimal modelling, planning, programming and controlling the training process as much as possible, as well as following its development during continuous selection of sportsmen and the conduction of the transformational training process.

2. METHODS

The subject sample consisted of 101 table tennis players (61 male and 40 female), aged 9-11 years, with training experience of 2.8±0.93. The measurements took place at ten table tennis clubs in Croatia. The measurements were conducted from September to October 2011. In each club, testing was carried out during three days in the evening training sessions. All the measurements were performed by 7 trained measurers, with the same measurer always measuring the same set of tests. The first day were measured anthropometric measurements, flexibility and repetitive strength tests, second day tests for estimating explosive strength and agility, and a third day of speed, coordination and beep test.

All parents were familiar with the research in accordance with Ethical codex for children research (Ajduković & Kolesarić, 2003) and agreed to participate in the research with written consent.

The variable sample for the assessment of morphological characteristics consisted of 15 standard anthropometric variables, measured according to the International Biological Program (IBP) which stands for a unique measuring methodology (Weiner and Lourie, 1969).

A set of standard motor measuring instruments (Metikoš et al., 1989; Gredelj et al., 1975) was chosen to assess the basic motor abilities. Twenty-four motor tests were used. Based on previous research, the assumption was that those tests cover the area of latent abilities dependent upon moving regulation as well as those dependent upon energetic regulation (Kondrič, 1995).

Factor analysis was also applied – the extraction of factors according the main components method, the selection of distinctive values according to the Kaiser criterion and the orthogonal (varimax) rotation matrix of factor loadings. The Kaiser-Meyer-Olkin test (KMO=.904) points to the justification of the matrix factorization. During the factor interpretation, factor loadings bigger than 0.4 were observed in the matrixes (16% of the explained variance).

3. RESULTS

Fifteen of the anthropometric variables projected onto two significant factors which describe 77.3% of the total variance of the implemented variable system (Table 1). The factor loadings unequivocally define the first factor as the skeletal dimensionality, while the other one has been defined as the adipose body volume factor. The communalities (h^2) have middle and high values, and they vary from .57 to .88, which indicates that variables have a significant variance in space defined by latent dimensions.

Table 1. Factor matrix for anthropometric variables

	Components		
	1	2	h^2
HEIGHT	**.929**	.062	.868
WEIGHT	**.634**	**.675**	.857
ARLENG	**.909**	-.019	.827
LEGLENG	**.841**	-.051	.710
BIAKR	**.825**	.266	.751
BICRIS	**.709**	.403	.665
BRDWR	**.757**	.170	.602
BRDKNEE	**.637**	**.535**	.693
BRDANK	**.745**	.124	.571
EXTFOR	.461	**.804**	.859
AKGUPP	-.023	**.918**	.843
AKGABD	.050	**.938**	.881
AKGBACK	.045	**.870**	.758
AKGTHI	.061	**.936**	.879
EXTFEM	.426	**.805**	.830
eigenvalues	5.920	5.675	
% of variance	**39.47**	**37.83**	

The first main component of the analysed morphological space defines 39.47% of the total variance of the manifested space, and it has meaningful correlations with variables which hypothetically measure the longitudinal dimensionality of the body (body height – HEIGHT, arm length – ARLENG, leg length – LEGLENG), and variables which hypothetically measure the transversal dimensionality of the body (shoulder (biacromial) breadth – BIAKR, hip (bicristal) breadth – BICRIS, wrist breadth – BRDWR, knee diameter (bicondylar breadth) – BRDKNEE and ankle diameter (bicondylar breadth) – BRDANK). Since that the aforementioned variables do not correlate highly with the other isolated component, save for the knee diameter (BRDKNEE) and body weight (WEIGHT), the listed component can be interpreted as a factor of skeletal dimensionality.

The second main component of the analysed morphological space describes 37.83% of the total variance, and it has meaningful correlations with variables which measure body volume (body weight – WEIGHT, extent of femur – EXTFEM, extent of forearm - EXTFOR), and all the variables which hypothetically measure the subcutaneous adipose tissue (upper arm skin fold – AKGUPP, abdominal skin fold – AKGABD, back skinfold – AKGBACK and thighbone skin fold – AKGTHI).

Since the connection of the aforementioned variables with the first isolated component is not high, it is possible to interpret this component as a factor of adipose body volume. By joining the measurements of body volume and mass with the measurements of the subcutaneous adipose tissue measurements, a unique growth and development control mechanism of children of this age is indicated to exist (Katić, Pejčić and Viskić-Štalec, 2004). Two variables which project on both of the components are noticeable in Table 1: body weight (WEIGHT), which is logical to have input in the factor of adipose body volume, while projections of body weight onto the first component are simply a reflection of significant positive correlation of longitudinal and transversal measurements with body weight.

The longitudinal and transversal dimensions represent a significant contribution to the total body weight at this age, but correlations between weight and longitudinal skeletal dimensionality systematically decrease during development (Kurelić et al., 1975). Another variable connected to both factors is the knee diameter, and it is explained in Kurelic's et al. (1975) research in which the bones' diameters at the age of 11, other than the significant projections onto the factor of skeletal dimensionality, are also related with the circular factor. The same authors also indicate that the factor of longitudinal skeletal dimensionality is always manifested as a specific latent dimension and that it is always correlated with the transversal dimension. The mutual connection of latent anthropometric dimensions is the biggest during prepuberty and it systematically recedes during further development. Connecting specific morphological dimensions into mutual factors is no rarity, especially when it is tied to researches dealing with morphological structures of non-sportsmen's children (Bavčević, Vlahović and Božinović Mađor, 2006), children of handball players (Bajrić et al., 2012), children of karateka (Jukić, Katić and Blažević, 2012), and children of tennis players (Al-Sayed, 2012).

To conclude, the space of morphological characteristics with young table tennis players is structurally undefined and undifferentiated, and according to its structure, it significantly differs compared to grown up table tennis players whose morphological structure is defined in three separately isolated dimensions: factor of circular dimensionality of the body and subcutaneous adipose tissue, factor of longitudinal dimensionality of the body and the factor of transversal dimensionality of the body (Saiti, 2015). The obtained morphological structure is identical to the structure of children and young sportsmen, and it indicates that during planning and programing the training process, trainers should accept the children's growth and development attributes.

Table 2. Factor matrix for motor space

	Components						h^2
	1	2	3	4	5	6	
MKZON	**.742**	.302	.098	-.021	-.018	-.068	.657
MPTL	.297	.311	-.141	-.351	**.494**	-.208	.615
SPR5M	**-.686**	-.197	.113	.012	-240.	.160	.606
TROSK	**.512**	**.585**	-.240	.137	.115	-.254	.758
MTAG	-.385	-.076	.209	-.284	-.259	**.475**	.571
MTAUS	**.758**	.335	-.156	-.090	.013	.090	.727
MFTAPN	.230	**.544**	-.159	-.207	-.011	-.022	.417
MFTAPR	.513	**.571**	-.146	.136	.077	.135	.653
MFLPRK	.056	.093	-.013	**-.687**	-.160	.114	.522
MFLISK	.019	.185	-.055	**.801**	-.041	-.019	.681
MFESDM	.295	**.677**	-.353	.187	.170	-.146	.754
MFESDN	.166	**.711**	-.324	.019	-.125	-.259	.721
MAGKUS	**-.739**	-.143	.247	.155	-.126	**.402**	.829
TRCSPS	**-.678**	-.111	.394	-.243	-.014	.266	.757
MPOLN	-.316	-.268	**.712**	.140	-.102	-.254	.774
MAGOSS	-.267	-.195	**.767**	-.248	.061	.107	.774
MTRPS	**-.746**	-.221	.269	.144	-.025	-.003	.699
MSLALT	**-.775**	-.192	.267	-.081	-.132	.031	.734
MBUMT	-.123	-.234	**.772**	.078	-.234	.050	.728
SKLEK	.259	**.523**	.022	.015	**.573**	.236	.725
MBMED	.496	**.578**	-.005	.355	-.058	.055	.712
MFRAZN	-.075	-.067	-.079	-.060	.035	**.836**	.721
MSTUPT	.467	.482	-.280	-.021	.214	.073	.580
CUC30S	.024	-.125	-.136	.193	**.830**	-.041	.763
Eigenvalue	5.415	3.457	2.602	1.805	1.631	1.569	
% of variance	22.56	14.41	10.84	7.522	6.794	6.538	

In factor analysis of motor variables, the Kaiser-Meyer-Olkin test (KMO=.856) indicates the compact correlation sets. The results of orthogonal rotation (Table 2) show six extracted factors which together explain 69% of variance. The participants' results in the definition of the motor space is the variable of lateral steps – MAGKUS with a communality (h^2) of .82. As for other variables, the projection of their communalities range from .57 to .77, and the variable with the lowest (.41) communalities is leg tapping –MFTAPN.

The first big component of the analysed motor space, which interprets 22.56% of variability, is connected to the variables which hypothetically estimate various motor dimensions, arm coordination and agility (juggle with matches – MKZON, lateral agility test – MTAUS, lateral steps – MAGKUS, run with direction change – TRCSPS, run around parallel bars – MTRPS, slalom run – MSLALT), and the variable which hypothetically estimates speed (5m sprint - SPR5M). Considering the structure of movement of the aforementioned variables, where 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, so the isolated component can be interpreted as the agility factor. The fact that these variables are best projected to the first factor of factor analysis is in favor of the idea of the author of this work, according to which these variables strongly differentiate the respondents and thus directly determine their specific motor efficiency in a table tennis game.

The second main component of the analysed motor space is 14.41% of the mutual variance, and it is significantly connected to the variables of explosive energy (medicine ball throw – MBMED, triple jump – TROSK, standing broad jump – MFESDM, and standing broad jump backwards – MFESDN) and the movement frequency speed (arm plate tapping – MFPAPR, leg tapping – MFTAPN), due to which it can also be interpreted as the factor of explosive energy and movement frequency speed. A significant correlation with this factor has been shown by push-ups on the bench (SKLEK) variable which evaluates the repetitive arm strength. The reason for that is due to the fact that after the start of the movement performance with each individual repetition, when the body mass inertness is high, it is necessary to initially speed up, which eases the movement performance, and it has been highlighted with those examinees who do not have enough relative power and who have difficulty starting each individual movement in a series of repetitions. Also, the triple jump (TROSK) variable and the medicine ball throw (MBMED) are significantly tied with the first factor, so it is assumed that in order to perform those tests, coordination also plays a vital role.

The third main component of the analysed motor space, which interprets 10.84% of the variability, correlates with variables which hypothetically measure coordination, polygon backwards (MPOLN), boomerang test (MBUMT) and the "number eight" movement test (MAGGOS). The movement structure of these motor tasks requires full body mobility, during which key problems, i.e. the ones on which the outcome of the task depends, are solved with intensive activity of the core muscles because the core movements have to happen at the same time, and during the whole locomotion which assumes certain obstacles to be beaten or overcome. Since the aforementioned variables have no significant correlations with other isolated components, it can be assumed that it represents the factor of full body coordination.

The fourth main component of the analysed motor space is significantly correlated with two variables which hypothetically measure flexibility of topologically different parts of the body (external arm circumduction with a bar – MFLISK, and forward bend and touch on the bench – MFLPRK), due to which it can be interpreted as a factor of shoulder and hip joint flexibility.

The fifth main component of the analysed motor space is strongly connected to the variables which hypothetically evaluate repetitive strength (sit ups – MPTL, push ups on the bench – SKLEK and squats in 30 s – CUC30), and it can be interpreted as a factor of repetitive strength.

The sixth main component is significantly correlated with the variable which hypothetically evaluates lower extremities flexibility (legs spread apart by lying with feet against the wall, measured under an angle – MFRAZN), and it can be interpreted as a factor of lower extremities flexibility. However, a significant correlation is shown with lateral steps (MAGKUS) and lateral agility test (MTAG) variables, which indicates that the abductor and adductor flexibility is connected to lateral side movement tests. The connection of body flexibility with the coordination factor has been obtained on a sample of grown-up table tennis players (Saiti, 2015) on which three latent factors of motor space have been extracted: the *factor of coordination*, i.e. the factor responsible for rapid assessment of the method and direction of movement, speed of movement in an unusual way, a quick change of direction of movement, simultaneously responsible for the efficiency of the explosive strength of leg muscles as well as the flexibility of the body. The second factor is defined as a *factor of strength of the muscles* on the left and right hand and the repetitive strength of the belly muscles, while the third factor is defined as the *speed factor*, incorporating the speed of frequency movements of the hands and legs.

The results show that the obtained structure is not in accordance with the hypothetically set structure of Metikos et al. (1982). But, on the other hand, the absence of certain hypothetical factors, the condensation of multiple factors into a single one, and the appearance of a general motor factor is no rarity, especially when sampled on children (Gajic, 1986).

4. CONCLUSION

In this research the results indicate that two factors were extracted in the morphological space of young table tennis players: the factor of skeletal dimensionality and adipose body volume factor.

The obtained morphological structure is identical to the structure of children and young sportsmen, and it indicates that trainers should accept the children's growth and development attributes.

Six factors were isolated in the motoric space. They are defined as: agility factor, i.e. the factor responsible for the rapid changes in direction of movement, the factor of explosive strength and frequency of movement, the factor of the whole body coordination, the factor of the shoulder and hip flexibility, repetitive strength factor and flexibility of the lower extremities factor.

The factor 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 in table tennis. The obtained results will enable trainers to be more objective when directing the long term development of young players, especially the development of specific motor skills in sensitive phases.

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Motivational Characteristics in Racket Sports – a Pilot Study

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Abstract: Outstanding performance in individual sports is based on intrinsic motivation. In the last years motivation has been evaluated through self-reported measurement tool that emphasise knowing an athlete down to their finest details. This study investigates 28 athletes, members of their national team, divided into 4 groups: 7 athletes from table tennis; 8 athletes from tennis; 6 athletes from judo and 7 athletes from fencing, who were evaluated with the Sport Motivation Scale, SMS 28. Data analysis was performed by comparing the group results with the Kruskal-Wallis and Mann-Whitney post hoc tests. The study results show significant differences between sports at a global level, composite score intrinsic motivation, p=.033 and composite score extrinsic motivation, p=.001. The Mann Whitney post hoc test revealed significant differences between athletes who practised table tennis and judo, extrinsic motivation external regulation, p=.005, r=0.52; composite score extrinsic motivation, p=.001, r=0.55 with a higher score for judo athletes and athletes who practised fencing, extrinsic motivation introjection, p=.011, r=0.46, with a higher score for table tennis athletes. The results of the analysis of cumulated results from racket sports and other types of sports were non-significant. Racket sports, like table tennis and tennis, have exclusively internal motivation tendencies as opposed to fencing and judo, which on the studied subjects, tend towards external motivation.

Keywords: racket sports, individual sports, motivation

1. INTRODUCTION

Measuring instruments have become a current practise in the attempt to explain human performance. The measuring of an athlete's motivation is a very important aspect for the people involved in high performance sports. Researchers in sport psychology, Pelletier et al. (1995), Elliot and Church (1999), Vallerand and Losier (1999), Li (1999) or Deci and Ryan (2002) have developed psychometric questionnaires that would allow to support the athletes, the coaches and all the sports experts

In the opinion of (Sindik, 2014; Kondric et al., 2010), in individual sports, motivation plays an important role in psychological skills when explaining certain performances or physical education. A first interest for this aptitude is marked by the reasons why an athlete wishes to surpass his/her own limits, most often pushed by some internal and external pressure that is hard to imagine for the public. A second interest is represented by the attempt to explain the burnout phenomenon, in which the potentially high performance athletes come to decide that they no longer wish to go on doing that sport (Martinent et al., 2014), because they have reached the end of the energies that they can put in it. Another aspect is the benefit of the athlete's engagement in that particular sport and the knowledge of the athlete's interests in it (Vallerand and Losier, 1999).

The athlete performing the activities in a conscious and wilful manner has multiple benefits in time, and so does the observation of the different levels of motivation between the athlete's actions and results, without knowing the degree of involvement in the activity (Gaudreau et al., 2010).

Therefore, researchers (Lochbaum et al., 2017) encourage specialists to conduct different investigations and studies that would allow the understanding of the motivation that underlies accomplishment in sports, but also the practice of various physical activities and exercises. In individual sports, the need for accomplishment and involvement is strictly conditioned by the athlete's intrinsic or extrinsic motivation. In tennis, the emotions that the junior players experience in contests need to be examined carefully in order for this phenomenon to be understood (Lewis, 2017).These criteria and observations have led to the conception of some objective investigation resources and have determined the need to use these instruments in order to draw some profiles. The purpose of drawing such profiles is to integrate the individual's stability in a given time frame and to analyze the changes that occur in time by using a longitudinal design (Chian Zason and Wang John, 2008). Moreover, the focusing of such research upon a certain age group helps the practitioners adopt the training programs that best respond to the subjects' emotional needs. Following the same trend, motivational profiles can offer the young players' coaches and families the explanation of some important associations, such as the need to recover, burnout, stress, coping (Martinent and Decret, 2015).

It has been noticed (Martinent and Decret, 2015) that, in the case of table tennis players, those who match the self-determined profile are characterized by a very good psychological state. In fencing, intrinsic motivation in junior fencers is dominant for the young age groups, the main characteristic being encouragement as a reward (Radu and Făgăraş, 2014).

The purpose of this study was to identify the motivational differences between the sports in which a racket or a paddle is used (table tennis and tennis) and other individual sports, respectively fencing and judo.

2. METHODOLOGY

This study investigates 28 elite junior athletes from Romania, mean age 17.01 ± .89 years. The athletes were divided into 4 groups including: 7 table were assessed using the Sport Motivation Scale, SMS 28 (Pelletier, 1995) with seven scales: intrinsic motivation (to know, to accomplish, experience stimulation), extrinsic motivation (identified, introjected, external regulation) and amotivation. The scale had a high level of internal consistency, as determined by a Cronbach's alpha of 0.872.

The survey was supervised by Transilvania University of Braşov. The participants' confidentiality was guaranteed and they were informed as concerning the use of the resulting data.

All survey responses were managed and calculated with IBM SPSS Statistics 18 software. Prior to conducting the main analysis, the data were examined for missing values, outliers and normality, using Shapiro-Wilk test. Due to non-normally distributed data, a non-parametric test was run, Kruskall-Wallis test. We also used Post-Hoc analysis, the Man-Whitney U test, with an alpha level of .05 and effect size. The aim to discover if there are any differences between groups regarding the motivation scales including.

3. RESULTS

Table 1. Descriptive statistics for the variables of the study

		A	B	C
Variable Name	N	M (SD)	Skewness (Std. Error)	Kurtosis (Std. Error)
1	28	24.11	-.249	-1.263
		(2.74)	.441	.858
2	28	25.11	-.583	-.785
		2.58	.441	.858
3	28	25	-1.197	.910
		3.27	.441	.858
4	28	20.82	-.324	-.669
		4.51	.441	.858
5	28	20.14	-.721	-.096
		4.18	.441	.858
6	28	20.96	-.911	1.000
		5.31	.441.	.858
7	28	8.07	.842	-.694
		4.08	.441	.858
8	28	74.18	-.395	-1.456
		7.80	.441	.858
9	28	61.46	-.861	.108
		12.55	.441	.858

(1) intrinsic motivation to know; (2) intrinsic motivation to accomplish; (3) intrinsic motivation to experience stimulation; (4) extrinsic motivation identified; (5). extrinsic motivation introjected; (6). extrinsic motivation external regulation; (7) amotivation; (8)composit score intrinsic motivation (intrinsic motivation to know; intrinsic motivation to accomplish; intrinsic motivation to experience stimulation; (9) composit score extrinsic motivation ((4) extrinsic motivation identified; (5). extrinsic motivation introjected; (6). extrinsic motivation external regulation.

The athletes were grouped according to their individual sports. The Kruskal – Wallis test indicated significant differences between sports at a global level, intrinsic motivation to know, p=.019; intrinsic motivation to accomplish, p=.017; extrinsic motivation - introjected, p= .003, extrinsic motivation - external regulation, p=.004; composite score intrinsic motivation, p=.033 and composite score extrinsic motivation, p=.001. The Mann Whitney post hoc test revealed significant differences between athletes who practiced table tennis and judo, with a higher score for judo athletes extrinsic motivation - external regulation, p=.005, r=-.52, composite score extrinsic motivation, p=.001, r=-.55; between table tennis and fencing, extrinsic motivation introjection p=.011, r=-.46, with higher score in table tennis and no significantly differences between table tennis and tennis. For tennis, post hoc test revealed significant differences with a higher score in judo for intrinsic motivation to know, p=.003, r=-.54; intrinsic motivation to accomplish, p=.008, r=-.48; extrinsic motivation identified, p=.029, r=-.40; extrinsic motivation introjected p=.013, r=-.45; extrinsic motivation external regulation, p=.001, r=-.55; composite score intrinsic motivation, p=.029, r=-.40; composite score extrinsic motivation, p=.001, r=-.58; and fencing, extrinsic motivation introjected, p=.040, r=-.38, with a higher score for tennis athletes. The last analyze was between judo and fencing, the results indicated significant differences with higher score in judo for intrinsic motivation to know, p=.022, r=-.42; intrinsic motivation to accomplish, p=.001, r=-.57; extrinsic motivation introjected p=.001, r=-.57; extrinsic motivation external regulation, p=.002, r=-.53; composite score intrinsic motivation, p=.001, r=-.56; composite score extrinsic motivation, p=.001, r=-.57.

4. DISCUSSION

The athletes who achieve distinctive performances can fulfil their tasks and stay focused on the task regardless of the challenges they face (Chang-Yong Chu et. al, 2010). The need for accomplishment is the main activation source when fulfilling tasks, by using some unconscious motifs that vary from one individual to another in the case of elite athletes based on the specificity of the sports they play (Schüler et al., 2010). This study of rackets sport has not revealed any differences between the players in the table tennis group and those in the tennis group, showing that, in the studied groups, motivation would have the same characteristics. It is worth noting that the combination of technical and tactical training (Raab, et al., 2005) are specific of this age. Notable differences were noticed between the players of table tennis and judo, respectively tennis players and fencers, with significant differences between intrinsic motivation to know, intrinsic motivation to accomplish, extrinsic motivation identified, extrinsic motivation introjected, extrinsic motivation external, composite score intrinsic motivation and composite score extrinsic motivation. The differences between fencing and rackets sport were identified in relation to the extrinsic motivation introjected. Players who played racket sports had an increased level of guilt comparing with the fencers. These results may be important from the perspective of the understanding of the differences between the specificity of each sport and the resemblance of the investigation trends: table tennis, tennis and fencing – versus table tennis, tennis – judo. Judo is a physical contact sport, as opposed to the other sports, in which the face to face confrontation is achieved with the aid of an object. The first possibility of understanding the differences among the sports and the shaping of an athlete's need for accomplishment is the association with the stimuli from the surrounding environment (Gracz and Tomczak, 2008), the coach being the main environmental element for the athlete. Such characteristics of the performance are owed to an environment that favours the shaping of the need for accomplishment, with adequate conditions for exercises that are connected to the granting of benefits, punishments and the self-identification with some important persons, some models. Researchers (Montero-Carretero, 2015) recommend that each conducted study should be interpreted based on the environment that surrounds the athlete, and the results thereof should be associated in this direction. Another approach, which is interesting for the study of elite athletes, is the possibility to get to know their experiences or feelings along the time. Through the evoked case studies, researchers (Debois, 2015) and (Debois, 2012) indicate a nonlinear path to excellence, with multiple normative and non-normative transitions starting from the beginning of the athlete's career and, at the same time, illustrate the shocks and downs that elite athletes might encounter in their search for excellence. A solution that allows to obtain more information about the elite athletes' adaptation to different situations is offered by researchers (Sève, 2007) by using (a) the video recordings of the matches (b) confrontational interviews with the players after the matches (c) transcribing the players' actions and the confrontation data (d) splitting their activity into elemental units and (e) identifying the typical content of the emotions and of the typical emotional situations.

5. CONCLUSIONS

This study has offered a perspective of the comparative knowledge of 4 individual sports in terms of the measurement of certain senior elite athletes' motivation with high performance expectations. The differences between the individual sports cannot provide information about the athletes' needs and motivations. In our study, the differences were noted between the rocket and paddle-using sports and judo. However, these differences were not noted in the comparisons with the fencers, which indicates a number of resemblances between the rocket and paddle-using sports and fencing. The lack of longitudinal studies excludes the possibility to check whether these findings can help forecast the future performances of these athletes. Any future researches should focus on the development of development of a set of tests that assess the multidimensional determining factors of talent and their predictive value in the longitudinal models (Faber, 2015).

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The Effect of Detraining on Cardiovascular Responses in Young Table Tennis Players

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Abstract: The purpose of this study was to evaluate the effect of a 20-day detraining on the cardiovascular responses. Ten (n=10) adolescent players (5 boys & 5 girls), aged 10.8±2.3yrs with body mass 47.5±1.4kg and stature 1.50±1.5cm completed a 10-week Multiball interventional training program and they were reevaluated after a 20-day detraining period. The Oxygen uptake (VO_{2max}), the blood lactate concentration (La) and the maximum Heart Rate (HRmax) were evaluated during the progressive exercise test to exhaustion on a motorized treadmill (S 2500, Tecmachine, Andrezieux-Boutheon, France). Pulmonary gas exchange and ventilation were recorded with the use of Filmate Pro spirometer (Cosmed, Rome, Italy) and Lactate concentration with the use of Accutrend Plus (Roche, Mannheim, Germany). The analysis of variance (ANOVA) with repeated factors (physiological variables vs. measurements) and the Bonferroni post-hoc comparisons were applied in order to compare the effect of different protocols on the players' performance. From the results, it was derived that a 20-day abstention from the table tennis training causes a marginal decline in the players' VO2max {(47.4±2.64 $ml.min.kg^{-1}$ -43.4±2.45 $ml.min.kg^{-1}$), p=0.81}. Also, a tendency for the mean La {(8.06±1. 1$mmol.l^{-1}$ - 7.83±1$mmol.l^{-1}$), p=0.63) and the mean HRmax {(203± 2.8$b.min^{-1}$-202± 2.52$b.min^{-1}$), p=0.81} maintenance of pre detraining values was observed. In summary, the Multiball training method can cause noticeable adaptations to the physiological abilities of adolescent table tennis players which are maintained after a 20-day interruption of the training procedures.

Keywords: VO_{2max}, multiball training, detraining

1. INTRODUCTION

Detraining is the total or partial loss of training adaptations. It is of great importance to know how the detraining physiological phenomenon affects not only the training periodization but also the unexpected injuries. The benefits of training and its subsequent biological and physiological adjustments have been extensively analyzed in literature (Braith & Stewart, 2006; Wessel, Arant & Olson, 2004; Paffenbarger, 2000).

Nevertheless, the consequences of a total cessation of training as well as the implications regarding the performance cannot be easily accessible since high-level athletes tend to meticulously design each phase of their training plan. Regarding the sport of table tennis, limited studies elaborate on the training cessation concerning the athletes' performance in relation to cardiovascular adaptations (Miodutzki et al., 2016).

Thus, the aim of the present study was to evaluate the effect of a 20-day detraining on the cardiorespiratory parameters after a 10-week Multiball training in table tennis adolescent players.

2. METHODS

2.1 Sample

Ten (n=10) table tennis players (5 boys & 5 girls) aged 10.8±2.3yrs, with body mass of 47.5±1.4kg and stature 150±10.5cm volunteered to take part in this study. The participants were active table tennis players and competed in the National Championship. The study was performed according to the rules of the Ethics Committee of Democritus University of Thrace.

2.2 Data Collection

The studied sample trained in an organized 10-week table tennis program using Multiball exercises. The players' Aerobic performance (VO_{2max}), capillary Lactate (La) and maximum Heart Rate (HR_{max}) were evaluated before and after the completion of the intervention program as well as after the training cessation. The Oxygen uptake (VO_{2max}), the blood lactate concentration (La) and the maximum Heart Rate (HR_{max}) were evaluated during the progressive exercise test to exhaustion on a motorized treadmill (S 2500, Tecmachine, Andrezieux-Boutheon, France). Pulmonary gas exchange and ventilation were recorded with the use of Filmate Pro spirometer (Cosmed, Rome, Italy) and Lactate concentration with the use of Accutrend Plus (Roche, Mannheim, Germany).

2.3 Statistical analyses

The analysis of variance (ANOVA) with repeated factors (physiological values vs. measurements) and the Bonferroni post-hoc test were applied in order to evaluate whether the Multiball training affects the adolescent table tennis players' performance after a 20-day detraining. All data analyses were performed by using the IBM-SPSS statistical software 21.0 for Windows. The statistical significance was set at $p<0.05$.

3. RESULTS

The results showed that after a 20-day of detraining a decline in the players' mean VO_{2max} {(47. 4±2.6ml.min.kg^{-1} - 43. 4±2.4ml.min.kg^{-1}, p=0.81} was recorded (Figure 1).

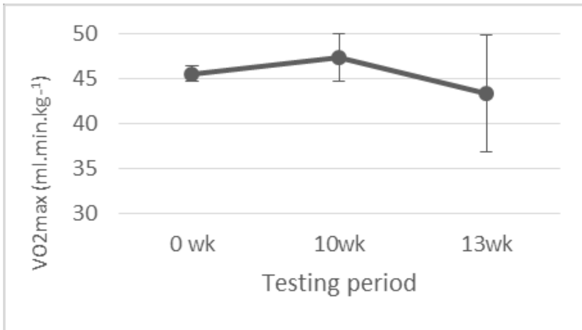

Figure 1. Changes (mean) in VO_{2max} pre (0 week), post the training intervention (10week) and after a 20-day detraining (13week).

In addition, a tendency for value restoration of table tennis players' La {(8.1±1. 1mmol.l^{-1}-7. 8±1mmol.l^{-1}), p=0.63} and HR_{max} {(203± 2.8b.min^{-1}-202±2.5b.min^{-1}, p=0.81} to the initial values was observed (Figure 2,3).

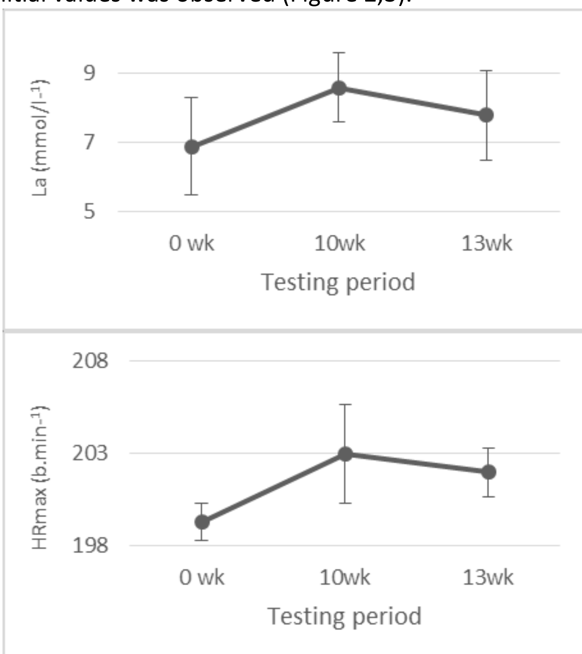

Figure 2,3. Changes (mean) in La and HR_{max} pre (0 week), post the training program (10week) and after the 20 days of detraining (13week).

4. DISCUSSION

Cardiorespiratory endurance. A great number of studies revealed that cardiorespiratory capacity is directly affected by training cessation (Evangelista et al., 2005; Moore et al., 1987). The results of the current study demonstrated that after a short training cessation a marginal decrease in the VO_{2max} was recorded. The above finding is in accordance with relevant studies (Tabata et al., 1996; Martin, Coyle, Bloomfield & Ehsani, 1986; Coyle, Martin, Bloomfield, Lowry & Holloszy, 1985) which proved that after a training cessation of less than 4 weeks acute change of VO_{2max} is noticed in a sample of high-level athletes. A fundamental study conducted by Houston et al., (1979) revealed that after the first 15 days of the detraining a 4% alteration of the samples' VO_{2max} can occur. Similar findings were recorded when after 14 days of the training cessation a 4.7% decrease in the VO_{2max} was presented in endurance athletes (Houmard et al., 1993; 1992). Similarly, the present study which was applied the training and detraining after a Multiball program in table tennis confirmed the findings of the above studies. Therefore, it appears that the rate of detraining is directly related to the context of training prior to the cessation. Consequently, the VO_{2max} decrease comes to 3.6-6% when there is systematic training before cessation (Wibom et al., 1992; Klausen et al., 1981; Ready & Eynon, 1981).

Blood Lactate Concentration. No significant changes are observed in La which seems to be in line with the other physiological parameters of the players. The La values maintenance indicates that the 20 days of training cessation does not bring about significant changes. A similar design study sampling endurance athletes has reported the same findings. In this study, there was no variation in lactate values even after longer cessation intervals of 12-31-45-84 days, indicating that the adaptations caused by training are keeping steady (Coyle et al., 1985).

Maximum Heart Rate: By assessing the HR_{max} we are aware of the fact that the values are mainly affected by the age and less by the training stimuli (Tanaka et al., 2001; De Marneffe et al., 1986; Jose & Collison, 1974). It seems, therefore, that the sample's HR_{max} is not destabilized after the 3 weeks of detraining. The above finding was also detected in a research work carried out by Klausen, Andersen & Pelle, (1981), even though other studies pointed out that the HR_{max} of a well-trained sample is likely to return to the initial values before the training (Houmard et al., 1993). Thus, no significant variation of the adolescent table tennis players' HR_{max} was observed after the 20 days of detraining.

5. CONCLUSION

In summary, the Multiball training stimuli seems to be efficient for the table tennis players causing only a marginal decrease in the VO_{2max} and without any negative effect on their cardiorespiratory parameters after a 20-day period of detraining. Nonetheless, the recorded marginal changes in the athletes' physiological parameters due to detraining should constitute an important tool in the training management of adolescent table tennis players.

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Kinematic Analysis of Top Spin Forehand with Celluloid and Plastic Ball

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Abstract: The top spin forehand (TSF) was always considered the most important and aggressive shot in Table Tennis. In 2014, the International Table Tennis Federation decided to introduce a new kind of ball, maintaining the same diameter (40 mm) but changing the material used from celluloid to plastic. The purpose of this study is to compare the kinematic of TSF, comparing the techniques used with the celluloid ball (CB) and the new plastic ball (PB). Ten male elite athletes were involved in the study. After a warm-up, the athletes were asked to play crosscourt TSF with the same racquet. A Ball machine served balls in the forehand corner. The participants performed ten cross TSF with the CB and ten with PB into a target at the opposite side of the table. For the kinematic analysis a stereo-photogrammetric system was used and the kinematic variables considered are angles between (expressed in degrees): shoulders-table, shoulder-racquet-table, pelvis-table, elbow flexion/extension, knee flexion/extension, and feet-table. Results showed no differences in kinematics variables of upper and lower limbs between TSF performed with CB and PB. This study shows that the type of ball has no substantial influence, this suggests that these athletes are able to adapt their technique to varying playing materials.

Keywords: kinematic, technique, top spin

1. INTRODUCTION

The top spin forehand (TSF) is the most offensive shot used in table tennis.

Kasai and Mori (1998) compared the execution of this shot through a qualitative analysis, not evaluating kinematic variables. They compared six athletes, three expert and three unskilled, respectively.

It is important to study the 3D kinematics to better understand the technical execution of the top spin forehand.

Kondric et al. (2007) evaluated selected kinematic parameters about top spin stroke performed with two different balls, 38- and 40-mm diameter. The study proved that the players increase the amplitude of the shot, due to the increased ball size introduced by the International Table Tennis Federation (ITTF).

In 2009, Iino and Kojima, investigated the effect of performance level and ball spin on the kinematic of TSF. They analyzed: racquet kinematics at ball impact, the variables linked to racquet acceleration and the some contribution of body segment and joint rotation to the racquet speed at impact. Comparing advanced and intermediate athletes, the authors found that lower and trunk axial rotation were the major contributors to the racquet speed at ball impact for both categories of players.

The same authors (Iino and Kojima, 2011) continued to study top spin forehand to determine the mechanical energy generation and transfer, comparing advanced and intermediate players.

In 2014, the ITTF decided to introduce a new kind of ball, maintaining the same diameter (40 mm) but changing the material used from celluloid to plastic.

The first aim of this study is to introduce new kinematic variables (angles) in the study of the TSF. The second purpose of this study is to compare the selected kinematic variables of TSF, evaluating the techniques used with the celluloid ball (CB) and the new plastic ball (PB).

2. METHODS

2.1 Participants

Ten male elite athletes were involved in the study (age 22.7 ± 7.4 years, height 177.3 ± 4.4 cm, mass 74.2 ± 10.7 kg). All participants were volunteers, tests procedures were fully explained, and all the athletes provided written informed consent to participate. The participants were right-handed and they were in the first 150 positions of the Italian Table Tennis official ranking at the moment of the research.

2.2 Materials

The racquet used was a Butterfly Primorac Off- (Tamasu, Japan) with Butterfly tenergy 05 Max rubber sheets (Tamasu Japan). A Ball machine (Joola Compact, Joola Company, Siebeldingen, GER) served balls (speed level 7 and freq. level 1) in the forehand corner. The table was a Joola 2000-S (Joola Company, Siebeldingen, GER). The CB and the PB used for this study were Joola Magic for training, and Butterfly G40+, respectively.

For the kinematic analysis a stereo-photogrammetric system was used (Smart-DX 7000, BTS Bioengineering, 10 cameras, 500 Hz, software version 1.10.451.0) and a total of 44 markers were attached on the athletes' skin. Further markers were attached also on the table (four) and on the racquet (five).

2.3 Experimental procedures

Figure 1 shows the experimental set-up prepared for the experimental procedures.

After a standard warm-up, the athletes were asked to play crosscourt TSF with the same racquet.

Firstly, participants were asked to play top spin forehand for a familiarization with the experimental setting.

Secondly, the participants performed ten cross TSF with the CB and ten with PB into a target at the opposite side of the table. The dimension of the target was 40 x 65 cm (Rodriguez, Vickers & Williams, 2002).

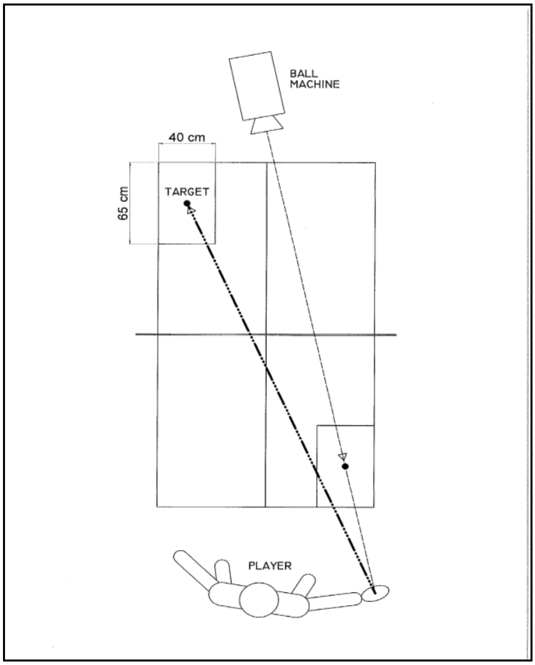

Figure 1. Experimental set-up

2.4 Kinematics

The right racket arm was modelled as an open kinematic chain of 5 segments (thorax, shoulder girdle, humerus, forearm, and hand-table tennis racket) with 9 degrees of freedom: 2 describing the mobility of the shoulder girdle, 3 of the glenohumeral joint, 2 of the elbow, and 2 of the wrist. The bone embedded systems of reference of thorax and of the proximal humerus were defined following ISG recommendations (Van der Helm, 1997). The table system of reference was defined as follow: the x axis was assumed as the middleline, the y axis was assumed as the end line, and the z axis consequently. Appropriate sequences of Euler angles were applied to estimate joint angles.

The kinematic variables are angles (expressed in degrees) between: shoulders-table (max, impact, and min), shoulder-racquet-table (max and impact), pelvis-table (max, impact, and min), elbow flexion/extension (max, impact, and min), knee flexion/extension (max, impact, and min), and feet-table (mean value).

Figure 2 shows the model representation of the angles previously described.

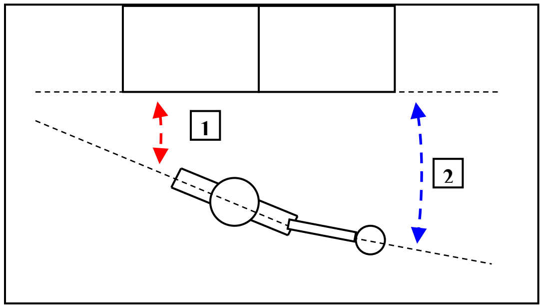

Figure 2. Model representation of the shoulder-table (1) and of the shoulder-racket-table angles (2)

Photo 1 displays the beginning of the action. The kinematic variables measured in this moment were the angles at the maximum value (MAX), expressed in degrees

Photo 1. Beginning of the action

The time at which the maximum speed of the racquet was calculated as the racquet-ball impact (IMP). This is an intermediate phase of the TSF execution followed by the final phase, showed by Photo 2. The kinematic variables measured in this moment were the angles at the minimum value (MIN), expressed in degrees.

Photo 2. End of the execution

2.5 Statistical analysis

For all variables, the mean values measured in the two examined conditions were compared using Student's t tests for paired data. For all tests, significance was set at $p \leq 0.05$.

3. RESULTS

The values of kinematic variables measured in TSF played with CB and PD are reported in Table 1 and Table 2, respectively. All data are reported as mean ± SD.

Table 1. Values of kinematic variables (expressed in degrees) about TSF played with CB

Variables (°)	CB		
	MAX	IMPACT	MIN
Shoulders-table	83 ± 5	26 ± 6	-16 ± 9
Shoulder-racquet-table	61 ± 21	-35 ± 9	-
Pelvis-table	54 ± 3	10 ± 3	-14 ± 12
Elbow (flexion/extention)	106 ± 13	95 ± 9	82 ± 6
Knee (flexion/extention)	151 ± 11	141 ± 7	121 ± 15
Feet-table (mean value)		10 ± 6	

Table 2. Values of kinematic variables (expressed in degrees) about TSF played with PB

Variables (°)	PB		
	MAX	IMPACT	MIN
Shoulders-table	82 ± 7	32 ± 5	-14 ± 12
Shoulder-racquet-table	59 ± 22	-39 ± 9	-
Pelvis-table	54 ± 6	12 ± 2	-11 ± 15
Elbow (flexion/extension)	100 ± 9	89 ± 14	81 ± 8
Knee (flexion/extension)	150 ± 11	141 ± 9	116 ± 9
Feet-table (mean value)		11 ± 6	

Results about statistical analysis are reported in Table 3.

Table 3. Results of Student's t test

Variables (°)	p-value		
	MAX	IMPACT	MIN
Shoulders-table	0,202	0,366	0,454
Shoulder-racquet-table	0,235	0,102	-
Pelvis-table	0,653	0,430	0,465
Elbow (flexion/extension)	0,753	0,086	0,100
Knee (flexion/extension)	0,125	0,959	0,328
Feet-table (mean value)		0,531	

Results showed no significant differences in kinematics variables of upper and lower limbs between TSF performed with CB and PB ($p>0.05$).

4. DISCUSSION

Scientific literature displays a limited number of researches about the biomechanics of TSF. Many authors analyzed selected kinetic variables comparing players of different performance level (Iino & Kojima, 2009), always considering the execution with the same ball (CB). In 2007, Kondric et al. evaluated selected kinematic parameters about top spin stroke performed with two different balls, 38- and 40-mm diameter, due to increased ball size introduced by the International Table Tennis Federation (ITTF).

In 2014, the ITTF introduced a new kind of ball, maintaining the same diameter (40 mm) but changing the material used from celluloid to plastic.

This is the first study comparing TSF performed with the two different balls, evaluating a selected list of kinematic variables. The evaluated parameters were mainly connected with the torsion movement of the body respect to the table. To the best of our knowledge, this is the first research evaluating these angles: mean value between feet and table, shoulders-table (max, impact, and min), shoulder-racquet-table (max and impact), pelvis-table (max, impact, and min), elbow flexion/extension (max, impact, and min), and knee flexion/extension (max, impact, and min).

No significant differences were observed for all lower and upper body angles. This study shows that the type of ball has no substantial influence, this suggests that these athletes are able to adapt their technique to varying playing materials.

Some limitations of the present study should be considered for future research. In particular, future perspectives include the analysis of racquet angles. Furthermore, the trajectory and the spin of the ball may also be examined.

In conclusion, the most important biomechanical parameters influenced by the position of the target on the court was the rotation of the upper and lower body. Kinematic variables should be taken into account to improve the shot effectiveness and to reduce the technical mistakes in intermediate players and beginners. In addition, coaches and physical trainers designing specific training programs for table tennis athletes should consider that top spin forehand executions require specific torsions and joint angles.

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Increasing Participation Through Top-Level Success? Long-Term Analyses of German, French and Austrian Table Tennis

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Abstract: There is a common assumption that successful elite sports would motivate people to participate themselves. However, the evidence for such a "trickle-down effect" is scarce. Rather than being a general effect, the inspirational function of top-level success only seems to enfold in specific cases, i.e. in certain sports, countries and periods. In this paper it is analyzed whether there have been trickle-down effects in table tennis in Germany, France and Austria, from 1964 to 2014. Therefore, relations between the countries' medal success at major international competitions and mass participation in table tennis (indicated by membership and licenses figures) are observed. Results reveal a diverse picture: While for Austria a strong effect can be confirmed, data indicates no significant effect for the case of France, and even a paradox one for German table tennis, with declining membership figures despite continuous success. Thus, as an automatic effect is not guaranteed, it seems necessary for organizations to pursue active leveraging strategies in order to promote the sport.

Keywords: trickle-down effect, table tennis, participation, top-level sport, leveraging

1. INTRODUCTION

Sport associations are usually interested in having a wide base of talents from which they can recruit future top athletes. In turn, the top shall motivate lower ranks to increase efforts. Furthermore it is proclaimed as one of the social functions of elite sport (Grix and Carmichael 2012, Haut 2014) that successful top-level athletes serve as role-models in many respects. They shall set an example in terms of discipline, integrity and fairness (Gaum and Haut, forthcoming), and their achievements shall inspire people to become active in sports themselves. Such "trickle-down effects" are frequently assumed by practitioners and organizers to happen automatically (Misener et al., 2015) after successful performances by their country's athletes.

However, while many active amateur athletes confirm to be motivated by elite performances (Mutter and Pawlowksi 2014), only few empirical studies have found an effect of top-level success on the extent of mass participation, e.g. for the case of football (Frick and Wicker 2016) or for Olympic sports in Germany (Weimar et al., 2015). Rather, the current state of research is that the often taken-for-granted trickle-down effect does only appear in specific cases (De Bosscher et al., 2013), i.e. increasing participation happened only in some sports, in some countries, in some periods. In this paper, the development of the relation between top-level success and mass participation shall be analyzed for the case of table tennis in Germany, France and Austria, for the period 1964-2014.

2. DATA AND METHODS

As indicators of participation in table tennis, in Germany and Austria annual figures on total members associated with the national table tennis associations (DTTB, ÖTTV) were used. Even though there are, on the one hand, passive members included, and on the other hand additional players who are active in informal settings are not, the indicator is adequate, as the clubs in both countries do cover people taking part in official competitions and leagues. For France (FFTT), detailed annual statistics are available on holders of a license, which is obligatory for those wanting to participate in official competitions.

Additionally, annual data on the total population of the countries and on the total members / license holders in all sports were gathered from national sport organisations (Deutscher Olympischer Sportbund; Ministère de la Ville, de la Jeunesse et du Sport; Bundes-Sportorganisation Österreich). These numbers were used to calculate the relative share of the population playing table tennis and the relative growth of table tennis participation compared to other sports – as indicators allow estimating if participation in table tennis developed similarly or differently than in other sports. For Austria, complete data was only available since 1972. For Germany, until 1989 only members in (and achievements of) the Federal Republic were counted.

Information on results of all World Championships (WC) and European Championships (EC) in the period observed, and of table tennis competitions at Olympic Games (OG) (since 1988) was gathered via ittf.com and ettu.org. Included in the analysis were all occasions on which an athlete of the countries involved reached at least the semi-final (i.e. including 4th place when a bronze medal match was played) in any competition, i.e. singles, doubles, mixed or team, for both men and women.

As an additional indicator of success, an Elite Sports Index according to De Bosscher et al. (2013) was calculated for every country in every year: Ten, eight, six and four points are awarded for positions one to four; this score is multiplied by six for OG, by four for WC, and by two for EC. For instance, in 2012 Germany won two bronze medals at the OG (2 x 6 x 6 = 72), a silver medal at the Team WC (1 x 8 x 4 = 32), and one gold (1 x 10 x 2 = 20) and three bronze medals (3 x 6 x 2 = 36) at the EC, resulting in a total ESI score of 160 (72 + 32 + 20 + 36).

First steps of the study were bivariate analyses of the relation between performances and participation. Medal success was considered as intervention, and its effect on the relative annual growth rate of table tennis (difference from annual growth rate of all other sports in the country) was measured by comparing means of successful and unsuccessful years (using partial eta-square as effect size measure). In an explorative procedure, different operationalizations of success were used, i.e. effects were calculated separately only for first places, Olympics, men's competitions, single competitions etc. Assuming the possibility of lagged effects, participation indicators were observed not only for the same year, but also one, two and three years after a success. As alternative, metric indicators the ESI for each year and country and the share of the population playing table tennis in each year in each country were (Pearson) correlated.

As it is clear that membership development in a sport depends on more factors than those observed, and the study thus has rather explorative character, a multivariate model was set aside.

3. RESULTS

Table 1 gives some indication about the general lines of the development of participation in table tennis in Germany, France and Austria. All countries have had their lowest number of players in the first year of observation, and table tennis has grown substantially since then in all countries. While the ÖTTV and FFTT reached peaks only recently – the former after a boom in the late 1990s, the latter with steady growth – the DTTB had most members (almost 800.000) after the German reunification in 1990, but lost continuously since then. However, according to the indicators considered, table tennis is currently still most popular in Germany, with 7.5 per mill of the population being members in a club.

Table 1. Participation and success in table tennis in Germany, France and Austria, 1964-2014

	Germany	France	Austria
Players 1964	203.000 (FRG)	27.200	16.200 (1972)
Highest (Year)	798.000 (1990)	202.000 (2014)	30.200 (2011)
Players 2014	589.000	202.000	27.200
(% of population)	(0.75%)	(0.35%)	(0.35%)
	OG: 5 (-/2/3)	OG: 2 (-/1/1)	OG: -
Medals	WC: 18 (1/7/10)	WC: 10 (2/1/7)	WC: 2 (1/-/1)
	EC: 87 (33/20/34)	EC: 31 (8/4/19)	EC: 29 (5/9/15)

Also, Germany is the most successful country within the period observed, with 110 medals won at OG, WC and EC. Most achievements stem from the period since 1989 (Jörg Roßkopf, Steffen Fetzner, Timo Boll, Dimitri Ovtcharov) and also from the late 1960s (Eberhard Schöler). French athletes have won a total of 43 international medals, the late 1970s (Jacques Secrétin) and the 1990s (Jean-Philippe Gatien, Patrick Chila) being the most successful eras. For Austria, Werner Schlager's bronze medal at the WC 1999 was the first one in the period observed; all of the 31 international medals have been won since then.

Overall analyses, without separating the countries, revealed a weak, but significant trickle-down effect for several indicators (see table 2): If any medals at OG or WC were won, the annual growth of memberships or license holders in table tennis in the country was 2 percentage points higher ($p<0.1$; $\eta^2=.021$) than the average membership or license holder growth in all sport associations in the same year. If a medal was achieved in a men's single competition, table tennis growth was even 4 percentage points higher than in the other sports ($p<0.05$; $\eta^2=.039$). Additional effects when only Olympic medals (no matter if gold, silver or bronze) or only gold medals (no matter if at OG or WC) were considered as treatment could not be confirmed. Correlates between the share of the population playing table tennis and the ESI were also (positively) weak but significant, in the year of the achievements (r = 0.295; p<0.01) as well as three years afterwards (r = 0.230; p<0.01).

Table 2. Relations between success and participation, various indicators

	Overall	Austria	France	Germany
Effect of any medal at OG or WC on relative TT growth (difference from other sports)	η^2=.021*	η^2=.299***	ns	ns
Effect of medal in men's single on relative TT growth (difference from other sports)	η^2=.039**	η^2=.339***	ns	ns
Correlates of Elite Sport Index and share of population playing TT	r = 0.295***	r = 0.565***	ns	ns
Correlates of Elite Sport Index 3 years ago and share of population playing TT	r = 0.230***	r = 0.508***	ns	r = -0.289**

However, the positive relation between success and participation is rather weak and the explained variance is quite small. But even more important for the estimation of the trickle-down effect are the results that derive from country-by-country analyses: Apparently, the overall effect derives solely from the case of Austria, for which correlates and effect sizes are rather strong, while the relationship between any of the indicators for success and participation is not significant for the French case. For Germany there is even slight indication for a paradox effect, as the share of the population being member of a table tennis club correlates negatively with the ESI score three years ago. To make sense of these results, the specific development of table tennis in each country regarding participation and elite success has to be considered again:

Obviously, Austrian table tennis has strong, above-average membership growth since the success of Werner Schlager. It is important to note that the major boost followed after the WC bronze medal in 1999, when ÖTTV membership growth was 34 percentage points higher than in the rest of Austrian sport associations, while the growth after Schlager's WC gold medal in 2003 was 'only' 6 percentage points higher than the average sports growth.

For France, the annual increase in the number of license holders was about 5 to 8 percentage points higher in table tennis than in the other sport associations after the biggest victories such as the mixed WC title by Secrétin / Bergeret in 1977 or the WC medals by Gatien and his double and team partners in 1993 and 1997. In spite of that, relations between success and participation indicators are not significant (p values slightly above 0.1), probably because table tennis growth has also been rather solid and mostly above-average in years without outstanding achievements.

Germany, finally, seems particularly intriguing: The strongest growth effect (7 percentage points higher than DOSB annual growth) occurred immediately after the 1969 WC at home in Munich, when Schöler and his teammates won two silver medals. Concerning the further development, the first remarkable point is that growth rates kept being clearly above-average (3-4 percentage points) for almost a decade in the 1970s, although achievements were not as outstanding as before – after a bronze in

WC mixed 1971, 'only' EC medals followed). Also the early 1980s show above-average growth without major success, probably thanks to a special programme promoting table tennis at schools. But afterwards – and that is the second and maybe most remarkable point – since 1989 the DTTB has lost about a quarter of its (than 800.000) members, although German players have won five Olympic (plus two in 2016) and ten WC medals since 1989, plus dozens of EC titles. And, that is important to note, table tennis memberships diminished up to 5 percentage points more per year than the rest of the German sport associations, which kept slightly growing or remained relatively constant. This recent decrease despite success and the earlier growth, which went partly without success, may explain the paradox results.

4. DISCUSSION

Results of the study show that there is no general trickle-down effect in table tennis. A participation 'boom' as a result of top-level success – as in the Austrian case – is quite exceptional. Neither is the relation between elite performances and mass participation a linear one, in that sense that frequent medal success would guarantee continuous growth – as the development in Germany shows. Rather it appears that chances for top-level inspired mass participation depend on the current situation and former development of the sport in a given country. Outstanding achievements – and outstanding does not necessarily mean Olympic gold medal – seem to be effective especially if the sport is not yet fully established (like in Germany in the late 1960s or in Austria in the late 1990s).

Clearly, elite success is only one factor affecting participation in table tennis, and probably only of minor importance. To be able to estimate the relevance of trickle-down effects more precise, additional factors, such as media coverage or promotion strategies of the associations, should be observed. Furthermore, additional cases (i.e. countries and periods) are needed to clarify the interaction of elite success and mass participation.

Given this uncertain state of research on trickle-down effects on sport participation in general and on the development of table tennis in particular, policy recommendations for practitioners and organizations interested in the promotion of the sport are difficult to discern. As automatic effects are unlikely, it is certainly not a suitable strategy to rely on elite success as a trigger for participation. Rather, outstanding achievements by top-level athletes should be considered as a special occasion in which public attention is higher – and thus chances for promoting the sporty with active leveraging strategies are better than usual.

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Differences in Psychological Skills in Table Tennis Players Depending on Sport Level

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Abstract: The objective of the study was to find out if there are differences in the psychological abilities related to sport performance, according to the level of sport practice (professional vs amateurs, international successes vs no international successes) in table tennis players. The sample consisted of 133 table tennis players from Spain. In order to measure the psychological abilities of table tennis athletes, the Spanish version of the "Psychological Characteristics Related to Sport Performance Questionnaire" (CPRD) was used. The results did not show significant differences (p>.05) in mental abilities (stress control, influence of performance evaluation, motivation, mental ability and team cohesion) among professional and amateur table tennis players. On the other hand, no significant differences (p>.05) were found in these mental abilities among athletes with and without international successes. It was concluded that there are no differences in psychological skills related to competition, depending on the level of sports performance, of Spanish table tennis players.

Keywords: mental skills, sport performance, racket sport

1. INTRODUCTION

On the way to success in table tennis is plenty of variables that make it difficult to arrive toward excellence (Elferink-Gemser, 2013). In this case, the psychological skills of table tennis players are included in personal variables that affect sport performance (Elferink-Gemser & Visscher, 2012). Some of the variables most examined in sport are: motivation, attention, stress, anxiety, self-confidence, moods, self-control and self-regulation, cohesion, interpersonal skills or emotional adjustment (Buceta, 1996; González, Valdivia-Moral, Cachón, Zurita, & Romero, 2017). In this regard, in the field of table tennis Chen, Chang, Hung, Chen and Hung (2010) emphasized the following psychological factors that affect elite players: "lack of confidence" “overstress” and “unable to cope” with opponent's tactics.

In the case of excess stress, it has been shown that table tennis due to the technical character requires a good control of stress, anxiety and anger because they can lead to a poor sport performance (Godoy-Izquierdo, Vélez and Pradas, 2009; Martinent, Campo and Ferrand, 2012). Moreover, there are researches that have shown that personality characteristics and emotions can help stress control in competition. In this case, they are self-confidence, self-efficacy, excitement and happiness (Cantón & Checa, 2012; Mowlaie, Besharat, Pourbohlool, & Azizi, 2011;

Robyn, Robyn, & Robert, 2010). In this sense, following Canton & Checa (2012) and Mowlaie et al. (2011) demonstrated that self-confidence and self-efficacy can help anger control during competition. In addition, excitement and happiness have also shown to be related to concentration; opposite to anxiety, discouragement, and anger (Robyn, Robyn, & Robert, 2010). The positive emotions lead to greater automation of movement, greater concentration and greater performance.

In the field of motivation in table tennis, in a previous work of Yoshizawa, Suzuki, Yonekawa, Okazawa, Tsuruhara, & Yamamoto (1992), they found differences in the motivation of the athletes in function of sport performance. Thus, male players who had a high-performance scored more athletic motivation, but there was less athletic motivation in male players who had a low performance score. In addition, in a study by Godoy-Izquierdo et al. (2009), there was a greater basic motivation in racket sports than in soccer and this research include table tennis players in racket sports.

In the field of performance evaluation, it has been shown that the perception of performance evaluation in racket sports is higher than in collective sports (Godoy-Izquierdo, Vélez, & Pradas, 2009). In addition, it has been shown that in table tennis (Graydon & Murphy, 1995) a positive relation has been obtained between the sport result and the extraversion, consequently this variable may have a special relation with the performance evaluation factor. In addition, extraversion can act as a mediating factor in the presence of public.

On the other hand, the previous studies have proved the positive relationship between psychological abilities and sport performance (Cox, Liu, & Qiu, 1996; Grossarth-Maticek et al., 1990; Mahoney, 1989; Mahoney, Gabriel, & Perkins, 1987), but gender and type of sport could modulate the relation between psychological skills and performance level (Elferink-Gemser, Visscher, & Lemmink, 2008). In general, Mahoney et al. (1987) and Mahoney (1989) describe elite athletes more motivated, more self-confident, more anxiety control and more focused on their own performance.

As previous studies have shown the importance of psychological skills to perform in table tennis, it is interesting to know what psychological skills are necessary to achieve success in table tennis. After the wide theoretical evidence that athletes with greater performance have better mental abilities in sport, the hypothesis established in this work is: athletes with greater level have better mental abilities related to sport performance than those with lower level. Therefore, the aim of this research was to find out if there were differences in the psychological abilities related to sport performance, according to the level of sport practice (professional vs amateurs, international successes vs no international successes) in table tennis players.

2. METHODS

Participants

The total study sample consisted of 133 Spanish table tennis players from Spanish geography. Of the total subjects, 20 are women (15%) 113 were men (85%) and with an age between 9 and 60 years old (*M*=27.55; *SD*=14.16). Of the total, 7 table tennis players were not federated (5.3%), 126 were federated (94.7%) and 21 were professional table tennis players (15.8%).

Variables and Instruments

In order to measure the Psychological Abilities of Table Tennis Athletes, the Spanish version of the "Psychological Characteristics Related to Sport Performance Questionnaire" (CPRD; Gimeno, 1999; Gimeno, Buceta, & Pérez-Llantada, 1999) was used. This questionnaire was elaborated from the Psychological Skills Inventory for Sports questionnaire (PSIS-r5; Mahoney et al., 1987). This instrument has a high internal consistency in all 55 items (α=.85), and values higher than .70 in three of the five scales that define its factorial structure: stress control (α=.88), the influence of performance evaluation (which is a specific stress variable) (α=.72), motivation (α=.67), mental ability (α=.34) and team cohesion (α=.78). The Stress Control (EC) scale consists of 20 items, it refers to potentially stressful situations in which control is necessary and the athlete's responses to training demands and competition. A high score indicates that the athlete has psychological resources to control the stress related to their sport. The Influence of Performance Evaluation scale (IER) consists of 12 items, it refers to the characteristics of the athlete's responses to situations in which they evaluate their own performance, or they argue that they are being evaluated by people who are significant to them. In addition, it also includes the assessment regarding the antecedents that can originate an evaluation of the athlete's sport performance. A high score indicates that the athlete shows a high control of the impact of a negative evaluation on their performance. The Motivation scale (M) consists of 8 items, it refers to the basic motivation for performance and sports achievement, and the daily motivation for daily training or competition. A high score indicates that the athlete is very motivated to practice competitive sports. The Mental Ability Scale (HM) consists of 9 items, and it refers to the use of a series of mental abilities that can affect the performance of the athlete in benefit of their performance. A high score indicates that the athlete has resources that can help him perform better. The Team Cohesion (CH) scale consists of 6 items, and it refers to the degree to which the athlete is attracted and identified with the sports group. A high score indicates that the athlete is willing to work with the team.

Process

First, the Spanish sports federations were contacted online; and coaches and athletes in person. The federations announced on their website the conditions to participate in the study. In this way, the interested athletes contacted the main researcher. The volunteer participants sent an e-mail to the researchers, and once they claimed their interest in participating, they received the link to the research questionnaire. On the other hand, in the case of contact with the athletes and coaches in person, the athletes would give their email to researchers to receive the instructions and the research questionnaire in their email. In both cases, the questionnaire could do in their free time. Once the participants accessed the questionnaire, they signed an informed consent. After signing the informed consent, they began to complete the research questionnaire. After completing the questionnaire, the data was hosted on the application "Google Drive." In which the research questionnaires were saved in excel electronic format.

Data analysis

The data analysis was performed using SPSS 19 version software. The descriptive analysis of average, minimum, maximum, frequencies, percentage and standard deviation were used to know the sample characteristics. The *U* Mann-Whitney was realized for independent samples to know the mean differences when the variables were quantitative, using a confidence interval of 95% level.

3. RESULTS

Firstly, to determine if there were differences in the psychological abilities related to sport performance, according to the level of sport practice, a *U* Mann-Whitney was realized for independent samples, in which the sample is divided into two groups: Professional Table Tennis Players (PTTP; N=22) and Amateurs (AP; N=113).

Table 1. Mental Abilities, Professionals and Amateurs

Mental Ability	*PTTP (N=22) M (DT)*	*AP (N=113) M (DT)*	*Z (p)*
Stress Control	51.50 (11.76)	51.27 (10.67)	-.215 (.83)
Inf. Performance Evaluation	27.77 (11.38)	24.85 (7.44)	-.62 (.53)
Motivation	25.90 (5.66)	24.35 (5.13)	-1.17 (.24)
Mental Ability	27.50 (6.06)	26.92 (5.99)	-.402 (.68)
Team Cohesion	23.86 (5.03)	23.26 (3.96)	-1.22 (.22)

In Table 1, the results didn´t show significant differences between professional and amateur table tennis players in mental abilities.

Secondly, to determine if there were differences in the psychological abilities related to sport performance, according to the level of sport success, a *U* Mann-Whitney was realized for independent samples, in which the sample is divided into two groups: International Success (IS; N=13) and No International Success (NIS; N=120).

Table 2. Mental Abilities and International Success

Mental Ability	*IS (N=13) M (DT)*	*NIS (N=120) M (DT)*	*Z (p)*
Stress Control	49.61 (6.51)	51.50 (11.18)	-.54 (.58)
Inf. Performance Evaluation	23.53 (7.27)	25.52 (8.34)	-1.06 (.28)
Motivation	26.76 (5.47)	24.38 (5.17)	-1.30 (.19)
Mental Ability	28 (5.94)	26.91 (6.00)	-.67 (.50)
Team Cohesion	24.46 (3.28)	23.24 (4.22)	-.82 (.41)

In Table 2, the results didn´t show significant differences between international success players and non-international success table tennis players in mental abilities.

4. DISCUSSION

The aim of this research was to find out if there were differences in the psychological abilities related to sport performance, according to the level of sport practice in table tennis players. Firstly, no differences were found in the psychological abilities of athletes depending on whether they are professional’s table tennis players or amateurs. E.g. other studies have found differences in psychological skills depending on sport performance (Cox et al., 1996; Graydon & Murphy, 1995; Grossarth-Maticek et al., 1990; Mahoney, 1989; Mahoney et al., 1987; Yoshizawa et al., 1992), but in this work, dividing the sample into professionals and amateurs no differences were found. Perhaps, the concept of being professional in the sport is too wide to be able to differentiate the psychological skills of athletes. In addition, there are previous studies that have shown that sport type influences in differences between psychological abilities in sport performance (Elferink-Gemser et al., 2008) and it could moderate the relationship. Consequently, the idiosyncratic characteristics of table tennis could make athletes stronger psychology abilities since the beginning and it could change the results. Secondly, no differences were found in the psychological skills of athletes between those who have international successes and those who do not succeed. In this case, the previous results are confirmed in which there is no relationship between psychological abilities in table tennis, according to amateur and professional athletes. This may show that differences in level of Spanish athletes with higher sport performance could reside in their technical, tactical, physical or personality skills, but not in their psychological skills related to sport performance (influence of performance evaluation, motivation, mental ability and team cohesion). Furthermore, it could be shown that the evolution of current table tennis is an extreme develop of technical skills and physical condition (Pradas, Salvà, González-Campos, & González-Jurado, 2015) and it could be the big differences between table tennis players depending on sport level.

The main limitation of this study is the difficulty of conceptualizing sport performance, because it is a very broad concept, difficult to define and is compound by a lot of variables which are difficult to measure. In addition, the results couldn´t be understood within the context of the culture and level of Spanish table tennis players. Another limitation is the search for professional table tennis athletes and with international successes, for their important commitments, complicated schedules and the small number of international successful athletes and professional table tennis players in Spain.

As proposal future research line, it would be interesting to compare these results with other sports to know how the practice of table tennis itself evolves the psychological skills of athletes. In this way, profiles could be established without the different sports modalities. In addition, it would be interesting to replicate this study with top international athletes depending on ranking position to find out how the levels of psychological abilities of these athletes evolve and thus to know if there are differences in this population.

The conclusion of this study is that, there are no differences in psychological skills related to competition, depending on the level of sport performance of Spanish table tennis players. In addition, this may be because the differences between players with higher and lower level reside in other skills of athletes such as tactical skills, physical skills or personality. Although, it is important to remark that in this study the professional and succeeded athletes were a small group, so maybe there are no differences a cause of sample characteristics.

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Motivation and Mental Ability Differences in Table Tennis Players Depending on Age

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Abstract: The objective of this research was to find out if there are differences in motivation and mental ability of table tennis athletes depending on age category (senior and veterans, and young table tennis players from 8 to 22 years old). The sample consisted of 133 table tennis players from Spain. In order to measure the psychological abilities of table tennis athletes, the Spanish version of the *"Psychological Characteristics Related to Sport Performance Questionnaire"* (CPRD) was used. The results showed higher levels of motivation (p<.01) and mental ability (p<.01) in young table tennis players. No differences were found in the other factors (stress control, influence of performance evaluation and team cohesion). Subsequently, the mental ability factors and motivation factors were separated, the results showed higher levels in young table tennis players in: visualization practice (p<.01), positive self-talk (p<.05) others mental abilities (p<.05) and basic motivation (p<.01). In addition, linear regression analyses (R^2=.83) showed a relationship between the other mental abilities related to focus, basic motivation and young table tennis players. It was concluded that young table tennis players have better mental abilities and motivation in the areas of: basic motivation, visualization practice, positive self-talk, and other mental abilities. Furthermore, basic motivation and other mental abilities are related to young table tennis players.

Keywords: mental ability, sport performance, racket sport, motivation

1. INTRODUCTION

In the last times, it has been an increase in the interest of knowing the differences between elite players and those athletes with lower level (Gimeno, Buceta, & Pérez-Llantada, 2007). In addition, the popularization of sport has grown and has gradually spread to all ages (Hernán, Fernández, & Ramos, 2004). In the case of Spain, veteran table tennis players compete as much as young players; therefore, the competition offer has been extended to all audiences and the need to perform is conceived at all ages. In this sense, according to Gimeno et al., (2007), the most outstanding variables for achieving success in sports are: motivation, attention, stress, anxiety, self-confidence, mood, self-control and self-regulation, cohesion, interpersonal skills or emotional adjustment.

In the case of motivation, in a study by Godoy-Izquierdo, Vélez and Pradas (2009), in racket and soccer players, younger players obtained higher levels of daily motivation and competitive motivation. In a previous work of Yoshizawa, Suzuki, Yonekawa, Okazawa, Tsuruhara and Yamamoto (1992) in table tennis, they found differences in the motivation of the athletes in function of the sport performance. In addition, in a study by Godoy-Izquierdo et al. (2009), there was a greater basic motivation in racket sports than in soccer.

In the case of anxiety, following Kent (2003) a high level of anxiety reduces performance because it affects the quality of attention and therefore, the execution. In addition, the technical nature of table tennis favors that an excess of uncontrolled activation could produce poor performance (Martinent, Campo, & Ferrand, 2012). Following González (2011) it is important to know how to control stress, so that it does not break into the mental and emotional balance of the athlete. The influence of anxiety on sports performance is clear, following Lundqvist, Kenttä, & Raglin (2011) low scores in this variable and combined with high levels of self-confidence are those that function as facilitators in sports achievement. In addition, Chen, Chang, Hung, Chen and Hung (2010) also emphasized that the three major psychological deficiencies of table tennis players are: "lack of confidence", “overstress” and "unable to cope" with opponent's tactics.

In the case of team cohesion, in table tennis makes sense because the need for athletes to strive for common team goals and cohesion centered on interpersonal relationships. In the case of teams that seek maximum performance, cohesion should be centered on the common objectives of the team (Gimeno, Buceta, & Pérez-Llantada, 1999).

On the other hand, the influence of the performance evaluation would be the athlete perception of his own performance and the perception of the evaluation that other relevant people do about the player (Gimeno et al., 1999). Furthermore, it has been shown that the perception of performance evaluation in racket sports is higher than in collective sports (Godoy-Izquierdo et al., 2009). On this way, the performance evaluation is important in table tennis because it could make feel uncomfortable the table tennis players.

In the psychological skills domain, in a study by Godoy-Izquierdo et al. (2009) in racket and soccer athletes, young athletes showed a low control of psychological skills (activation control and anxiety, use of positive self-phrases, successes attribution and failures, coping with successes and failures, use of visualization, concentration control, reflexivity vs. impulsivity, and self-confidence) compared to older athletes.

For the importance that has taken to perform in all the sport career ages and for the importance that show the psychological abilities related to the sport performance. “In this sense, the hypothesis that was established in this research work is that the older athletes have better mental abilities related to sport performance than younger table tennis players. The objective of this research was to find out if there are differences in motivation and mental ability of table tennis athletes depending on age category (senior and veterans, and young table tennis players from 8 to 22 years old).

2. METHODS

Participants

The total study sample consisted of 133 Spanish table tennis players from Spanish geography. Of the total subjects, 20 are women (15%) 113 were men (85%) and with an age between 9 and 60 years old (*M*=27.55; *SD*=14.16). Of the total, 7 athletes were not federated (5.3%), 126 were federated (94.7%) and 21 were professional table tennis players (15.8%).

Variables and Instruments

In order to measure the Psychological Abilities of Table Tennis Athletes, the Spanish version of the "*Psychological Characteristics Related to Sport Performance Questionnaire*" (CPRD; Gimeno, 1999; Gimeno, Buceta, & Pérez-Llantada, 1999) was used. This questionnaire was elaborated from the Psychological Skills Inventory for Sports questionnaire (PSIS-r5; Mahoney, Gabriel, & Perkins, 1987). This instrument has a high internal consistency in all 55 items (α=.85), and values higher than .70 in three of the five scales that define its factorial structure: stress control (α=.88), the influence of performance evaluation (which is a specific stress variable) (α=.72), motivation (α=.67), mental ability (α=.34) and team cohesion (α=.78). The Stress Control (EC) scale consists of 20 items, it refers to potentially stressful situations in which control is necessary and the athlete's responses to training demands and competition. A high score indicates that the athlete has psychological resources to control the stress related to their sport. The Influence of Performance Evaluation scale (IER) consists of 12 items, it refers to the characteristics of the athlete's responses to situations in which they evaluate their own performance, or they argue that they are being evaluated by people who are significant to them. In addition, it also includes the assessment regarding the antecedents that can originate an evaluation of the athlete's sport performance. A high score indicates that the athlete shows a high control of the impact of a negative evaluation on their performance. The Motivation scale (M) consists of 8 items, it refers to the basic motivation for performance and sports achievement, and the daily motivation for daily training or competition. A high score indicates that the athlete is very motivated to practice competitive sports. The Mental Ability Scale (HM) consists of 9 items, and it refers to the use of a series of mental abilities that can affect the performance of the athlete in benefit of their performance. A high score indicates that the athlete has resources that can help him perform better. The Team Cohesion (CH) scale consists of 6 items, and it refers to the degree to which the athlete is attracted and identified with the sports group. A high score indicates that the athlete is willing to work with the team.

Process

First, the Spanish sports federations were contacted online; and coaches and athletes in person. The federations announced on their website the conditions to participate in the study. In this way, the interested athletes contacted the main researcher. The volunteer participants sent an e-mail to the researchers, and once they claimed their interest in participating, they received the link to the research questionnaire. On the other hand, in the case of contact with the athletes and coaches in person, the athletes would give their email to researchers to receive the instructions and the research questionnaire in their email. In both cases, the questionnaire could be done in their free time. Once the participants accessed the questionnaire, they signed an informed consent. After signing the informed consent, they began to complete the research questionnaire. After completing the questionnaire, the data was hosted on the application "Google Drive." In which the research questionnaires were saved in excel electronic format.

Data analysis

The data analysis was performed using SPSS 19 version software. The descriptive analysis of average, minimum, maximum, frequencies, percentage and standard deviation were used to know the sample characteristics. The student *t* test for independent samples was used to know the mean differences when the variables were quantitative, using a confidence interval of 95% level. Linear regression was performed in order to estimate the predictive value of mental ability depending on age. The Cohen *d* was used to analyze the effect size and thus to know the magnitude of the differences found in the Student *t* test. Following Cohen (1988) it can be considered the effect size results as: *d*=.02 (small), *d*=.5 (moderate), *d*=.80 (big effect) (Cohen, 1988).

3. RESULTS

Firstly, to determine if there are differences in mental ability of table tennis athletes depending on age category, a t-test was realized for independent samples, in which the sample is divided into two groups: Young Table Tennis Players (YTTP; N=63) and Senior and Veterans (SV; N=70). Subsequently, Cohen *d* was calculated from those variables that had obtained significant differences.

Table 1. Sport Performance Characteristics, young, senior and veterans

Mental Ability	*YTTP (N=63) M (SD)*	*SV (N=70) M (SD)*	*t (p)*	*d Cohen*
Stress Control	52.25 (10.35)	50.47 (11.22)	.94 (.345)	.19
Inf. Performance Evaluation	24.81 (6.92)	25.81 (9.30)	-.70 (,484)	.07
Motivation	23.85 (5.04)	23.47 (5.17)	2.70 (.008)**	.47
Mental Ability	28.72 (5.83)	25.61 (5.78)	3.01 (.003)**	.53
Team Cohesion	23.65 (3.53)	23.10 (4.64)	.775 (.44)	.14

Note. *p<.05; **p<.01

In Table 1, the results showed higher levels of motivation (p<.01; d=.47) and mental ability (p<.01; d=.53) in young table tennis players.

Secondly, to determine if there are differences in motivation factors depending on age category, a t-test was realized for independent samples, in which the sample is divided into two groups: Young Table Tennis Players (YTTP; N=63) and Senior and Veterans (SV; N=70). Subsequently, Cohen *d* was calculated from those variables that had obtained significant differences. I would like to add: In this case the motivation factors were divided into: basic motivation, daily motivation and goal setting motivation.

Table 2. Motivation, young players, senior and veterans

Motivation	*Young TT Players (N=63) M (SD)*	*Senior and Veterans TT Players (N=70) M (SD)*	*t (p)*	*d Cohen*
Basic Motivation	14.29 (3.55)	12.60 (3.35)	2.84 (.005)**	.49
Daily Motivation	10.01 (2.36)	9.58 (2.72)	.97 (.33)	.16
Goal Setting	3.43 (1.12)	3.37 (1.09)	.34 (.73)	.08

Note. **p*<.05; ***p*<.01

In Table 2, the results showed higher levels in young table tennis players in basic motivation (*p*<.01; *d*=.49).

Thirdly, to determine if there are differences in mental abilities factors depending on age category, a *t*-test was realized for independent samples, in which the sample is divided into two groups: Young Table Tennis Players (YTTP; *S*=63) and Senior and Veterans (SV; *S*=70). One more time in this analysis are measured the goal settings but adding new items that talk about mental ability in goal settings. Subsequently, Cohen *d* was calculated from those variables that had obtained significant differences. I would like to add: In this case the mental abilities were divided into: visualization, goal setting, positive self-talk, performance analysis, ability deficit, tension control and other mental ability.

Table 3. Mental abilities, young players, senior and veterans

Mental abilities	*Young TT Players (N=63) M (SD)*	*Senior and Veterans TT Players (N=70) M (SD)*	*t (p)*	*d cohen*
Visualization	11.90 (3.44)	9.98 (3.11)	3.35 (.001)**	.58
Goal Setting	10.29 (2.69)	9.51 (2.87)	1.59 (.114)	.31
Positive Self-Talk	4.28 (1.02)	3.81 (1.19)	2.43 (.016)*	.42
Performance analysis	3.63 (.95)	3.65 (1.12)	-.122 (.903)	.04.
Ability deficit	5.79 (2.93)	6.12 (2.80)	-.669 (.50)	.08
Tension Control	3.42 (1.13)	3.20 (1.26)	1.06 (.29)	.15
Other mental ability	14.85 (3.09)	13.64 (3.69)	2.05 (.042)*	.35

Note. **p*<.05; ***p*<.01

In Table 3, the results showed higher levels in young table tennis players in: visualization practice (*p*<.01; *d*=.58), positive self-talk (*p*<.05; *d*=.42) and others mental abilities (p<.05; d=.35).

In Table 4, a linear regression was performed to know the predictive value of each statistically significant variables in t test, in this case visualization, Positive Self-Talk, other mental ability and basic motivation. The predictive model was significant (F=217.99; p<.01). In addition, the model showed and high predictability (R^2=.83). The results showed that other mental abilities and basic motivation significantly positively predicted the age of the participants.

Table 4. Linear regression to predict motivation variables

Variables	*B*	*Error típ*	*Beta*	*t (p)*
Visualization	.004	.019	.032	.241 (.81)
Other Mental ability	.069	.016	.622	4.027 (.00)**
Positive Self-Talk	.104	.054	.27	1.917 (.057)
Basic Motivation	.104	.004	.900	23.78 (.00)**

Note. *p<.05; **p<.01

4. DISCUSSION

The objective of this research was to find out if there are differences in motivation and mental ability of table tennis athletes depending on age category (senior and veterans, and young table tennis players from 8 to 22 years old). The results showed higher levels of mental ability in young table tennis players, in the factors: visualization practice, positive self-talk and others mental abilities. In this case, the young players present better goal setting, objective performance analysis, greater use of positive self-talk, visualization and cognitive self-regulation. Moreover, this research work contradicts the previous study of Godoy-Izquierdo et al. (2009), which showed low control of psychological skills in young athletes compared to older athletes, but this study analyzes a sample with a smaller age range (from 9 to 17 years old) and in a smaller sample with table tennis, football and badminton. Thus, the results could be modified by the age range of the sample, but it is important not to forget that these psychological abilities (goal setting, objective performance analysis, greater use of self-positive-talk, visualization and cognitive self-regulation) are important to have a good performance in competition (Gimeno et al., 2007). Therefore, these abilities could limit veterans and senior performance in competition against the younger players.

On the other hand, the results showed higher levels of motivation in young table tennis players, in the factor: basic motivation. In this sense, young athletes show more training motivation, greater establishment and achievement of goals, motivation to overcome day by day, focus on training and motivation to be better. In addition, they give more priority about the sport in their life than seniors/veterans and value more positively the cost/benefit of the sport practice. These results follow the previous study of Godoy-Izquierdo et al. (2009), where younger players obtained higher levels of daily motivation and competitive motivation. There, in this sample with more age's differences it is proved that younger table tennis players have more motivation than older table tennis players.

One of the research limitations is the categorizations that have been used to divide the groups by age. In this way, the division of lower categories is a huge age range in which there may be an evolution in the domain of psychological skills. In addition, the union of seniors and veterans is also a limitation, because each group presents different socio-labor characteristics. Moreover, it´s important to understand the results in the context of Spanish society and the current properties of Spanish table tennis players leagues system and competition.

As proposal future research line, it would be interesting to compare these results with other sports to know the different profiles that each sport could make. Furthermore, it would be interesting to replicate the study dividing into different categories of table tennis to know the differences between each category of athlete development. In this way, could be established an evolution of the psychological abilities to work by the sports psychologist at each stage of the table tennis players career. Moreover, it could be interesting to know the influence of motivation and mental ability in the future achieve of sport performance.

The conclusion of this study was that young table tennis players have better mental abilities and motivation in the areas of: basic motivation, visualization practice, positive self-talk, and other mental abilities. Furthermore, basic motivation and other mental abilities are related to young table tennis players. In addition, the performance and learning differences between seniors/veterans and young table tennis players could be due to de differences in the levels of motivation and mental abilities, although there are other factors that influence like: age, family, work, studies, etc.

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Match Characteristics of Professional European Male Table Tennis Players

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Abstract: The purpose of this study was to investigate the match characteristics of professional male table tennis players considering analyses of men's singles competition at the 2015 European Games held in Baku. Forty five players which were competing in Men's individual event at EG 2015 in 46 matches were analysed. Match characteristics were also analysed according of the phase of competition (from the 1st round to final) and considering the performance level of players. Performance indicators were: played points, games, set and match duration, the number of strokes in point (average and longest rallies). From these observations, the proportion of match time spent in play (effective playing time of whole match and sets) was determined. For all indicators descriptive statistical parameters were calculated, while differences according phase of competition and performance level of players were analysed using one-way ANOVA ($p<0.05$). Players played average 101.07±22.34 points per game (best of seven) and 18.2±1.00 points per set. Points in the game and sets were increasing during the playing from stage to stage. Mean strokes per point (rally) was 4.76±1.64, and longest rallies in games were 9.37±3.75. Total match time in competition was 35.0±6.1 min (in range, from 28.0-46.0 min) and it was increased from stage to stage. Duration of played set was 6.07±0.7 min (4.8-7.7 min). In all analysed performance indicators according of the phase of competition statistically significant differences were noted ($p<0.05$). These results provide original information about the match characteristics which can be used in modelling of the training process.

Keywords: table tennis, competition, activity analyses, notational analyses, player performance

1. INTRODUCTION

Table tennis is played throughout the world by people of all ages and standards in a recreational or competitive basis. Despite the global popularity of table tennis, the physical demands and player performance in competition are not fully understood, and nobody determined the influence of analysed factors of the game in playing result. There is a need for analyses of competitive table tennis for the objective evaluation of matters such as associations between performance and player characteristics, training and nutritional interventions, and environmental conditions. Match analysis is an area of sports science and describes the analysis of actual sports competition. Notational analysis (Downey, 1992) and notational analysis (Hughes, 1995) are methods for analysing dynamic and complex situations which include competition in sport.

There are researches in table tennis which were related with this topic, but as the rules of the game were changed, these changes had influence into the game match characteristics.

There are more authors which analyse the match characteristics in the past, since Guan (1992). Modern table tennis was analyzed at the top competitions (Drianovski and Otcheva, 2002; Katsikatedils et al., 2007). Also, because change of rules, for some authors as Djokic (2007) was interesting to analyse how this changes the influence of structure and game characteristics. It is important to mention that only one study (Zagatto et al., 2010) analyzed temporal variables in official matches considering the prohibition of speed glue.

This type of analysis in high-level table tennis competitions could provide important information for training prescription, especially in different levels and phases of the competition.

In order to obtain more accurate information the aim of the study was to assess activity patterns and performance during real competition in high level table tennis players considering analyses of men's singles competition at the 2015 European Games held in Baku.

2. METHODS

2.1 Sample

Forty five players which were competing in Men's individual event at EG 2015 in 46 matches were analysed. Match characteristics were also analysed according to the phase of competition (from the 1st round to final) and considering the performance level of players. Also, for comparison, and the women's individual event in same competition was analyzed.

2.2 Performance indicators

Performance indicators measured to provide information about the stresses of match play were:

1. PLYPOI - Played points in match,
2. POISET - Number of played points per set,
3. PLYSET - Number of played sets
4. MPTIME - Match playing time (duration)
5. SETIME – Set playing time (duration)
6. STRAVG - Number of strokes in point (average rally – only successful strokes were counted)
7. STRLON - Number of strokes in point (longest rally– only successful strokes were counted)

Data were taken from the official site of Baku 2015 European Games, with results and statistical data from all played matches on http://www.baku2015.com/table-tennis/

2.3 Statistical analyses

For all indicators descriptive statistical parameters were calculated, while differences according phase of competition and performance level of players were analyzed using one-way ANOVA ($p<0.05$).

3. RESULTS

The mean values and standard deviations of the observations made during the matches in men's and women's single competition and derived data are presented in Table 1.

Table 1. Game characteristic of men and women – all played matches

Variable	Men (N=46)	Women (N=47)
PLYPOI	101.1±22.3	93.6±25.6
POISET	18.2±1.0	19.1±1.0
PLYSET	5.5±0.6	5.2±1.1
MPTIME	35.0±6.1	39.4±7.1
SETIME	6.3±0.4	6.8±1.6
STRAVG	4.7±1.6	6.3±2.8
STRLON	9.4±3.7	15.2±10.0

The mean values and standard deviations of the observations made during the matches considering stage of competition in the men's single event and derived data are presented in Table 2.

Table 2. Game characteristics of men – by stage of competition

	1st round	2nd round	3rd round	¼ finals	½ final	Final/3rd place
Variable	(N=15)	(N=15)	(N=8)	(N=4)	(N=2)	(N=2)
PLYPOI	101.3±26.1	103.5±21.4	102.2±16.6	78.7±10.7	93.5±.5	128.5±2.8
POISET	18.8±1.0	18.5±1.1	17.8±1.0	17.5±1.0	17.0±1.0	19.8±1.2
PLYSET	5.4±1.2	5.6±1.0	5.75±.8	4.50±.5	5.50±.5	6.50±.5
MPTIME	31.9±5.9	33.6±6.0	36.1±4.7	28.0±5.2	34.5±4.6	46.0±7.2
SETIME	5.8±.07	6.01±.82	6.2±.56	6.2±.56	6.3±.57	7.1±.11
STRAVG	3.7±1.1	3.7±.88	5.2±1.34	2.0±.00	6.5±.57	3.0±.00
STRLON	8.3±2.7	9.3±3.29	13.1±3.44	4.5±.53	14.5±1.73	8.0±.00

3.1 Results of ANOVA

Results of ANOVA between all played matches between men and women showed the existence of statistically significant differences in 4 from 5 analyzed game indicators.

Table 3. Results of ANOVA between men and women

	Men (N=46)	Women (N=47)	F	Sig.
PLYPOI	101.0±22.3	93.5±25.6	4.555	.034
SETIME	6.1±.7	6.8±1.6	14.870	.000
STRAVG	3.9±1.3	6.3±2.7	54.244	.000
STRLON	9.4±3.7	15.2±10.0	27.605	.000

In performance indicators according of the phase of competition statistically significant differences were noted ($p<0.05$):

- 1st and 2nd round – there were no statistical significant differences in performance indicators.
- 2nd and 3rd round – there were two significant differences in average rallies per point (p=.000) and longest rally played in point (p=.001). The rally and longest rallies in points increased from 2nd round to 3rd round.
- 3rd round and ¼ final – there were noted significant differences in all observed aspects of the game: number of played points (p=.002), number of played points per games (p=.001), average rally in points (p=.000) and longest rallies (p=.000). Number of points and played games increased, as and the number of played rally and longest rallies per point.
- ¼ and ½ final - Also, there were observed significant differences between ¼ final and semi-final matches in: number of played points (p=.023), number of played points per set (p=.014), average rally in points (p=.000) and longest rallies (p=.000). Instead previous differences, number of played points, played games, average and longest rally increased in semi-final matches.
- ½ final and Final & 3rd place match - Also, there were observed significant differences between the semi-final and final (and 3rd place) matches. Differences were noted in played points (p=.000), number of playing points per set (p=.050), minutes of played games (p=.035), average rally (p=.000) and longest played rally (p=.000). Number of points, played points per set and played time per game increased, while the average and longest rally decreased.

4. DISCUSSION

The aim of this research was to asses' match characteristics and performance during high level table tennis players' competition.

According the phase of competition from 2nd round there were observed statistically significant differences. Matches till ¼ final were longer with more rallies, while semi-final matches were easy finished. After that in final and 3rd place match, all game parameters increased except rally. The same conclusion made and previous researchers (de Mello Leite et al., 2017; Katsikadelis et al., 2007) that the reduction in rally duration increase rest time through the competition phases (quarterfinals to finals).

Between men and women match characteristics, there were statistically significant differences in played points (men played more points in the match), played games time (games were longer in women category), and women played longer average rallies in the match. So, the matches in women and men's competition were different. Men's table tennis is more powerful and dynamic and last less instead women's play.

These data can be used as the base for the creation of exercises in training. From the aspects of duration of exercise - according time of sets and match. Also, from the aspects of rally – if the intention of exercising is situational training in men's exercise point must be finished in 4th ball, while in women's exercise till 7th ball.

5. CONCLUSION

These results provide original information about the match characteristics which can be used in the modelling of the training process, especially in high level table tennis. Also results indicate that there is a notable difference in match characteristics between men and women, so the training process should be different according to gender.

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Role of Serve and Return of Serve at European Games 2015 Table Tennis Tournament

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Abstract: The aim of this study was match analyses considering the efficacy of serve and return of serve in high level table tennis. The analysis of game was performed using official data from 46 matches played by 45 best European players in Men's singles competition at European Games held in Baku 2015. Performance indicators were: playing on own serve (percentage of won and lost points on own serve) and return of serve (percentage of winning points on opponent serve). All games from 1st round till the final match were analysed (253 sets and 4649 played points). Players were analysed according to match outcome (winners/ losers) and performance level (better/lower ranked). For all descriptive statistic parameters were calculated. The differences between winners and losers were analysed with independent samples t-test (p<.05), while differences according performance level and according phase of competition were tested using One-way ANOVA (p<.05). Percentage of winners on their serve won point efficacy was 60.60±7.43% (in the range from 47.27 to 83.33%), lost points were 39.37±7.47% (16.17-52.73%) and won points on opponent serve was 53.28±6.73% (40.91-70.97%). Percentage of losers won point on their serve was 46.76±6.67% (29.03-59.09%), lost point's 53.28±6.73% (40.91-70.97%) and won points on opponent serve 39.37±7.48% (16.17-52.73%). Statistically significant differences in efficacy (Winner/Loser) were identified in all analysed performance indicators. There were no significant differences according to the phase of competition and performance level. This study indicates that these activities can be monitored as a valuable performance indicators, especially in competition and confirm importance for the assessment of training.

Keywords: table tennis, performance analyses, serve, receive of serve

1. INTRODUCTION

The serve in racket sports is categorized as a special performance indicator, in table tennis serve is the stroke that puts the ball in play and is often referred to as one of the most important stroke in the game of table tennis. The quality of the serve seems to be a critical factor that influences the result of the match. It has become a principle weapon which may offer the player an advantage in the strong third-ball attack and a direct scoring or point winning immediately after serving. Also, the receive (return) of service is the same important as a service, especially with changing ITTF regulations which require that the ball must be visible as soon as it has been projected from the free hand, which means that the reaction of the opponent might be easier.

In general, servers should take maximum advantage of a service in order to score and on the other hand, for receivers, it is important to minimize the effect of a service. Research has shown that 80 percent of all points in the table tennis end of the fifth stroke. Even if the point continues past the fifth stroke, one player usually is in a winning position at the fifth stroke (McAfee, 2009). There are many of the performance and notational analyses researches which point on the importance of these activities (Malagoli Lanzoni, Di Michele & Merni, 2014), but since there are continuous change of rules – and improvement of playing equipment (table tennis ball), they have an impact on this activity, and because of that there is a need for permanent monitoring.

Serve and receive seem to be important indicators of performance in high-ranking table tennis players, so many authors concerned with serve and return efficacy and relation between them (Djokic, 2002a; 2002b; 2003; Katsikadelis, Pilianidis & Mantzouranis, 2013, Zhang et al., 2013; Malagoli Lanzoni, Di Michele & Merni, 2014, Djokic, Munivrana & Levajac 2016a; 2016b).

Therefore, the aim of this study was match analyses considering the efficacy of serve and return of serve in high level table tennis.

2. METHODS

2.1 Sample

The analysis of the game was performed using official data from 46 matches played by 45 best European players in Men's singles competition at European Games held in Baku 2015. Also were analyzed and women singles event with 46 best European players in the same competition.

2.2 Performance indicators

Performance indicators were:

1) WONSER - playing on own serve (percentage of won serve)
2) LOSSER - playing on own serve (percentage of lost points on own serve)
3) WOPSER - return of serve (percentage of winning points on opponent serve).

All games from 1^{st} round till the final match were analyzed (253 sets and 4649 played points). Players were analyzed according to match outcome (winners/losers) and performance level (better/lower ranked).

For all players was calculated formula (1) which represent an index of serve/return success ($SRSS_i$):

$$SRSS_i = \frac{WONSER + LOSSER}{WOPSER} \qquad (1)$$

3. RESULTS

In table 1 show results of descriptive statistics for all analyzed players, according match outcome (winner/loser).

Table 1. Descriptive statistics for all analyzed players

	(n=46)	Mean± Std. Dev	Min	Max	Range
WONSER	winners	60.32±7.59	47.27	83.33	36.06
	losers	46.74±6.74	29.03	59.09	30.06
LOSSER	winners	39.65±7.63	16.17	52.73	36.56
	losers	53.30±6.80	40.91	70.97	30.06
WOPSER	winners	53.14±6.72	40.91	70.97	30.06
	losers	39.20±7.47	16.17	52.73	36.56

Statistically significant differences in efficacy (Winner/Loser) were identified in all analyzed performance indicators (p=.000).

In table 2 are shown results from stage to stage of competition for men and women competition.

Table 2. Descriptive statistics according stage of competition (men/women)

		N	Mean - men	N	Mean - women
WONSER	1st round	15	60.14±8.99	15	63.76±9.35
	2nd round	15	62.28±6.85	16	60.19±9.26
	1/8 final	8	58.89±6.53	8	56.29±6.45
	1/4 final	4	63.92±8.01	4	55.07±6.59
	1/2 final	2	56.52±3.07	2	57.54±5.04
	final 3rd place	2	55.77±1.93	2	59.20±3.30
	Total	46	60.60±7.43	47	60.07±8.60
LOSSER	1st round	15	39.82±9.08	15	36.23±9.35
	2nd round	15	37.71±6.85	16	39.80±9.26
	1/8 final	8	41.10±6.53	8	43.70±6.45
	1/4 final	4	35.98±8.06	4	44.92±6.59
	1/2 final	2	43.47±3.07	2	42.46±5.04
	final 3rd place	2	44.22±1.93	2	40.80±3.30
	Total	46	39.37±7.47	47	39.92±8.60
WOPSER	1st round	15	54.85±6.52	15	61.23±12.71
	2nd round	15	51.43±6.48	16	53.43±6.96
	1/8 final	8	52.01±8.33	8	56.91±7.70
	1/4 final	4	56.80±4.05	4	51.10±5.83
	1/2 final	2	57.44±9.02	2	58.28±10.50
	final 3rd place	2	49.20±4.49	2	55.41±5.03
	Total	46	53.28±6.73	47	56.60±9.61

There were no significant differences according to the phase of competition and performance level.

According previous formula results in table 3 is shown index of serve/return success (SRSS) for players – medalist.

Table 3. Percentage and Index of serve&return ($SRSS_i$) for medalist players

	WONSER	LOSSER	WOPSER	$SRSS_i$	$SRSS_i$ - Mean
Ovtcharov 2nd round	59.0	41.0	58.5	2.86	
Ovtcharov 3rd round	68.8	31.3	71.0	4.47	
Ovtcharov ¼ final	67.3	32.4	62.9	4.02	
Ovctharov ½ final	58.7	41.3	51.1	2.66	3.27
Ovtcharov Final	54.4	45.6	52.4	2.34	
Mean	**61.6**	**38.3**	**59.2**		
Samsonov 2nd round	68.9	31.1	53.5	3.93	
Samsonov 3rd round	62.3	37.7	47.2	2.90	
Samsonov ¼ final	73.5	26.5	54.3	4.83	
Samsonov ½ final	54.4	45.7	63.8	2.59	3.21
Samsonov Final	47.6	52.4	45.6	1.78	
Mean	**61.3**	**38.7**	**52.9**		
Kou 1st round	59.6	40.4	54.4	2.82	
Kou 2nd round	56.1	43.9	46.4	2.34	
Kou 3rd round	54.9	45.1	49.0	2.30	
Kou ¼ final	59.1	40.9	55.3	2.80	
Kou ½ final	36.2	63.8	45.7	1.28	2.32
Kou 3rd place	57.1	42.9	46.0	2.41	
Mean	**53.8**	**46.2**	**49.5**		

4. DISCUSSIONS

A service and return activities analyses were objective of this research.

According results which shown significant statistical differences between winners and losers in service/return activities, we can assume that these activities are the most important points to consider in the table tennis analysis. Even, the tactical and technical challenges faced by servers and receivers are different due to the special nature of service, they are strongly related to result outcome as Katsikadelis, Pilianidis & Mantzouranis (2013) and Djokic, Munivrana & Levajac (2016a; 2016b) concluded.

Analyses of the percentage of successful serve/receive activities according the phase of competition showed that the efficacy of serving decrease as the competition goes on, and as the opponents are more equal. The percentages of lost serve, and related to that – won point on opponent serve (return) increase.

Calculated values of Index of serve&return show that in future this formula can be used as a measure of quality of played matches and tournaments, and as an indicator of players shape (does the player win his match easily or in a tight match, and according the opponent rank, we can make a conclusion about our player performance). In this case, the best rank players (and finalists) have higher values of source instead other players (and has better results instead of 3rd place player).

The limitation of this study was the fact that from official statistical data, we couldn't see the realization of the serve (considering the fact how many points were won directly with serve, with 3rd, 5th or more stroke after serve - because serve has a strong impact on the scoring or losing tendency in the early phase of rallies, and same considering return of serve). This will be observed in some future research.

5. CONCLUSION

In conclusion, the winning outcome in table tennis matches is strongly related to the successful serve and return activities. The findings of this study, could be valuable for the training orientation of the table tennis players.

This study indicates that these activities can be monitored as a valuable performance indicators, especially in competition and confirm importance for the assessment of training.

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Table Tennis Prevalence in Primary Schools of Zaragoza (Spain)

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Abstract: The aim of this study was investigate Table Tennis (TT) prevalence as part of physical education in primary school (6-12 years).
Correlation design was used with an ex post facto analysis. In order to analyze TT prevalence a no probabilistic population census questionnaire was used for the sample, i.e. 81 teachers (49 male and 32 female). Table Tennis Attitudes Questionnaire (TTAQ) was used to collect all data. 13.6% of our simple uses TT as an educational content. Results shown that alternative racket sports (55.6%), badminton (49.4%) and tennis (33.3%) were prevalent in educational content. We hypothesize that teachers tend to use sports in which they are experts. 11.1% of our sample shown knowledge about TT. Significant differences ($p>0.05$) were found between gender (X2=5.980; $p=0.14$) in terms of TT motivation. More experienced teachers (X2=25.567; $p=0.02$) and older ones (X2=12.74; $p=0.04$) used TT as an educational content. There is a correlation between neglecting TT benefits and accentuating the barriers to their possible application in school ($r=-0.419$, $p=0.003$). In general, teachers consider TT as a beneficial content during physical activity classes, although the main barrier is a lack of specific material at schools. In conclusion, TT has a low incidence as an educational content in physical activity subject during primary school.

Keywords: table tennis, racquet sports, physical education, primary school.

1. INTRODUCTION

In Physical education (PE) scholar contents are in constant review. This subject is not an invariable whole of knowledge but a reflection of different ways to understand PE (Devís, 1996). Hence, is necessary to keep reviewing contents and methodologies in PE.

It is known that teaching schedules often give more relevance to major sports (Napper-Owen, Kovar, Ermiler, & Mehrhof, 1999; Zabala, Viciana, & Lozano 2002; Robles, 2008; Robles, 2009), so knowing why are teachers using those sports it´s important. (Robles, Tomás, Castillo, Giménez, & Robles, 2013; Robles, Giménez, Abad, & Robles, 2015; Iglesias, 2015).

Last modifications in Spanish educational system make reference to Table Tennis (TT) as an educational content. Investigate Table Tennis (TT) prevalence as part of physical education in primary school in Aragón (Spain) was the main goal of our study.

2. MATERIAL AND METHODS

Purpose and hypotheses:

The aim of this study was investigate Table Tennis (TT) prevalence as part of physical education in primary school (6-12 years). The following objectives were set:

- Know if teachers contemplate TT as a beneficial content in PE.
- Establish factors that helps or acts as a barrier on TT ambit development expressed by teachers.
- Know TT prevalence on PE scholar contents.

Research model:

Correlation design was used with an ex post facto analysis. A census survey was used with a none probabilistic sampling. To recollect data *Table Tennis Attitudes Questionnaire* (TTAQ) (Herrero, 2015) was used.

Population and sample:

The sample of our study was professoriate of Zaragoza city (Aragón, Spain).
81 teachers (49 male and 32 female), which means a 24.4% of total population with an error of 9.5% for a 95% confidence.
Although simple is not representative this is a pioneering study.

Data collection tools:

TTAQ was adapted to educative context of this study. Teachers answered sociodemographic and racket sports questions and the following scales:

1. TT benefits (TTB).
2. Facilitators to TT school application (FTTSA).
3. TT application barriers (TTAB).

Likert answered with four options were used i.e. from totally agree to totally disagree.

In order to check internal validity the Cronbah Alpha (α) was applied. We found acceptable values for first scale and optimum for the second. (Table 1).

Table 1. Reliability coefficients α for each scale

scale	α
1. TTB	.726
2. FTTSA	.890
3. TTAB	.913

Data analysis:

For data analysis descriptive and inferential procedures have been carried out. For descriptive statistics mean, standard deviation, and absolute and relative frequencies were used. For inferential statistical procedures, contingency tables, chi-square tests of Pearson, linear correlations, and analysis of variance and covariance were performed. For this, the scale was normalized to a Z score. Microsoft Excel and IBM SPSS Statistics Base 22.0 software were used.

3. RESULTS AND DISCUSSION

Sample was composed by 60.5% males and 39.5% females, ages 41.7 ± 9.75 and teaching experience 17.37 ± 9.58 years. 66.3% of the simple works at public schools while 33.8% remaining works in private schools.

Specific racket sports (RS) information that teachers reveals is shown in Figure 1. Badminton and tennis an alternative RS show the highest knowledge. Just 11.1% teachers have TT formation while 27.2% shown none RS formation

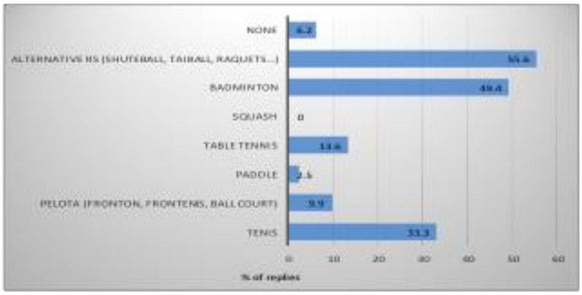

Figure 1. RS contents carried out at schools

These results contrast with the study by Herrero (2015), in the context of secondary education in the Community of Murcia, where badminton obtained 31.5%, tennis 13.5%, and none RS 9.9%. However, table tennis obtained a very similar value (12.7%). Figure 2 shows RS contents developed through EP lessons.

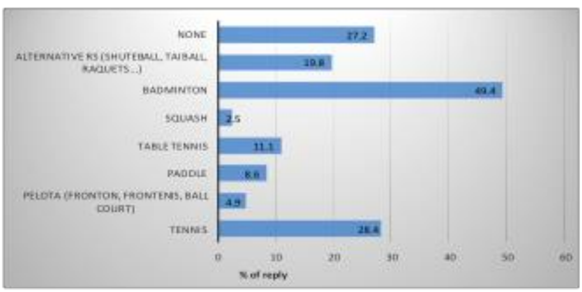

Figure 2. Specific RS training

More than half of the sample (55.6%) does alternative RS lessons, almost half (49.4%) does badminton lessons, while 13.6% develops TT lessons. 6.2% of teachers reports any RS content during PE lessons. This results differ with those find by González, & Aznar (2007) were RS such Badminton (71.48%), tennis (19.04%), alternative RS (11.72%9 and TT (8.97%) were taught in the province of Alicante (Spain). TT shows a low presence.

TTB scale has six items and frequencies are shown in Table 2. TTB. TT is an ideal content to introduce in the school environment with the relevant adaptations (Bauer, Dlisle, & Charpentier, 2011) depending on student's needs, since it can be a motivating way to achieve general objectives of stage age and PE.

Table 2. TTB scale items and descriptive data

	Mean	SD
Item 1	1.78	.709
Item 2	1.96	.475
Item 3	1.93	.527
Item 4	2.06	.644
Item 5	1.94	.535
Item 6	2.15	.614

FTTSA scale descriptive values are shown in Table 3. Our results contrast with a study performed by Zabala, Viciana, & Lozano (2002), and Robles (2008), were teachers tend to select PE contents with greater contribution to learning process.

Table 3. FTTSA scale items and descriptive data

	Mean	SD
Item 7	1.47	1.179
Item 8	1.29	.849
Item 9	1.06	.748
Item 10	.94	.772
Item 11	.94	.854
Item 12	1.06	.854

TTAB descriptive values are shown in Table 4. Mean=0.44 and ST=0.14. Contrast with values founded by Robles et al. (2013). It is shown that 54.2% of secondary school teachers select content to be taught from those who know and dominate the most. Aznar (2010) points out that teachers consider as a barrier that rackets, fliers, etc., are very expensive and specific materials, which also deteriorate easily. Some authors provide solutions such adaptation of materials to the problem, (Iglesias, 2015; Pradas, Castellar, Quintas, & Rapún, 2016).

Table 4. TTAB items and descriptive data

	Mn	DT
Item 13	.40	.494
Item 14	.31	.465
Item 15	.34	.477
Item 16	.47	.538
Item 17	.71	.744
Item 18	.45	.641

Table 5 shows Pearson correlations between scales. We suggest that teachers with a negative perspective for TT has a negative attitude to include this sport as an educational content. (r=-.419, p=.003).

Table 5. Pearson correlations between scales

	1	2	3
1. TTB	-		
2. FTTSA	.423 .116	-	
3. TTAB	-.419** .003	-	-

**Significate correlation set at 0.01

Through an analysis of the covariance (ANCOVA), and considering as covariables the rest of academic qualifications contemplated in this study, it has been observed that those who are not graduated in PE have higher positive attitudes towards this sport (F = 4.45, p = .039). This result coincides with that obtained by Herrero (2015).

Chi-square test (χ^2) were performed to find relationship between sociodemographic variables and scales items. Women are less susceptible than men to apply TT as an educational content because they find it none motivating (χ^2=5.980; gl=1; p=.014; ϕ=.303). On the other hand men find that TT deteriorate easily (χ^2=8.358; gl=2; p=.015; ϕ=.383).

Older teachers apply more TT contents than younger ones (χ^2=8.041; gl=3; p=.045; ϕ=.317).

Also, the older the teachers the more tables are available at school (χ^2=17.083; gl=2; p=.047; Φ=.468) and they use them more (χ^2=12.741, gl=6; p=.047; ϕ=.587) as well as those who have more teaching experience (χ^2=25.56; gl=14; p=.029; ϕ=.820).

Teachers without specific formation on RS show less predisposition to TT contents and they find it dangerous for students. (χ^2=12.091; gl=3; p=.007; ϕ=.399). In relation to danger during TT lessons, teachers with PE degree consider this sport less dangerous than other RS (χ^2=11.583; gl=3; p=.009; ϕ=.413). Our results shown that teachers who do not teach PE find this educational content very expensive. (χ^2=9.51; gl=3; p=.023; ϕ=.356).

4. CONCLUSIONS

In general, teachers consider TT as an educational content especially those who have university degree and specific formation about TT.

Main barrier for teachers is absence of specific TT material at schools.

Age, experience and formation seems to be the main reason to include TT as an educational content in PE lessons.

Women find TT very motivating for students.

TT is taught in very few schools in Zaragoza in comparison with other RS.

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Case Study of National Kaohsiung University of Applied Sciences' Students Interest in Leisure Sports Who Had Taken Table Tennis Courses

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Abstract: At National Kaohsiung University of Applied Sciences (KUAS), students have options to choose specialized sport courses as part of their physical education curriculum. The main purpose of this study was to investigate whether the sport would stick with the students and have perceived positive impact for the future for those who chose table tennis. A total of 322 surveys were analysed. Frequencies, percentages, means, standard deviations, t tests, one-way ANOVA and Scheffe's method were used for the study. The results of the study could be used as a teaching reference. The summary provided below was based on the analysis: (1) The top three leisure sports with highest participation were table tennis, jogging, and weight training. There was no significant difference in the participation rate between male and female students. Moreover, most students hoped to spend 500 NT or less per year for exercise related expense. (2) The top three motives for students to participate in leisure sports were to be healthier, to relax, and to have fun. Lack of time was the top reason to prevent students from participation. (3) Table tennis school team players were more likely to pursue the same sport during their spare time and in the future. They were also more willing to spend money for the sport. (4) Most students had positive experience in taking table tennis course, especially in terms of learning the techniques and gaining confidence in the sport. (5) Regardless of the age groups, by joining table tennis competition, many players felt the game helped them mentally, spiritually, and physically.

Keywords: table tennis, motive, exercise pursue, leisure sports.

1. INTRODUCTION

The government of Taiwan has been trying to improve the quality of living among its people continually for many years. National health insurance system was implemented. Furthermore, beginning in 1998, Taiwan shortened the mandated working days to five days a week every other week, as opposed to the original six days a week every week (Cheng, 1998; Tsai 1999; Wu & Lin, 1999). On May 15th of 2015, Legislative Council passed by the "Labor Standards Law" amendment. Once again, it shortened the statutory working hours, from 84 hours per two weeks, to 40 hours a week. In essence, the same as implementing working five days a week with two days off. This act took place on January 1st of 2017. The Ministry of Labor estimated that 3.4

million labor workers can benefit (Huang, 2015).

Some experts in Taiwan estimated that individuals have six hours of free time every day in Year 2000 (Cheng, 1998). With above mentioned policies in place, more people have free time and longer free time. Ideally, most people should be involved in some form of exercise and be health conscious. Everyone knows that exercise is good for the body. But for adequate and consistent participation, there needs to be a conducive environment where people are exposed to various kinds of leisure sports that will become part of their lives (Chang, 1998). Table tennis is a sport which is very popular in many Asia countries, Taiwan is no exception. It is a relatively easy sport to pick up. One can still have fun with table tennis regardless of his/her table tennis skill. In Taiwan, starting from elementary schools all the ways to universities, there are many schools whom recruit students to join table tennis teams and clubs. Every year, there are many different type of table tennis competitions organized by different organizations. In order to keep the sport flourishing, it is important for teachers to create an environment where students want to pursue table tennis as one of their leisure sports.

In Taiwan, people are gradually becoming aware of the importance of exercise (Cheng, 1998). Where do students go to do their exercise? What kind of leisure sports do the students prefer? What kind of leisure sports are feasible for universities to offer? At National Kaohsiung University of Applied Sciences (KUAS), students on their second and third year of study, they have options to choose sport courses they prefer to attend as their physical education (PE) class. Table tennis course is one of the selections. Through this study, the opinions of KUAS students will be discerned. Hopefully, the results of this study will have a positive impact on table tennis courses offered in KUAS with an outlook of greater participation.

2. METHODOLOGY

The main purpose of this study was to investigate students' preference in participation in table tennis in the future if they chose table tennis course as their PE class to attend at KUAS. Students who chose table tennis course as their election PE course during the first semester of year 2016 were selected as subjects of the study. Survey questions were developed for this study by the researchers. Information gathered from the literature review and research was used for developing survey questions. The survey was divided into four parts which were current leisure sports participation, motives in leisure sports participation, experience of taking table tennis course, and emotions of playing table tennis.

There were 18 weeks in the semester, surveys were handed out on 16 weeks to get a more accurate view about how students' feelings toward table tennis courses they took. Total of 360 surveys were distributed, with 322 surveys returned, including ten table tennis school team players. The return rate of the survey was 89.4%. SPSS 17.0 in Chinese version was used to calculate frequencies, percentages, means, standard deviations, t test, one-way ANOVA and Scheffe's method analyze data for the study.

3. RESULTS AND DISCUSSIONS

The findings are based on responses of 322 KUAS students who took table tennis course as their PE class. Data was analyzed from the 216 male students and 106 female students, including 10 table tennis school team players.

3.1 Students current leisure sports participation after school

Study done by Chen, Y.F., Chen, M.K., & Huang, C.C. (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. This is consistent with the finding in this study. From Table 1, one can see most of the respondents (64.7%) answered that able tennis was the leisure sports in which they currently got involved, with majority of them (53.5%) participated twice per week. Jogging and weight training were the next two most popular leisure sports among students with 57.2% and 58.4% of them participated less than once per week. Only the top five leisure sports students participated were shown in Table 1.

Table 1. Leisure sports participation after school.

Leisure Sports	Participation Rate	Participation Frequency
Table tennis	64.7 %	53.5 % (2/Week)
Jogging	43.1 %	57.2 % (< 1/Week)
Weight training	30.2 %	58.4 % (< 1/Week)
Basketball	30.1 %	68.0 % (< 1/Week)
Billiard	28.8 %	71.1 % (< 1/Week)

One of teachers' primary tasks is to guide students on the learning process. With positive aggressive approach toward teaching, lasting influence can be made on students with passive attitude toward exercise (Chen, R.C., Zhang, C.L., & Lee, Y.L., 2016). Therefore, it is important to understand students' motivation in order to guide them to get involved in leisure sports. From Table 2, it showed 14.9% of respondents spent less than once a week on after school leisure sports, 22.0% participated twice a week, and 18.9% participated three or more times a week. While the largest group of respondents (42.2%) participated in after school leisure sports once a week, 1.9% of respondents indicated that they did not participate at all in after school leisure sports. By doing data analysis on the participation level with 10 table tennis school team players alone, all of them participated in after school leisure sports at least once a week.

Table 2. Participation rates on leisure sports.

Level of Participation	Frequency	Percentage
Never	6	1.9 %
< 1/Week	48	14.9 %
1/Week	136	42.2 %
2/Week	71	22.0 %
≥ 3/Week	61	18.9 %

From Table 3, the t value and p value for gender differences in KUAS students' level of participation were 1.112 and .366 respectively. There was no significant difference found in participation level between male students (M = 3.523) and female students (M = 3.377). Both male and female students felt indifferent with the statement that they thought it was doable to participate in leisure sports at least once per week.

Table 3. Difference between KUAS male and female students' participation level.

	Mean			
	Male	Female	t	p
Level of Participation	3.523	3.377	1.112	.366

From Table 4, it showed that majority of the respondents (68.9%) were willing to spend up to 500 NT on leisure sports related expense. 8.4% of respondents were willing to spend more than 2500 NT. By doing data analysis, it showed that 10 table tennis school team plays were more willing to expend money on leisure sports than other respondents. Two of the players were willing to spend 2001~2500 NT, the others were willing to spend more than 2501 NT on leisure sports related expense.

Table 4. Expense on leisure sports.

	Frequency	Percentage
< 500 NT	222	68.9 %
Between 500~1000 NT	41	12.7%
Between 1001~1500 NT	16	5.0 %
Between 1501~2000 NT	13	4.0 %
Between 2001~2500 NT	3	0.9 %
>2501	27	8.4 %

3.2 Motives in leisure sports participation

Motivation is driven by behavioral 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). To be able to encourage one to participate in leisure, it is very important to understand one's motive(s) in order to get a good result. From the Table 5, the most frequently cited motives for participating in leisure sports was physical health (69.6%). This was followed by relaxation (55.6%), having fun (47.8%), and tension release from other classes taken (45.3%). The least frequently cited motive for participating in leisure sports was to re-invigorate oneself (23.0%).

Table 5. Primary motives on participating in leisure sports.

Primary motives	Frequency	Percentage
For physical health	224	69.6 %
To relax	179	55.6 %
To have fun	154	47.8 %
To release tension from other classes	146	45.3 %
For mental health	122	37.9 %
For social purposes	101	31.4 %
To learn sports skills	100	31.1 %
To re-invigorate oneself	72	23.0 %

From Table 6, the top reason preventing students from the sport participation was not enough time (69.9%), following by heavy school work/job (45.3%) and effect of weather (34.8%). Only the top five reasons preventing students from participation were shown on the Table 6.

Table 6. Primary reasons preventing leisure sports participation.

Primary reasons	Frequency	Percentage
Not enough time	225	69.9 %
Heavy school work/job	146	45.3 %
Weather effect	112	34.8 %
No companion	91	28.3 %
Lack of transportation	70	21.7 %

3.3 Experience of taking table tennis course

Having good experience has a big impact on one's willingness to do things continuously. Regardless of what sports one gets involved, interest and satisfaction are two primary factors which support one to continuously participate. It is important for teacher to teach students differently according to his/her ability in order to get students interested in playing table tennis and continue to play during his/her spare time (Chen, Y.F., Chen, M.K., & Huang, C.C., 2015). From Table 7, by doing data analysis on gender comparison regarding to likeness of attending table tennis course offered at KUAS, the mean for male and female respondents was 4.102, and 4.189 respectively. There was no significant difference on table tennis enjoyment ($t = -.797$, $p = .138$). Both respondents agreed they liked to attend tennis course offered at KUAS. By taking table tennis course, both male ($M = 3.907$) and female ($M = 3.915$) respondents, agreed it can help them to develop interest in sport and continue to pursue in the future. One's table tennis skill and confidence in playing could also be improved by attending classes.

Table 7. Experience on attending table tennis classes.

	Mean			
	Male	Female	t	p
Enjoy table tennis class	4.102	4.189	-.797	.138
Develop interest and future pursue	3.907	3.915	-.065	.436
Table tennis skill improvement	4.102	4.170	-.582	.219
Confidence built	3.944	4.094	-1.275	.204

3.4 Emotions of playing table tennis

One's emotion wellbeing has huge impact on how his/her study in school or job performance. Playing table tennis can help some people to release stress and bad emotions. From Table 8, how one's feeling toward playing table tennis when attending table tennis classes offered at KUAS is summarized. Using one-way ANOVA and Scheffe's method, emotions toward playing table tennis between different age group could be compared. The F value and p value for "enjoy table tennis games with other opponents" were .739 and .522. Values for "strong will to play well with other opponents during table tennis games" were .0407 and .857. Values for "improving one's skill by playing with other opponents" were .591 and .738. Values for "being more focus on playing table tennis games with others" were .599 and .731. Values for "able to learn and improve planning strategies when playing table tennis games with other opponents" were 1.446 and .197. Values for "able to release tension by playing table tennis" were .788 and .580. Finally, the F value and p value for "able to improve one's mind thinking by playing table tennis were .827 and .549. By looking at the Table 8, it showed there was no significant difference among different age group regarding their emotions toward playing table tennis. By computing Scheffe's method, also no significant difference was found among different age group regarding their emotions toward playing table tennis.

Table 8. Emotions toward playing table tennis.

	F	p
Enjoy table tennis games with others	.739	.522
Will to play well with others	.407	.857
Improve one's skill by playing with others	.591	.738
Focus on playing table tennis games	.599	.731
Plan strategies when playing table tennis games	1.446	.197
Release tension by playing table tennis	.788	.580
Improve mind thinking by playing table tennis	.827	.549

4. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were drawn as a result of the research findings of the study regarding to KUAS students' interest in leisure sports whom had taken table tennis courses.

(1) Table tennis, jogging, and weight training were the top three leisure sports that respondents indicated that they currently involved. No significant difference

found in the after school sports participation between male and female respondents.

(2) Most respondents were willing to spend 500 NT or less yearly on leisure sports related expense. The second highest percentage of respondents were willing to spend 500~1000 NT.

(3) To be healthier, to relax and to have fun were the top three motives indicated by the respondents which triggered them to get involved in the leisure sports; whereas lack of time, heavy school work/job, and weather effect were the top three reasons which prevent them for participation in the leisure sports.

(4) All ten table tennis school team players considered table tennis as one of their leisure sports, and were willing to spend significant more money on sport. Also, their current after school leisure sports participation rate was at least two times per week.

(5) Most respondents had good experience taking table tennis course offered at KUAS. They not only had a great time attending table tennis classes, but they also gained skill and confidence from participating in the classes.

(6) Students have time to play table tennis with other students during class time. Regardless of the age or year of study, most respondents felt they could benefit mentally, spiritually, and physically from playing table tennis or table tennis games with other classmates.

Findings of the study can be used as teaching reference for teachers who teach table tennis at KUAS. It is important for teachers to understand students' needs and to motivate them participate in leisure sports on their own. Table tennis is a great option for Taiwanese students. It does not cost a lot of money to participate. There is no need to consider the weather since it is played indoor. It is also easy to find people to play with, and can be found in many places nearby. Students in Taiwan have many exposure to table tennis since they were young. Since table tennis courses are offered every semester at KUAS, it is a great opportunity for teachers to further foster interests in table tennis amongst the students. Hopefully it will become the choice of leisure sports once they go into the work force.

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The Effects of the Self-Talk Types and Task Complexity on the Accuracy of Forehand Top Spin of Advanced Players

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Abstract: The purpose of this study was to determine the effects of the motivational and instructional self-talk and task complexity on the accuracy of forehand top spin of table tennis in advanced players. The 30 male advanced players (28±10.6 years old) were divided into 3 groups (2 experimental and 1 control). The task complexity was determined by color of ball and impact place. In other words, sequence sending of the ball were changed after two balls and this trend continued. The keywords for motivational self-talk were "I can do" and " I correctly recognize", and for Instructional self-talk “pay attention” and "Close your paddle". Masters et.al (2008) test was used to measure the accuracy of forehand topspin. After the pre-test, subjects took part in 6 training sessions including 20 trails per session. After 48 hours, they participated in post-test. The data were analyzed by paired-samples t-test, one way ANOVA and Tukey post hoc test. Results showed that there is a significant difference between the instructional and motivational self-talk in terms of task complexity. These findings suggested that instructional self-talk is the effective variable in performance of tasks that needs high complexity decisions and accuracy.

Keywords: instructional self-talk, motivational self-talk, task complexity, table tennis

1. INTRODUCTION

In recent years, numerous interventionist techniques have been developed to improve the performance and satisfaction of athletes in the area of applied psychology (Miller, 2006). These techniques play an important role in improving the performance (Goudas, 2006). In this regard, cognitive strategies, by using the effective patterns such as self-talk, goal setting, relaxation and motivation regulation, have created positive changes (Papaioannou, Theodorakis, Ballon, & Auwelle, 2004). A special type of these techniques is self-talk (Miller, 2006). It refer to the internal and external dialogue used by the performer, using slow or loud voice, during performing the skills (Chroni, Perkos, & Theodorakis, 2007); In simple terms, as Hardy (2004) states, self-talk refers to oral expression (overt or covert) of athletes; essentially, self-talk has a multi-dimensional structure and one dimension of it is concerned with the performance (Hardy, Begley, & Blanchfield, 2015).

Self-talk is a cognitive strategy and an educational tool that can be useful in learning and performing athletic skills. In addition to bringing a change in the thinking of the leaner and releasing him from a state of inactivity, it can lead to changing and modifying the current attitude with regard to the task being done (Ziegler, 1987). Self-talk using the right keywords helps athletes to organize their thoughts, control and focus on the parts of basic skills, or motivate themselves to further try during their practice (Zinsser, Bunker, & Williams, 2006). Theorists think of self-talk as a necessary component for mental programs related to training for skills, so many coaches take self-talk as a part of their plans (Hardy et al., 2015). Self-talk, in addition to having positive and negative aspects, has two main functions: motivational and instructional; it seems that the motivational dimension of the self-talk, due to inspiring one to further work and creating morale and confidence, can facilitate performance; on the other hand, the instructional dimension, due to easing the performance by focusing the appropriate attention, can improve technical information and tactics adopted (Zinsser et al., 2006). Another technique that may affect the motor performance and learning is the task complexity. Complexity of task depends on many factors; achieving to level of skill in one exercise session, degrees of freedom task and ecological aspects (Wulf and Shea, 2002).

The definition of task complexity only on the basis of certain characteristics or outcomes of the task is difficult. It is assumed that the complex task reaction time is more (Klapp, 1995); also, it needs more motor time, incorrect answers and much instability (Schmidt, Zelaznik, Hawkins, Frank, & Quinn Jr, 1979), or more degrees of freedom (Wulf and Shea, 2002). Each of the features mentioned can affect the complexity of the task involved; on the other hand, the increase in the degrees of freedom cannot always lead to the further complexity of the task. In fact, it may reduce the complexity of the task, like dexterity with the ball using one hand or two hands. While the degree of freedom is increased, the complexity is reduced (Wulf and Shea, 2002). Researchers working in the field of training variables (training pattern) and task complexity have concluded that the good training program should be based on factors such as the characteristics of the task (for example, difficulty) (Keetch and Lee, 2007).

The task complexity influences the initial levels and the amount of effective learning; generally, the results show that there may be some difference in the learning styles of simple and complex tasks (Wulf and Shea, 2002). The complexity of the task can have a powerful effect on both performance and response selection (Fitts and Posner, 1967); the increase or decrease in the amount of time between the decision on "what" and "how", by manipulating the speed of the ball or changing the size or weight of the ball, can have a dramatic effect on performance (Xiaopeng, 1998); also, increasing the number of stimuli and responses can affect the quality of throwing through creating ambiguity.

Rahavi et al. (2009) showed that participants had a better performance in the complex tasks, rather than the simple ones, showing the existence of a variable like task complexity involved in learning.

According to the definitions mentioned above, it can be said that the task complexity could be due to two factors , one is associated with the task itself and the second one is in connection with the training conditions, performance or characteristics of the individual performer concerned. Guadagnoli and Lee investigated task complexity in two different areas including nominal task difficulty and functional task difficulty. In fact, the nominal task difficulty is only related to the features of the task and has nothing to do with performance opportunities, training or the skill level of the performer (Guadagnoli and Lee, 2004). According to this definition, the nominal task difficulty includes cognitive and motor factors required for the task.

Functional task difficulty refers to the amount of challenge the task may impose on the individual, according to the skill level of the individual and the circumstances under which the task should be carried out. Another thing to bear in mind regarding the complexity of the task is the issue of expertise. Due to the expertise obtained, the processing and memory requirements are automatically reduced. So if someone has already learned a task, it is not complex for him anymore. Under this condition, the reaction time and motor movement are reduced and the efficiency is increased (Hardy, Begley and Blanchfield, 2015). One of the most important factors in information processing and the accuracy of the skill is decision-making. In fact, deciding on what to do in a given athletic position is based on the environmental information received by the participant, in relation to the knowledge base. So the difference in the perception and basic knowledge suggests that beginners are different from experts in making decisions.

More research carried out on decision-making in sports has been done on outdoor sports. In open sports such as tennis and football, the environment is constantly changing. In dealing with the environmental demands, outdoor sports participants need to constantly make decisions that should be fast and accurate (Masters, Poolton, Maxwell, & Raab, 2008). Based on the definitions discussed in this paper, the researchers' aim to answer the question whether motivational and instructional self-talk, with the task complexity, can influence the skill of top-spin forehand among the advanced players? The main question refers to "is there any difference between motivational and instructional self-talk in terms of task complexity on the accuracy of top-spin forehand of advanced players?”

2. METHODOLOGY

A quasi-experimental method (including two experimental groups and one control group) was employed in this field study. The design of the study was based on pre and post-tests with a control group. The statistical population was equal to the sample, including 30 advanced players who were invited to an adult table tennis team in the super league. They were in three homogenous groups, with each one consisting of 10 players with the age range of 28±1/6.

Measurement tools

In order to collect detailed data on age, physical activity and the physical health, the personal characteristics form was used.

40 40-mm balls (20 yellow and 20 white balls), ping pong ball thrower, Newgy Robo-pong 2000, digital video cameras Sony Alpha A6000, and standard table tennis table, were used in the present study.

Data analysis method

Research training protocol took two weeks and in every week, three sessions, and for each session, a block of 20 trials was carried out (Masters et al., 2008). At first, the manner of the exercise protocol and the scoring for the strikes were orally explained to the participants and then this was followed by practical demonstration through the coach. To ensure a proper understanding of the protocol practiced by the participants, before the pre-test, the ability of individuals in choosing the correct answer was orally evaluated in twenty trials so that they were asked to which side the ball had to be struck. Subjects were then pre tested after training. Pre-test mean scores were compared to find any significant differences and if necessary, to adjust the groups; such differences were not observed among the groups. So, the participants were randomly divided into 3 equal groups, each consisting of 10 (motivational self-talk, instructional self-talk and control). For each of the experimental groups, separately, some information was provided about self-talk, along with the keywords which were supposed to be used and explained. Then they were asked to use the key words before doing the intended task. Then, in four-sessions (every other day), the phase of acquisition of training protocol was carried out. During this exercise, self-talk intervention was applied just before the execution of hitting the top spin by the participants, in two groups (motivational self-talk and instructional self-talk).

The intervention took place in the two groups, such that the participants used words loud or in a whispering manner, they repeated them. The keywords used for motivational self-talk were "I can do" and "I correctly recognize" and for the instructional self-talk, they were "pay attention" and " Close your paddle". After the completion of the acquisition of the participants, the post-test was performed.

The task consisted of table tennis top-spin strike of the balls sent to the end of the table. Depending on the direction of hitting and the area of the zone of table targeted, according to the colour of the ball, test stage and the turn of ball throwing were different. The way to create curve and hit the forehand top spin was explained to the participants. At the end of the table, there was a ping-pong ball thrower which could send the ball with the size of 40 mm at a rate of 15 balls per minute.

The balls were sent to the central line of the table, with 20 cm distance from the table. 40 balls (20 yellow balls and 20 white balls) were put in a ball holder in and were thrown regularly and together.

The launcher, including six large square (50 × 50 cm), was marked in two rows on the table. Within each of squares, which were in the last row, there was a smaller square with the dimensions of 25 cm by 25. During the test phase, every ball that went in to zones 1 or 3 would get three points, zones 4 and 6 would get two points, and other zones would get one point. No score was given to the balls going the wrong way or outside the table. For example, when the target was the right side of the table, the regions 2, 5, 8 and 9 would get a score and the regions 1, 4 and 7 would get the zero score (Master et al., 2008) (Figure 1).

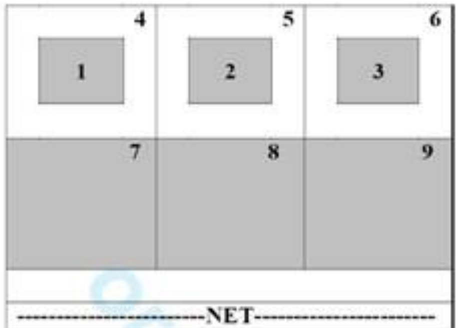

Figure 1. Table zoning

The complexity of the task was determined by the colour of the ball and where it was hit. In other words, after every two balls, the manner of hitting was changed, such that in the trials 1 and 2, white balls were hit toward right and the yellow ones to the left; in the trials 3 and 4, the while balls were hit toward left and the yellow ones toward right and this trend continued. The maximum possible score was 60 points in the blocks of 20 trials (Masters et al., 2008).

Statistical method

Descriptive statistics was used for drawing graphs, tables and providing indices of central tendency. Shapiro Wilk normality test was used to investigate the normality of the data. Homogeneity of variances was tested by the Levine's test. As for the analysis of data, in order to investigate the influence of the type of self-talk and task complexity in the pre-test, the paired samples-t test was used. On the other hand, one-way ANOVA was used in the post-test condition and for the comparison of the groups, the Tukey post-hoc test was used. Data analysis was done using SPSS software, version 20, at 0.05 confidence level.

3. RESULTS

Results obtained by one-way ANOVA showed no significant differences in the mean scores of the three groups in the pre-test ($F_{(2, 29)}$=0.734; P =0.489), such that each of the groups was at a particular skill level; in fact, there was no difference in the skill level of the three groups prior to the intervention or treatment. Also, based on the scores obtained from the test groups, there was a statistically significant difference at p<0.05 ($F_{(2, 29)}$ =10.161; P =0.001). Comparison of the post hoc using Tukey test showed that there was a significant difference in the post- test of instructional self-talk and motivational self-talk group (P =0.003). In the instructional self-talk group, there was a significant difference with the control group (P =0.001). In the motivational self-talk group, there was no significant difference with the control group (P =1.000).

The paired samples –t test was run to evaluate the effect of intervention on the scores of skilled players in the accuracy of top spin forehand in the post-test. Statistically, there was a significant increase in the scores related to the accuracy of forehand top spin group in the instructional self-talk group during the pre-test (SD = 6.41, M=33.1) until the post-test (SD =7.23, M =44.8) ($t_{(9)}$ =1.055, P =0.001). Also, there was no significant increase in the scores related to the accuracy of forehand top spin in the motivational self-talk group in the pre-test (SD = 8.84, M=29.5) until the post-test (SD = 10.70, M=30.9) ($t_{(9)}$ =8.718, P =0. 319). Furthermore, there was no significant increase in the scores related to the accuracy of forehand top spin in the control group at the time of the pre-test (SD = 5.42, M=32.4) until the post-test (SD = 6.65, M=29.5) was ($t_{(9)}$ =1.287, P =0.230) (Table 1).

Table 1. The comparison of pre- to post-test scores of different groups of the study

Groups	Time	Mean	Std. Deviation	T (two domains)	Sig.
instructional self-talk	Pre-test	33.1	6.41	1.055	0.001
	Posttest	44.8	7.23		
motivational self-talk	Pre-test	29.5	8.84	8.718	0.319
	Posttest	30.9	10.70		
Control	Pre-test	32.4	5.42	1.287	0.230
	Posttest	29.5	6.65		

4. DISCUSSION AND CONCLUSION

This study aimed to determine the effect of motivational and instructional self-talk and task complexity on top spin forehand accuracy of table tennis in advanced players. The results showed that there was a difference regarding the effect of motivational and instructional self-talk and task complexity on the scores obtained upon hitting forehand top spin in table tennis. The Tuckey post hoc test was used to determine the difference between groups, showing a significant difference between instructional self-talk group and the control group. In other words, by employing instructional self-talk and task complexity to hit the forehand top spin, the accuracy was improved.

The results of present study agree with those of Hardy et al. (2015), which investigated the effect of instructional vs. motivational self-talk on skilled athletes in football shooting task using the dominant and non-dominant foot, showing that instructional self- talk could be more effective in tasks which are based on accuracy.

Also, the results of the present study support the findings of Zourbanos et al. (2013), who had investigated the effects of instructional self-talk intervention on the performance of motor tasks, showing the positive effect of it in performing the task (Zourbanos, Hatzigeorgiadis, Bardas and Theodorakis, 2013). The results obtained by

Zetou et al. (2012) showed that participants in the instructional self-talk group have better performance than participants in control group (Zetou, Vernadakis, Bebetsos and Makrari, 2012).

But, based on the findings of Chang and colleagues (2014), who investigated the role of self-talk, features of motor behavior and self-efficiency in the novice softball players, motivational self-talk in the task of throwing the ball to a far distance, as compared to instructional and irrelevant self-talk, led to a better performance, thereby showing disagreement with the current research (Chang et al., 2014). One of the probable reasons for this inconsistency could be the age and expertise of the participants, as well as the nature of the task done, since throwing the ball to a far distance involves using more power, which, in turn, requires more motivation. Also, the findings in the field of swimming task showed that the effects of motivational self-talk task on improving Swedish swimming was more than that of the instructional self-talk (Kolovelonis, Goudas and Dermitzaki, 2011).

The reasons for the inconsistency of the results of this study can be attributed to the age of the participants and the nature of the task. In addition, the results of the current study run counter to those obtained by Blackslee and Goff (2007) on improving the performance of the horse riders (Blakeslee & Goff, 2007), and Harvey et al. (2002) on the implementation of golf (Harvey, Van Raalte, & Brewer, 2002); both of these studies had no belief in the positive effect of self-talk on the athletic performance. One of the reasons for the disagreement between this research and the current study could be related to the gender and expertise level of the participants.

Self-talk can be regarded as a cognitive strategy and an instructional-psychological tool that can be used for practicing and learning athletic skills. In addition, it can lead to changing the thought of the trainee, such that it lets him get release of the inactivity state, thereby changing the thought patterns with regard to the task being done (Ziegler, 1987). By employing self-talk and using the right keywords, athletes can be helped to organize their thoughts, control and focus on the major parts of the skill to motivate themselves to work more during exercise (Zinsser et al., 2006). Planned Self-talk acts as one of the important variables in improving skills acquisition. With the improvement of skills, the nature of thoughts- according to the type of skills, the learning needs of the athlete can be a range of instructional and motivational self-talk and self-talk can used to alter the thoughts (Hatzigeorgiadis, Zourbanos, Mpoumpaki, & Theodorakis, 2009).

Based on the results obtained in this study, it is suggested that that coaches, along with physical practice, employ self-talk as well as task complexity, such that athletes, especially more skilled ones, in doing tasks with low levels of complexity, can use instructional self-talk more.

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A Study of Motion About Table Tennis" Step" and "Cross Step"

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Abstract: In order to make efficient shots, table tennis sport needs to apply flexible and agile step movement. It shows the importance of the step under the requirements of short-range and high speed especially using the techniques of "step" and "cross-step" during a game. Therefore, the purpose of this study is to explore the comparison between the side drive and rush attack with "right-side step" and forehand strokes with "cross step". The research method is using push - side flapping test for the six college table tennis athletes. Six college student athletes are testing their speed of step movement and scoring rate for this study by using "step" and "cross step" techniques for each group and each group is continuously testing for ten sets which each set has three balls.

The results showed that there were no significant differences in the speed of movement and the scoring rate between the "step" and "cross step". It's suggested that the coach apply the training of step and need to find out athletes' personal and reasonable step movement for "step" or "cross-step" training, so that the athletes' steps can have better coordination efficiency.

Keywords: step, cross step, table tennis

I. Background and Motivation for the Study

1. BACKGROUND FOR THE STUDY

Chuang Chih-Yuan went through to the table tennis semi-final at the London 2012 Games Olympics. Chuang Chih-Yuan and Chen Chien-An won the first men's doubles champion for Taiwan at the 2013 World Table Tennis Championships and raised a burst of upsurge in the popularity of table tennis, many table tennis classrooms and clubs therefore opened, thus enhanced the participation of table tennis enthusiasts. However, it also gradually increased opportunities for people to participate in and learn table tennis. There are no statures and age restrictions in table tennis, and it provides the table tennis enthusiasts with technicality, competitiveness and entertainment, as a result table tennis became a popular sport in Taiwan.

Short distance and rapid change are the characteristics of table tennis. The two sides need to prejudge the direction and the spin of the on-coming ball and determine to fight back with the body in place under the circumstances of small balls, fast speed and changeableness. Hence the use of technique and the occasional spot response are most required, and a good performance is really difficult to achieve without highly skilled techniques and tactics. Responding to such series of judgments, the most needed by shots is the step movement of body and feet. Should you desire to improve your technique, the step training cannot be missed. Continuity of action, control over the stability of the ball, and rush attack consciousness are subject to the step movement. Yu Kuang-Le (2012) indicates that the highest speed of table tennis is up to 126 km / h, and the requirement of human body response speed is the highest in table tennis among all sports. A smooth, powerful and continuous return after a high-speed on-coming ball requires step movement as a guarantee. It is not only the hub of timely and accurate use as well as convergence of all technical actions, but also a strong guarantee of tactics implementation.

Steps of table tennis are categorized into five major types: single step, striding step, level step, jumping step and cross step. The most important steps of which are level step and cross step, because these two steps are the ones of technical connectivity, and whether or not you should be able to continue the oppression and launch an offensive is subject to these two steps. Lu Cheng-Chun (2013) points out that the step is an important part of table tennis. Footwork is the fundamental premise of rational use of technique, and swing movements cannot be ensured to be normally performed unless a favorable place is seized through the footwork. Ouyang Chin-Shu and Wu Te-Cheng (2002) also propose that footwork training is the key to technical and tactical training and the most important part of the special physical training. To get the hang of footwork application, a process required to go through is to develop a positive idea when training and to highlight the forehand and sideways forehand stroke training, the footwork will naturally be good as a result.

Step is an indispensable process of table tennis strokes, of which the "level step" and "cross step" are the most important and most commonly used two steps, generally such step training is exercised by using multi-ball practice to train athletes' ability of such step movement. Each athlete or coach has a different teaching method and use habit, and most of the steps are acquired by coaches through personal experience or from observing the games. None of the current relevant research literature has shown the best efficiency can be achieved by using which step at such distance in terms of "push-side flapping". This study, a simple biomechanical analysis is used for the "push-side flapping" as a designated experimental project, will explore that whether the use of level step or cross step is able to achieve the best performance and render the athletes possible to faster and more accurately strike the ball and the coach can instruct the athletes based on sports science data and documentation guide to use steps.

2. PURPOSE OF THE STUDY

This study mainly analyzes the biomechanical data of the designated project "push-side flapping" on the comparison of the two steps "level step" and "cross step" in table tennis sport to understand the uniqueness and effectiveness of the two steps action and to implement comparative analysis to provide coaches, athletes and related entities with training reference.

3. OPERATIONAL DEFINITION AND INTERPRETATION

(A) Level Step

Move method of level step is left foot and right foot and move left and right as shown in Figure 1. The movement is characterized by the stable center of body weight and the horizontal movement towards the on-coming ball upon transposition.

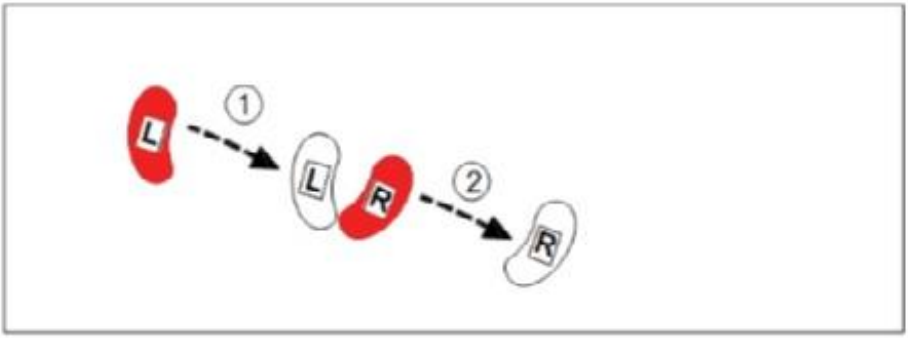

Figure 1-1. Step to the Right (Chang Ting-Jui, Tsai Chien-Lu, 2012, Page5)

(B) Cross Step

Cross-step movement uses the foot close to the direction of the on-coming ball as the non-kicking foot, the other foot fast takes a big step towards the direction of the on-coming ball, and then the other foot restores, as shown in Figure 2.

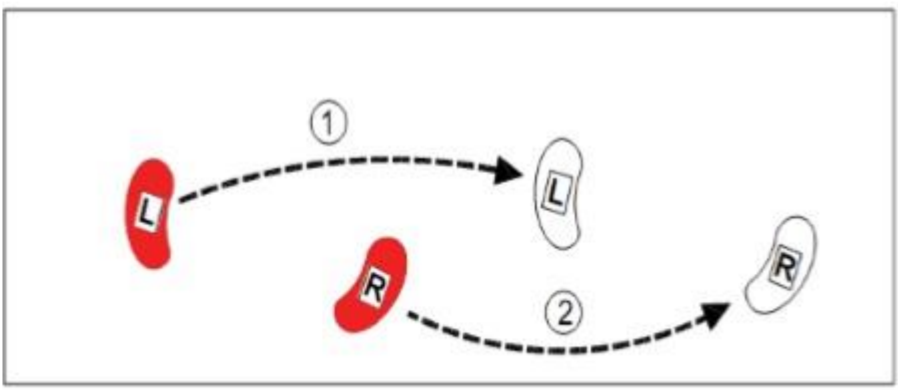

Figure 1-2. Cross Step to the Right (Chang Ting-Jui, Tsai Chien-Lu, 2012, Page5)

(C) Push-Side Flapping

A technique which begins with a backhand attack, and a big angle flap to the other side after the re-convergence of an attacking sideways forehand drive.

4. SCOPE AND LIMITATIONS OF THE STUDY

This experiment uses stopwatches to calculate the step movement time and manually calculate the number of goals for six college table tennis athletes, implementing the experiment on two types of step movement (pyramid limited right-side flop's actual distance: 3.3 m, limited distance from front table to the ping-pong table: 1.2 m) and scoring rate by manually feeding balls, serving (average speed of 3 km / hr, feeding range: 0.7 m × 0.7 m) to three spots of push-side flapping (backhand landing point and forehand landing point: 1.3 m).

II. Procedures and methods

1. OBJECTS OF STUDY

A total of six college table tennis athletes including four men and two women athletes are the main experimental objects (four men's height: 175.3 ± 7.2cm, weight: 73.83 ± 5.8 kg, two women's height: 155.7 ± 8cm, weight: 57.23 ± 4.02kg, of whom four athletes are right-handed players, two are left-handed players). In the experiment, a man with years of teaching experience, 168 cm, 58 kg, takes the post of multi-ball feeding, right-handed flat top spin, the subjects must cooperate with the experimental test and understand the purpose and process of the experiment.

2. TIME AND PLACE OF EXPERIMENT

Experiment Time: May 12, 2016. Place: Table Tennis Court in National University of Kaohsiung, Taiwan (R.O.C.).

3. DESCRIPTION OF EXPERIMENTAL ACTION

This study aims to explore the comparison between the side drive and rush attack with "right-side step" and forehand strokes with "cross step". The action design is as follows:

Subjects first use from backhand attack and sideways forehand strokes to the right-side flap, of which the limited distance is 3.3 m, using "level step" and "cross step" techniques for each single group and each group continuously tests for ten sets of which each set has three balls. The subjects may perform subjectively most powerful or stable shots and the most complete action.

4. EXPERIMENTAL INSTRUMENTS AND EQUIPMENT

A JOOLA standard table tennis table with a net, and pyramids, stopwatches, tape measures, chalk, a notebook PC, and 2 video cameras (each one for the front and the rear).

5. EXPERIMENTAL SITE CONFIGURATION

Experimental operation site configuration is as shown in Figure 1.

The experiment actually limits the movement distance of the subjects as shown in Figure 2.

Figure 1. Experimental Operating Site Configuration

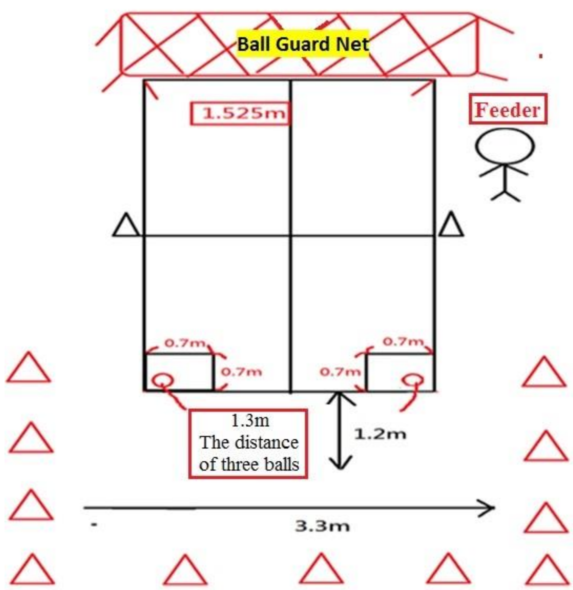

Figure 2. Experimental Limits

(A) A ball feeder fully feeds flat top spins and the serve must go into the effective area (square with a side length of 70 cm), as shown in Figure 2.

(B) The subject shall respectively use two steps to make shots within its limits.

6. EXPERIMENTAL PROCEDURE

(A) Explain the purpose and the process of the experiment to the subjects before the test, and let the subjects warm up and get familiar with the venue.

(B) Check the two cameras, feeders' stability and ball velocity before the start of the experiment.

(C) The subject shoots the ball with a forehand stroke on the right side of the table and sideways for the area, backhand stroke on the left side of the table area without being limited to the scope of the counter-attacking area.

(D) Collect each subject's data, analyze and retrieve the average number of goals and the movement time of all subjects by using excel data after the experiment,

(E) Experimental test process in Figure 3.

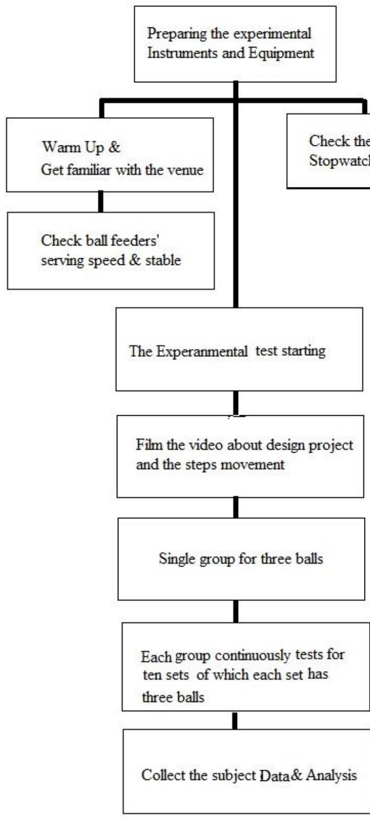

Figure 3. Experimental Test Process

III. Results and Discussion

The experimental results described in the following table indicate that the average number of goals of the level step single group (three balls) is 2.16, and the time average is 3.31 seconds, as shown in Table 1.

Table 1. Scoring Rate and Time Statistics for Level Step Single Group

Subject	Number of Goals	Time (Second)
A	2	3.06
B	3	3.17
C	3	3.09
D	2	3.18
E	2	3.40
F	1	3.98
Average	2.16	3.31

The experimental results described in Table 2 indicate that the average number of goals of the cross step single group (three balls) is 2, and the time average is 2.815 seconds.

Table 2. Scoring Rate and Time Statistics for Designated-Project Single Group

Subject	Number of Goals	Time (Second)
A	3	3.17
B	1	2.92
C	2	3.18
D	1	2.19
E	3	2.87
F	2	2.56
Average	2	2.815

The above points out that the single-ball cross-step movement speed is approximately 0.465 seconds higher than that of the level step. Cross-step has the characteristics of faster movement; however, the number of goals is 0.16 balls less than that of the level step. Manifestly an athlete is able to move to the on-coming ball position in a shorter time by using the cross step in the course of the game when encountering a stronger and a large-angle forehand on-coming ball.

The experimental results described in Table 3 indicate that the average number of goals of the ten level-step groups is 26.5, and the time average is 26.69 seconds.

Table 3. Scoring Rate and Time Statistics for Ten Consecutive Designated-Project Groups

Subject	Number of Goals	Time (Second)
A	30	25.86
B	29	28.56
C	24	29.09
D	28	25.28
E	25	25.72
F	23	26.69
Average	26.5	26.69

The experimental results described in Table 4 indicate that the average number of goals of the ten cross-step groups is 26.1, and the time average is 26.645 seconds.

Table 4. Scoring Rate and Time Statistics for Ten Consecutive Designated-Project Groups

Subject	Number of Goals	Time (Second)
A	25	25.43
B	26	26.32
C	28	28.50
D	27	27.93
E	27	27.30
F	24	24.66
Average	26.1	26.645

The above points out that the cross-step movement speed of the ten consecutive groups is approximately 0.045 seconds higher than that of the level step, while the number of goals is 0.4 balls less than that of the level step. It saves a little time; however, the scoring rate has significantly reduced. Therefore, facing the large-angle forehand on-coming ball after a sideways rush attack in the course, an athlete can save a little time, nonetheless the scoring rate is worse than that of the level step. The athlete should perform based on his/her naturally emerged footwork. In order to smoothly transpose steps, the athlete shall have better coordination efficiency.

IV. Conclusion and Suggestions

1. CONCLUSION

(A) Analyzing the step movement time of cross-step and level-step sideways forehand stroke with convergence of a big-angle forehand shot after a backhand attack, the experimental results show that cross-step movement speed of either single groups or ten consecutive groups is higher than that of the level step.

(B) Experimental data show that the number of goals of the cross step is less stable compared to the level step, thus the scoring rate of the cross step is lower.

2. SUGGESTIONS

Step transposition for athletes in the game significantly impacts the technical and tactical aspects. Analysis of film action by the front and the rear cameras points out that when the subjects transpose by using the cross step, the legs' push power drives rotation of the trunk and waist of the human body, the arm swing path becomes longer, and the arm fights back against the on-coming ball through the rotation in the follow-up shots. And, because the angle between the backswing of the shot location moved by the cross step and the torso rotation is relatively large compared with the significant ups and downs of centre of body weight, as a result the subjects cannot accurately and steadily hit the ball. Level steps may lead to a stable return stroke action and an improved scoring rate; while cross step may enable the shot in place within a short time. In terms of either level steps or cross steps, muscle endurance, lower limb muscle strength and agility are very important, in which the athletes may be particularly and additionally trained. The author suggests that athletes and coaches adjust step transposition used in accordance with athletes' individual lower limb muscle strength and habits. Two types of step are required to increase dexterity during the practice process in order to accurately determine and adjust steps at the game and to get into the best hitting position and perform the most effective return stroke.

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Analysis of Mental State of Athletes Under Pressure Using Electroencephalograph (EEG)

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Abstract: There is a close relationship between training and competition in all competitive sports. However, athletes experience often to fail to show their skill in the game which they have mastered in the training. Mental control is very important for athletes to keep good playing skill. In this work, influences on brain waves of coaching method and calling of coaches to players were investigated to see the mental state of players. Case 1 is the one where a player is required to count the number of rally during the play and to hit the ball according to the instruction. The results of Case 1 showed that the player has higher concentration. Case 2 is the training of block defense against an offensive opponent. It was found in Case 2 that the player feels some modest pressure and tends to becomes nervous. It is expected to develop the training method which makes mental state in the training similar to that in the competition.

Keywords: mental state electroencephalograph (EEG) coaching method

1. INTRODUCTION

In the sports competitions, the psychological problem is a truism, but it's a topic that must be faced and solved for the athlete. Modern biological psycho social medical model think that the human body is a unified whole life of psychology and physiology two functions. Psychological function and physiological function influence each other and conditioned by each other, then constitute complete human life activities. Under normal circumstances psychological function and physiological function are in a harmonious state. Two functions keep a certain balance and together with the environment to form a "Harmonious body«. However, if the environment changes, such as the social environment, living environment or the competition environment changes, it will affect the physical and mental balance. Sometimes there will be a state of physical and mental tension, which is caused by the environment changing. The theory of modern competitive sports training thinks that the athletic performance is not only unilateral outstanding skill which can reach the peak, but many factors integrated. That is the integration of physical strength, skills and psychological factors. Many matches have proved that in the modern sports competition, psychological factors have played an important role. Table tennis is a technically sophisticated and powerfully confrontational sport. In the formal match, athletes almost rely on themselves' ability to carry out individual combat in the confrontation process. With the rapid development of table tennis technology, the antagonism of competition is increasing day by day. The outcome of one match depends on one or two points, success and failure are just a step away. Especially the system is changed from 21 points to 11 points, the athlete's psychological quality requirement is higher. At the crucial moment of the match, the factors that determine the outcome are not the technology you have, but your mental quality and will. The loss of the whole match may be just a momentary slip. Obviously, for the highly skilled projects such as table tennis, poor emotional state will lead to failure. So the psychological control of table tennis players will directly affect the result of the entire match. But a lot of players miss the success in the key match because of tension. Some skills can only play half of the level in the match because the psychological factors affect them. Dislocation of competition and practice affects many athletes. So this study aims at this problem to examine. The pressure is putted on the athletes in the training and using the brain wave instrument to measure the response of the athlete under pressure so that we can analyze the stress tolerance of the athlete and the shortcomings of skill which is reflected under pressure. At the same time, the coach and the athlete get a clearer understanding of themselves so that the results of the competition and the practice are closed.

2. METHOD TEST 1

First, In order to verify whether it is possible to test EEG during exercise, in the first stage of the experiment we are made 5 plans about exerciser basic training and then to make a request put pressure on the athletes.

Test subject: Niigata University Table Tennis Member (A total of 10 people). At the moment, we already tested 3 people. As shown in Table 1.

Table 1. Niigata University Table Tennis Member

	age	body weight	height	Table tennis career
sub,A	19	46kg	152.3㎝	10years
sub,B	21	53kg	166㎝	9years
sub,C	22	58kg	164.7㎝	10years

Experiment contents：

1. Footwork (Half forehand drive)
2. Game (One round 11point)
3. Count (One forehand one backhand for a continuous 30)

4. Reduce miss (Make 20 balls in succession)
5. Block (All table block)

analysis method: MATLAB FFT

EEG measure method and reading of EEG： Electrode of the EEG used: In this study we will adopt "referential derivation". It is consist of referential electrode and exploring electrode. Here we have selected six of the exploring electrodes. FP1, FP2, FZ, CZ, O1, O2, respectively. Electroencephalography (EEG) is an electrophysiological monitoring method to record electrical activity of the brain. It is typically noninvasively, with the electrodes placed along the scalp, although invasive electrodes are sometimes used in specific applications. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain. [1] In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a period of time, [1] as recorded from multiple electrodes placed on the scalp.

Diagnostic applications generally focus on the spectral content of EEG, that is, the type of neural oscillations (popularly called "brain waves") that can be observed in EEG signals.

Baseline brain waves a total of five, as shown in Table 2.

Table 2. Baseline brain waves a total of five

Band	Frequency (Hz)	Explanation
Alpha	8Hz-13Hz	It emerges when you are not mentally active.
Beta	14Hz-25Hz	It appears appears when you are thinking carefully
Theta	4Hz - 8Hz	It appears when shallow sleep and when concentrate
Delta	1Hz-3Hz	It appears when shallow sleep and when concentrate
Gamma	26Hz↑	It is ideal for mind and body conditions such as golf, tennis , table tennis, basketball.

3. TEST 1 RESULT

3.1 Test 1 case 3

At this stage, case3 is a basic practice and requires a plan of count. In this plan, the brain wave analysis results show that we can see more concentrated brain waves from the brain waves of the experimenter. The center portion CZ has higher amplitude, and the high concentration of 14-30Hz β wave and 30Hz above γ wave appeared higher frequency. As shown in Figure 1. A lot of β wave and γ wave can be seen from the high incidence of Occipital region O2 part in the relaxation α wave. As shown in Figure 2. It is woken up at a higher level.

From this analysis we can see that in order to achieve the goals, the athletes play more attention on the usual basic exercises than no requirements of the exercise. Moreover, in order to reduce mistakes, the attention will last longer.

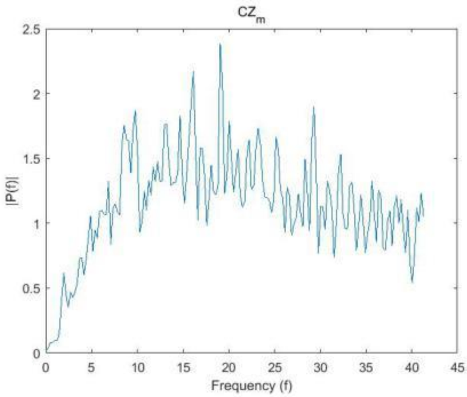

Figure 1. Case 3: CZ EEG（Average Value）

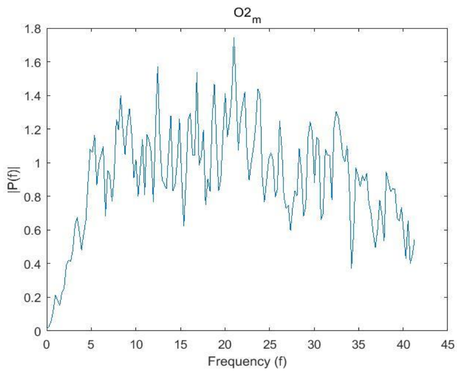

Figure 2. Case 3: O2 EEG（Average Value）

3.2 Test 1 case 5

Case 5 is a defensive practice. From the results of experimenter's brain wave analysis, we can see that the plan is one of the most volatile in the five plans that have been worked out. The mean value of six electrode sites tested which represents the θ-wave of the concentrated component shows a higher electric potential. Especially, the central portion CZ's 14 ~ 30Hz β wave also shows a high electric potential. It can be inferred that the experimenter has a high level of concentration and a certain pressure from the result. In addition, O1, O2 part's θ wave has a stronger reaction than other plans. In contrast, α wave's reaction is lower. Defensive practice is a technique to defend against opponents. So it will give athletes greater pressure in the passive state. Compared with other practice plans when drawing up plans, this plan allows athletes to feel more pressure as shown in Figure 3.

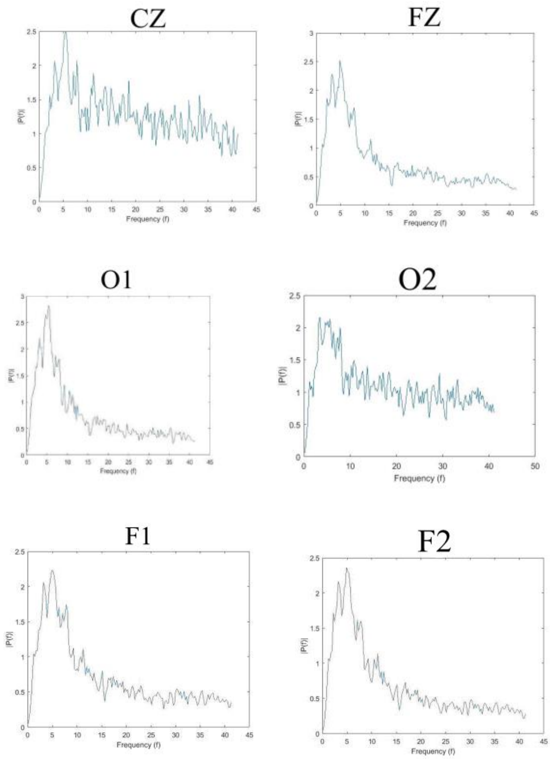

Figure 3. Case 5: CZ, FZ, O1, O2, F1, F2, EEG（Average Value）

4. Method TEST 2

In the intense movement, the electrode line will shake with the movement, which may affect the correctness of the measurement. So in order to avoid such problem in the next test, we draw up one technique “serve and receive” which is a smaller range of movement but need a good psychological quality to complete. Serve and receive play a very important position in the match for the table tennis players. Each ball starts from serve and receive the ball. Most of the time, it decides that the athlete is active or passive. So this test will draw up the test plan based on this technique. The measurement of brain waves is used to detect the use of this technique by the athlete under pressure.

serve condition:

long serve 3 point (left, center, right) target point (A6 size), The goal is ten inside into five.

short serve 3 point (left, center, right) target (point (A6 size), The goal is ten inside into five.

receive condition: up down spin, right up spin down spin, left up spin down spin

receive method: stop, stroke loop, target（point (A6 size), The goal is ten inside into five.

Each technology is limited to 10 balls, and subject must put that the ball can reach the target area, at least five.

5. TEST 2 RESULT

At this stage, two experimenters are tested. Everyone's idea and personality are different, so everyone's brainwave is different. In test 2, each technique have 10 balls, total 15 techniques.5 of 10 balls should enter the target point. The first experimenter completed one of 15 techniques which are set up before. From the result of brainwave analysis, the reaction of the experimenter's sincipital FZ is stronger. Compared with the result, we found that the closer the target is got to, the higher the tension and concentration of the experimenter's brainwave become. In a strange and unfamiliar technical test, the reaction of θ wave that represents the concentration of attention is higher, conversely, when the distance from target is further, the fluctuation of the brainwave is less. As shown in Figure 4.

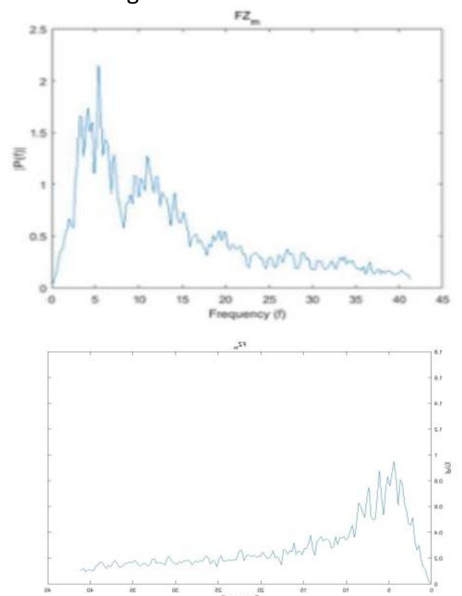

Figure 4. Receive: right top spin loop EEG FZ and receive：under spin stop EEG FZ （average value）

The results of the two experiments were all the same. But the analysis results are different.

The second experimenter completed one of 15 techniques. From the result of analysis, his strong reaction's brainwave is located at the center portion CZ, forehand FZ and the left Occipital region O1. As shown in Figure 5. From the result of brainwave analysis, when the experimenter is in touch with a new technique, the strength of θ wave in CZ and FZ sections is higher. α wave 's amplitude of Occipital region O1 which has a high incidence of α wave is low, conversely, θ wave's amplitude is higher as shown in Figure 6. It is inferred that the awakening's level of the experimenter is higher and the concentration's strength is stronger. In addition, the experimenter is relatively calm when he got close to the target, and more nervous when he is far from the target.

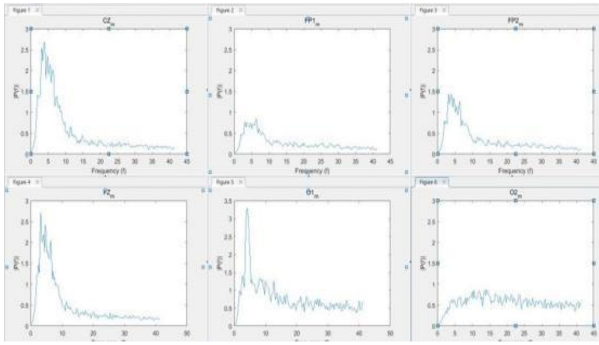

Figure 5. Short serve cross EEG all electrodes (Average Value). The result is 4 in 6 out

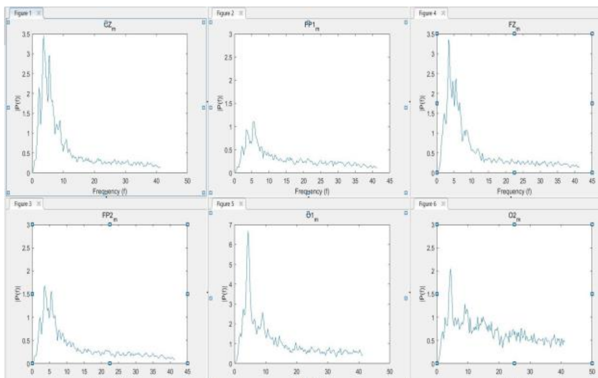

Figure 6. Short serve straight EEG all electrodes (average value). The result is 1 in 9 out

6. CONCLUSION

The first experimenter and the second experimenter's common ground is that the reaction of the six electrode channels is weakened when the experiment proceeds to the second half. It is inferred that under the situation of high difficulty and their own technical capacity not enough, long training will lead to reducing athlete's attention.

According to the above results, everyone's mental state and personality characteristics are different. We can infer changes in athletes in the field from brainwaves. We can also use an EEG to grasp an athlete’s mental state. Based on this study, we can apply pressure to athletes during training, then through the observation of their brainwaves master the weak point of an athlete’s technology. Coaches can thereby develop effective training programmes for athletes. A third stage for developing this research based on the two stages mentioned above is planned.

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The Effect of Glucose Supplements on Exercise Capacity in Table Tennis Players

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Abstract: Investigations were conducted on three groups of subjects table tennis players at the Olympic Center - Bistrita (n = 5/group, age = 20.1 ± 0.5 years, G = 69.98 ± 0.3 kg, I = 173.5 ± 5.4 cm). Program effort, with the consent of the subjects, covered, for all lots: two weeks of specific training for 1 hour robot (machine throwing balls) with a frequency of 60 balls/min., with permanent change of directions of throw; robot is used for specific training in table tennis. Loads were studied: group I - control; group II - preload daily glucose, 250 ml of an aqueous solution with a concentration of 30% glucose, 2 hours prior to training; group III - day post-load glucose, 300 ml of an aqueous solution at a concentration of 40% glucose in 2 doses of 150 ml, 30 minutes and 60 minutes after the end of training. Determinations: indirect determination of aerobic capacity, pre- and post-training, 2 weeks after Astrand-Ryhming method; indirect determination of anaerobic exercise capacity, pre- and post-training, 2 weeks after the method used by the Center for Sports Medicine, Bucharest. Conclusions: Administration of glucose supplements to table tennis players train daily causes significant increases in aerobic and anaerobic exercise capacity, which can contribute to increased performance. Glucose supplementation pre- and post-effort, determined to improve predominant aerobic capacity.

Keywords: Glucose supplements, exercise capacity, carbohydrate metabolism, table tennis

1. INTRODUCTION

Numerous studies have focused attention on the importance of nutritional strategies and effects on metabolism and physical performances. Carbohydrates provide 2/3 of the dietary requirements; the need for carbohydrates increases once with the increase of the physical effort intensity.

Glucose and glycogen are the main fuels involved in cell metabolic processes through anaerobic or aerobic glycolysis. For a person weighting 70 kg, the total supplies of CHO are 2500 kcal: 400-450 g muscle glycogen (13-15 g/kg of muscle), 100 g liver glycogen and 20 g extracellular glucose. The plasma glucose value is estimated to 70-110 mg/dl (3.9-6.1 mM/l). (Ganong, 2003). The plasma glucose level is provided by the liver glycogen and carbohydrates intake. The level of glycemia may be indirectly influenced by the metabolism of muscle glycogen.

During physical effort, the energy requirements of muscle are initially supplied by muscle glycogenolysis. When the effort duration increases, the muscle requirements for glucose are supplied by the liver glycogenolysis and by an increased accumulation of glucose in muscles.

After effort, the liver glycogen is restored through glucogenesis, the glucose being generated from amino acids, glycerol, pyruvate and muscle lactate and the decrease of liver glucose quantity (Guyton and Hall 1996, Derevenco, 1998, Drăgan, 2002).

2. CONTENTS

Hypotheses

In this paper we have studied the effect of glucose supplementation on the table tennis player's effort capacity, before and after effort.

The following hypotheses have been enunciated:

1. How does glucose supplementation influence the aerobic and anaerobic capacity of effort in table tennis players?
2. Are there any differences between the glucose supplementation before and after effort and the aerobic and anaerobic effort capacity in the table tennis players?

Material and methods

Investigations have been carried out on 3 groups of table tennis players from the Olympic Centre - Bistrita (n = 5/ group, age = 20.1 ± 0.5 years, Weight = 69.98 ± 0.3 kg, Height = 173.5 ± 5.4 cm).

Physical activity program

With the previous approval of the participants, the physical activity program for all groups included as follows: 2 weeks of 1 hour specific training using the ball throwing machine at a frequency of 60 balls/min., permanently changing the ball directions; the machine is used in table tennis specific training.

Groups

The following groups have been studied:

- 1st group – the witness group
- 2nd group – daily glucose supplementation before training, 250 ml aqueous suspension containing 30% glucose, administered 2 hours before training
- 3rd group – daily glucose supplementation after training, 300 ml aqueous suspension containing 40% glucose, administered in two doses of 150 mil each, after 30 minutes and 60 minutes after the training.

The supplementation has been established using the average values from the specialty literature. During the experiment, the participants had a mixed diet: 60% carbohydrates, 25% fatty acids and 15% proteins.

Measurements

- Indirect determination of aerobic capacity before and after training, at each 2 weeks, using Astrand-Ryhming method :https://www.brianmac.co.uk/cycle6min.htm
- Indirect determination of anaerobic capacity before and after training, at each 2 weeks, using the method of the Center of Sport Medicine, Bucharest. An effort test

performed on a cycle ergometer Fleisch, where the load increases once with the rotation number per time unit; The subject should perform from the first second of pedalling a maximum number of rotation during one minute with the load established in accordance with the participant's gender, age, weight and sport branch.

Astrand-Ryhming Test consisted in a 6 minutes submaximal effort performed on Fleisch cycle ergometer at a rotation of 40-80/min and intensity of 175 W/kg, maintained constant for the whole duration of test. (Drăgan, 2002)

Based upon the heart rate measured in the last 10 seconds of pedalling, we have indirectly calculated/established the following indices of effort capacity:

- Maximal consumption of O2 – VO2 max – expressed in ml
- Maximal aerobic power – VO2 max/kg – expressed in ml/kg
- Heart rate reserve in effort – VO2 max/heart rate – expressed in ml/min. (Drăgan, 2002)

We have measured:

- The maximal anaerobic power, expressed in maximal wattage achieved from the 5^{th} to 10^{th} second
- The overall anaerobic capacity, based upon the total effective work made in one minute, expressed in kgm/min (Drăgan, 2002).

In order to interpret the results we have applied 1.3 correction.

Results have been reported on the requirement of aerobic and anaerobic power in table tennis.

Theoretical values have been calculated using the following formulas:

- Heart rate in effort = 9.17 + 0.29G
- Maximal aerobic power = 107 – 0.4 x G
- Maxim anaerobic power = 285 + 6.5 x G
- Overall anaerobic capacity = 71.33 – 0.267 x G

where G = Weight.

The qualifications granted on the participants are in accordance with data of the Centre of Sport Medicine of Bucharest (Drăgan, 2002).

Statistical processing of results

Statistical processing of the results has been made using the StatView v. 4.5 Program. We have targeted two aspects:

- Descriptive analysis; for each parameter we noted the mean ± standard deviation
- Analysis of the significance of difference between means

For the comparison of two groups we used Student's t- test for unpaired sample, writing the t value obtained and the threshold chosen for statistical significance p (the results considered as being significant were those with $p \leq 0,05$);

For the comparison of three groups (e.g.: the three moments when the parameter of oxidative stress have been assessed) we used the Fischer – ANOVA test, by writing the value of F and the threshold chosen for statistical significance p; in addition, we noted the significance of the difference between means of each two groups considered one at the time - – in this case the value of p was not written, instead we marked it with S or NS, according to the significance or insignificance of the results related to p = 0,05.

3. RESULTS

3.1. The aerobic capacity is substantially improved by training. The indices of effort capacity reveals as follows:

- For the 1st group – a significant increase of VO2 max, maximal aerobic power and heart rate reserve after training.
- For the 2nd group – a substantial significant increase of VO2 max, maximal aerobic power and heart rate reserve after training.
- For the 3rd group – a substantial significant increase of VO2 max, maximal aerobic power and heart rate reserve after training. (Table 1 and Figure 1 a)

3.2. Glucose supplementation leads to an improvement of qualifications for the maximal aerobic power starting from average to very good for the 2nd and 3rd group and an increase of heart rate reserve in effort from good and very good to outstanding, for the same groups (Table 1. and Figure 1 b,c)

3.3. The anaerobic capacity has little modifications by training. The indices of anaerobic capacity reveals as follows:

- For the 1st group – an insignificant increase of maximal anaerobic power and overall anaerobic capacity comparing with those before training.
- For the 2nd group – a significant increase of maximal anaerobic power and overall anaerobic capacity comparing with those before training.
- For the 3rd group – a substantial significant increase of maximal anaerobic power and significant increase of overall anaerobic capacity comparing with those before training. (Table 2 and Figure 2 a)

3.4. Glucose supplementation leads to an improvement of qualifications for the maximal anaerobic power and for overall anaerobic power, starting from average too good for the 2nd and 3rd group. (Table 2 and Figure 2 e,f)

Table 1. Aerobic capacity indicators (a = before training, b = after training)

Indicator	G =	Group 1 69.40 ± 0.25 kg	Group II 70.15 ±0.91 kg	Group 111 70.40 ± 0.82 kg	Statistical significance
Maximal consumption of 02 (ml)	a	3560.60 ±30.31	3734.08 ± 17.94	3952.25±12.31	1 a-b: $p < 0.01$
	b	4216.05 ± 10.23	5156.02 ±25.01	5296.89±42.90	II a-b: $p < 0.001$ III a-b: $p < 0.001$
Maximal aerobic power (ml/kg) Qualifying	a	51.32 ±0.42	53.23 ±3.51	56.14 ±5.22	1 a-b: $p < 0.01$
	b	60.75 ± 1.25	73.50 ±2.47	75.24 ± 4.23	II a-b: $p < 0.001$
		M	M (60%)* VG (85%)	M (60%)* VG (85%)	III a-b: $p < 0.001$
Heart rate reserve in effort (ml/min)	a	22.82	25.93	28.63	Ia-b: $p < 0.01$ IIa-b: $p < 0.001$ IIIa-b: $p < 0.001$
Qualifying	b	30.55 M * VG	40.92 G * E	44.13 VG * E	
Heart rate (c/min)	a	156	144	138	
	b	138	126	120	
Excellent theoretical values for indicators					
Heart rate in effort (ml/min)		29.2	29.51	29.58	
Maximal aerobic power (ml/kg)		79.24	78.94	78.84	

where M = mediocre, G = good, VG = very good, E = excellent

Table 2. Anaerobic capacity indicators (a = before training, b = after training)

Indicator	G =	Group I 69.40 ± 0.25 kg	Group II 70.15 ± 0.91 kg	Group III 70.40 ± 0.82 kg	Statistical significance
Maximal anaerobic power (W) Qualifying	a	475	521	523	1 a-b: $p < 0.05$
	b	425	610	650	II a-b: $p < 0.01$
		M	M* G	M * G	III a-b: $p < 0.001$
The overall anaerobic capacity (kgm/kg/min) Qualifying	a	37.5 ±3.2	35.3 ± 1.02	34.6 ±2.2	
	b	38.9 ±2.4 M	43.2 ±2.5 M * G	44.3 ± 1.5 M * G	II a-b: $p < 0.01$ III a-b: $p < 0.01$
Excellent theoretical values for indicators					
Maximal anaerobic power (W)		736.1	740.9	742.6	
The overall anaerobic capacity (kgm/kg/min)		52.8	52.59	52.53	

Where M = mediocre, G = good, VG = very good, E = excellent

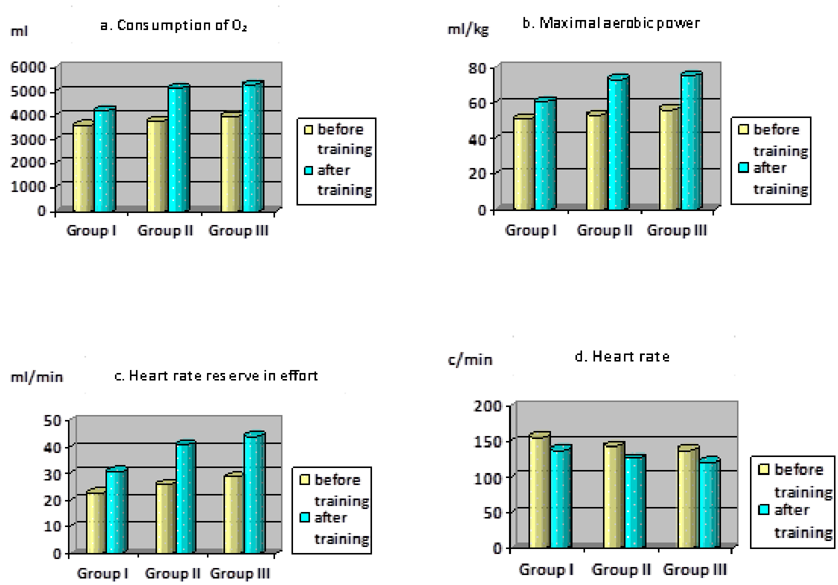

Figure 1. Aerobic capacity indicators

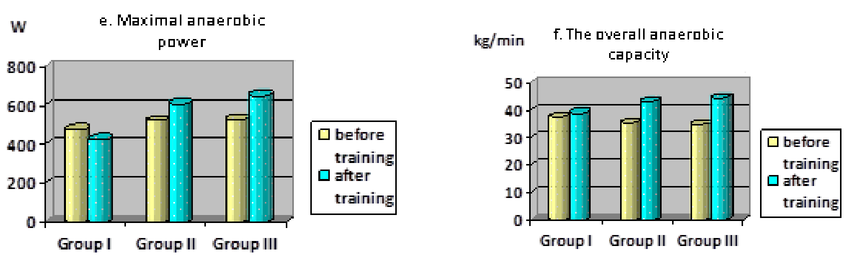

Figure 2. Anaerobic capacity indicators

4. DISCUSSIONS

Influence of effort on carbohydrates metabolism

Many studies support an increase utilization of glucose on muscle level during effort, in different categories of athletes:

• Dropping the reserves of muscle glycogen through anaerobic glycogenolysis (Drăgan, 2002) and aerobic glycogenolysis (Weineck, 1995);

• Increasing the uptake of glucose in the muscles in the absence of insulin through GLUT-2 transporters (Guyton and Hall 1996); the importance of normal content of GLUT-4 transporters which are insulin dependent for uptake (Fueger et al., 2004) and of the redox status which is influenced by SRO and SRN (Balon and Yerneni 2001);

• Importance of crabohydrates diet (hypo~ or hyperglucidic) in restoring the muscle glycogen reserves (Drăgan, 2002) and in reducing the gluconeogenesis and catabolism;

• Importance of a diet rich or poor in fatty acids on the muscle glycogen reserves (Zderic et al., 2004);

• Mobilization of glucose from the liver glycogen reserves, after the depletion of the muscle glycogen reserves, during the long-term efforts (Weineck, 1995);

• Importance of the endurance training in increasing the glycogen muscle reserves (Guyton and Hall 1996); reducing the activity of pyruvate dehydrogenase in the skeleton muscles (Leblanc et al., 2004);

• Particularities of glycogenolysis in active and inactive muscles (Kohler and Boutellier 2004).

We notice that the following processes take place during the physical effort on the plasma level:

• Initial hyperglycemia through liver glycogenolysis or

• Hypoglycemia during the intense and prolonged effort, a process partially balanced by sympathetic adrenal activation and gluconeogenesis increase (Ganong, 2003).

The well-trained participants have a more stable glycaemia level (Derevenco, 1998).

Several researches on human subjects, different types of athletes revealed different modifications:

• An increase of glycaemia during the intense physical efforts (Rankin, Ocel and Craft, 1996; Kreisman et al., 2003), long-term physical efforts (Fu, You and Kong, 2002; Chevion et al., 2003), and anaerobic, aerobic and mixed efforts (Ilhan et al., 2004)

• A decrease of glycemia on an empty stomach (Derevenco, 1976), in moderate intensity effort (Chearskul and Srichantaap 1994; Ueda et al., 1997; Robson, Blannin and Walsh, 1999) and long-term effort (Stroud et al., 1997; Ko, 2004), and in vibration training (Di Loretto, Ranchelli and Lucidi, 2004)

• Little modifications in long-term effort (Pockock and Richards 1999), in the effort made during the cycle ergometer activity in elderly persons (Legakis et al., 2004), astronauts (Sauseng-Fellegger et al., 1992) and drivers (Tsopanakis and Tsopanakis, 1998) and during the moderate intensity effort, especially in well-trained individuals (Dzuvo-Hadzovic et al., 2004).

Several recent data put emphasis on the level of glycemia and on adjusting the glycemia doses for effort.

Glycemia dosage – Glycemic index (GI) – has highly importance for planning the nutrition strategies in what concerns CHO and its supplementation in physical effort. Planning of GI in CHO supplementation for athletic performance optimization proved to be a new and an extremely interesting research subject for nutrition in sport.

Studies revealed that a diet rich in CHO with a low GI represents an adequate source of CHO before extended efforts, while a diet rich in CHO with an increased GI seems to be suitable for restoring the glycogen storage after effort, by stimulating the glucose and insulin response (Wagenmakers, 1999).

The results of our experimental research, which comply with literature data, show the importance of adjusting the glycemia doses and mentioning the IG in order to increase the aerobic capacity in effort, during the administration of glucose supplementation before effort and to recover the glycogen storage when administered after effort (Figure 3).

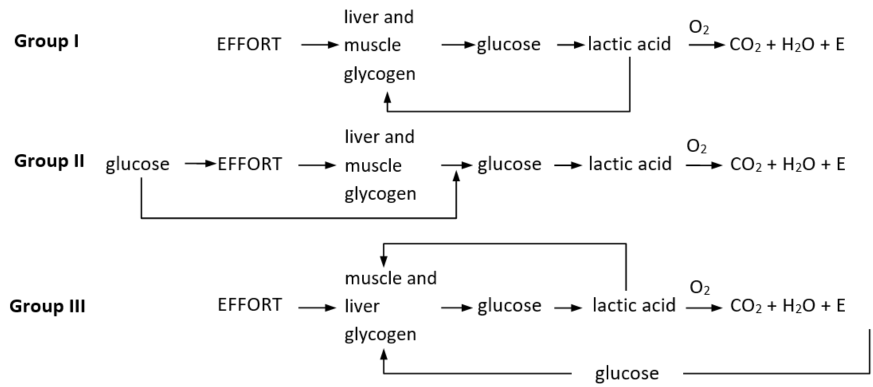

Figure 3. Glucose supplementation before and after aerobic effort

Researches made on human subjects reveal the improvement of anaerobic capacity in effort, which is highly important for table tennis players who make a mixed effort, mostly aerobic, with bursts of anaerobic power.

We checked the results of experimental researches in athletes before and after effort, by monitoring some of the parameters of capacity in effort after glucose supplementation. On table tennis players who are making mixed physical effort, the favorable effects of glucose supplementation are noticed mostly in their aerobic capacity in effort, as the tennis table players usually make aerobic effort with bursts of anaerobic power. The results obtained on athletes comply with experimental data related to the increase of aerobic capacity in effort after glucose supplementation. Taking into consideration the particular character of the effort made by tennis players, the improvement of anaerobic capacity plays a significant role.

5. CONCLUSIONS

1. Administration of glucose supplementation in table tennis players who perform daily training, leads to significant increases in aerobic and anaerobic effort capacity, which may contributes in increasing performance.

2. Supplementation of glucose before and after physical effort in table tennis players, leads to the improvement especially of aerobic effort capacity.

6. RECOMANDATIONS

Our results allow us to give few recommendations to the nutritionist and the sport physician, to the trainer and the athlete, regarding an adequate diet and a rational use of some food products containing carbohydrates.

During physical effort, we recommend the carbohydrates administration under the form of sucrose, glucose and fructose in the following forms:

- 20-30-40% aqueous solution
- powder: Dextropur, Glucopur, Dextrovit, Eleutal, Multivita glucose, in doses of 25-30 g, 1,5 hours before effort in long-term physical activity and 15 minutes before effort in short-term physical activity
- beverages containing 2-2,5 g%, administered 30 minute before effort when the physical activity is performed in warm environment and beverages containing 15-40 g%, when the physical activity is made in cold environment (Drăgan, 2002).

Other products based on carbohydrates that are used in athletes are: fructose (levulose), sacarose (refined sugar) and sorbitol (found in Alglutot and Vitaspol).

In concentrations over 40%, the carbohydrates solutions may cause nausea and vomiting after ingestion.

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The Comparison of Arousal, State Anxiety and Self-Confidence Between Women and Men Elite Table Tennis Players

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Abstract: This study was conducted to compare the arousal, self-confidence, somatic and cognitive anxiety among Iranian elite male and female table tennis players. The subjects were 40 elite table tennis players (20 men and 20 women, mean age of 22.90 ±4.90 years) who participated in 2016 national qualifying competitions. Arousal and cognitive anxiety levels were measured by “Sport Grid-Revised” (Ward & Cox, 2004), self-confidence and somatic anxiety were measured by two items of the Mental Readiness Form (MRF-3; Krane, 1994), 10 minutes before the scheduled time of the match. Independent sample t-test was used for data analysis. In comparing women with men, results showed that women arousal level was significantly higher and their somatic anxiety was significantly lower than that of men, but there were no significant difference between their self-confidence and cognitive anxiety. However, in comparison between winner and loser groups the results showed that self-confidence in winner group was significantly higher than the loser group but the cognitive anxiety in loser group was significantly higher than the winner group. These findings demonstrated there were gender-based differences in arousal and somatic anxiety of elite table tennis players before the start of the match, but self-confidence and cognitive anxiety were effective psychological variables on performance during the match.

Key words: table tennis, gender, arousal, anxiety, self-confidence

1. INTRODUCTION

For years, researches have shown that interaction between arousal and psychological moods have multiple effect on performance and behaviour (Edwards, Hardy, 1996; Janelle, Singer, & Williams, 1999). Arousal is a continuum of neural activation from sleep to intense excitement. Physiological arousal means physiological activity of autonomic nervous system, which can be quantified by measuring heart rate, blood pressure, and skin conductivity (Vaezmousavi and Mosayebi, 2007, p. 164). Felt arousal reveals a perception of physiological arousal; in other words, how a person's feelings are motivated or activated. The felt arousal is different from actual physiological arousal, although the felt arousal is thought to be derived from the physiological arousal (Raedeke and Stein, 1994). Anxiety is a negative emotional state characterized by feelings like worry and fear. State anxiety, which consists of cognitive state anxiety that it related to the mental elements of anxiety and somatic state anxiety is associated with physiological arousal. Studies have shown that anxiety levels experienced by the individual, reflects the needs of arousal and activation of a sport skill (Vaezmousavi and Mosayebi, 2007, p. 164). Multidimensional theory (Liebert& Morris, 1967) suggests that performance are affected by cognitive and somatic anxiety differently. According to this theory, when players before the match showing upper cognitive anxiety, extreme amount of somatic anxiety and inferior self-confidence, they will perform very poorly in the race (Iizuka, Marinovic, Machado and Vilani, 2005). Many studies have revealed that high levels of cognitive anxiety can have a devastating effect on enforcement tasks (Hardy, Beattie, & Woodman, 2007) and there is a negative linear relationship between cognitive anxiety and performance (Martens et al., 1990). LeUnes and Nation (2002) Believed that the multidimensional relationship between state anxiety and athletic enforcement is complex and requires more investigation. Martens et al. (1990) propose that there is an inverted U-shaped relationship between physical anxiety and performance that with lesser and upper levels of somatic anxiety, the performance will failed. Also they suggested a linear relationship between self-confidence and performance. Bunch of psychological research has been done in the field of individual differences arousal and anxiety, especially about elite athletes. Including Hanin researches (1980), which measures the level of anxiety before the race outboard elite athletes get that anxiety is different in every person.

One aspect of the study of individual differences is on gender factor that pay to investigate the differences between men and women in psychological variables in sport situations. Schaal et al. (2011) Stated that many psychological differences associated with gender is related to sport mental stress that can cause some mental disorders so that even can be seen among elite athletes. Studies have shown that young girls athlete have reported higher levels of anxiety (Costello, Egger, Angold, 2005). Many studies in sport psychology have displayed that state anxiety can also be influenced by gender, so that female athletes have shown higher cognitive and somatic anxiety than male athletes (Woodman and Hardy, 2003; Thatcher, Thatcher and Dorling, 2004; Cartoni, Minganti, Zelli, 2005; Neil, Cropley, Hanton and Mellalieu, 2007; Parnabas, Mahamood, 2010). But a number of studies have indicated that there is no significant difference in cognitive and somatic anxiety between men and women players (Ramella-Deluka, 2003). Researches in the field of gender differences in arousal level is very low. Also some studies has been done to investigate the self-confidence of men and women athletes. For example, Lin, Li, Lin, Lu (2011) displayed that Self-confidence is a moderating variable between past performance and practice hours in table tennis players.

On the other hand one way to evaluate the effects of psychological variables on performance, is comparing these variables between winners and losers. Iizuka et al. (2005) in a study on table tennis players showed that there is no significant difference between winner and loser group in cognitive state anxiety, somatic anxiety and self-confidence variables. Covassin and Pero (2004) indicated that winner tennis players demonstrated significantly greater self-confidence, lower cognitive and somatic anxiety levels than loser players. Also Modrano and Guillen (2011) revealed that gender differences were not found for self-confidence and anxiety characteristics.

According to what was said, many studies still are needed to determine differences in psychological variables, according to the gender, variety of skills, different skill levels, different levels of competition, single or team sports, and many other factors. The first objective of this study was comparison of psychological variables (arousal, self-confidence, competitive state and somatic anxiety) between male and female elite table tennis players. The second objective was to compare these variables between the two groups of winners and losers. These objects help us to understand that in a table tennis match which of these variables has been affected by gender and which of them have more influence on performance.

2. METHODS

2.1 Participants

Forty elite table tennis players (20 men and 20 women) who participated in 2016 Iran national qualifying competitions, volunteered to take part in this study during their participation. Participants were make certain confidentiality regarding the information collected and their personal identity. All participants completed the Sport Grid-Revised (Ward and Cox, 2004) and MRF-3 (Krane, 1994) ten minutes before the start of their first match. Then we divided all participants into two groups (win or lose) based on the result obtained in that match.

2.2 Instruments

Arousal and cognitive anxiety. The "Sport Grid-Revised" (Ward and Cox, 2004) was used to measure the levels of arousal and cognitive anxiety. Sport Grid-Revised is a 9×9 grid with which people evaluate their cognitive anxiety in a continuum in the range of "not worried to very worried" in horizontal axis, as well as their arousal state in a continuum in the range of “very low activation (very flat or sluggish) to very high activation (very pumped-up)” in the vertical axis. Here, the words "arousal and excitement" have been used as synonymous terms. The horizontal and vertical continuums measure cognitive anxiety and arousal level on a 9-point Likert scale, respectively. Ward and Cox (2004) showed that these two variables are not correlated with each other ($r=-0.07$) and are independently measured, which makes Sport Grid-Revised suitable as a measurement tool. The validity of structure, content, convergence, and reliability of the questionnaire was determined by Ward and Cox (2004).

Self-confidence and somatic anxiety. In 1994 Krane redeveloped the Mental Readiness Form by name MRF-3 with an 11-point Likert scale, a brief measure of the three CSAI-2 subscales. The MRF-3 consists of three items (i.e., single-item subscales for cognitive and somatic anxiety and self-confidence) and can be completed in just a few seconds corresponding to how one is thinking, physically feeling, and feeling confident. In this study we used the somatic anxiety and self-confidence items.

3. RESULTS

The data analysis revealed that participants had a mean age of 22.90 years (SD= ±4.90). Means and standard deviations for Arousal, Cognitive Anxiety, Somatic Anxiety and Self-Confidence are presented in Table 1.

Table1. Means and SD for psychological variables of women and men.

Variables	Subject	N	Mean	Std. Deviation
Arousal	women	20	6.30	1.21
	men	20	5.20	1.43
Cognitive Anxiety	women	20	3.90	1.61
	men	20	4.10	1.68
Somatic Anxiety	women	20	3.50	1.90
	men	20	6.10	1.25
Self-Confidence	women	20	7.70	1.89
	men	20	7.00	1.71

The results of independent sample t-test showed that women arousal level was significantly higher and their somatic anxiety was significantly lower than that of men, but there were no significant difference between their self-confidence and cognitive anxiety (Table 2).

Table 2. Independent t-test to compare the psychological variables of women and men.

Variables	F	t	df	Sig. (2-tailed)	Mean Difference
Arousal	1.63	2.61	38	.013	1.10
Cognitive Anxiety	.288	-.383	38	.704	-.200
Somatic Anxiety	2.05	-5.099	38	.000	-2.60
Self-Confidence	.268	1.22	38	.228	.700

The players of the study were separated into two groups considering their results in their first match. Means and standard deviations for psychological variables of winners and losers are presented in Table 3. The results showed that losers' cognitive anxiety level was significantly higher and their self-confidence was significantly lower than that of winners, but there were no significant difference between their arousal and somatic anxiety (Table 4).

Table 3. Means and SD for psychological variables of winners and losers.

variables	The First game	N	Mean	Std. Deviation
Arousal	lose	20	5.50	1.23
	win	20	6.00	1.58
Cognitive Anxiety	lose	20	4.80	1.36
	win	20	3.20	1.50
Somatic Anxiety	lose	20	5.00	2.05
	win	20	4.60	2.11
Self-Confidence	lose	20	6.10	1.16
	win	20	8.60	1.46

Table 4. Independent t-test to compare the psychological variables of winners and losers.

variables	F	t	df	Sig. (2-tailed)	Mean Difference
Arousal	.158	-1.11	38	.274	-.500
Cognitive Anxiety	1.78	3.52	38	.001	1.60
Somatic Anxiety	.311	.607	38	.547	.400
Self-Confidence	.962	-5.97	38	.000	-2.50

4. DISCUSSION

The first purpose of this study was to compare the arousal, self-confidence, somatic and cognitive anxiety among Iranian elite male and female table tennis players. The results showed that female arousal level was significantly higher and their somatic anxiety was significantly lower than that of male, but there were no significant difference between their self-confidence and cognitive anxiety. The results of somatic and cognitive anxiety did not support the previous researches that believe gender can affects state anxiety and women player have higher somatic and cognitive anxiety than men player (Seeley, Storey, Wagner, Walker, Watts, 2000; Woodman and Hardy, 2003; Thatcher, Thatcher and Dorling, 2004; Cartoni, Minganti, Zelli, 2005; Neil, Cropley, Hanton and Mellalieu, 2007; Parnabas, Mahamood, 2010). Our cognitive and somatic anxiety results were according to some studies that showed there is no significant difference between women and men athletes in terms of cognitive anxiety but did not agree with results of somatic anxiety (Ramella-Deluka, 2003). Also the result of self-confidence and anxiety were similar to Modrono and Guillen (2011) that showed Gender differences were not found for anxiety or self-confidence characteristics in windsurfers competing at high levels of competition. There is limited research with regard to compare the arousal of high-level male and female athletes.

Second propose was to comparison the psychological variables of winner and loser players. The multidimensional theory hypothesis (Libert and Morris, 1967) that low levels of cognitive anxiety, moderate somatic anxiety and high self-confidence were essential for perfect performance (Iizuka et al., 2005). The results of this study showed that losers' cognitive anxiety level was significantly higher and their self-confidence was significantly lower than that of winners, these results supported the multidimensional theory in table tennis players. But there were no significant difference between their arousal and somatic anxiety, these results did not confirm this theory. Cognitive anxiety results were consistent with previous investigations that have suggested that cognitive anxiety level must be low for a successful performance (Covassin and Pero, 2004; Ussher and Hardy, 1986; Weinberg and Genuchi, 1980). Also our results agreed with Covassin and Pero (2004) that showed the winning tennis players displayed significantly higher self-confidence and lower cognitive and somatic anxiety that our result of somatic anxiety did not consistent with that study. We argue that when table tennis players demonstrated higher scores on cognitive anxiety earlier to the match, therefore they may have been affected by these destructive emotions, which in turn may have played a role in their diminished performance and consequent loss. On the other hand winning athletes have higher levels of self-confidence they revealed fewer worry about performance than did the losing players.

The results of this investigation, in general, support the findings reported in previous studies that showed successful competitors to display higher self-confidence than unsuccessful competitors (Feltz, 1988). Results suggest that athletes who have a higher self-confidence incoming match are more likely to be successful. One probable reason is that confident athletes trust in their skill to execute well and win (Covassin and Pero, 2004). Bandura's (1977) self-efficacy theory suggests that outcome expectations are critical in evaluating the relationship between self-confidence and performance. In turn increases or reductions in self-confidence were perceived to have more of a straight effect on performance. These factors would allow athletes who believe that they are in control to maintain their confidence and positive feelings even in the face of adversity (Hanton and Connaughton 2002). Therefore, athlete who have a stronger trust in their own ability may win even if they are matched against an opponent with better physical skills. So the results of this study are consistent with those formerly suggested that athletes with a positive mental attitude prior to match tend to be more successful (Covassin and Pero, 2004).There are several advantages for studying the relationship between self-confidence, state anxiety, and performance of table tennis players. Because table tennis is a sport in which the player plays in the 1 single match is the best player on the team, the second best player competes in the 2 singles match and etc... Therefore, while there are differences in skill level, generally the best player on one team is competing against the best player on the opposing team. Here the successful and winner player is a person that has the optimal level of arousal, self-confidence, somatic and cognitive anxiety than opponents. Furthermore, Covassin and Pero (2004) suggested that mental state prior to the start of a tennis match has a critical part in overall success or failure and that ability to get mentally ready for rivalry may be an aspect of the match that you have to play well to succeed.

In conclusion, winning table tennis players were more self-confident and had lower anxiety scores prior to their matches than the losing players that potentially able to make logical decision and relaxed under stress conditions and were not as affected by negative situations. These properties may be a key aspect of the players that separates the successful from the unsuccessful athletes. The findings of present study demonstrated there were gender-based differences in arousal and somatic anxiety of elite table tennis players before the start of the match, but self-confidence and cognitive anxiety were effective psychological variables on performance during the match.

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A Study on the Effect of Service Failure, Compensation Toward Consume Again of Table Tennis Club

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Abstract: Table tennis is suitable for all ages, and there are so many projects and equipment about table tennis in many schools and sports centers. Then some table tennis clubs gradually appeared. As it may have some service failure in the service process, the purpose of this study is to understand the relationship of service failure, compensation and intention of reconsumption. The consumers of table tennis club are the objects in this study, and then 143 valid questionnaires are available. The statistical methods are factor analysis, correlation analysis and stepwise regression. The results show that there are positive relationships among service failure, compensation and intention of reconsumption, and service failure; compensation has a positive effect on intention of reconsumption. Therefore, the conclusion is that the intention of reconsumption of consumers from table tennis club is depend on their cognition of service failure and compensation from clubs. Finally, we hope to promote intention of reconsumption of consumers from table tennis club and it can provide some appropriate suggestions and references for the managers through this study to make these clubs can have a sustainable development.

Keywords: table tennis, service process, sustainable development

1. INTRODUCTION

Table tennis is one of the most popular sports of people in Taiwan. Table tennis is an indoor and moderate sport, and it also doesn't need too much sport venue and cost, moreover it is suitable for every one of all ages. The risk of sport injury of table tennis is low, and it is also very interesting and competitive, then it is not affected by the weather and the seasons (Wang and Hsu, 2006). So in recent years, more and more table tennis players from Taiwan have excellent performance among the world competitions, due to this, it also raised the trend of table tennis sports in Taiwan. At the same time, table tennis related industries are also increasing, including table tennis clubs and surrounding commodities.

Bammel and Burrus-Bammel (1992) pointed out that there are so many benefits of engaging in leisure activities, and people can get benefits of physical, social activities, relax, education, mental and aesthetics through the experience of participation in leisure activities.

In recent years, because of the improvement of the domestic economy, people have begun to emphasize health, so that exercise is necessary. There are many table tennis enthusiasts who would participate in table tennis activities during their free time in many table tennis clubs and training places throughout the country. However, the table tennis club business has just started, and it is a part of service industry. So there may be some mistakes in service process. When a service failure occurs, it may lead to unpleasant experiences for consumers, therefore, compensation of service is an important strategy. Above all is to explore whether and the compensation from clubs is appropriate for the service failures, and whether it can make up for the loss of consumers, and it also has an influence on the intention of reconsumption of consumer. This is the motivation of this study. It is hoped that we can understand the life style of table tennis enthusiasts more through this study and help the development of table tennis clubs in Taiwan in the future.

To sum up, the purpose of this study is to explore the relationship between service failure, service compensation, and intention of reconsumption, and the influence of service failure and service compensation on intention of reconsumption of table tennis club consumers in Taiwan.

2. METHODS

2.1 Participants

The object of this study is the consumers of the table tennis club in Taiwan, and 145 questionnaires were sent by convenience sampling, and 143 valid questionnaires are available, the effective recovery rate was 98.6%.

The participants were 69.4% males and 30.6% females, and the majority of the age group was from 20 to 30 years old.

2.2 Measures

In this study, the service failure, service compensation and intention of reconsumption scale were adopted to Chen and Hwang (2015), and then adapted according to the needs of this study.

2.2 Data analysis

In this study, we used factor analysis, correlation and multiple stepwise regression analysis, and the statistical software used in the study was spss20.0.

3. FINDINGS

3.1 Exploratory factor analysis

Table 1. Exploratory factor analysis

Constructs	Item	Service Failure	Compensation	Perceived RIsk
Service Failure	a1	.839		
	a2	.836		
	a3	.902		
	a4	.919		
	a5	.916		
Compensation	b1		.941	
	b2		.884	
	b3		.907	
	b5		.849	

(continued)

Constructs	Item	Service Failure	Compensation	Perceived RIsk
Perceived RIsk	c1			.968
	c2			.963
	c3			.978

Nunnally (1978) pointed out that the factor loading should be greater than 0.4, but the fourth service compensation factor is less than 0.4,so it must be deleted, and the others are greater than 0.4 standards.

3.2 Reliability Analysis

Table 2. Reliability Analysis

Variable	Cronbach's α
Service failure	.928
Compensation	.918
Consume Again	.968
Total	.930

Nunnally (1978) proposed: It is better that Cronbach's α values must be greater than 0.7. From the above results, it is found that the Cronbach's alpha of all items ranged from 0.918 to 0.968, which are more than 0.7 of the standard, so it showed that there are good reliability in all items.

3.3 Correlation Analysis

Table 3. Correlation Analysis

	Service failure	Compensation	Consume Again
Service failure	1		
Compensation	.556	1	
Consume Again	.666	.744	1

**p<0.01

From the above analysis, it is found that there is a significant positive correlation between service failure and service compensation and intention of reconsumption, especially there is the highest correlation between service compensation and intention of reconsumption.

3.4 Multiple stepwise regression analysis

Table 4. Multiple stepwise regression analysis

Variable	B	Std.Error	Beta	t	Sig.
(Constant)	-.157	.224		-.703	.483
Service Failure	.346	.058	.365	6.011	.000
Compensation	.713	.080	.541	8.909	.000
R^2			.646		

Dependent variable: Consume Again

From the above results, it was found that service failure and service compensation would affect the intention of reconsumption, and both of them had significant prediction for intention of reconsumption.

4. DISCUSSION

According to the results of this study, we can found that service failure and compensation about the table tennis clubs were related to whether they would be willing to go to the club again or not. So that the club today should take appropriate strategy to make up for consumers due to the service failure. The quality of service is important to the service industry, if we can pay more attention to the management of service, we will also be able to reduce the failure through service process and enhance the willingness of the customers of table tennis club.

From the results of multiple regression analysis, we can found out that whether the service failure or compensation they have or not could predict the customers' willingness to the clubs again.

In addition, the purpose of this study is to explore the influence of service failures and service compensation on the intention of reconsumption of table tennis clubs. Gelbrich et al. (2016) mentioned in the study, through some integrated research and findings, there was an influence between relationship quality and compensation, so it is suggested that researchers can increase the quality of the relationship as a new variable in the study in future.

Finally, this research is aimed at the Sporting Club of table tennis, but due to the diversity of clubs, it is suggested to explore the difference of this research result with others. It is hoped that the result will be useful for reference to related clubs and then they can provide a more comfortable and valuable place for customers.

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The Effect of Implementing Plastic Ball in Chinese Excellent Female Table Tennis Players' Technique and Tactics Performances

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Abstract: According to the regulation launched by ITTF (International Table Tennis Federation), the official materials utilized in manufacturing table tennis balls have been changed from celluloid to plastic since 1st of July, 2016. That is to say, from then on, plastic ball has officially emerged on ITTF events. The main purpose of this study aimed to explore the effect of implementing plastic ball in Chinese excellent female table tennis players' technique and tactics performances (i.e. three-part skill performances) during the early transition period (from February 2013 to August 2015). This study had been done with the eyes on 32 games (177 rounds in total) participated by Xiaoxia Li, Ning Ding, Shiwen Liu and Lingyu Zhu, and with the method of video observation, mathematical statistics and comparative analysis. Based on the research, the developing tendency of plastic ball can be anticipated will be better and better. The research results can be concluded as follows: (1) When using plastic ball, there was less effect in serve part while was quite large effect on receive part and there was great effect in rally part. (2) When using plastic ball, contributes to serve part that players were easier to attack rivals. (3) The athletes benefited from using plastic ball in receive part that they were more proactive even were capable to change situations from passive to active. (4) When using plastic ball, the rounds that athletes played in rally part were increased so that the competitions would be more eye-catching. According to the conclusion, it could be found that using plastic ball has exactly affected female players' technique and tactics performances (i.e. three-part skill performances). It brought positive effects on Xiaoxia Li, Shiwen Liu and Lingyu Zhu while brought negative effects on Ning Ding.

Keywords: table tennis, celluloid and plastic balls, technique and tactics performances

1. PREFACE

Chinese table tennis women players were called mythical in the highest peak of the women's table tennis world. Chinese women table tennis players in the top of the world, and six of the top ten are Chinese. As we all know Yining Zhang, Nan Wang retired after Beijing Olympics, but Xiaoxia Li, Ning Ding, Shiwen Liu and Yuling Zhu represented a new generation of women table tennis players. This succeed is closely associate with Chinese technology and tactics analyze, training methods and innovation on the basis of inheritance and learning, scientific training ideas, all of this urged Chinese table tennis players get outstanding achievements.

Along with the ITTF constantly reform of laws and regulations of table tennis. The ITTF has made Five changes: First, since October 1st, 2000, the weight of table tennis has been changed from 2.5 grams to 2.7 grams, with a diameter of 38mm to 40mm; Second, starting from September 1st, 2001, the rotation of serving has been changed from 5 to 2 per square, and each game will be changed from 21 to 11; Third, since September 1st, 2002, the ITTF has proposed that there be no occlusion service; Fourth, since September 1st, 2008, use inorganic glue; Fifth, July 1st; 2014, all the major international competition to use the new material is plastic ball, and the diameter of the new ball standard from 39.50 - 40.50 mm to 40.00 - 40.60 mm, to July 1st, 2016, celluloid ball will no longer be accepted at official ITTF tournaments. All of the reforms have a profound impact on the development of table tennis, and put forward higher requirements of the athletes.

In this article we collected data from almost three years Chinese women table tennis offensive players Xiaoxia Li, Ning Ding, Shiwen Liu, and Yuling Zhu. This article used game video observation and statistics, analysis and comparison to analysis they use celluloid balls and plastic balls in the games. I am looking forward to the results of this study can support their training and competition in the future; it is good to theoretical study connect with practical training and competitions ; and also try to find out the problem of using the new plastic balls, and in-depth analysis to find the effective way to solve the problems.

2 Literature Review

After reading a lot of books about table tennis, we found that at present time most studies focused on the relation to table tennis tactics, the teaching and training, the referee and rules, and of which more than 60% of the references are about table tennis technique and tactics. We can know technique and tactics is very important to the study of the table tennis competitions.

Piren Su (2004) in the Table Tennis Training point out: the development of the technique and tactics of usually in front of tactics, improved the original technology can appear the corresponding new technology, and may produce new tactics; in return, the advanced tactics can actively promote the development of technology. Technology is the foundation of tactics, if you have a variety of techniques then you can master comprehensive and practical tactics better. Only by using tactics properly in the competition can fully utilized the technology. In training, you can only practice the techniques with tactical awareness that you can get real useful practical skills.

Jianjun Tang (2005) in the book A Course of Table Tennis Technical and Tactical relationship point out: technology is the foundation of tactics, and at the same time tactics reflect technology. If you master comprehensive technical, you can use the game tactics better; if you mater stronger technology and comprehensive theoretical knowledge, you can finish the technical more efficient.

Huanqun Wu (2002), in the Table Tennis Prosperous Study point out: technological innovation promoted the development of table tennis in a way, the innovation of the technology not only created new technology, but also improve the quality of the ball on the basis of the original technology.

Mai-jiu Tian (2000) in the Sports Training point out: China table tennis development can stand at the international top, the reason is China have the leading theory knowledge, the correct guide practice training, continue innovation to maintain advantages, special features prominent, technique comprehensive, high quality and scientific research of the coach team, the information system.

3 Research Subjects and Methods of Research

3.1 The Research Object

This study included Chinese Four excellent women table tennis players, they used celluloid balls and plastic balls t of the games, including 16celluloid ball matches and 16 plastic ball matches; Li Xiaoxia, Ding Ning, Liu Shiwen, Zhu Yu-Ling each use celluloid ball 4 matches and 4 matches with plastic ball. Keep the same with their opponent, only competition balls changed.

3.2 The Research Methods

3.2.1 Video Observation

Selection of outstanding Chinese women table tennis players Xiaoxia Li, Ning Ding, Shiwen Liu, and Yuling Zhu used celluloid ball and plastic ball in the matches in 2013-2015, their opponent never changed but the match ball changed. On the basis of selection they use celluloid and plastic ball game each 16 matches, 32 matches in total.

3.2.2 Mathematical Statistics

The study statistics in total 32 matches, 177 games, the original data will input in Microsoft Excel, and establish the database. After the data was obtained using the SPSS software to conventional statistical analysis to get analysis results.

The data are recorded according to the relevant technical indicators.

This article mainly uses the table tennis three statistical methods analyze by three parts: serve part, receive apart and stalemate part.

The three statistical methods calculate the rate of each part:

The score average of the part = (score of the part)/(total point of the part)x100%

The usage average of the part = (total point of the part)/(total point of the match)x100%

In this paper, the method is used to evaluate the data and the evaluation criteria.

Table 1. Three paragraphs of evaluation in singles

	Usage (%)	Score (%)		
		Pass (%)	Good (%)	Prefect (%)
Serve part	25～30	60	65	70
Receive part	15～25	30	40	50
Stalemate part	45～55	45	50	55

Note: Wu Huanqun, Zhang Xiaopeng and other people in the preparation of the 25th Olympic Games and the scientific and technological services concluded

3.3 Comparative Analysis Method

Classifying video statistics and make forms, then horizontal and vertical comparison analysis when they use celluloid and plastic ball in the match. Comparison and analysis the use of celluloid and plastic ball when the three parts of the utilization rate, the change after using plastic ball, the score and usage of every plate.

4 The Results and Analysis

4.1 Use of Three Sections of Celluloid and Plastic balls

4.1.1 Use of celluloid ball - three pieces of analysis

Table 2. Chinese excellent women's use of celluloid ball three analysis

		Xiaoxia Li	Ning Ding	Shiwen Liu	Yuling Zhu	Average
Serve part	Score	58	50	51	30	47.3
	Loss	37	26	25	18	26.5
	Score Per	61.1%	65.8%	67.1%	62.5%	64.1%
	Usage Per	21.8%	19.4%	17.7%	16.6%	19.1%
Receive part	Score	55	49	50	25	44.8
	Loss	80	78	73	58	72.3
	Score Per	40.7%	38.6%	40.7%	30.1%	38.4%
	Usage Per	31.0%	32.3%	28.6%	28.7%	30.3%
Stalemate part	Score	99	106	119	57	95.3
	Loss	106	84	112	101	100.8
	Score Per	48.3%	55.8%	51.5%	36.1%	48.6%
	Usage Per	47.1%	48.3%	53.7%	54.7%	50.6%

From the Table 2 we can know: Xiaoxia Li, Ning Ding, Shiwen Liu, Yuling Zhu, when using celluloid ball the score and usage condition: in the serve part, the Four players score 61-68%, serves as an average 64.1% and the range is small, the overall performance is stable; their score percentage are within the normal range (60% - 70%), of which Shiwen Liu serves above other three players, her score percentage close to the perfect level; Overall the usage percentage level is low, Xiaoxia Li usage percentage is slightly higher than other Three players, but still below the normal use of the lower level (25%); Shiwen Liu and Yuling Zhu usage percentage is low, they were good to active but get score by one plate ability is insufficient.

In receive part, expect Yuling Zhu, other three players scoring percentage was between 38% and 41%, the scoring rate was very stable and very good. Yuling Zhu had the lowest scores percentage, and she had more errors in judging the ball when she received. Four women players usage between 28-33%, higher than the normal range of the limit (25%), it means all of them very active in the receive part, get the initiative, and prepare for the stalemate part.

In the stalemate part, Four women players score percentage between 36 to 56%, the range is wide, it means Four players score ability is obviously different. Yuling Zhu score percentage in the stalemate is the lowest (36.1%) of the four players, and she did not pass the level of lowest lower limit (45%); Ning Ding and Shiwen Liu are relatively good at the stalemate part. The usage percentage in the stalemate of four players were in the normal range of 47 to 55%, and that Shiwen Liu and Yuling Zhu usage percentage is higher than Xiaoxia Li and Ning Ding.

4.1.2 They used plastic ball three pieces of analysis

Table 3. Chinese excellent women's use of plastic ball three analysis

		Xiaoxia Li	Ning Ding	Shiwen Liu	Yuling Zhu	Average
Serve part	Score	49	47	60	52	52
	Loss	36	28	21	24	27.3
	Score Per	57.6%	62.7%	74.0%	68.4%	65.6%
	Usage Per	25.1%	17.4%	18.7%	19.5%	19.9%
Receive part	Score	55	57	59	51	55.5
	Loss	59	82	92	77	77.5
	Score Per	48.2%	41.0%	39.1%	39.8%	41.7%
	Usage Per	33.7%	32.3%	34.9%	33.0%	33.4%
Stalemate part	Score	73	111	94	92	92.5
	Loss	66	106	107	93	93
	Score Per	52.5%	51.2%	46.8%	49.7%	49.0%
	Usage Per	41.1%	50.3%	46.4%	47.6%	46.7%

From the Table 3 we can know: in the serve part, four players score percentage in 57-74%, and the range is widely. After using the plastic ball, Four players performance obviously different, in which Xiaoxia Li score percentage below the level limit (60%); Ning Ding score percentage in the normal range; Shiwen Liu score percentage as high as 74.0%, more than excellent level limit (70%), the ability to sound attack after using the plastic ball pretty good, Yuling Zhu score percentage near excellent level (70%). The usage percentage about Four players, Xiaoxia Li had the highest usage percentage of 25.1% to reach the normal usage range, while the other Three players is low than the limit level(17-19%), it means after using the plastic ball, serve part although slightly increased, but still low than level.

In the receive part, Four players score percentage between 39-49%, the range is narrow, and the average level is high. Xiaoxia Li score percentage is higher than others', and, and it means she did more proactive in receive part, she dared to sound attack the ball and the ball is powerful to her opponent. Other player's usage percentage between 39-41%, and score percentage is good, and there was no significant difference between the three players. The average usage percentage (41.7%) and the overall usage percentage (32-35%) were higher than the normal range level (25%), it can conclude that Four players were very active in the receive part, and they had better ability to reverse passive to active in the matches.

In the stalemate, four players score percentage between 46-53%, the range is narrow, and all performance stability, and the score percentage in the normal level. Xiaoxia Li and Ning Ding score ability is better than other Two, Shiwen Liu score ability is relatively poor. Usage percentage was in the normal range (41-51%), Xiaoxia Li' usage is lowest than others', and lower than the limit of normal (45%), Ning Ding usage percentage is highest in the stalemate part.

4.2 The comparison between the use of celluloid balls and plastic balls was analyzed

Table 4. Four people compared the average number of frames

Stalemate plate number (including the fifth panel)	Plastic ball	Celluloid ball
Xiaoxia Li	7.95	7.81
Ning Ding	8.80	8.27
Shiwen Liu	9.36	7.75
Yuling Zhu	9.13	8.27
Average	8.81	8.62

From the Table 4 we can know: the number of the round increased, the number of turns increased and the enjoyment increased. During the match the ball in the air longer running time and velocity of slow, and the number of round tend to be less.

5 Results and Conclusion

5.1 Results

5.1.1 After using plastic ball, there was less effect in serve part while was quite large effect in receive part and there was great effect in rally part.

5.1.2 Using plastic ball contributes to serve part that players were easier to attack rivals.

5.1.3 The athletes benefited from using plastic ball in receive part that they were more proactive even were capable to change situations from passive to active.

5.1.4 When using plastic ball, the rounds that athletes played in rally part were increased so that the competitions would be more eye-catching.

5.2 Conclusion

It could be found that using plastic ball has exactly affected female players' technique and tactics performances (at the start of using plastic ball). It brought positive effects on Xiaoxia Li, Shiwen Liu and Lingyu Zhu while brought negative effects on Ning Ding.

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Competitive Readiness among Male and Female Table Tennis Student-Athletes: Basis for a Proposed Training Program

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Abstract: The study determined the competitive readiness of male and female table tennis athletes of the University of the Philippines before the 2016 UAAP Inter-collegiate Table Tennis Competition. It answered the following questions: 1. What is the profile of the table tennis varsity athletes, as measured by the CRSTTA (Competitive Readiness Scale for Table Tennis Athletes)? 2. Is there a significant difference between male and female athletes? and 3. What training program can be proposed based on the result of the study. Using descriptive research design, the CRSTTA was administered two (2) weeks before the competition to twenty-two (22) table tennis athletes of the University of the Philippines (14 males and 8 females). The CRSTTA is a 60-item, Likert-type instrument to measure competitive readiness in the areas of mental toughness, coach ability, physical readiness, tactical readiness, anxiety management, motivation, attention and concentration, self-confidence, and team sociability. Results showed that both men and women had high levels of competitive readiness (mean=2.94, SD=0.89 and mean=2.92, SD=0.92). It also showed that there is no significant difference between genders in regards to competitive readiness. Though the results were significant before the start of the competition, this was not enough to compare if the results of the test have significant differences with the outcome of the competition, since the teams only duplicated the final rankings from the previous year. It is highly recommended that a proposed intervention training program be developed to address competitive readiness of table tennis.

Keywords: CRSTTA, competitive readiness, inter-collegiate competition

1. INTRODUCTION

People have been competing in sports for hundreds of years, but only recently have sport psychologists systematically studied competitive behaviors in sport.

(Weinberg and Gould, 1999). Such competitive behaviors have also been the subject of interest among coaches, physiologist, and athletes themselves. Behaviors that happen before and during competition ranges from feelings of anxiety, poor concentration, mental toughness, employment of tactics and strategies during the game, and the motivation to win and be the best, just to mention a few. These behaviors further define the athlete's readiness to compete. This type of readiness cuts across all types of sports, and table tennis is definitely not an exception.

Normally, players go to competitions without knowing whether they are fully equipped with the necessary skills needed for playing their best such as physiological, technical, and psychological skills combined. What they have learned to believe is that, table drills, physical conditioning, and coaching are enough to make them perform their best during competition. Only to find out that despite their everyday table drills, match plays, and tune up matches, a lot of players end up choking or unable to perform well. The question is, are the players only ready because they have attained a high level of playing skill?

Competitive Readiness lie on the theoretical framework of readiness in terms of the following factors or variables:

1. Mental Toughness - the capacity to constructively, non-defensively, positively, and realistically with calm clarity even under the pressure of competition. (Loehr, 1994).
2. Coachability – the capacity of the athlete to absorb specific instructions from the coach.
3. Physical Readiness – the physiological level of the athlete that matches the demands of the competition season, such as physical conditioning.
4. Tactical Readiness – the ability of the athlete to apply tactical strategies during the competition season.
5. Attention and Concentration – capacity of the athlete to maintain focus, avoid distractions, and set aside other things that are not related to the game.
6. Anxiety Management – ability of the athlete to control negative emotions during the game such as anger, worry, frustration, and tension.
7. Self Confidence - ability of the athlete to maintain positive thoughts about oneself in terms of performance and winning.
8. Motivation – capacity of the athlete to view competition as enjoyment and rewarding both intrinsically and extrinsically.
9. Team Sociability – ability of the athlete to be a team-player and maintain healthy relationships with the coach and team-mates.

The above factors and variables are skills that can be learned over a period of time and should be incorporated in the athletes training. People responsible in the development of competitive readiness are the coaches, sport psychologists, exercise physiologists, and the athletes themselves.

This study ventured into assessing the competitive readiness of male and female table tennis varsity players of the University of the Philippines who competed during the 79th UAAP (University Athletic Association of the Philippines) Table Tennis Event. The results of the study gave the researchers the impetus to write a proposed competitive readiness training program that addresses training needs of table tennis players who are preparing for their next competition.

2. PURPOSE OF THE STUDY

The study determined the competitive readiness of male and female table tennis student-athletes of the University of the Philippines before the 2016 UAAP Inter-collegiate Table Tennis Competition.

The following questions were answered:

1. What is the profile of the male and female table tennis student-athletes, as measured by the CRSTTA (Competitive Readiness Scale for Table Tennis Athletes)?
2. Is there a significant difference between male and female student-athletes?

3. METHODS

3.1 Research Design

Descriptive Research Design was used in the study.

3.2 Instrument Used

CRSTTA (Competitive Readiness Scale for Table Tennis Athletes, Lopez and Santelices, 2015), a 60-item Questionnaire to measure competitive readiness covering the areas of Mental Toughness, Coachability, Physical Readiness, Tactical Readiness, Anxiety Management, Motivation, Attention and Concentration, Self-Confidence and Team Sociability

3.3 Participants of the Study

Twenty-two (22) Table Tennis student-athletes of the University of the Philippines (14 males and 8 females).

3.3 Procedure

Before the CRSTTA was administered, the researchers explained to the student-athletes the purpose and importance of the study. The researchers told the student-athletes to read each question carefully and answer each of the questions honestly and without bias. It was also assured that confidentiality of the respondents will be strictly followed. The CRSTTA was administered to the student-athletes two (2) weeks before the UAAP Table Tennis Season, the most prestigious inter-collegiate table tennis competition in the country.

Results of the test were subjected to statistical analysis which were used to answer the problems posted for the study. Subsequently, a proposed competitive readiness training program was presented.

3.4 Analysis of Data

Descriptive Statistics and t-Test for independent samples were used in analyzing the data,

4. RESULTS

4.1 What is the Profile of the Male and Female table tennis student-athletes, as measured by the CRSTTA?

Table 1. Mean results of the total score of each subject and their description

Subjects (male, n=14)	Mean of the Total Score	Description
Subject 1	2.97	High Level of CR
Subject 2	2.93	High Level of CR
Subject 3	2.87	High Level of CR
Subject 4	3.11	High Level of CR
Subject 5	3.22	High Level of CR
Subject 6	3.18	High Level of CR
Subject 7	2.82	High Level of CR
Subject 8	3.08	High Level of CR
Subject 9	2.93	High Level of CR
Subject 10	2.97	High Level of CR
Subject 11	2.45	Low Level of CR
Subject 12	3.00	High Level of CR
Subject 13	2.87	High Level of CR
Subject 14	2.78	High Level of CR

Table 2. Mean results of the total score of each subject and their description

Subjects (female, n=8)	Mean of the Total Score	Description
Subject 1	2.97	High Level of CR
Subject 2	2.97	High Level of CR
Subject 3	2.92	High Level of CR
Subject 4	2.83	High Level of CR
Subject 5	3.1	High Level of CR
Subject 6	2.82	High Level of CR
Subject 7	3.08	High Level of CR
Subject 8	2.65	High Level of CR

4.2 Is there a significant difference between male and female student-athletes?

Table 3. Mean score of all the subjects and standard deviation per gender

Gender	Mean Score per Gender	Standard Deviation	Description
Male	2.94	0.89	High Level of CR
Female	2.92	0.92	High Level of CR

Table 4. t-Test of significant difference between Male and female participants

T-value	P-value	Significance
0.717	0.24	Not significant

at $p < 0.05$ level of significance

4.3 What competitive readiness training program can be proposed based on the results of the study?

4.3.1 Title of Program: Competitive Readiness Training Program
4.3.2 Rationale of the Program: to attain Peak Performance by developing Competitive Readiness
4.3.3 Objectives of the Program
a. General
b. Specific
4.3.4 Target Participants: Varsity table tennis student-athletes
4.3.5 Duration and Frequency of the Program: 6 months, 3 sessions a week student-athletes at 3 hours/session
4.3.6 Program Contents
a. Psychological Skills
Development to cover the following areas such as mental toughness, attention and concentration, anxiety management, self-confidence building and motivation
b. Technical and Tactical Skills
Development to cover the following areas such as coachability, tactical readiness and team sociability
c. Physical Readiness for skill-related physical components such as agility, power, balance, coordination, speed and reaction time
4.3.7 Methodology
A. Assessment Phase
a. Orientation of the Program
b. Interviews, testing and needs analysis
c. Preparation of Training Modules
B. Training Phase
a. Lectures and discussion
b. Video presentation and analysis of the different factors of Competitive Readiness
c. Application and observation of learned skills in the areas of physical, psychological and technical/tactical
C. Evaluation Phase
a. Post-competition assessment and observation
b. Comments, suggestions and improvements
4.3.8 Program Facilitators-Team managers, psychologists, coaches, exercise physiologists, physical therapists and sport nutritionists

4.3.9 Cost Implications

a. Honorarium for experts
b. Testing instruments
c. Sports equipment
d. Food and contingency fund

5. DISCUSSION

Results of the study showed that male participants (n=14) attained high levels of competitive readiness as measured by the CRSTTA, except for subject number 11 who scored a low level of competitive readiness. Female participants on the other hand (n=8) also attained high levels of competitive readiness. These results mean that they are highly ready for the competition. That their physical, tactical, and mental condition are sufficient to withstand pressure of the game and maintain good performance. These could be attributed to the players' training program which was designed and implemented by the coaches with the help of sport psychology consultant. Such program include psychological skills training, and individualized tactical drills and physical conditioning.

The t-test of significant difference yielded no significant differences (t value=.717, p value=.24) when males and females were compared in terms of their measured competitive readiness. Meaning, gender does not have any difference in terms of competitive readiness. A male player or female player can attain a high level of competitive readiness.

The proposed competitive readiness training program intended to train the table tennis athletes in different areas for them to be ready for competition. It contained the areas of psychological skills development, technical and tactical skills development, and physical readiness. All of which are designed to be done within six (6) months prior to competition. Evaluation measures shall be conducted after the competition.

6. CONCLUSION

With the use of the CRSTTA, the researchers were able to assess the competitive readiness of male and female table tennis student-athletes, which led to the proposed Competitive Readiness Training Program.

The CRSTTA is highly recommended to assess competitive readiness among table tennis student-athletes. Furthermore, it could be used to assess competitive readiness for national table tennis athletes as basis for their Training Program.

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A Study on the Selection, Training, and Tournament Strategies of the 22-peat Tainan City Men's Table Tennis Team at the National Games (1984 - 2011)

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Abstract: The purpose of this study is to explore the development history of Tainan City men's table tennis team, construing and inferring the modes of the team's selection, training, and tournament strategies. The study integrates ex post facto research, historical research, document analysis, and field interviews. After a comprehensive analysis and discussion of the collected data, the study obtained the following conclusions, which are summarized below: 1.In player selection, Tainan primarily uses performance-based selection criteria, which enhances its visibility and attracts top players at all levels from other regions of Taiwan to enrol in Tainan's schools. The smooth educational pipeline from elementary to junior high to high school ensures a source stability in the flow of excellent players, gradually establishing a selection pyramid of table tennis players.2.In training, the training programs are developed according to different levels of hitting strokes. Elementary schools focus on penhold techniques in their basic skills training. Junior high and high schools emphasize technical and tactical skills, shakehand grip techniques, comprehensive training on attacking from both sides, and integration of physical fitness, technique, and psychology. The training program's major characteristic is its high self-motivation and team morale. 3. With respect to management during tournaments, the Tainan table tennis team adopts a combination of both militaristic (firm) and democratic (flexible) managing styles. Players' accommodations are centralized and uniformly managed. The team spend day and night together to develop good chemistry and high cohesiveness among team members. Rigorous management of the players' regular work and rest routine, coupled with individualized pre-match psychological counselling, helps players attain peak state of body and mind. 4. From the grassroots level in junior high school to the national team, Tainan City has set up a pyramid school structure that has produced great table tennis players, generation after generation. The system receives logistic support from both government and private sectors, assists players in securing successful employment after retirement from the sport, and is known for its unified management of player selection, training, and competition. This system also has allowed Tainan City to dominate men's table tennis for a long time, and thus deserves our attention.

Keywords: Table Tennis, Competitive Sports, Tainan City, National Games, Sports History.

1. INTRODUCTION

In reviewing the history of competitive table tennis in Taiwan, since Kuo-ting Lee obtained the men's singles gold medal at the 1966 Asian Games, which was the first time that medals were awarded to table tennis at the Asian Games, a large number of outstanding Taiwanese players have emerged in the 1970s. Generations of talented competitive players have come and gone, passing the baton from one to the next, including players such as Jung-chan Hsu, Wen-chia Wu, Peng-lung Chiang, Chih-yuan Chuang, Chien-a Chen, and Yun-ju Lin [1]. To wit, players from Taiwan have successively achieved success on the international stage. For example, Peng-lung Chiang, the king of the penhold style, won bronze at the 1999 World Table Tennis Championships for men's singles and men's doubles (partnering with Yan-shu Chang); Chih-yuan Chuang reached even greater heights by winning the men's singles title at the International Table Tennis Federation (ITTF) World Tour Grand Finals at the end of 2002; at the 2005 World Youth Championships, Hung-chieh Chiang and Sheng-cheng Huang jointly won the men's doubles title, and Sheng-cheng Huang also won a bronze medal in the men's singles event; at the 2006 ITTF Swedish Junior Open, Hung-chieh Chiang obtained both men's singles and men's doubles gold medals; in 2012 Chih-yuan Chuang was crowned the men's singles champion of the Spanish Open, and reached the semi-finals stage at that year's London Olympics; in 2014 Chih-yuan Chuang and Chien-an Chen jointly won the men's doubles title at the World Table Tennis Championships, creating a new page for the history of Taiwan men's table tennis after the duo captured the Iran Cup trophy in international competition.

Breaking down the origins of Taiwan's table tennis players, it is found that the majority of players active in domestic and international circuits after the 1980s and 1990s come from the Tainan City area, including players such as Wen-chia Wu, Hui-chieh Huang, Peng-lung Chiang, Yan-shu Chang, Wen-tang Hsieh, Shen-chin Ping, Hung-chieh Chiang, Chih-chi Wu, Sheng-cheng Huang, Chien-tu Huang, and Tzu-i Yang. Of the 12 players selected to the 2012 national table tennis team for the Republic of China, a third of the players had come from Tainan City (Peng-lung Chiang, Sheng-chen Huang, Hung-chieh Chiang, and Chih-chi Wu). Additionally, from 1984 to 2011, Tainan City Men's Table Tennis Team set an absolute record by winning 22 consecutive championships at the restructured National Games and its predecessor, the Taiwan Games. Why the "Tainan Gang" can attain such outstanding performance in table tennis? Because the historical materials related to Taiwan's table tennis are rare and not well-preserved, this has aroused the authors' interest into investigating the selection, training, tournament, and winning strategies of the Tainan City table tennis team. The authors hope to draw sports academia's attention to the preservation of Taiwan's competitive sports history. This is the author's motivation and goal for conducting the study.

2. METHODS AND FRAMEWORK

2.1 Research methods

This study aims to explore the development history of the Tainan City table tennis team between 1984 and 2011, construing and inferring the modes of the team's selection, training, and tournament strategies. To achieve that research goal, this qualitative research paper integrates comprehensive literature review, historical research, and semi-structured interviews. The scope of the study is defined by works related to the development history of table tennis in Tainan City (1984-2013). Data sources consist of primary data as the study's backbone, secondary data as supplementary evidence, and cross-comparisons of both to avoid errors or falsehoods. The literatures cited in this paper have all withstood internal criticism and external criticism, hence its validity and reliability is not in doubt. In view of the long research period and number of years that had gone past, some of the information is not completely preserved, resulting in the loss of literature. If there is no textual information or document to support important references, then such information can only be collected through interviews to understand the circumstances of that time. To the extent that the authors had conducted an exhaustive and thorough study, insisting on finding out the truth and faithfully presenting the historical materials, it is not appropriate for the study to make too much inference regarding the historical development facts of the 22-peat Tainan City men's table tennis team at the National Games. This is the main limitation of the study.

2.2 Research steps

In the design of research methods, quantitative research tends to focus on "verification," whereas the value of qualitative research is its emphasis on "discovery." This study uses qualitative research as the backbone, and relies on quantitative research for evidence. In this study, the interviews were immediately coded and recorded after the interviews were conducted. To enhance the study's reliability, the researchers had carefully examined the interview notes and contents of the recordings after each interview, converting raw interview data into written transcripts. The interview transcripts were then provided to interviewees for their perusal and revised until their consent was obtained. In this study, the researchers have combined long-term investment, continuous observation, triangulation, peer discussion, membership review, thick description, and other research methods, hence the study's reliability should not be a problem.

2.2 Research framework

The research framework for the present study is shown in Figure 1 below:

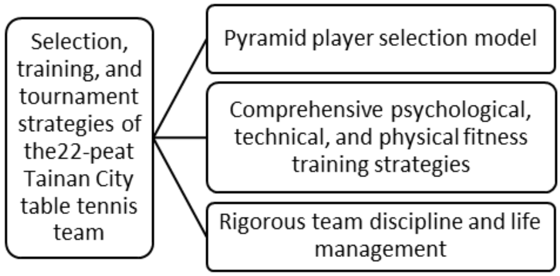

Figure 1. Research Flow Chart

3. RESULTS AND DISCUSSION

3.1 Player selection – creating an elementary-junior-high-high school pyramid system

The promotion of competitive sports must be a gradual process. The process works like a pyramid: only when the foundation is solid can one reaches to the top. Applied to Taiwan's education system, the elementary school is the primary selection stage, the junior high school is the intermediate selection stage, high schools and universities are the advanced selection stage, and national athletes belong in the elite selection stage—these stages represent how Taiwan cultivates its competitive sports talents. Successful identification and selection of talent means that one is half-way to training success. By balancing both training and "selection", one can achieve more with less effort. At present, the selection methods most commonly used by sports coaches are the experience selection method and the scientific selection method. The combination of both methods can lead to the discovery of truly special talents.

Elementary school: junior stage

According to research by Chung-hung Lin [2], the establishment of "Tainan municipal table tennis training camp" in 1977 was a watershed event for the development of the sport of table tennis in Tainan City. Since the 1970s, three schools in Tainan City had been designated by the Ministry of Education as table tennis focus development schools, which deeply influenced the effectiveness of table tennis promotion in the area: Chang Jung Senior High School (1977), Jhongsiao Junior High School (1984), and Degao Elementary School (1986). Tainan junior table tennis stage really took off when the Ministry of Education designated Degao Elementary School table tennis team formed by teacher Hung-yi Ping as one of "table tennis focus development schools."

Junior high-school: intermediate stage

Jhongsiao Junior High School men's table tennis team was founded in 1982, which received enthusiastic support from its then school principal, Ming-huang Hong. The team primarily consisted of elite players from the south of Taiwan, and they were all trained in the "Tainan municipal table tennis training camp" and placed under centralized accommodations for better control of their training schedules. As result of the team's outstanding performances, the school was designated as a "table tennis focus development school" in 1984 by the Ministry of Education. In 15 editions of the National Mandarin Cup from 1981 to 1996, the school obtained a record of 10 championships. The school has successively produced national players such as Sheng-chin Ping, Wen-tang Hsieh, Peng-lung Chiang, Yan-shu Chang, Kuang-nan Yan, Chin-te Li, Chun-chuan Wang, Cheng-yu Shih, Wen-jui Li, Jui-feng Chen, Chih-chi Wu, Hung-chieh Chiang, Wen-wei Sun, Sheng-cheng Huang, and others.

High-school: senior stage

In 1975, teacher Lung-his Wu reorganized the table tennis team at Chang Jung High School, recruiting six players all as temporary choices: Chi-pin Chen, Yung-chih Tsai, Ming-tang Wang, Ching-fu Chuang, Fu-yuan Huang, and Tsu-chang Huang. Since 1976, the school has won consecutive National High School Table Tennis Championships. Currently, four elite players, Jung-chan Hsu, Wen-chia Wu, Lien-hua Wang, and Tsung-min Hung have joined the school, who will seek to extend Chang Jung High School's two decades of dominance in the sport.

Section summary

The establishment of "Tainan municipal table tennis training camp" in 1977 laid the foundation for table tennis in Tainan City [3]. The authors believe that a smooth educational pipeline is a critical factor to players obtaining excellent performances. Because men's players in Tainan City all study and train together during junior-high and high schools, they have no other worries than a full dedication to training. Coaches implement a coherent scientific training system from elementary to junior high to high school, so the effectiveness of training programs doubles with half the effort.

Table 1. Tainan City's Table Tennis Training Strategy Modes

Level Stage	Elementary School	Junior High School/High School	University/Adult
Training Focus	Basic skills	Attack after service, attack after returning service, the first three strokes, and other technical and tactical applications	Comprehensive training—psychological, technical, and physical aspects
Training Method	Multi-ball training and drills	training by competition	Combination of both competition and practice

3.2 Training: a cyclical training model

The founder of the "Tainan gang" in table tennis, Chung-hsiung Lin [4-5], set up his first team in 1977 with players such as Wen-chia Wu and Hui-chieh Huang, beginning the era of Tainan table tennis on tables located under the bleachers of the Tainan Municipal Track & Field Stadium. Differing from the other professional coaches, Chung-hsiung Lin focuses on the athletes' physical fitness, psychological state, team discipline, and tacit understanding. Coach Lin takes in a group of young people who are still growing, and plays the roles of both coach and parent. He also leads the team by using an entrepreneurial spirit and militaristic management style, doing things one step at a time according to short, intermediate, and long-term goals. The first eight players trained by coach Lin included Wen-chia Wu, Hui-chieh Huang, Yung-ching Cheng, Te-yuan Hsu, Yuan-chang Lo, Chuan-lung Wang, Chin-hsiang Chen, and Tung-ho Wu. With the exception of Yung-ching Cheng and Tung-ho Wu, the other six players had all been selected as national-level players. Because the players all live and sleep in dormitories, coach Lin is basically the players' coach and parent. Coach Lin takes care of all the players' needs, such as food, cloths, housing, transportation, education, entertainment, as well as health. Members of the table tennis team get along with one another like family members.

Tainan's table tennis method focuses on the trinity of psychology, technique, and physical fitness elements [5]. In fitness training, the idea is to strengthen the players' physical quality: horizontal bar, dumbbells, push-ups, weightlifting, long-distance endurance, and sprints all help to develop explosive force in the legs.

In technical aspects, the objective is to strengthen players' speed, as well as their serves and ability to return serves Particular emphasis is put on the quality of serves, increasing the degree of spin and creating offensive opportunities. In attack after serve, special efforts are made to take the initiative away from the opponent with the racket. Also, create variations in service returns, so that opponents hit the ball awkwardly, fail to attack, or even make mistakes. Next, with respect to footwork, training can help players gain agility, and in relation to speed, training improves the quality of attack so that opponents can only muster defensive strokes without the power to launch a counter strike. Tactical training focuses on the opponent's techniques. Tactical research is conducted from the first service stroke to the fifth stroke, finding a variety of plays to cope with speed changes, spin changes, rhythm changes, and ball placement changes. Additionally, doubles training is strengthened. Attacks after serves, returns, rallies, footwork moves in doubles play are all practiced in increasing levels of difficulty so that members develop good team chemistry as well as a fighting spirit during training competitions.

Regarding the psychological ability training of players, training is based on mental activities affecting the body, physical activities affecting the spirit and emotions, and mutual influences between the mind and the body, so that personal characteristics are developed through the interaction among thoughts, spirits, emotions, and style. Sports training should be based on interest. The coach simply uses a variety of stimuli, controls the natural impulses of players, and induces the players into performing at a high level. The training progress for each player is all different; the trend can be up or down like waves. When breakthrough, stagnation, and slump periods occur, it is necessary to investigate the individual reasons, modify the training plan, and attempt to overcome them. Before the National Games, the purpose of psychological adjustment is to shape and stabilize the player's optimal psychological state, thus ensuring the best display of competitiveness level.

Table 2. Training program during National Games

Time Period	Time	Contents
Morning 8:00 Wake-up music – 8:30 Breakfast – 8:50 Morning exercises		
Morning	9:00-11:30	Basic training: Push and block Left push and right attack Forehand spin Backhand spin Front-end spin Middle-end spin rally Loop drive Spin attack on both sides Smash
11:30-2:00 Noon break		
Afternoon	2:00-5:00	Technical training: Serve Attack after serve (Third-ball attack) Return serves Footwork training Dealing with chops Singles match Doubles match
	5:00-5:40	Muscle strengthening training every Tuesday, Thursday, and Saturday: Dumbbells Abdominal muscle training Leg explosiveness training Physical fitness training every Monday, Wednesday, and Friday: Long runs 3000 meters Variable runs Back-and-forth runs 30 meters Sprint runs 50 meters Rope jumping

Source: provided by coach Chung-hsiung Lin of Tainan Table Tennis Hall.

Section summary

Coach Chung-hsiung Lin puts great emphasis on the cultivation of team morale and the concept of honor, which induces players to make greater progress. In addition to conducting the usual basic training, coach Lin also uses a set of “magic weapons” that he learned while serving as education squad leader in military service. He often gives his players motivational pep talks, teaches them military songs, and requires them to answer back in short commands, thus nurturing the players’ psychological state and raising their confidence on a daily basis. He is even more stringent with respect to the players’ moral integrity. He practices what he preaches, and does not socialize with the outside world or receive money or gifts from fans, all for the purpose of preventing the players from acquiring bad habits.

3.3 Management during tournaments

The tasks of athletes when participating in tournaments are to do their best in fully displaying their competitive abilities, and to transform those abilities into ideal athletic performances. As the proverb says, "talented disciples are trained by strict masters." Coach Chung-hsiung Lin is known for his strict training routine, putting particular emphasis on player attitude and temperament and attaching great importance to team discipline. If a player has seriously violated team rules, he is immediately dismissed from the team. However, after more than 30 years at the helm of the team, coach Lin's team management style has also evolved from one that was highly militaristic to one that is more democratic, much like how times and concepts have changed and transformed. Players train Monday through Saturday, and their three meals of the day are all provided by the Hall. For players who are still developing, the types of food have also strict requirements. With respect to work and rest management, roll call is taken every night at 10:30pm, and players must sign in and be in bed by 11pm. This strict management style ensures each player's safety. In recent years, smartphones have become widespread. Worried about their impact on practice, coaches will ask players to turn in their smartphones before going to bed each night. This procedure prevents players from using their mobile phones for an extended period of time before sleep, and not obtaining enough rest the following day for classes or training practice.

4. CONCLUSION

The study integrates ex post facto research, historical research, document analysis, and field interviews. After a comprehensive analysis and discussion of the collected data, the study obtained the following conclusions, which are summarized below:

1. Tainan City men's table tennis team was founded in 1977 by coach Chung-hsiung Lin. Its 22 championships over a 27-year period are clearly an indication that the team has been extremely successful in passing down its competitive heritage and tradition of excellence. Over the course of its 22-peat performance at the National Games, it was not always smooth sailing for the team every year. Yet fortunately Tainan City always seemed to be able to avert defeat by relying on team strength and skills.
2. In player selection, Tainan primarily uses performance-based selection criteria, which enhances its visibility and attracts top players at all levels from other regions of Taiwan to enrol in Tainan's schools. The smooth educational pipeline from elementary to junior high to high school ensures a source stability in the flow of excellent players, gradually establishing a selection pyramid of table tennis players.
3. In training, the training programs are developed according to different levels of hitting strokes. Elementary schools focus on penhold techniques in their basic skills training. Junior high and high schools emphasize technical and tactical skills, shakehand grip techniques, comprehensive training on attacking from both sides, and integration of physical fitness, technique, and psychology. The training program's major characteristic is its high self-motivation and team morale.

4. With respect to management during tournaments, the Tainan table tennis team adopts a combination of both militaristic (firm) and democratic (flexible) managing styles. Players' accommodations are centralized and uniformly managed. The team spends day and night together to develop good chemistry and high cohesiveness among team members. Rigorous management of the players' regular work and rest routine, coupled with individualized pre-match psychological counseling, helps players attain peak state of body and mind.
5. From the grassroots level in junior high school to the national team, Tainan City has set up a pyramid school structure that has produced great table tennis players, generation after generation. The system receives logistic support from both government and private sectors, assists players in securing successful employment after retirement from the sport, and is known for its unified management of player selection, training, and competition. This system also has allowed Tainan City to dominate men's table tennis for a long time, and thus deserves our attention.

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Technical Analysis of the 2016 Rio Olympic Games Women's Single Table Tennis Championship Competition

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Abstract: 2016 Olympic women's single table tennis champion Ding Ning, and her final opponent, runner-up Li Xiao-Xia were subjects of this study. Using analysis chart of table tennis three-stage techniques to compare these two players' performance during championship competition, coaches in Taiwan can base this as a training reference. By doing statistical analysis and discussion, the conclusions were made as shown in the followings: (1) Using the three-stage techniques score rate, Ding Ning rated "excellent" both in 'attack after serve' and 'attack after receive serve', with "good" in 'rally'. Her techniques showed fast speed, fast tempo, and powerful serve which could gave opponent fatal blow to win a point. At the same time, with game tactic needs of second and third hit, stable forehand and backhand skills could also win the point. Because of her excellent skills in serve, receiving serve, and defense, positive attitude with vigorous attack when rallying with opponent were the reasons for her to won single table tennis championship in 2016 Rio Olympic Games. (2) The three-stage techniques score rate of Li Xiao-Xia although showed up to a certain standard, but obviously was no better than Ding Ning. Overall, it showed "fail" in 'attack after serve', "good" in 'attack after receive serve', and "excellent" in 'rally' on the score rate.

Keywords: table tennis, three-stage techniques, attack after serve, attack after receive serve, rally

1. INTRODUCTION

Table tennis players not only have to train continuously, but they need to seek new ways of training themselves, and try to improve skills in order to have good performance in the competitions. To be able to compete with good players from all over the world, using scientific methods, conducting systematic sport training research, and investigating factors which affect players' game performance, the players can then increase the chance of winning the game (Hou, Chen, and Wu, 2008). In order to make effective control of this rapid change in table tennis sport, it is necessary to make diagnosis and evaluation of the technique used and overall strength of the players in each stage of the competition (Wu, Qin and Zhang, 1993). Long term tracking other players' way of playing in terms of skill and strategies used, the player can strive for better performance when facing with them in the future competitions.

Three-stage techniques score rate method is a theory published in 1990 by China scholars, Huan-Qun Wu and Zhen-Biao Li. They selected China national table tennis team players as the research subjects. They divided table tennis techniques into three segments and analyzed table tennis competitions. Attack after serve, attack after receive serve, and rally were the three segments used to calculate each table tennis player's score. By analyzing each segment scoring point(s) and usage, a table tennis game winning mode could be established (Zhu, 1999). De-Cheng Wu in 1998 indicated that during the preparation of the 1996 Olympic Games, China's table tennis science and technology research public relations team used three-stage techniques score rate method to analyze 200 copies of data. The method was repeatedly used in world's major competitions, such as Asia Table Tennis Championships, World Table Tennis Championships, and Olympic Games. The result showed players can perform better by knowing their opponents' way of playing games. In the field of table tennis technique analysis, the segmentation evaluation method played an important role in athletes' training in China.

To summarize, three-stage techniques score rate method is currently the most commonly used method for analyzing table tennis players' game due to its simplicity and effectiveness. Ding Ning who won the 2016 Rio Olympic Games women's single table tennis championship competition, and her opponent Li Xiao-Xia were the subjects used to conduct the study. Three-stage techniques score rate method was used to analyze and compare these two players' performance. By analyzing the techniques used in the game, one can have a grasp about current women's state of table tennis. Findings can be used as training reference for coaches, and helps to improve the technical standards.

2. METHODOLOGY

2.1 Subjects

2016 Rio Olympic women's table tennis single competition champion Ding Ning, and her final opponent Li Xiao-Xia were the subjects used for the study. The basic information about these two subjects was shown in Table 1.

Table 1. Basic information of the subjects.

Name	Nationality	Playing Style	World Ranking Until 2016.10
Ding Ning	Chinese	Left-handed, shakehand grip	No. 1
Li Xiao-Xia	Chinese	Right-handed, shakehand grip	No. 3

2.2 Method

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

(1) Personal computer

(2) Table tennis competition record table

Game record developed by Con-Guin Guo in 1999 was used to record changes of each scoring process.

(3) 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 Ding Ning

Ding Ning was a winner for the 2016 Rio Olympic women's table tennis single competition. She beat her opponent by the score of 4:3 in the final. Her comprehensive technical performance was analyzed as follows:

(1) Attack and Defense After Serve

As shown in Table 2, Ding Ning in the final match against Li Xiao-Xia, after her serve, she used aggressive attack tactic 20 times which scored 16 points and lost 4 points, 80% of score rate and 80% of usage rate. Comparing her 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" level. Looking at her attack style, Ding Ning attacked opponent's return 17 times by using her forehand, whereas she only attacked opponent's return 3 times using her backhand. It showed that she was good at the forehand attack on the opponent's return. From the biomechanical point of view, using forehand to hit the ball creates more powerful impact and stability than using backhand to hit the ball in general.

In addition, looking at the defense style of returns from Ding Ning, she used this style of returning ball only 5 times during the game which scored no point but lost 5 points, 0% of score rate and 20% of usage rate. Overall, it showed that the aggressive attack tactic Ding Ning used was more effective in defeating the opponent.

(2) Attack and Defense After Receive Serve

As shown in Table 2, during the final match, Ding Ning used aggressive attack tactic 12 times after receiving serve which scored 8 points and lost 4 points, 67% of score rate and 67% of usage rate. Her performance reached "excellent" level. Looking at the attack style of returns from Ding Ning, she used both forehand attack and backhand attack 6 times each. In addition, looking at the defense style of returns from Ding Ning, she used it 4 times, scored 4 points and lost 0 point, 100% of score rate and 22% of usage rate. From the statistical analysis, it revealed Ding Ning used both forehand and backhand attacks on receiving serve and reached "excellent" level. Also the defense score rate reached "excellent" level. It indicated that she had strong defense overall.

(3) Rally

As shown in Table 2, Ding Ning in the final match had a total of 81 rallies, attacking return ball 56 times, which scored 29 points and lost 27 points, 52% of score rate and 69% of usage rate. The performance on her rally reached "excellent" level.

Table 2. Technical performance analysis record table of Ding Ning who played against Li Xiao-Xia

Total number of serve		Forehand attack after serve		Backhand attack after serve	
34		Total number	17	Total number	3
		Point gain	13	Point gain	3
		Point lose	4	Point lose	0
		Score rate	76	Score rate	100
		Usage rate	68	Usage rate	12
Serve		Attack after serve (forehand + backhand)		Defense after serve	
		Total number	20	Total number	5
Point gain	8	Point gain	16	Point gain	0
		Point lose	4	Point lose	5
Point loss	1	Score rate	80	Score rate	0
		Usage rate	80	Usage rate	20
Total number of receiving serve		Forehand attack after receiving serve		Backhand attack after receiving serve	
18		Total number	6	Total number	6
		Point gain	4	Point gain	4
		Point lose	2	Point lose	2
		Score rate	67	Score rate	67
		Usage rate	33	Usage rate	33
Serving error of the opponent		Attack after receiving serve (forehand + backhand)		Defense after receiving serve	
0		Total number	12	Total number	4
		Point gain	8	Point gain	4
		Point lose	4	Point lose	0
		Score rate	67	Score rate	100
		Usage rate	67	Usage rate	22
Total number of consecutive ball playing		Consecutive attack		Consecutive defense	
81		Total number	56	Total number	25
		Point gain	29	Point gain	0
		Point lose	27	Point lose	25
		Score rate	52	Score rate	0
		Usage rate	69	Usage rate	31

3.2 Comprehensive technical performance analysis of Li Xiao-Xia

Li Xiao-Xia won a silver medal for the 2016 Rio Olympic women's table tennis single competition. In the final, she was defeated by the score of 3:4 to her opponent. Her comprehensive technical performance was analyzed as follows:

(1) Attack and Defense After Serve

As shown in Table 3, Li Xiao-Xia in the final, after her served, she used aggressive attack 29 times of which scored 17 points and lost 12 points, 59% of score rate. Comparing her score rate on "attack after serve" with three-stage techniques score rate model, it was at "fail" level. Looking at her attack style, Li Xiao-Xia attacked opponent's returns 16 times using her forehand and 13 times using her backhand. She scored 11 points on her forehand attack and lost 5 points, having 69% of score rate, which showed her performance on forehand attack reached "good" level. On her backhand attack, she scored 6 points and lost 7 points, having 46%of score rate, which showed her performance on backhand attack reached "fail" level. From the analysis, it showed that Li Xiao-Xia used both forehand attack and backhand attack as a playing tactic on "attack after serve". It also showed that she scored better on using forehand attack than using backhand attack. Overall, comparing with Ding Ning, she had lower score rate on "attack after serve" which might due to unable to serve effectively to her opponent.

(2) Attack and Defense After Receive Serve

As shown in Table 3, Li Xiao-Xia in the final match, she used aggressive attack 11 times after receiving serve which scored 5 points and lost 6 points, 45% of score rate and 73% of usage rate. Her performance reached "good" level. Looking at her attack style on returns, she used forehand attack 4 times and backhand attack 7 times. In addition, looking at Li Xiao-Xia defense style of returning ball, she used it 4 times, scored 3 points and lost 1 point, 75% of score rate, and 27% of usage rate. From the statistical analysis, Li Xiao-Xia used both forehand and backhand attacks on receiving serve which was the same as Ding Ning chose to do. But her backhand attack only had 29% of score rate, which ranked at "fail" level, much lower than her forehand attack, 75% of score rate which ranked at "excellent" level. On the defense score rate, her performance reached "excellent" level. It indicated that she and Ding Ning had similar playing style. Li Xiao-Xia also showed strong defense ability.

(3) Rally

As can be seen from Table 3, Li Xiao-Xia in the final match had a total of 79 times rallies, attacking return 58 times, which scored 33 points and lost 25 points, 57% of score rate and 73% of usage rate. Her performance on "rally" reached "excellent" level.

Table 3. Technical performance analysis record table of Li Xiao-Xia who played against Ding Ning

Total number of serve	Forehand attack after serve		Backhand attack after serve	
34	Total number	16	Total number	13
	Point gain	11	Point gain	6
	Point lose	5	Point lose	7
	Score rate	69	Score rate	46
	Usage rate	55	Usage rate	45
Serve	Attack after serve (forehand + backhand)		Defense after serve	
	Total number	29	Total number	0
Point gain 5	Point gain	17	Point gain	0
	Point lose	12	Point lose	0
Point lose 0	Score rate	59	Score rate	0
	Usage rate	100	Usage rate	0
Total number of receiving serve	Forehand attack after receiving serve		Backhand attack after receiving serve	
17	Total number	4	Total number	7
	Point gain	3	Point gain	2
	Point lose	1	Point lose	5
	Score rate	75	Score rate	29
	Usage rate	27	Usage rate	47
Seving error of the opponent	Attack after receiving serve (forehand + backhand)		Defense after receiving serve	
2	Total number	11	Total number	4
	Point gain	5	Point gain	3
	Point lose	6	Point lose	1
	Score rate	45	Score rate	75
	Usage rate	73	Usage rate	27
Total number of consecutive ball playing	Consecutive attack		Consecutive defense	
79	Total number	58	Total number	21
	Point gain	33	Point gain	1
	Point lose	25	Point lose	20
	Score rate	57	Score rate	5
	Usage rate	73	Usage rate	27

4. CONCLUSIONS AND RECOMMENDATIONS

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

(1) Three-stage techniques score rate of Ding Ning, showed her performance on

both "attack after serve" and "attack after receive serve" as "excellent". Her performance on "rally" was rated as "good". Characteristics of her techniques were: fast in speed, fast tempo, powerful serve, able to give opponent fatal blow, able to use forehand and backhand attack on second and third hits to score the point according to her game tactics, excellent skill on receiving serve and defense, aggressive attitude to attack opponent during rally, and consistent rally to score points. By possessing many good characteristics of table tennis skills, no wonder she was able to won the 2016 Rio Olympic Games women's single table tennis championship competition.

(2) Although three-stage techniques score rate of Li Xiao-Xia had reached a certain level, it is obviously not as good as Ding Ning. Overall, her performance on "attack after serve" was rated "fail", "attack after receive serve" was rated as "good", and "rally" was rated as "excellent". In the future, when playing major games, she should try to improve on being consistent, and improve on "attack after serve" and "attack after receive serve" in order to achieve better results.

Three-stage techniques score rate method has repeatedly used in major world table tennis competitions, which successfully allow players know each other's style of play to be able to get good results. Relevant authorities should actively organize workshops for coaches and teach different levels of coaches on how to effectively use technical analysis. To become a world level table tennis player, one must possesses comprehensive techniques, and has to know how to show his/her strength when playing games. Therefore, when training players, coaches need to know how to train table tennis players effectively during training process by using three-stage techniques score rate method. By enhancing each player's strength, the technical standards of table tennis players can be reached to a higher level.

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The Influence of Leisure Motivation and Exercise Involvement on Exercise Habit

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Abstract: This study examined the relationship between leisure motivation, exercise involvement and frequency of exercise habit of undergraduates in Table Tennis. The following research questions were addressed: leisure motivation and exercise involvement were positive significantly associated with each other; exercise involvement and frequency of exercise habit were positive significantly associated with each other; leisure motivation and frequency of exercise habit were positive significantly associated with each other. Five colleges' students, namely Living Technology, Management, Design, Arts and Tourism were selected. Participants were 328 Table Tennis course students (156 male, 172 female) in college of Living Technology (n=67), Management (n=69), Design (n=61), Arts (n=65) and Tourism (n=66). The data obtained from survey were then analyzed by using SPSS program. Descriptive statistical methods and correlation analysis were used to analyze the research data. Findings of this study demonstrate that both leisure motivation and exercise involvement had a significant correlation in the frequency of exercise habit. The results will be discussed and could be useful to increase the health-enhancing exercise habits.

Keywords: physical education course, table tennis, correlation analysis

1. INTRODUCTION

Leisure corresponds to voluntary activities which to provide entertainment, relaxation, vitality and stimulation to participants (Altintas, De Benedetto and Gallouj, 2017). The Self-Determination Theory (SDT, Deci and Ryan, 1985, 2002) distinguishes three main types of motivation: intrinsic motivation (IM), extrinsic motivation (EM) and amotivation (AM). IM is linked to the pleasure one gets from the task itself or from the sense of satisfaction in completing or even working on a task. Ryan and Deci (2000) defined intrinsic motivation as "doing of an activity for its inherent satisfactions rather than for some separable consequences" as well as an individual is intrinsically motivated to do something when he/she likes what they are doing. The core of intrinsic motivation is recognizing that every individual has that activity, action or behavior which they love to do and which they are motivated to perform for just this reason. Extrinsic motivation, on the other hand, was defined as "a construct that pertains whenever an activity is done in order to attain some separable outcome". The contrast between intrinsic and extrinsic motivation by explaining the difference in motive behind an individual's involvement in an activity. Finally, amotivation (AM) is a lack of intrinsic and extrinsic motivation, that is no reason is perceived to initiate or continue the activity (Atlanta's et al., 2017).

Kyle and Chick (2002) suggested that leisure involvement is best conceptualized as a multidimensional construct with the most important dimensions as follow: 1) Attraction: perceived importance or interest in an activity or product, and the pleasure derived from doing or consuming it; 2) Sign: unspoken emelents that the activity or product consumption converys about the person; and 3) Centrality: to lifestyle, referring to both social contexts and the role of the activity or product in the person's lifestyle. Beaton, Funk, Ridinger, and Jordan (2011) identified that "sport involvement is present when individuals evaluate their participation in a sport activity as a central component of their life and provides both hedonic and symbolic value" and conceptualized sport involvement as a multifaceted construct which measured of hedonic value, centrality, and symbolic value.

Undoubtedly, sports is an activity that is fun to do, yet it has several positive effects on a person's life as well (Sevindir, Yazici and Cetinkaya, 2014). Keating, Guan, Piñero and Bridges (2010) reported a review of studies on college students' physical activity behaviors. It is reported that about 40% to 50% of college students are physically inactive. Therefore, participation in physical activity regularly is the key factor in maintaining health in modern society. Lacking of physical activity is a significant health problem in the college population. A primary issue in physical activity research is developing an understanding of motivation.

2. METHODS

2.1 Participants

The sampling was conducted from 328 students who were taking the physical education of table tennis class in the university. 48% and 52% of participants were male and female, respectively. The ages were raged between 18-20 years old and most of the participants were 20 years old (42.6%). 20%, 21%, 19%, 20% and 20% of the participants were studied in college of Living Technology, Management, Design, Arts and Tourism, respectively. The sampling number was roughly the same proportion in each college.

2.2 Measurements

This empirical research was specifically conducted in a table-tennis course of university. A questionnaire with a total number of 38 items which included dimensions of leisure motivation, exercise involvement and exercise habit were distributed to participants. Participants were asked to evaluate the degree to which they agreement on a 7-point Likert scale from "1" equal "Strongly Disagree" to "7" equals "Strongly Agree".

Leisure motivation

A total 28-item revised from Luc G. Pelletier et al. (1995) was used to determine the extent to which the leisure motivation of participants. The scale included a series of statements which included such that: “Because it is one of the best ways I have chosen to develop other aspects of myself”, “Because it is a good way to learn lots of things which could be useful to me in other areas of my life”, “For the pleasure that I feel while learning training techniques that I have never tried before”, “Because it is one of the best ways to maintain good relationships with my friends”, “I often ask myself; I can't seem to achieve the goals that I set for myself”. (See Table 1).

Exercise involvement

A total 9-item scale revised from Brown, Smith and Assayer (2016) was used to 97 determine the extent to which the exercise involvement of participants. The scale included a series of statements which included such that:” My interest in table tennis says a lot about who I am”, “A lot of my life is organized around table tennis”, and “I would be lost without table tennis”. (See Table 2).

Exercise habit

Exercise habit was accessed with the item adapted from Fleeing et al. (2013) which modified from Verplanken and Melkevik (2008). Participants were asked to 105 think about the item: “being as physically active as I have been during the past two 106 weeks”. Participants were asked to evaluate the degree from “1” equal “Strongly Disagree” to “7” equals “Strongly Agree”.

3. RESULTS

The mean score of leisure motivation and exercise involvement were shown in Table 1 and Table 2. As shown in Table 1, the top 5 high scored items of leisure motivation were: “Because it is a good way to learn lots of things which could be useful to me in other areas of my life “ (m=4.69), “For the pleasure I feel in living exciting experiences” (m=4.20), “To show others how good I am good at my sport” (m=4.14), “Because I must do sports regularly” (m=4.11), and “Because it is one of the best ways I have chosen to develop other aspects of myself” (m=4.07), respectively. Among all the items, in contrast, “Because I like the feeling of being totally immersed in the activity” has the lowest average scores (2.93). As shown in Table 2, on the other hand, the top 5 high scored items of exercise involvement were: “Table tennis is my favorite sport”(m=4.65), “My interest in table tennis says a lot about who I am” (m=4.23), “Table tennis helps others see me the way I want them to see me” (m=4.21), “A lot of my life is organized around table tennis” (m=4.19) and “I really enjoy table tennis” (m=4.17), respectively. Among all the items, however, “Many of my friends are interested in table tennis” has the lowest average scores (3.88). As shown in Table 3, Correlations between dimensions for leisure motivation, exercise involvement and exercise habit for all respondents (n = 328).

Table 1. The mean score of leisure motivation

Question: WHY DO YOU PRACTICE YOUR SPORT?	mean score	Std. Deviation
1. For the pleasure I feel in living exciting experiences	**4.20**	0.68
2. For the pleasure it gives me to know more about the sport that I practice	3.87	0.75
3. I used to have good reasons for doing sport, but now I am asking myself if I should continue doing it	3.9	0.85
4. For the pleasure of discovering new training techniques	3.98	0.74
5. I don't know anymore; I have the impression of being incapable of succeeding in this sport	3.6	0.93
6. Because it allows me to be well regarded by people that I know	3.99	0.8
7.Because, in my opinion, it is one of the best ways to meet people	**4.04**	0.8
8. Because I feel a lot of personal satisfaction while mastering certain difficult training techniques	3.97	0.79
9. Because it is absolutely necessary to do sports if one wants to be in shape	3.95	0.83
10.For the prestige of being an athlete	3.87	0.84
11. Because it is one of the best ways I have chosen to develop other aspects of myself	**4.07**	0.71
12. For the pleasure I feel while improving some of my weak points	4	0.74
13. For the excitement I feel when I am really involved in the activity	3.74	0.86
14. Because I must do sports to feel good myself	3.53	0.88
15. For the satisfaction I experience while I am perfecting my abilities	3.85	0.82
16. Because people around me think it is important to be in shape	3.72	0.79
17. Because it is a good way to learn lots of things which could be useful to me in other areas of my life	**4.69**	0.56
18. For the intense emotions I feel doing a sport that I like	4.03	0.36
19. It is not clear to me anymore; I don't really think my place is in sport	3.11	0.71
20. For the pleasure that I feel while executing certain difficult movements	3.67	0.67
21. Because I would feel bad if I was not taking time to do it	3.2	0.72
22. To show others how good I am good at my sport	**4.14**	0.77
23. For the pleasure that I feel while learning training techniques that I have never tried before	3.16	0.52
24. Because it is one of the best ways to maintain good relationships with my friends	3.83	0.58
25. Because I like the feeling of being totally immersed in the activity	<u>2.93</u>	0.81
26. Because I must do sports regularly	**4.11**	0.87
27. For the pleasure of discovering new performance strategies	3.5	0.65
28. I often ask myself; I can't seem to achieve the goals that I set for myself	3.12	0.68

Table 2. The mean score of exercise involvement

Question: WHY DO YOU PRACTICE YOUR SPORT?	mean score	Std. Deviation
1.I really enjoy table tennis	**4.17**	0.68
2.Table tennis is my favorite sport	**4.65**	0.51
3.I know a lot about table tennis	4.06	0.91
4.My interest in table tennis says a lot about who I am	**4.23**	0.75
5.Table tennis helps others see me the way I want them to see me	**4.21**	0.58
6.Table Tennis means I can really be myself	3.99	0.77
7.A lot of my life is organized around table tennis	4.19	0.63
8.Many of my friends are interested in table tennis	<u>3.88</u>	0.85
9.I would be lost without table tennis	4.16	0.71

The correlation between leisure motivation and exercise involvement could be considered moderately correlated which showed an r = .52, p<.05. The correlation between exercise involvement and exercise habit, however, also could be considered as moderately correlated (r = .57, p<.05). The leisure motivation and exercise habit, however, could be considered as a modestly correlated which showed an r = .28, p<.05.

Table 3. The correlations between dimensions for leisure motivation, exercise involvement and exercise habit

Dimension	leisure motivation	exercise involvement	exercise habit
leisure motivation	-		
exercise involvement	0.52*	-	
exercise habit	0.28*	0.57*	-

Note: * p<.05

4. DISCUSSION

This research was designed to examine the relationship between leisure motivation, exercise involvement, and exercise habit. Participants were students who took the physical class of table tennis. A questionnaire on a 7-point Likert scale with a total number of 38 questions which included dimensions of leisure motivation, exercise involvement and exercise habit were distributed to participants. The highest scored item of leisure motivation, “Because it is a good way to learn lots of things which could be useful to me in other areas of my life”, showed that learn to learn is an important consideration of leisure activities. The highest scored item in second aspect, exercise involvement, refer to “Table tennis is my favorite sport” showed that personal interesting can have a enhance in physical activity involvement. The results also represent that there were positive relationship between leisure motivation and exercise involvement, leisure motivation and exercise habit, exercise involvement and exercise habit.

5. CONCLUSION

According to our research results, the present study provided an empirical evaluation for relationship between leisure motivation, exercise involvement and exercise habit. More specifically, the findings of this study demonstrate that both leisure motivation and exercise involvement had a significant correlation in the frequency of exercise habit. The results could be useful to increase the health-enhancing exercise habits.

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Differences in Match Statistics During Table Tennis Team Event in Rio and London Olympic Games

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Abstract: The aim of this study was to analyse game statistics at different phases of the game by the table tennis players at Olympic Games in Rio 2016 and London 2012, by determining the differences in game statistics indicators in these two competitions. We analysed 236 games matches from Rio and 214 games matches from London, played during team event. From each game were collected 27 parameters. In this analysis, the average match and rally durations with different rally analysis among 16 teams played at Olympics has been provided. The official website of 2016 Rio Olympics and 2012 London Olympics were used as a means of collecting data and during the matches, the results and analysis of a total 450 matches published on this site were recorded and evaluated. The study was carried out on total of 346 players (174 women and 172 men) who participated from 16 countries. Descriptive statistical analysis of data (mean, standard deviation, minimum and maximum values, percentage distribution) was done by using SPSS 17.0 for Windows. Statistically significant differences in performance indicators between the table tennis matches played on the Olympic Games in Rio and London are found for the variables: Whole match duration / without breaks between sets, Game duration of 1st set, Game duration of 2nd set, Game duration of 3rd set, Game duration of 4th set, Total points won in match and Total points lost on own serve in whole match (all in the direction of higher means for the matches played in Rio Olympic Games). The only statistically significant higher mean for the matches played in London Olympic Games is found for the indicator Total points won on own serve in 5th set. When looked at the data obtained in this study, it is observed that the highest mean match durations are influenced by the style of play and the longest mean rally durations comes with defensive players. As a conclusion, according to the 2016 Rio Olympics and 2012 London Olympics analysis, table tennis coaches must revise technical and tactical elements when playing on best of five matches and they have to prepare special schedules for category properties. The results presented are important to monitor the athlete's performance during the game and to readjust strategies based on point difference.

Key words: table tennis, London Olympic Games, Rio Olympic Games, match analysis

1. INTRODUCTION

Match analysis is crucial for the improvement of a table tennis player. Any competitive match is the final test of how good the player is in the technical, tactical, mental and physical aspects of the game. Some coaches, rather than taking methodical notes, analyses table tennis matches only by watching them. Table tennis is a sports game characterized by its continuous changing situations during games. After table tennis was introduced in 1988 Seoul Olympics, the performance capabilities of table tennis players attracted attention of sports scientists and researchers worldwide. Among other methods, statistics are very important for table tennis players and coaches, especially when they are analysing matches or tournaments. The basic elements of table tennis matches are technical elements which appears in single rallies (Munivrana et al., 2015).

To make the conditions of the game more appealing and to increase the number of sponsors and audience, International Table Tennis Federation (ITTF) made some changes on the rules. During last 20 years this way table tennis went through changes in relation to its regulations and scoring system. Since the implementation of bigger ball and shorter sets, studies have investigated match differences and similarities in comparison to previous equipment and rules (Zhang, 2002; Takeuchi et al., 2002; Tang, Mizoguchi and Toyoshima, 2002; Tsuji and Muguruma, 2002). The temporal structure of table tennis matches, such as duration of the game, duration of the rally, pause time, effective time played, number of rallies and point won on own or opponents service have also been quantified and described in the new scoring international matches (Katsikadelis et al., 2010; Djokic, 2007; Seve and Poizat, 2005; Seve, 2003). These values have been recorded during last four Olympic Games.

As it was shown above, the temporal, technical and tactical characteristics of table tennis matches were widely studied. However, little attention was given to the variability of the points during the game and to its influence on the match outcome. In other three racket sports, the scoring system was widely investigated through mathematical modelling and statistics (Abian et al., 2014; Abian-Vicen et al., 2013; Barnett, O'Shaughnessy, & Bedford, 2011; Percy, 2009; Filipčič, Filipčič and Berendijaš, 2008; Clarke, 1994).

According to Marcus (2001), the difference in scored points between the players can be used to infer competitiveness and performance level of the athletes. He discussed whether the number of points that a table tennis player scored in a match should be used in the rating system. Following his research also Coupet and Réache (2007) proposed a statistical model to estimate the probability of victory of a set or a match based on the points scored by the table tennis players. Malagoli Lanzoni, Di Michele and Merni (2014) have analysed selected shot characteristics in top-level table tennis matches, with a special focus on comparing the playing style of Asian and European players. A strong association was found between strokes and footwork types, with most stroke types executed each after specific footwork types. When compared to Europeans, Asians used more frequently the most aggressive strokes and footwork types. The temporal structure of table tennis matches have been further analysed by notational analysis for competition (Wu and Escobar-Vargas, 2007a, 2007b; Wilson and Barnes, 1998).

In order to implement the appropriate strategy into the training process of a table tennis player, this paper presents a set of variables which can be of importance in one table tennis match.

The aim of this study was to analyse game statistics of table tennis players at different phases of the game at Olympic Games in Rio 2016 and London 2012, by determining the differences in game statistics indicators in these two competitions.

2. METHODS

Participants

Two hundred thirty six games from 2012 London Olympics and two hundred fourteen from the 2016 Rio Olympics were analysed (n=450). All of them are games from men's and women's team event. According to the ITTF rules in team matches, players have played best of 5 games. The study was carried out on total of 346 players (174 women and 172 men) who participated from 16 countries.

Materials

The official website of 2016 Rio Olympics and 2012 London Olympics were used as a means of collecting data and during the matches, the results and analysis of a total 450 matches published on this site were recorded and evaluated.

Variables

The independent variables were the place where the games were played (London 2012 Olympic Games *vs* Rio 2016 Olympic Games). The dependent variables were the timing factors: whole match duration, duration of the single games 1 to 5, number of points won in each set and total points won in the match respectively, biggest lead (for each set and for the whole match), points won and lost respectively on own serve (for each set and for the whole match), the longest rally and the average of the rally length (for each set and for the whole match).

Statistical analysis

The following software programs were used: *Microsoft Excel spreadsheet* (Microsoft) to store the results and *SPSS v. 17.0* (SPSS Inc., USA) to perform the statistical calculations using descriptive and inferential statistical tests and to calculate means, standard deviations and ranges. Mann Whitney U-test was used to determine the differences in performance indicators between the table tennis matches played on the Olympic Games in Rio and London. All the differences are commented on the level of statistical significance at $p<0.05$.

3. RESULTS

Table 1. Differences in performance indicators between the table tennis matches played on the Olympic Games in Rio and London

Group Statistics					
	Olympic Games	N	Mean	Std. Deviation	Mann Whitney U-test (p)
Winning sets	Rio	236	1.91	1.236	0.436
	London	214	1.79	1.307	
Lost sets	Rio	236	1.91	1.236	0.436
	London	214	1.79	1.307	
Whole match duration / without breaks between sets	Rio	236	32.58	11.126	**0.001**
	London	214	29.19	9.493	
Game duration of 1st set (min)	Rio	236	6.49	1.848	**0.021**
	London	214	6.10	1.556	
Game duration of 2nd set (min)	Rio	236	6.73	1.801	**0.029**
	London	214	6.36	1.646	
Game duration of 3rd set (min)	Rio	236	7.11	2.016	**0.000**
	London	214	6.50	1.949	
Game duration of 4th set (min)	Rio	129	7.45	1.858	**0.003**
	London	100	6.84	1.824	
Game duration of 5th set (min)	Rio	62	8.19	2.055	0.505
	London	22	8.55	2.154	
Points won in 1st set	Rio	236	9.06	3.040	0.977
	London	214	9.17	2.752	
Points won in 2nd set	Rio	236	9.08	2.859	0.791
	London	214	9.05	2.773	
Points won in 3rd set	Rio	236	9.03	3.101	0.872
	London	214	9.05	2.998	
Points won in 4th set	Rio	130	9.22	2.904	0.853
	London	100	9.07	2.761	
Points won in 5th set	Rio	62	9.44	2.609	0.443
	London	22	10.05	2.591	
Total points won in match	Rio	236	34.70	11.198	**0.023**
	London	214	32.54	9.658	
Big lead 1 (points)	Rio	236	3.10	2.591	0.670
	London	214	2.93	2.351	
Big Lead 2 (points)	Rio	236	2.97	2.515	0.979
	London	214	2.94	2.417	
Big Lead 3 (points)	Rio	236	3.06	2.639	0.958
	London	214	3.03	2.541	
Big Lead 4 (points)	Rio	130	2.76	2.518	0.492
	London	100	2.95	2.484	
Big Lead 5 (points)	Rio	62	2.84	2.334	0.606
	London	22	3.05	2.058	

(continued)

Biggest lead in all sets	Rio	236	5.20	2.598	0.352
	London	214	4.94	2.445	
PWOS 1 (points)	Rio	236	4.71	1.753	0.653
	London	214	4.91	1.677	
PWOS 2 (points)	Rio	236	4.64	1.860	0.319
	London	214	4.83	1.879	
PWOS 3 (points)	Rio	236	4.66	2.085	0.724
	London	214	4.62	1.927	
PWOS 4 (points)	Rio	130	4.75	1.717	0.736
	London	100	4.80	1.735	
PWOS 5 (points)	Rio	62	4.53	1.817	**0.003**
	London	22	5.59	1.501	
Total points won on own serve in whole match	Rio	236	17.81	6.014	0.133
	London	214	17.18	5.356	
PLOS 1 (points)	Rio	236	4.35	1.872	0.585
	London	214	4.26	1.735	
PLOS 2 (points)	Rio	236	4.43	1.829	0.128
	London	214	4.21	1.725	
PLOS 3 (points)	Rio	236	4.31	1.861	0.274
	London	214	4.43	1.811	
PLOS 4 (points)	Rio	130	4.41	1.728	0.623
	London	100	4.27	1.675	
PLOS 5 (points)	Rio	62	4.81	1.502	0.281
	London	22	4.45	1.503	
Total points lost on own serve in whole match	Rio	236	16.77	5.976	**0.011**
	London	214	15.36	5.334	
MCPW 1 (points)	Rio	236	3.65	1.812	0.572
	London	214	3.43	1.425	
MCPW 2 (points)	Rio	236	3.47	1.523	0.532
	London	214	3.54	1.546	
MCPW 3 (points)	Rio	236	3.53	1.694	0.322
	London	214	3.42	1.725	
MCPW 4 (points)	Rio	130	3.44	1.409	0.068
	London	100	3.93	1.689	
MCPW 5 (points)	Rio	62	3.71	1.335	0.178
	London	22	4.18	1.259	
Most consecutive points won in total	Rio	236	5.01	1.747	0.389
	London	214	4.86	1.691	
GDO 1 (points)	Rio	236	.60	1.016	0.713
	London	214	.56	.976	
GDO 2 (points)	Rio	236	.58	1.095	0.781
	London	214	.54	1.055	
GDO 3 (points)	Rio	236	.53	.987	0.612
	London	214	.63	1.147	

(continued)

GDO 4 (points)	Rio	130	.42	.815	0.443
	London	100	.56	1.057	
GDO 5 (points)	Rio	62	.63	1.231	0.149
	London	22	1.27	1.882	
Greatest deficit overcome in total	Rio	236	1.47	1.397	0.770
	London	214	1.47	1.506	
LongRa 1 (strokes)	Rio	236	12.14	5.186	0.583
	London	214	12.64	6.432	
LongRa 2 (strokes)	Rio	236	12.92	6.669	0.517
	London	214	13.38	7.896	
LongRa 3 (strokes)	Rio	236	14.08	8.479	0.792
	London	214	14.11	10.671	
LongRa 4 (strokes)	Rio	130	13.72	6.665	0.463
	London	100	15.02	8.265	
LongRa 5 (strokes)	Rio	62	14.68	8.693	0.500
	London	22	15.55	11.232	
Longest rally (strokes) of all sets	Rio	236	17.37	8.460	0.988
	London	214	17.54	10.525	
AverRa 1 (strokes)	Rio	236	5.24	1.689	0.874
	London	214	5.18	1.531	
AverRa 2 (strokes)	Rio	236	5.47	2.094	0.725
	London	214	5.57	3.037	
AverRa 3 (strokes)	Rio	236	5.68	2.440	0.468
	London	214	5.57	2.615	
AverRa 4 (strokes)	Rio	130	5.72	1.868	0.605
	London	99	5.90	2.513	
AverRa 5 (strokes)	Rio	62	5.77	2.385	0.182
	London	22	5.91	1.875	
Average rally in whole match	Rio	236	5.52	1.903	0.204
	London	214	5.42	2.158	

Legend: Big lead (1-5) - Biggest lead in sets from 1st to 5th; PWOS (1-5) - Total points won on own serve in sets from 1st to 5th; PLOS (1-5) - Total points lost on own serve in sets from 1st to 5th; MCPW (1-5) - Most consecutive points won in sets from 1st to 5th; GDO (1-5) - Greatest deficit overcome in sets from 1st to 5th; LongRa (1-5) - Longest rally (strokes) in sets from 1st to 5th; AverRa (1-5) - Average rally in sets from 1st to 5th
Bold: differences statistically significant at p<0.05

Statistically significant differences in performance indicators between the table tennis matches played on the Olympic Games in Rio and London are found for the variables: Whole match duration / without breaks between sets (32.58 vs 29.19, p=0.001), Game duration of 1st set (6.49 vs 6.10, p = 0.021), Game duration of 2nd set (6.73 vs 6.36, p = 0.029), Game duration of 3rd set (7.11 vs 6.50, p = 0.000), Game duration of 4th set (7.45 vs 6.84, p = 0.003), Total points won in match (34.70 vs 32.54, p = 0.023) and Total points lost on own serve in whole match (16.77 vs 15.36, p = 0.011) – all in the direction of higher means for the matches played in Rio Olympic

Games. The only statistically significant higher mean for the matches played in London Olympic Games is found for the indicator Total points won on own serve in 5th set (4.53 vs 5.59, p = 0.003).

4. DISCUSSION AND CONCLUSION

As shown in Table 1, most of the analysed characteristics haven't shown significant differences between the London and the Rio Olympic Games. Especially all indicators connected to rally length haven't shown significant differences which maybe surprisingly shows that the introduction of the new plastic ball didn't change the length of the rallies.

Possibly the players adapted their style or technique to the new ball that the rallies haven't become longer but surprisingly on the other hand the total match duration, accordingly the duration of the single games (except 5th game) were significantly longer in the Rio Olympic Games than in the London Olympic Games.

To explain a longer match/game duration without more ball contacts (= rally length) there seem to be two possibilities. Either the breaks between the points are longer or even with the same amount of contacts (= same rally length) the time duration of a single rally was extended. Both could be influenced by the new plastic ball. According to the opinion of several players and coaches, the physical part became more important with the new plastic ball. Players have to invest more energy and power to generate the same speed and spin as it was possible with the old celluloid ball. Maybe players adapted their style because of that reason. Thus, the rally length is still the same but the players are more exhausted and take longer breaks after a rally. To confirm that assumption more detailed studies on the actual playing time and the breaks between rallies respectively have to be carried out. This could lead to a changed load profile for the players during matches which should be considered by the players and coaches in their future training process.

In conclusion, the results presented are important not only to monitor the athlete's performance during the game and to readjust strategies but also to find indications which could lead to a readjustment of the training processes of the players to improve their future performances, in that case for example of the training load structure.

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A Study on the Relationship of Influence of Attitude, Trust, Perceived Risk and Intention of Investment in Online Crowdfunding of Table Tennis Enthusiasts

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Abstract: Over the past few years, crowdfunding has become main means of many sports teams and amateur athletes to raise funds for training and registration. The purpose of this study is to understand the table tennis enthusiasts' attitude, trust, perceived risk and intention of investment toward crowdfunding. There are 180 table tennis enthusiasts for the subjects. The statistical methods are factor analysis, correlation analysis and structural equation modeling. The results show that the attitude is directly related to trust, perceived risk and intention of investment, and there is also a direct relationship between trust and intention of investment. However, there is no significant correlation between perceived risk and intention of investment. Therefore, the conclusion is that both attitude and trust are important variable toward intention of investment. Finally, we hope that the study can make it possible for sports teams to get more resources and the necessary sponsorship.

Keywords: crowdfunding platform, intention of investment, sports team

1. INTRODUCTION

Startups need resources to succeed, and the most important thing is to raise money (Gompers and Lerner, 2004; Gorman and Sahlman, 1989; Kortum and Lerner, 2000). Compared to the traditional means of fund-raising, crowdfunding is a new way to raise funds more quickly and effectively. And the idea of crowdfunding is actually derived from micro finance (Morduch, 1999) and the concept of outsourcing (Poetz and Schreier, 2012). Due to the development of technology and social media, the platform of crowdfunding appears gradually. The First crowdfunding platform is “Kickstarter” which began in the United States in 2009 and provide creative proposals in various fields for fundraising. Kickstarter is the largest crowdfunding platform in the world.

In recent years, there are many well-known crowdfunding platform in Taiwan, like FlyingV, Zeczec, Webackers, DIT funding and so on. According to the Backer-Founder which is a consultant company of crowdfunding, there were total of 501 successful cases of crowdfunding abroad or in Taiwan in 2015, especially it grew rapidly from 2012 to 2015, with the proposals of technology products, running events and even social movements and so on. The diverse proposals show diversified features of the crowdfunding platform in Taiwan, and began to develop a new marketing strategy.

In recent years, some critics believe that more and more sports teams have been created by some innovative methods like crowdfunding in United States (Simkins, 2014). In the field of sports, crowdfunding has become a popular fund-raising tool, and also become the main means for amateur athletes to raise money of training and registration (Fallone, 2014). For example, some Olympic athletes from America and Canada successfully attended in the Sochi Winter Olympics by the money came from the crowdfunding, it's the same as the well-known Jamaica sledge team (Zerucha, 2014).

There are more and more crowdfunding platforms to provide for athletes and amateur sports teams in recent years, including RallyMe, Pursu.It, Dream Fuel, Sport Funder, and Makea Champ (Fallone, 2014). Many foreign athletes have been able to raise the funds they need through these platforms and they can have a good performance in the field of sports.

Look at Taiwan, the crowdfunding platforms started late, especially there are few ones for sports. However, “BUBU steps forward” is the first crowdfunding platform of sports in Taiwan, and it is wanted to make more and more people pay attention to these athletes and sports activities in Taiwan through this platform. The platforms use some ways to five feedback to the sponsors like souvenirs, sporting goods, or experience sharing. Then people can involve in sports events not only by mass media, but also by sponsoring others.

Sports activities have been noticed by people. With more and more people participating in sports events and activities, many athletes are actively nurtured in Taiwan. According to the survey from Daily View, the Taiwanese‘s top 10 favorite sports, including baseball, badminton, table tennis and so on from 2014 to 2015.

However, table tennis has been enrolled in the 2008 gold program of government in Taiwan, which will be included in the important competition item of Beijing Olympic Games. Table tennis is suitable for all ages in Taiwan. In recent years, there are more and more excellent table tennis players from other Asian countries, but because of the lack of competitiveness and resources in the environment of table tennis in Taiwan, a lot of amateur athletes are difficult to show their strength in the field of sports. Therefore, it is helpful for these table tennis players if there are a lot of sponsorship from companies or masses.

Such as the development of Internet nowadays, sports players in Taiwan should learn the ways of foreign athletes mentioned above to raise money for training and competition. And due to the few relatively studies in Taiwan, therefore, this study is to explore the willingness and behavioral intentions of crowdfunding of the sponsors.

The purposes of this study are as follows:

a. To explore the relationship between attitudes, trust, perceived risk and sponsorship intention.

b. To explore the effects of attitude, trust and perceived risk on sponsorship intention.

2. METHODS

2.1 Research model

The purpose of this study is to explore the attitude, trust and perceived risk of the masses for online crowdfunding of table tennis, and the influence on investment willingness. As show as the follow construct in Figure 1.

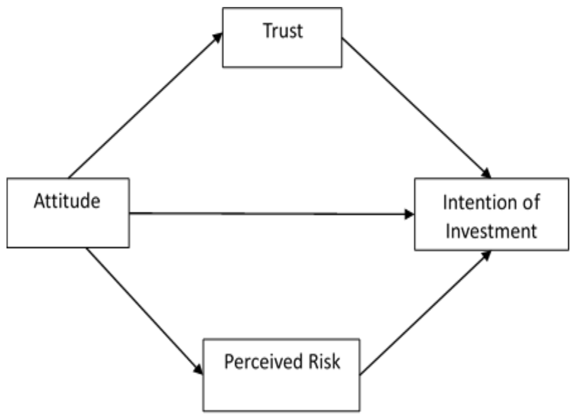

Figure1. Research model

2.2 Participants

The research participants were the table tennis enthusiasts, and the investigation time was from January 28, 2017 to February 1, 2017, with purposive sampling on the internet. 180 questionnaires were collected, including 49.4% of men, 50.6% of women, and the subjects age 45 years (inclusive) above is up to 37.9%, and 46.6% of participants have ever experienced in crowdfunding.

2.3 Measures

The attitude scale of this study is based on the scale of Ajzen (2011), Kautonen and Fink (2015), and was revised according to this study.

The trust scale was based on the scale of Gefen (2000), Kim Ferrin (2008), Mayer, Davis and Schoormam (1995), and was revised according to this study.

The perceived risk scale of this study was based on the scale of Bhatnagar et al. (2000), Jacoby and Kaplan (1972), Kwak, Fox and Zinkhan (2002), Yue and Weiguo (2015) and the perceived risk scale was revised according to this study.

The Intention of Investment scale of this study was based on the scale of Bonsón et al. (2015), and the intention of investment scale was revised according to this study.

2.4 Data analysis

In this study, factor analysis and correlation analysis were analyzed by SPSS 20.0, and the relationship between the three variables was explored by the PLS, and the route pattern of this study was developed.

3. FINDINGS

3.1 Exploratory factor analysis

Table 1. Exploratory factor analysis

Constructs	Item	Attitude	Trust	Perceived Risk	Intention of Investment
Attitude	a1	**.878**	.443	.268	.630
	a2	**.926**	.443	.206	.625
	a3	**.888**	.437	.248	.616
	a4	**.906**	.503	.181	.628
	a6	**.894**	.458	.209	.589
Trust	b1	.408	**.871**	.157	.546
	b2	.453	**.910**	.110	.531
	b3	.396	**.880**	.135	.511
	b4	.455	**.903**	.164	.561
	b5	.504	**.877**	.226	.526
	b6	.437	**.779**	.201	.447
Perceived Risk	c1	.224	.215	**.793**	.196
	c2	.221	.123	**.858**	.125
	c3	.175	.105	**.824**	.188
	c4	.188	.090	**.851**	.153
	c5	.216	.251	**.734**	.221
	c6	.095	.017	**.702**	.059
Intention of Investment	d1	.625	.555	.200	**.948**
	d2	.678	.569	.204	**.941**
	d3	.615	.549	.191	**.905**

Nunnally (1978) raised that factor loading should be higher than 0.4, and the factor loading of fifth item of attitude scale is "-.264", less than the recommended standard value of 0.4, so it would be deleted. And then, all factor loadings are higher than 0.4.

3.2 Construct validity

Table 2. Construct validity

Item	AVE	Cronbach's Alpha	Composite Reliability	Attitude	Trust	Perceived Risk	Intention of Investment
Attitude	.808	.940	.954	**.899**			
Trust	.759	.936	.950	.509	**.871**		
Perceived Risk	.633	.886	.912	.247	.190	**.796**	
Intention of Investment	.867	.923	.951	.688	.599	.213	**.931**

According to Nunnally (1978), the Cronbach's alpha must be higher than 0.7 and then the item has a high degree of consistency, also has good reliability. From the Table 2, we know that the Cronbach's alpha coefficients of the four variables are higher than 0.7, so this construct has good reliability and validity.

3.3 Goodness of model fit

Table 3. Goodness of model fit

	AVE	Composite Reliability	R^2	Cronbach's Alpha	Communality	Redundancy	GOF
Attitude	.808	.954		.940	.808		
Trust	.759	.950	.259	.936	.759	.195	
Perceived Risk	.633	.912	.061	.886	.633	.035	.473
Intention of Investment	.867	.951	.557	.923	.867	.250	

PLS measure mode with appropriate indicators for GOF. The GOF measure is 0.1 for the weak degree of fitness, 0.25 for moderate fitness, and the intensity of fitness for the 0.36. From the Table 3, we can see that all accord with the standard.

3.4 Mediation analysis

Table 4. Mediation analysis

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)	P
Attitude -> Trust	.509	.511	.057	.057	8.926	.000
Attitude -> Intention of Investment	.512	.508	.057	.057	9.024	.000
Attitude -> Perceived Risk	.247	.262	.070	.070	3.531	.000
Trust -> Intention of Investment	.334	.334	.063	.063	5.276	.000
Perceived Risk -> Intention of Investment	.023	.029	.065	.065	.354	.723

a. Attitude has a direct impact on trust, investment intention and perceived risk
b. Trust also has a direct impact on investment intentions
c. Perceived risk has no significant effect on investment intention
d. Attitude can influence investment intention through trust and perceived risk

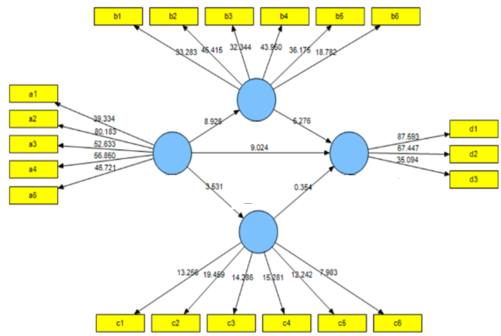

Figure 2. Path Analysis of Attitude, Trust, Perceived Risk and Intention of Investment.

4. DISCUSSION

The results of the structural equation model are as follows：

a. The attitude of the masses has a direct influence on trust and investment intentions and perceived risk, especially a high influence on trust and investment intentions. It shows in terms of crowdfunding, the attitude of the crowdfunding platform of the masses is the most important factor that make the sponsors be willing to contribute in the future.
b. Trust also has a direct influence on investment intentions. It shows that trust positively affect the investment intentions of crowdfunding of people.
c. The results show that there is no significant relationship between perceived risk and intention of investment, which shows that the people do not reduce the intention to invest because of the perceived risk of the crowdfunding platform.

5. CONCLUSIONS

According to the analysis, the most important factor of the intention of investment is their attitude towards the online crowdfunding platform, therefore, if the crowdfunding platform provides interesting and attractive programs, it can improve the people's recognition of the project, and it is possible to raise the public's attitude towards the proposals and to increase their willingness of investment.

And there is also a high influence among attitudes and trust, this shows that when the masses have a good attitude towards the crowdfunding platform, the degree of trust of the crowdfunding platform is high. This is important for the uncertainty of the Internet nowadays, therefore, if online crowdfunding platform want to get more people's investment, then they should enhance the attitude and trust of the masses.

The results also show that the perceived risk of the masses has no direct impact on the intention of investment to the crowdfunding platform, so it is assumed that the masses may consider there is not too much risk in their contribution. But there are still many uncertainties and risks in the Internet world, therefore, it is recommended that online platform should continue to comply with the provisions of relevant laws and regulations, and avoid leakage of personal information of the masses.

The purpose of this study was to explore the influence of attitude, trust and perceived risk on intention of investment. However, there are many factors affecting the investment behaviour of the masses. It is suggested that future researchers can add other factors to explore the investment behaviour of crowdfunding. Today, many online crowdfunding platforms are likely to be the trend in the future, it is also suggested that results in this study could be a reference for more relevant groups and platforms.

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PART 2
Professional papers

The Mobility of Sports Communication-the Study About Mobile News Clients Apply in the Table Tennis Tournament

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Abstract: With the rapid development of communication technology and Internet technology, mobile phone has become one of the most important carriers of information dissemination. It not only changed the traditional one-way mode of information, but also established the real-time interaction between the information communicator and receiver. It also breaks the limitation of time and space on information transmission, and speeds up the efficiency of information communication. If we conformed to this trend and gave full play to the role of mobile news client in the promotion and broadcast events, changed the traditional model about spread of sports events, finally we would realize the movement of sports communication. This paper is based on an example as the mobile news client in the table tennis competition in communication. We studied the dilemma of mobile news client communication in the table tennis competition. We got the dissemination of accurate communication and content innovation in the communication Mobile News client in the table tennis competition, which will further enhance the tennis event's influence and promote the rapid development of table tennis.

Keywords: sports communication, mobile news client, table tennis tournament, Olympic Games

1. INTRODUCTION

It has always been a symbiotic relationship between the sports and the media. The development of sports not only provides a rich source of news information for the media, but also brings huge economic benefits to the media industry. At the same time, the rapid development of the media also provides a broader platform for sports communication. According to CNNIC's latest survey data shows that China's use of mobile Internet users has reached 600 million, The Internet users use mobile Internet time has exceeded the use of traditional computers. In this context, the major news media began to pay attention to the role of mobile terminal in sports news communication. They propagandize the major sports events actively by creating a mobile news client, and the mobile communication of sports events is preliminarily realized. But in this process, the majority of sports mobile news client presents the trend of homogenization in the sports news content. The sports mobile news client is restricted directly to development. We need break through the current development dilemma of the sports mobile news client. If we want to extend the table tennis tournament, we should also conform to the current development, and use the sports mobile client's strong role in communication, then we can enhance the attention and influence of table tennis of the people.

2. Mobile news client, mobile platform for large-scale sports events

From the view of the evolution of China's information communication media, it has experienced the evolution of traditional media, network media and mobile media. With the emergence of new media such as WeChat, micro-blog, news client, mobile media has become the dominant force in the process of information communication in china. As a type of mobile media, news client appeared later than WeChat and micro-blog, which began to appear in 2011. Mobile phone users are gradually welcomed it in recent years. While the mobile news client is using digital mobile communication technology, technology, news services installed on the user's mobile phone, with the convenience and mobility of mobile phone, mobile news client changed the traditional media information dissemination "fixed" characteristics. The most significant impact on the spread of sports events is the realization of the sports events. The mobile news client has the following advantages in the process of spreading the large-scale sports events.

2.1 Filling the people's fragmentation of the time, so that users can understand and pay attention to sports news in time

At present, people live and work more and more quickly, which makes it difficult for people to have a piece of time to browse the news, only in the relatively fragmented time to browse information. After the mobile news client appears, users only need to watch sports events on the mobile phone or browse sports news, which means that enables users to understand the content and information of sports events in the time range of "fragmentation", improve the efficiency and speed of sports events, and realize the real-time communication of sports events.

2.2 Integrating a variety of forms of communication

The traditional sports news communication platform often has the remarkable characteristic, For example, sports TV channels rely mainly on video communication, sports broadcast mainly rely on sound transmission, sports newspapers and magazines rely mainly on text communication. These forms of sports news communication have some limitations, For example, the sports TV channel is often broadcast live as the main form, and live time is strictly limited. The sports broadcast and sports newspapers, magazines in the process of sports events in the process of communication is difficult to reflect the vividness and image, and sports news is often lagging behind. While relying on mobile news client, sports event communication can avoid the defects of traditional media in the process of sports events. On the mobile news client, not only can transmit text, sound, pictures and other information, but also can live video, or watch sports highlights, it can integrate a variety of information communication mode, rich sports competition broadcasting content.

2.3 Enhancing the audience's personalized experience

In 1974, American Israeli sociologist put forward the famous theory of "use and gratification" in his book "the use of personal and mass communication". According to the theory, the audience can use the media to restrict the process of media communication. Through the mobile news client, the audience can choose their favorite sports events, they can interact and exchange with other groups of audience, which enhances the audience's personalized experience of sports events. Because of the advantages of the mobile news client in the process of the dissemination of sports events, it has become an indispensable mobile platform in the process of large-scale sports events, Under the background of the continuous improvement of mobile communication technology in the future, mobile news client will play a more important role in the process of sports events, and even replace the traditional sports event broadcast.

3. Homogeneity of news content in sports events -- the practical dilemma of mobile news client application in sports events

In 2012, in the process of the London Olympic Games, some sports events were tried to spread through the mobile news client, which opened the mobile news client to spread the prelude to large-scale sports events. In 2014, during the twentieth Brazil World Cup, mobile news client has a large number of downloads, then CCTV as the only broadcast the World Cup sports channel, the client downloads has remained in the top five level, On June 15 -22 2013 mobile client downloads ranked first. The Downloads of Tencent sports, Sina sports client was also maintained at the top ten levels. In the 2016 Olympic Games of Rio, the attention rate of mobile news client is 1.36 times the PC side, 76.1% of Internet users pay attention to the Rio Olympic Games in the mobile terminal, mobile intelligent equipment has greatly surpass the TV and PC end, a large number of users first select mobile smart devices to obtain information of the Olympic games. This fully shows that the mobile news client plays an increasingly important role in the dissemination of sports events in the process, more users use mobile news client to watch sports events and browse sports news, these has created favorable conditions for the movement of sports communication. Therefore, in order to get more people's attention, table tennis events should also make full use of mobile news client for the spread of the event. But from another point of view, a lot of mobile news client in the dissemination of sports events, showing the phenomenon of homogenization in the content, which has become the practical difficulties in using mobile news client in sports competition. Specific point of view, the current sports news content homogenization is mainly reflected in the following two aspects.

3.1 The content of different news client shows homogeneity

"Content is king" and "channel is king" has been the focus of discussion in the media industry. Because of the emergence of mobile news client, it enriches the channels of information dissemination of sports events. However, some of the domestic sports channels over emphasize the importance of "channel is king", they pay too much attention to the sports news release through mobile news client, The design of many sports news client does not focus on the original content, sports news content homogeneity not only will cause waste of media resources, cause the video copyright infringement events, lead to visual fatigue. Lots of audience will be run off.

3.2 The same news client content showed homogeneity

At present, the homogenization of news content in sports events appears not only between different news clients, but also on the same news client platform. The repeated news coverage reduces the user's enthusiasm to use the news client, which is not conducive to the further development of mobile news client. Not only that, some news client on their own brand media coverage of sports news content homogenization problem is also more prominent. For example, the mobile phone client video of CCTV5 is broadly the editing of CCTV5 TV program, Sina sports news client news content is basically the same to the content of sina sports channel portal, which is not conducive to highlight the mobile news client personalization features and features. News content and Sina sports channel portal news client sina sports mobile content is basically the same, which is not conducive to highlight the mobile news client personalized functions and features. It can be seen that the content homogeneity is a major problem that restricts the development of news client, and it is also a difficult problem to be solved in the process of communication.

4. Accurate communication and content innovation: how to use and select mobile news client in sports events

From the foregoing discussion, mobile news client plays an irreplaceable role in a variety of sports communication, which makes people no longer stay passively watching sports games, and allows more people to participate in sports events in the process of communication. But as new information media, mobile news client in the actual application process still faces some difficulties, we must actively get rid of these difficulties, in order to give full play to the role of the mobile news client in the dissemination of sports events in the process, finally we can realize the mobile communication of sports.

4.1 Changing the content of mobile news client design logic to achieve accurate dissemination of sports news

In the process of sports event communication, many mobile news client in the content of the homogeneity of the phenomenon is more serious, one of the important factors is not adhere to the correct content design logic. The continuous news coverage reduces the user's enthusiasm to use the news client, which is not conducive to the sustainable development of mobile news client. Based on this, the sports mobile news client in the content of the production process should first pay attention to distinguish itself from its own portal website, which can rely on the professional content of the portal website to accumulate a certain number of users, But the production level in the mobile news client content, should pay more attention to the user's individual needs, determine the user information in the individual needs of sports events in different stages. And combined with the specific sports scene, produced the sports information of personalized, to achieve accurate dissemination of sports event news. A mobile client in sports information content design we must adhere to this logic thinking, we should focus on the idea of sports content design, in order to adapt to the mobile Internet era sports mobile communication requirements. When reporters of the Tencent, Sohu, Sina News client are doing propaganda Olympic swimming competition, they seize the image of Yuanhui Fu in "the expression" for publicity, not only make every family known "the power" of Yuanhui Fu said, but also let more people pay attention to the China swimming competition, improve the Chinese swimmers awareness, to achieve the precise spread of swimming sports the event. For the spread of table tennis, we should draw lessons from the mobile news client on the swimming competition propaganda method, identify the highlights of the highlights, conduct propaganda and popularize.

4.2 Strengthening mobile news client content innovation

Innovation is the motive force of the survival and development of media, under various sports news clients emerge in an endless stream background, it is difficult to maintain the sports news client news content copy only rely on other platforms, we must innovate the content, we can play sports news client role in the propagation of sports match. At the first, to innovate the selected topic of sports events, and expand the scope of coverage of sports events. In the report of the sports competitions, sports events can be related to the industry, characters, historical background and other good use, which will improve the sports news coverage data of sports mobile news client and expand the sports report view. On the second, increasing the interactive experience, and highlighting the differences of sports news reports. During the 2014 Nanjing Youth Olympic Games, Organizing committee planed and put into effect "the online spiritual baptism, the line of physical and mental participation activities", not only attracted a large number of users concerned about the Youth Olympic Games, but also allowed some audience groups to experience the Youth Olympic Games scene. When we use the sports mobile news client in the publicity of the sports competitions, we can learn from this experience. we can design all kinds of activities in sports events reporting process to enhance the interactive experience of the audience, not only can improve the audience's attention, also can realize the differences of news reports of sports events.

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An analysis on Social Value and Function of Sport of Table tennis in the World from the Perspectives of Education, Politics, Economy, and Culture

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Abstract: Through the principia of sociology, this thesis utilizes the of documents and logic analysis to analyse the relationship between table tennis sports and social development in international areas from educational, political, economic and culture perspectives, in the hope of offering some pertinent advice available to the sustainable development of table tennis around the world. Analysis shows table tennis has strong educational function, can promote physical and mental health, improve interpersonal communication skills and cooperative ability and cultivate awareness of fair competition. Table tennis also serves a unique political function and has become an important means of international diplomacy. Table tennis has become a sports industry, and is of great significance to promote the professional and international progress of table tennis clubs across countries. Through the perspective of sports culture preservation, the culture of table tennis is characterized by shareability and nationality. Through estimation from an innovative angle, measures such as increasing the height of net and reforms on competition rules may become the trend of future development in the future of the table tennis.

Keywords: table tennis, sociology, education, politics, economy, culture

1. INTRODUCTION

Table tennis is a worldwide popular Olympic sport, featured by strong technical characteristics and fierce opposability, and is a kind of sports game that integrates wisdom and passion. Under the vigorous promotion of International Table Tennis Federation (ITTF), table tennis is achieving a rapid development all over the world. This paper used basic principles of sociology to analyze the relation between table tennis and various social systems from educational, political, economic and cultural perspectives. This paper also predicted the future reforms on competition rules, hoping to provide recommendations for the healthy development of table tennis all over the world.

2. TABLE TENNIS HAS STRONG EDUCATIONAL VALUE

2.1 Improve agility, coordination and reaction capability, strengthen cardiopulmonary function and protect vision

Table tennis is an excellent sports game for exercising agility and speed, and is featured by small ball size, fast speed, various changes, and strong technical characteristics. In the process of a competition, the flying speed of a table tennis can reach up to 20 m/s, and usually, a fast attack from the opponent can reach a player's table in only 0.15 s. In such a short time, players shall not only judge the placement, rotation and speed of the incoming ball of the opponent, as well as the opponent's tactical intension quickly and accurately, but also conduct corresponding technical action to return quickly, decisively and coordinatively. Thus it can be seen that table tennis is a sport of great benefit for developing speed, agility, and quick reaction capability.

Table tennis is a sport of medium intensity and featuring aerobic metabolism, has certain enjoyment and intensity of endurance training. Table tennis is a long-term exercise with adjustable intensity, it can prolong diastole and increase myocardial blood supply without causing myocardial ischemia, and is a safe sport. Insisting on exercising table tennis for a long time can improve the oxygen exchange function of respiratory system, increase the capacity and ventilation volume of the lump, and enhance cardiopulmonary function and promote physique enhancement. Since table tennis is characterized by small size, fast speed and various rotation changes, it requires that the players must constantly focus on the incoming ball, continuously adjust the dioptre of crystalline lens according to the back and forth movement and placement changes of the ball, to force the crystalline lens and ciliary muscle to constantly shrink and relax. Meanwhile, table tennis can promote blood circulation of the body. Therefore, table tennis can improve the adjusting capacity of eye mechanism and improve the vision.

2.2 Cultivate people's confidence and sense of enterprising, improve human's intelligence level, and build people's psychological quality and strong will quality

The winning or losing of table tennis games usually comes out immediately after the competition, and such quick and clear feedback information is easier to stimulate people's confident and spirit of enterprising. Table tennis competition enables people to frequently taste the feeling of failure and realize that winning or losing is just a normal and natural result. All the players who lost the game are expecting the next game, hoping to try harder and improve their skills. The competition process of table tennis is complicated, which requires the players to be good at observing the opponent's technical characteristics, analyze the opponent's psychology, and try to figure out the opponent's tactical rules, formulate countermeasures according to actual situations, and decisively give an unexpected return to the opponent. The intellectual competition between players of both sides is rather intensive, therefore, exercising table tennis for long time is good for cultivating independent problem analyzing and solving ability and enable comprehensive intellectual development. Table tennis is a sport of strong competitive characteristics, and during the intense and fierce competition, the players shall keep in a state of high concentration, this requires that the players shall have good physical quality and strong will and perseverance, while such will quality is of great significance for people to adapt to social life. Therefore, doing table tennis exercise for long time is good for the cultivation of psychological quality and will quality.

2.3 Cultivate individual's interpersonal skills, cooperative spirit and sense of fair competition

Table tennis, through exchanging technical skills, communicating ideas and, establishing and maintaining friendship, can enhance mutual trust, understanding and friendship between players. Such social environment which widely builds good and harmonious relationship with others plays a good role in cultivating individual's active social adaption ability. Table tennis players for doubles and team games shall maintain high tacit cooperation, encourage and comfort each other, in order to cultivate individual's cooperative spirit and team spirit. Though sports games reflect the nature of competition in every single aspect, every competition is binding to its own rules. Moreover, due to its characteristics of being equally available for every people to play according to the competition rules, everyone can enjoy its entertainment and share it's fun, no matter whether they are men, women, the old or the young, regardless the race, color, social status or belief. The equal participation nature of table tennis is good for forming the sense of fair competition.

3. ANALYZING POLITICAL FUNCTION OF TABLE TENNIS FROM A PERSPECTIVE OF INTERNATIONAL DIPLOMACY

In 1970s, Chinese diplomacy was under a severe political environment, but fortunately, Chinese leaders creatively took table tennis as the breakthrough to carry out diplomatic offensives, which was called "Ping Pong Diplomacy". The successful experience of "Ping Pong Diplomacy" laid excellent foundation for the contact of Sino-US national leaders. It is the "Ping Pong Diplomacy" that brought President Nixon's visit to China, and the establishment of Sino-US diplomatic relation, which also embodies the gigantic charm of "Ping Pong Diplomacy".

With the improvement of status of table tennis all over the world, top leaders of many countries also consider table tennis as an important sport for national communication. In May 2008, President of the People's Republic of China - Hu Jintao, attended the closing ceremony of Japan-China Friendship Exchange Year 2008 along with current Japanese Prime Minister - Yasuo Fukuda and former Japanese Prime Minister - Nakasone Yasuhiroand, and played table tennis with Japanese table tennis player – Fukuhara Ai. On May 24 2011, American President Obama and his wife visited Britain, President Obama and British Prime Minister Cameron played table tennis and exchanged table tennis skills with students in Globe Academy, London. British Prime Minister Cameron gave American President Obama a ping pong table during his visit to the USA on March 14, 2012, and during his visit to China on December 4, 2013, British Prime Minister Cameron exchanged and played table tennis with primary school students in Longjiang Road Primacy School, Chengdu, Sichuan. Chinese President- Xi Jinping visited Lincoln High School on September 24, 2015 and gave 3 ping pong tables and some table tennis bats and balls to students in Lincoln High School, while all these table tennis ball products are from Chinese table tennis brand – Double Happiness.

Through review and analysis of these examples of "Ping Pong Diplomacy", we can easily figure out that table tennis plays an important role in improving international prestige, enhancing friendship of people of all countries, promoting world peace and so on. Ping Pong Diplomacy is an important diplomatic means for promoting communication and contact of various countries of the world.

4. ANALYZING ECONOMIC VALUE OF TABLE TENNIS FROM A PERSPECTIVE OF PROMOTING MARKET DEVELOPMENT

In the current world, regions where table tennis is flourished are limited to Europe and Asia, while in Europe, table tennis is mainly flourished in Germany, Sweden and a few other countries. Germany is the country that started professional development of table tennis a long time ago, and Germany's professional development of table tennis is dated from 1966, and Germany is considered as the country with the most complete implementation of professional development of table tennis. Germany's professional table tennis clubs, through development of over 50 years, have established perfect operating mechanism (Dou, 2012, p.147). Enterprises or clubs are operating separately, independent from governmental funding. There are complete league tournament organizations, and the government has limited administrative intervention to league tournaments or clubs. Players have strong professional awareness and commonly have a long professional career. The competition system of league tournaments is normalized, which reflects the operation regularity of professional sport clubs under market economy conditions to some extent.

In middle 1990s, Chinese Table Tennis Association launched the competition system of club, and since then, table tennis clubs began to flourish in China (Sun & Wang, 2010, p.68). In 1999, the first China Table Tennis Club Super League was held, marking that Chinese table tennis club league was developing towards the professional road. With the constant evolution of table tennis competitions, the intangible assets such as television broadcasting rights, advertisement naming rights, franchised souvenir with club logos owned by professional table tennis clubs have been effectively developed. Moreover, it also drives the rapid development of fitness entertainment industry, sport agency industry, sport media industry, sport gaming industry, even general service industry such as catering, restaurants, tourism and other related industry. China Table Tennis Club Super League has become the top league recognized in international table tennis circle. It attracts many world famous players including Timo Boll, JOO Se Hyuk, Jorgen Persson, and Miu Hirano to join in. The participation of these famous players brought huge economic benefits and social benefits, raising the attention of numerous news media, even foreign media, has increased the reputation of the League and promoted the development of table tennis industry.

CCTV statistics shows that during the 53rd World Table Tennis Championships hold in Suzhou, China in 2015, which was rebroadcasted by CCTV -5 Channel, the rebroadcasting of Men's Single Final, that is, Ma Long vs Fang Bo, ranked the first among all same-time CCTV programs. The rebroadcasting of Women's Single Final, that is, Ding Ning vs Liu Shiwen also ranked the second among all same-time programs. This shows that table tennis is one of the programs with extremely high audience rating in China. Under such environment, various businesses have recognized this commercial opportunity, and we can see numerous table tennis sponsorships all over the country, for example, Changhong, ANTA, Double Happiness etc. These sponsorship brands have also increased their reputations and obtained huge commercial benefits.

The establishment of professional table tennis club brought vitality for table tennis, and the clubs play an important role of leading the main consumer groups in creating benefits for table tennis industry economy. China Table Tennis Super League, as the top-level league all over the world, plays a significant role in promoting and driving the worldwide development levels of table tennis, accelerating the formation of table tennis industry and so on. China, as the "kingdom" of table tennis, shall make even more effort on accelerating the international and professional development of table tennis clubs and constantly carry out reforms on table tennis clubs to set a good example for the worldwide promotion of table tennis sport.

5. ANALYZING CULTURAL FUNCTION OF TABLE TENNIS SPORT FROM A PERSPECTIVE OF INHERITANCE

5.1 Inheritance of table tennis culture

With the development of economy and society, table tennis has undergone a process of culture accumulation. Table tennis has feature of inheritance, and its heritage process is the process of abandoning the old and promoting the new. China's table tennis culture absorbed the essence of the contemporary world table tennis culture, creating a table tennis culture with Chinese characteristics. The whole process is mutual absorbed, dynamic and harmonious. Fusion, inheritance and changes are constantly happening, so it seems that table tennis has experienced the spread of culture, and then undergone differentiation. People can easily grasp the differences between table tennis and culture, and there was always table tennis culture integration phenomenon in every era. After years of development, people eventually recognized the existence of inheritance value in table tennis, which has now become a kind of advanced culture and been confirmed by history in constant development (Wang, 2014, p.89).

5.2 Shareability of table tennis culture

Table tennis is originated in the UK, and has an authentic western cultural origin. No matter the cultural value carried by table tennis culture or the sport culture embodied by its sport forms, they all reflect strong characteristics of western culture. Western culture and Chinese culture have significant difference, table tennis, as the carrier of western culture, was not rejected by local Chinese culture like other western cultures when it's firstly introduced into China, nor caused any serious conflict between different cultures. On the contrary, table tennis rooted and sprouted in Chinese land, developed and grew strongly, and became the "national sport" of China, as well as a symbol of Chinese culture. The constant spreading of table tennis culture all over the world has been recognized by people of different colors, races and nationalities, therefore, it can be easily seen that table tennis culture is a kind of worldwide shared culture.

5.3 National character of table tennis culture

Table tennis culture has its national character, and table tennis have developed towards different directions at different levels in different nations, regions and countries, and formed distinctively different playing techniques and styles (Li, 2016, p.97). When doing table tennis, people usually understand and recognize its natural rules from their own national culture, therefore, table tennis all over the world have deep national marks, which reflects the diversity of natural cultures, which further formed different playing techniques and tactical styles. For example, Asians are characterized by clear mind and agile reaction, therefore, mainly formed the playing style of short-court pen-hold grip fast attack, for example, Chinese player Liu Guoliang and South Korean player Ryu Seung-Min, as well as the looping playing technique of pen-hold and shake-hand combination fast attack which has rapidly developed in recent years, for example, Chinese player Ma Long in terms of shake-hand playing and Chinese player Xu Xin in terms of pen-hold playing. Europeans are precise, and like being distinguished and taking adventures, therefore, they mainly formed the playing style of shake-hand two-side looping combination fast attack, for example, German player Timo Boll etc.

6. PREDICTION OF DEVELOPMENT TREND OF TABLE TENNIS COMPETITION RULES

6.1 Summary of revisions on international table tennis competition rules in last 7 years

Since the first session of the World Table Tennis Championships in 1926, the world's table tennis has established a history of nearly a hundred years, and has encountered several reforms on competition rules. Since 2010, ITTF has made several main reforms on table tennis competition rules as follows: (1) In May, 2011, ITTF approved resolution of comprehensive prohibition of celluloid balls after the closing of London Olympic Games; (2) Since July 1, 2014, the safe and environmentally friendly new plastic balls made of high-molecular polymer materials are used in all major games including Olympic table tennis matches and tours, World Cup matches, ITTF open tournaments and finals. The diameter of the new ball was changed from the original 39.50 – 40.50mm to 40.00 – 40.60mm, and ITTF requires all new plastic balls shall use the nominal name "40+"; (3) In 2015, ITTF hold a conference to vote through two changes on competition rules. One change is relevant to the nationality. The original rule specifies that after players under the age of 15 who have changed their nationalities shall wait 3 years before representing a new country to participate in the competition; Switzerland Table Tennis Association proposed that if the player did not represent his original country to participate in the game, he can represent a new country to participate in the game after waiting 1 year, and the Board of Directors unanimously passed the proposal; (4) In 2015, the new regulation on thickness detection of table tennis rubber (from Article 6 of Instructions on ITTF Table Tennis Racket Detection T9) specifies that if the detected value of evenness of racket surface is a positive figure, this measured value might be added to the thickness of the racket. (5) Since January, 2016, a new ITTF regulation on nameplates was officially launched, which specifies that for the "Super Series Primer" and "Main Series Primer" matches in world tour games, players must have their names printed on the back of their sport shirts from the beginning of regulation games. (6) On October 1, 2016, the proposal raised by Germany Table Tennis Association "Proposal of allowing coaches to give bench coaching before a score is given during competition process" was officially implemented. In last 7 years, these reforms on competition rules increased the extent of impressiveness of table tennis competitions, advocated audience's interest, to meet their entertainment needs, guide, stimulate and promote the public's consumption on sports items, maximize the benefits of competition events, form circulated feedback mechanism in rule reforms, event organization and management, event operation and all other procedures, and promote sustainable healthy development of table tennis. The purpose of reforms on table tennis rules is to make this sport more popularized to increase the ornamental value of the game and achieve balanced development in different countries and regions of the world (Ren, Feng, Fu, Yu & Wang, 2017, p.58-59). Therefore, it can be predicted that the future reform trend is still aimed at reducing ball speed and increasing the number of rounds.

6.2 Prediction of competition system reforms

6.2.1 Increase of height of table tennis nets or enlarge area of table-tennis tables

The purpose of increasing net height is to reduce ball speed and slow down competition process, while by enlarging the area of table-tennis tables, the number of rounds is increased, which enables the audiences to enjoy excellent competitions (Jia, 2013, p.111). Increasing the height of table tennis nets is good for European players' playing style of middle-court and short-court looping combination fast attack featured by spin, in this way, it will definitely increase the European players' achievements in worldwide table tennis competitions, and make the development of table tennis more balanced along different regions. It is also more beneficial for advocating the activity of other European and American countries to participate in table tennis sports. Meanwhile, it also provides opportunities for the defensive playing style represented by chopping, and further diversifies the playing styles of table tennis sports.

6.2.2 Not calling let service as a result of net service

To increase the degrees of excellence and excitements of the game, 5-point system is adopted in the deciding games in team competitions and single competitions to replace 11-point system, and the rule of winning by two net points ahead opponent in deciding games was cancelled and changed into winning by getting five points first, and such trend will definitely make the competition even more exciting and thrilling.

Regarding the service, net service will not result in calling let service, but is considered as normal service. Such reform has two benefits: on one hand, it can ensure the smoothness of table tennis competitions, and on the other hand, it also reduces the referees' judgment missing and misjudgement of net service.

7. CONCLUSION

In summary, table tennis, as a sports game with rich connotation, can promote physical and mental health, improve cooperative ability and cultivate awareness of fair competition. With the enhancement of its status all over the world, table tennis acts as an important communication means on international political and diplomatic affairs, and also promotes the cultural communication and inheritance between countries. Table tennis has become a sports industry, and promoted the development of sports economy of various countries.

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Theoretical and Practical Knowledge for Table Tennis Coaches Development in a Sports Science Bachelor's Degree

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Abstract: This study aims to describe an extra-curriculum program for table tennis coaching practice during a Sports Science Bachelor's Degree in Brazil. We describe the contributions of the program for table tennis coaches' development. The program was based on bottom-up approach, which eight undergraduate students designed the classes/training activities and they were supervised weekly by three professors (PhD) of different knowledge areas. These supervision meetings were thus important to students integrate theoretical and practical knowledge. The proposed program contributed for table tennis coaches' development in a Sports Science Bachelor's Degree in Brazil.

Keywords: sport coaching, table tennis, game-based pedagogy

1. INTRODUCTION

In Brazil, the Bachelor degree in Sports Science/Physical Education is mandatory to be a sport coach in most sport, as in table tennis (Brasil, 1998). However, these Undergraduate courses´ curriculum have not been focused on coaches' specific competences, giving more support for a general intervention in participation sport level (Milistetd, Trudel, Mequita and Nascimento, 2014). Racket sports, as table tennis, are less regular on Undergraduate curriculum. It is more common we find collective sports, as athleticism and swimming. Besides that, in all sports is usual to approach in a traditional discipline structure with a few connections with others sports or extracurricular experiences and the coaching relationship in practice. Additionally, the curriculum presents few of coaching practice, which is fundamental to the coaches' development (Milistetd, 2015).

In University context, there is a few variation of learning experiences, mainly practice; it makes this environment restrictive for sport coaching skills and competences development. This is because the literature indicates that the coach learns in various contexts and from various sources. Nelson et al. (2006) organize these sources in three possibilities: (1) Formal Sources: programs developed in educational systems and institutionalized (undergraduate programs, graduate programs, and professional certificate programs); (2) Non-Formal Sources: educational activities organized and systematized outside of formal contexts with the purpose of developing specific knowledge for specific groups (seminars, speeches, workshops, conferences); (3) Informal Sources: daily experiences and interaction situations with the environment (experience as an athlete, reflection, experience as a coach, books, internet, sharing experiences).

Although it recognized the value of formal sources – as our academic context – and non-formal sources of knowledge, researches prove that informal sources are identified by coaches as being more significant for learning to operate and to develop as such (Côté, 2006; Nelson et al., 2006; Milistetd, 2015). This reality is justified because the formal and non-formal programs, even though introduces an essential concept for the training of coaches, in most cases is addressed through prescriptive methodologies and in a decontextualized way of the reality of the coaches (Wilson et al., 2010; Jones et al., 2012; Trudel et al., 2010; Milistetd, 2015; Milistetd et al., 2014).

Considering coach development as an all-encompassing term that refers to the process leading towards enhanced expertise (Mallett, Trudel, Lyle and Rynne, 2009, p.325), we identify a gap on Brazilian coach's development model at University: how can this context provides trainee coaches practical experience on the field, once they cannot coach without the degree? In addition to simulated practice opportunities in disciplines and internships, university extension programs seem to be an important option (Mililstetd, 2015).

From this, this study aims to describe an extra-curriculum programme for table tennis coaching practice during a Sports Science Bachelor's Degree.

2. METHODS

The project drew upon a qualitative approach, with immersion in the practical field – a Sport Science course in a Brazilian University – using the Action-Research (Thiollent, 2011) as a method and the Field Diary as a research tool.

2.1 Participants

Three PhD professors with three different backgrounds (Sport Pedagogy, Exercise Physiology, and Biomechanics) are the central participants of this research. In an interdisciplinary approach, they organized this coach development program, with in deep participation of eight undergraduate students of a Sport Science course, considered here as "trainee coaches".

The PhD professors organized a learning context focused on students, using problem-based learning, providing real situations to be solved by the trainee coaches. This process is the focus of this study.

2.2 Data

In this process of searching new ways to professional development and continuing education, the Action Research has been pointed out as consistent and effective perspective. Tripp (2005) argues that Action Research is a strategy for teacher improvement, seeking to improve teaching, in favor for students learning. Action Research is a method that the researcher participates directly in the reflections about the work and was chosen for facilitating organizing and systematizing a course proposal for trainers, in order to potentiate their education, making it possible to share this didactic experience.

For Thiollent (2011) is an empirical basis research, with a strict relation with the practical intervention in the action or resolution of a collective problem by researchers and participants, all involved in a cooperative or participatory manner. The aims of the coaches' course were to equip coaches to deal concrete issues of the empirical context. So we suggested as a main theme the construction of teaching-training pedagogical procedures in table tennis from an interdisciplinary perspective.

The program comprising a total of 30 classes (45 h) per 4 months, and was focused on game-based pedagogy. It was based on bottom-up approach, which eight undergraduate students designing the sessions activities, been supervised weekly by the three supervisor professors.

In addition to applying training for beginner table tennis players, the trainee coaches were participating in fortnightly meetings with PhD supervisors, in which different themes were addressed, among them: design of games for the teaching of table tennis, composition of a training session, differences in approach between beginner and advanced athletes, teaching-training ball spin, the application of guided discovery in the teaching-training of the sport. Besides that, professional of other racket sports were invited to introduce their teaching-training perspective. Another element considered throughout the process was the interface between teaching-training and research. Formations and research experiences were promoted, in a way complementary to those interested, in two projects: one is about non-linear pedagogy in the teaching of table tennis and another on the evaluation of strategic-tactical competences in the modality.

With regard to ethical care, this study was approved by the local research ethics committee.

3. RESULTS

3.1 Describing the program

In the Brazilian context, pedagogical issues seem not to be most emphasized in sport research, including Table Tennis. For example, there is an absence of scientific references about coaching and Table Tennis. A review was made in Brazilian journals between 2000 and 2015, and only one paper on this subject was identified (Galatti et al., 2016). Without scientific support on coaching qualification in table tennis, especially in the Brazilian context, we decided to offer a program for students of Sport Sciences from School of Applied Sciences– University of Campinas.

Our decision is justified since the preparation through certification courses and updating have shown to be valuable for the development of sports coaches (Nelson et al., 2006), however, it is the experiences in practice that have been recognized by coaches as key learning opportunities (Lemyre, Trudel, & Durand-Bush, 2007; Stoszkolski and Collins, 2016).

This is explained by the fact that these experiences provide opportunities for learning mechanisms other than memorizing or reproducing information, which are still very frequent in university disciplines or courses for coaches offered by federations (Milistetd et al., 2014; 2016). In coaches' case, information from their own context has greater meaning, since they involve their own action, feelings and reflection, leading to a greater impact on their learning (Callary, Werthner, & Trudel, 2012). However, there is a concern that these experiences do not ensure quality learning, because in many cases the coaches may end up only replicating the practice of other trainers and common sense (Cushion et al., 2010). Therefore, the current suggestions on the development of sports coaches suggest a combination of formative processes and learning experiences in different contexts, such as in universities, workshops and workplaces (International Council for Coaching Excellence [ICCE], 2013). That said, besides a general discipline of Racket Sports, we offer in our curriculum a specific elective discipline of Table Tennis, so that the trainee coaches have a curricular structure, which supports the practical program in table tennis.

The trainee coaches were encouraged to propose the training activities based on scientific evidences, and to develop research proposals from this coaching practice. The supervision meetings were important to integrate theoretical and practical knowledge. We observed a difficulty by the students to develop their initial classes/training, which was minimized throughout the programme. Thus, they were able to design a session focused on athlete`s competences and games (not on drills); communicate with athletes by questioning, not showing or telling them what to do; and reflect about their own coaching skills.

According to Côté (2006) coaches learn to train through three specific situations: their previous experiences as an athlete, their learning experiences as a coach and through educational programs aimed at coaches. It is from these learning situations that they acquire the professional, interpersonal and intrapersonal skills necessary for their performance as coaches. With this, we assumed that by increasing their knowledge and skills in dealing with difficult situations, we would enable coaches to succeed in specific situations. It was up to the trainee coaches to prepare and apply the classes and the supervisors had the role of mediators of the process, following the planning, evaluating the classes already given, indicating readings and stimulating the reflection on the action, based on active methodologies of education and expanding their professional competences (Cortela, Milistetd, Galatti, Crespo & Balbinotti, 2017). Therefore, the supervisors had the role of proposing problems for the trainee coaches, who would seek for solutions in meetings without the participation of the supervisors, based on the practical experiences that they had during the semester.

In addition, the experience gained by both the trainee coaches and the supervisors themselves were considered by time and as the program was successful, new challenges were being incorporated into the trainee coaches. For example, at the end of 2014, the most experienced trainee coaches were able to restructure a tactical-technical periodization, prioritizing basic skills for the game at the beginning of the semester and specific at the end, in the following composition of contents: tactical fundamentals, ready position, serve, forehand and backhand, and basics notion of spin.

This base was applied in two more offers of late-start programs, one in the first half of 2015, and another in the second half of the same year.

In the second half of 2015, the program reached its maturity, comprising 30 classes (45 h) during 4 months, and had the focus on applying nonlinear pedagogy. It was based on a bottom-up approach, which eight undergraduate students designed the classes /training activities.

This model was maintained in 2016. In the last 8 months, we have advanced from the proposition of training based on scientific evidence for the production of science from the intervention of the trainer. Thus, the trainee coaches with interest in researching were organized into two groups, which, with the supervision of the PhD teachers began to develop tests for evaluation of complex skills in table tennis, as well as organize the teaching proposal role focused on the teaching-training of the modality in a Non Linear Pedagogy approach. (Chow, 2013). Therefore, the literature that previously supported the practice of coaches is now, also the base for them to develop methods of evaluation of their athletes and to contribute with the training of other coaches, offering a new methodological proposal for table tennis.

As part of the process of construction and execution of this project, meetings for planning and structuring occurred with weekly attendance, with the teachers as mediators of the process and meetings only between the monitors to prepare the classes. In order to strengthen this environment, we built an Interdisciplinary Research Group on Racket Sports (GRIPER), School of Applied Sciences, University of Campinas.

GRIPER's discussions have addressed specially our guiding problem: to construct and investigate teaching-training methodologies in table tennis from an interdisciplinary view and dialogue.

4. CONCLUSION

Table tennis coaches need to master a range of expertise in different areas, and some of these are acquired from coaching practice. The proposed programme contributed to a table tennis coaches development in a Sports Science Bachelor’s Degree in Brazil.

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Fundamental Stage of Development in Table Tennis (Polish Experience)

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Abstract: The purpose of this article is to describe the development of the program realized in Poland from 2010 to 2017 "FUNdamentals, from dream to Mastery in table tennis". We define FUNdamental stage as initial and basic stages of development of Primary School children. On the basis of the theoretical model in 2009 we started the program for children, coaches, managers, parents etc. Until 2017 it has been growing as constantly improving prototype on small scale including: over 200 whole-day workshops for coaches in 20 cities; over 500 two hours' skype teleseminars; over 150 coaches had finished the program FUNdamentals 1; over 30 coaches had finished FUNdamentals 2; over 2000 children participated in the program; almost 1000 children attended over 20 training camps. In the process of continuous monitoring: observation forms, skill observation charts, match analysis, interviews with participants, testing, after action reviews and other action research principles and tools were used. The presentation in the article includes main issues of how do people develop within the program (trainers, children); how is the training culture developed (relationships between people); how does the FUNdamental's training system (clubs, classes, schools) develop; what conclusions are drawn from monitoring the program for further improvement.

Keywords: FUNdamental stage, development of children and coaches, training culture, training system.

1. INTRODUCTION

The purpose of this article. The purpose of this article is to describe the development of the program realized in Poland from 2010 to 2017 "FUNdamentals, from dream to Mastery in table tennis". In this article we want to answer (a) how do people develop within the program (trainers, children)? (b) how is the training culture developed (relationships between people)? (c) how does the FUNdamental's training system (training centers) develop? (d) what conclusions are drawn from monitoring the program for further improvement?

Training system in table tennis. The table tennis training system is a set of interrelated elements: people, material resources, procedures and goals. The vision of integral table tennis training system [8] takes into account three aspects:

a) personal development of people (human capital), i.e. the personal mastery of players, trainers, leaders of organizations, parents;

b) the development of culture (social capital), i.e. synergy, communication based on good agreement and trust, team spirit, etc.);

c) developing a system that is monitoring, setting goals and objectives, organizing and managing training, planning, implementing, and verifying the functioning of the entire organization.

Research on the training system in Poland [7] showed that a particularly weak link in Poland was the initial and primary period (children aged 6-13 years).

FUNdamental stage of children's development. The paper is about FUNdamental stage, defined as it was presented by Istvan Balyi in the lecture "Long Term Athlete Development", during 5th Professional and National Coaches Seminar in Sydney 1999 and as it was defined in the book "Integralny tenis stołowy" [8] on page 357: FUNdamental stage 1 is about general FUNdamentals with optimal age 6-8, and FUNdamental stage 2 is about specific FUNdamentals with optimal age 9-12. The latest version of "FUNdamentals", "Learn to Train", "Train to Train" etc. concept of Balyi, Way, Higgs [1] was published in 2013, few year after the program "FUNdamentals, from dream to Mastery" (in Poland) was started. So, "FUNdamentals 2 stage" can be also named as "Learn to Train stage" with optimal age 9-12 (usually before puberty). FUNdamental program is mainly for Primary schools children of 6-13. It is the best time to master the complete table tennis technical skills. FUNdamentals 2 stage is the best stage for building specific technical-tactical fundamentals according to chosen playing type-style.

Program "FUNdamentals, from dream to Mastery in table tennis". In 2010, we launched the program "FUNdamenals, from dream to Mastery", which had the following assumptions:

a) the use of world-wide knowledge [1, 3-6, 8-24, 27, 29-44] of the training and education of children between 6 and 13 years of age in different systems, with particular reference to how the world's masters are trained (and where evidence is most based);

b) training of trainers, physical education teachers and parents to be able to organize and develop children's training;

c) FUNdamental stage children's training;

d) the development of culture based on the principles of mastery, mindfulness and cooperation [2, 8, 14, 26];

e) development of the system - the network of training centers (schools, classes and clubs) in which FUNdamentals 1 and FUNdamentals 2 are run [8].

In the years 2010-2017, within the framework of the program, we completed, among others: over 200 days of whole-day workshops for trainers / leaders in more than 20 cities; over 500 two-hour skype teleconferences; over 150 trainers have completed the annual training program FUNdamentals 1; more than 30 trainers have completed the annual training program FUNdamentals 2; nearly 1000 children participated in 23 summer and winter training camps; so far, over 2000 children have been trained in various places in Poland.

The program is constantly developing and refining new coaching resources.

2. METHODS

Action research. The research method used in the study was the action research of

Ernest T.Springer [28]. In this process the following procedures were used: (a) watching-collecting data; (b) thinking - research and analysis: what is going on? how? why? (c) action - plan, implementation and evaluation.

After Action Review. One of the main tools used systematically after each training cycle is the After Action Review method [25]. Under this method, program participants answered the following questions: (a) what was expected to happen? (b) what actually occurred? (c) what went well and why? (d) what can be improved and how?

Other research tools. Specific tools were used to study the level of motoric qualities tests [8], technical structure check-lists of Wang Jiazheng and Wu Xiuwen [8], technical quality testing of Liu Tianyang [18], game analysis of Wu Huanqun [8, 36] and psychological inventory of James Loehr [8] were used in the study.

3. RESULTS

3.1. Personal development of young players. It seems that the most developed are those children who realise the whole offered program:

• In physical training - they like sport and are willing to carry out all coordination exercises, agility, speed, power (and do not spend too much time in front of the computer etc.);

• In mental training, they have largely developed inner motivation to constantly improve their technical skills, physical fitness, positive attitude and mindfulness;

• In technical training - they understand the priority of learning to improve the technique at the stage of development in which they are and know why:

- in each lesson, we use presentations of the world's best patterns in a given technique, we do imitation training, multi-ball training, one-ball training, testing tasks, monitor the performance with video camera, summarize each training session;

At the end of each training session we encourage children to summarize their attitudes, attentiveness and quality of training, we encourage them to keep a training diary;

- after each cycle / camp we work together with children and the team of trainers "characteristics of the player" where we summarize progress, test results, etc .;

- In technical training we use technical presentations of the world's best training materials, such as "Dahao pingpangqiu" [43,44,41] while teaching children basic technical terms in Chinese, because there are no equivalents in the Polish language, etc.;

• In tactical training (as in technical training), they practice with motivation and understanding why: during internal competitions we use tactical presentations, we follow closely what works and what does not work, the players share their reflections, coaches summarize the performances together, we do interviews with children so as to maximize development of tactical awareness;

3.2. Personal development of trainers and leaders of the organization. It seems that in the program trainers make the most significant progress in technical, methodical, and organisational knowledge and skills who:

• participate in training workshops for technical trainers (F1, F2), physical (F0), mental (F3), tactical (F5) and construction of the training system (F4);

• are constantly studying training materials on various aspects of training and organization;

• take active part in training camps where they train for 10 days under supervision and in cooperation with other trainers and participate in evening after-day checks, technical analysis, competition analysis, etc. .;

• participate in weekly teleconferences, during which we cover the full spectrum of training and organizational issues and current issues;

• they are the most able to transfer knowledge and skills developed during workshops, camps and teleconferences to work in their day training center, club.

3.3. Development of culture. Clubs and teams that are developing the most cultivate a culture based on the pursuit of personal mastery, healthy communication and cooperation:

• they are particularly active in training, teleconferencing, camps;

• participate in weekly teleconferences;

• have developed the tools of effective communication internally and externally (with local authorities, schools, parents, other participants in the program), using everyday communication tools offered by Otto Scharmer in his leading from the emerging future and U-lab program [26]: "presencing”, “deep listening," “talks in organizations”, “empathetic walk”, “case clinic” etc. .;

• constantly exchange training and organizational experiences during workshops, teleconferences, camps, competitions;

• take part in joint ventures, especially during camps such as museum exits, cruises, boat trips, meeting interesting people, watching inspirational films (like "As One", "Pollyanna", "Bragden", “Peaceful Warrior”), as well as singing specially written for training camp songs with motivational content for fair training;

• create environments that meet the basic needs of children - interest, recognition, trust, respect, independence, responsibility [24].

3.4. Development of training system for 6-13 years old children. Clubs that are growing the most:

• have a particularly committed leader / leader who has initiated the major processes of integral development of people, relationships, and systems;

• have created the team - several coaches and trainers;

• create a learning organization together: they choose people who aspire to personal mastery; have a common vision; they jointly set goals, implement them and summarize them;

• create conditions for practically unlimited training opportunities for the most talented children;

• create network of training centers around a central location, in the form of classes and sports schools;

• develop particularly good relationships with parents who help and invest in their children;

• introduce a continuous monitoring system for trainers and players - do summary of the exercise, training, season, motor, technical, game analysis, mental toughness inventory, etc.;

• in the planning process, taking into account the design of (1) the deliberate practice, (2) the integral lesson, (3) the annual plan and (4) the perspective plan.

4. DISCUSSION & CONCLUSIONS

We are aware of the fact that we are still far from the level that China and the leading Asian countries have. In Polish society there is no fashion for sports in general, and fashion for table tennis in particular. Table tennis is not in the mainstream media in Poland. Some internet media offer vitriolic viewpoints. Program FUNdamentals is an innovative program that is very different from the standards accepted in Polish clubs, where there is recreational training and individual lessons with the "most talented" children. We do not have scientific cooperation with universities. At the academies of physical education, table tennis coaches are not trained, so graduates who are physical education teachers do not know the basics of table tennis. In Poland, the social status of the coach fell. Trainers work without financial gratification. We have many challenges – eg. developing skills to deal with difficult emotions during the competition and treating mistakes, adversities and failures as lessons to learn. The challenge is to create similar age groups of 6-7 year olds who work together on the program. The group of people associated with the program is small so there is a need for further development of number of coaches. We can probably improve our website and marketing significantly. Working with the system under these conditions requires huge personal sacrifices from the trainers.

However, there are many positive implications for the program:

• Three clubs have developed to the greatest extent: Bogoria Grodzisk Mazowiecki, LKTS Luboń, MKS Czechowice-Dziedzice; These clubs have extensive small training centers network around the central training facility; Currently they belong to the best in their regions;

• In the following years, children trained in the program started appearing on nationwide children's competitions and gradually getting better and better sports results;

• In May 2017 the Under 13 champion of Poland was a 10-year-old trained in our program;

• Among the nation's top children we have players playing different styles: two-wings topspin shakehand grip, fast and topspin shakehand grip, two-wings attack with penhold grip, backhand-chop+forehand-attack defender, etc.;

• In May 2017 a small group of children from the program debuts in the Cadet Challenge in Cetniewo;

• In 2016 we started cooperation with the Polish Superleague to create a network of training centers around all the leading clubs in Poland;

• Program FUNdamentals leads to the development of a completely different culture, creating healthy relationships between people, moving the conversation to another level;

• Both children and coaches, from different parts of the country, have a sense of community, usually like to train, work, compete and spend time together;

• In the program we have a group of passionate people who love what they do and this work is meaningful for them;

• The history of the development of the program and documentation of various actions can be found on the pages of integral table tennis:

www.integralnytenstolowy.com and on facebook;

• So far the program was developed as a small-scale prototype, but we are currently working with the PTTF on the transfer of the program into a nationwide scale;

• During the program period 2009-2017, thousands of video clips, audio recordings, mental maps, photos, and so forth were collected and recorded; We have not had the opportunity to develop it all yet;

• Probably from an academic point of view, an integral model for training children aged 6-13 years requires further and deeper research - more elaboration, using quantitative methods, system analysis etc.

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PART 3
Posters

VISUALIZATION OF TABLE TENNIS SKILL BY NEURAL NETWORKS AND FUZZY INFERENCE

: For Realization of Artificial Coach

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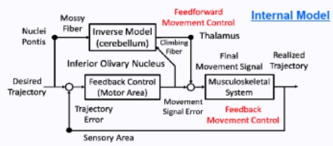
Kansai University, Kansai University, Hannan University, Hannan University, Doshisha University

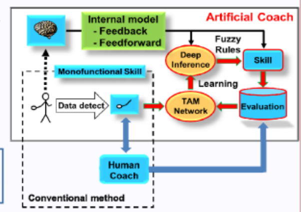
ABSTRACT : The internal model is based on the model of Allen-Tsukahara and is able to express physical motion by associativity of feedback and feedforward control processes. The Topographic Attentive Mapping (TAM) network is a biologically-inspired classifier that bears similarities to the human visual system. The proposed pruning algorithm allows extracting knowledge as represented by the network structure. Deep Inference by Fuzzy Inference is a representation method of mapping inputs to outputs using fuzzy set theory and ensemble learning. In this paper, the technique rules are extracted by learning algorithm in order to classify the skill level of players of table tennis from the sensor data with the TAM network and Deep Inference by Fuzzy Inference. In addition, the difference between the elite player and beginner is visualized, and how to improve skills specific to table tennis as an "Artificial Coach" is discussed.

Internal Model and Artificial Coach

- In the forward component of the internal model, the output is controlled by motion so that the actual movement trajectory converges onto the target position as much as possible.
- In the inverse model, low-level learning is slow, but learning is performed so that the error between the position of the motion signal and the position of the actual trajectory of the movement decreases, so as to adjust the position of the actual movement using signals from the forward model.

Internal Model



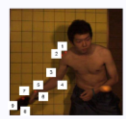


Purpose of this Study

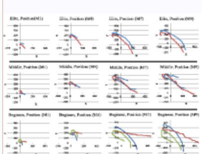
In this paper, a dataset of forehand strokes of table tennis is analyzed with a TAM network and a deep inference which is a boosted TAM network. In addition, fuzzy rules describing the skill of forehand strokes are extracted depending on the player's performance level.

Experiment

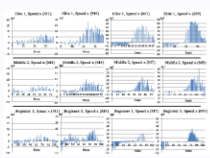
- A pitching machine (Yamato table tennis Co., Ltd., TSP2050) was set at about 30 cm from the end line of the table and diagonally from the subject.
- Balls were set to be thrown at elevations of 20 degrees, 25 speed levels and 30 pace levels.
- A 90 fps high-speed camera (Digimo Campany, VCC-H300, resolution: 512 × 512 pixel) was used to record subjects for 10 min what resulted in 54000 recorded frames. From this data, image sequences of 40 to 120 frames were extracted.
- During each 10 min recording, the subject continued swinging the racket for 100 to 150 times.
- Fifteen subjects were divided into three groups:
  - 7 Elite players: who belonged to the table tennis club of the Hannan University.
  - 3 Middle level player: who had previously belonged to a table tennis club during their junior high school or high school.
  - 5 Beginner: without any table tennis experience.
- Nine measurement markers were set to detect movement on the right upper arm of subjects, at 1) the acromioclavicular joint, 2) the acromion,3) the head of radius, 4) the head of ulna, 5) the styloid process of radius, 6) the styloid process of ulna, 7) the right apex marker in the racket edge, 8) the left apex marker in the racket edge, and 9) the upper apex marker in the racket.



Measurement Markers



Position



Velocity

Correlation Coefficients

Player	Horizontal (x)	Vertical (y)
Elite	0.985	0.790
Middle	0.919	0.607
Beginner	0.073	-0.04

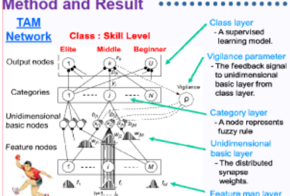
Width of Swing Pattern

Player	M_1		M_4		M_9	
	Min	Max	Min	Max	Min	Max
Elite	-3	114	-29	254	-267	372
Middle	-10	116	-25	236	-218	577
Beginner	-33	152	-50	239	-214	697

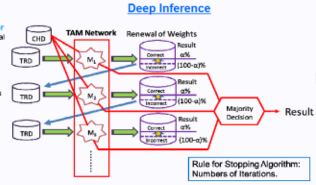
- Since the correlation coefficients were evaluated at 0.985 in the *x* direction and 0.79 in the *y* direction, respectively, elite players thus acquired a fairly stable racket swinging motion.
- Regarding the width of the swing pattern in the horizontal direction (*x*) at the first (M_1), fourth (M_4) and ninth (M_9) markers, elite players appear to swing rather compactly, whereas beginners make large swings.
- The swing pattern of elite players allowed them to reach maximum speed at the point of contact with the ball.
- Looking at the swing speed of beginners at marker M_9, the speed appears to be reduced just before hitting the ball, and subjects seem to wait until the ball hits the racket. This is sometimes referred to as either "a movement to meet a ball with the racket" or "a movement to delay the body".

Method and Result

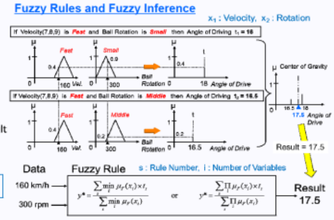
TAM Network

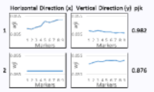


Deep Inference



Fuzzy Rules and Fuzzy Inference





Rules of Elite Players

Rules of Beginners

Input Variables of Rules

x, y	Input Variables
1	position(1,2)
2	position(3,4)
3	positon(5,6)
4	position(7,8)
5	position(9)
6	velocity(1,2) =⊿ position (1,2)
7	velocity(3,4) =⊿ position (3,4)
8	velocity(5,6) =⊿ position (5,6)
9	velocity(7,8) =⊿ position (7,8)
10	velocity(9) =⊿ position (9)
11	position(3,4) / position (1,2)
12	position(9) / position (1,2)
13	position(9) / position (3,4)
14	position(9) / position (5,6)
15	velocity(3,4) / velocity (1,2)
16	velocity(9) / velocity (1,2)
17	velocity(9) / velocity (3,4)
18	velocity(9) / velocity (5,6)

Rules of Elite Players (x) Rules of Elite Players (y)

Rules of Beginners (x) Rules of Beginners (y)

- In this Figure, the difference between the elite player and the beginner is shown very conspicuously, making it easy to formulate table tennis skills as a rule.

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XV. ITTF SPORTS SCIENCE CONGRESS
Düsseldorf 2017

NOTATIONAL ANALYSIS IN TOP-LEVEL TABLE TENNIS: A CASE STUDY

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1. INTRODUCTION

The analysis of competitive performance, known as performance analysis, has achieved a significant position among sports sciences. Hughes & Franks emphasized that notational analysis is useful for several purposes, such as technical/tactical evaluation, motion analysis, and the development of databases or reference models for coaches and athletes [1]. Hughes & Bartlett analyzed the structure of various sports disciplines, identifying different kinds of indicators: technical indicators (shots, footwork, etc.), tactical indicators (direction of shots, etc.), and biomechanical indicators [2]. In Table Tennis, notational analysis is mainly used to investigate shots' effectiveness and to compare different categories of players [3][4].

2. AIM OF THE STUDY

This study aimed to analyse a selection of technical/tactical indicators during top-level Table Tennis matches performed by the same top-level Table Tennis Player (TTP). A complete set of performance indicators were collected by video analysis: shots, footwork, impact position of the ball on the table and rally outcome. It could be useful to obtain an individual performance profile.

3. METHODS

Eight matches of a TTP, played against eight different opponents (OPP) in 2013-2014 international tournaments were randomly selected. The selected matches were downloaded from the websites www.ittf.com and www.ettu.org. Each match was analyzed in slow motion with the software Kinovea (www.kinovea.org), at a replay speed one fifth of the real one (0.2X).

The type of stroke used by the players (service, push, top spin, block, top counter top, smash, lob, drive and flick) was recorded for each shot. This shot type classification is based on a general technical model associated to an internationally shared terminology [5][6]. The others classification are based on a previous study about notational analysis [4].

Previous studies showed a very good intra- and inter-observer reliability of stroke types as recorded in actual table tennis matches using the present classification and methodology [4][7].

4.1 RESULTS

The shot most used by TTP was topspin (26.4%), followed by service (21.8%), push (19.0%), block (14.7%), top c. top (10.6%), flick (5.7%) and others (1.8%).

When considering forehand and backhand shots, TTP preferred to play topspin-F (20.2%), push-F (14.8%), block-B (14.2%), topspin-B (13.5%), and top c. top-F (12.3%). OPP showed similar shot distributions.

The distribution of footwork for TTP was: one step (37.0 %), chassè (21.0%), no step (18.0%), crossover (11.2%), pivot (11.2%), and Slide (1.6%), while for OPP the distribution was: one step (37.0%), no step (24.0%), chassè (18.0%), crossover (10.0%) and pivot (6.5%).

Concerning the area, TTP received serves mostly in area 3 (54.3%), 2 (24.5%), and 5 (4.8%), while he served mostly in area 2 (42.0%), 3 (30.0%), and 5 (17.0%).

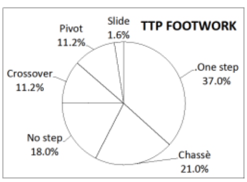
Finally, winning shots for TTP were topspin-F (39.0%), topspin-B (19.0%), while TTP errors were top spin-F (19.0%), block-B (19.0%), top c. top-F (18.0%).

TTP SHOT DISTRIBUTION (%)

Top	26.4
Service	21.8
Push	19.0
Block	14.7
Top c. top	10.6
Flick	5.7
Others	1.8
TOT	100

TTP SHOT DISTRIBUTION (%)
considering forehand and backhand execution

Top forehand	20.2
Push forehand	14.8
Block backhand	14.2
Top backhand	13.5
Top c. top forehand	12.3
Push backhand	9.6
Block forehand	4.6
Flick backhand	3.7
Flick forehand	3.6
Others	3.5
TOT	100



TTP RECEIVING AREAS (%)

3.4	54.3	24.5
9.1	3.8	4.8

TTP SERVING AREAS (%)

3.1	1.4	17.0
42.0	29.7	6.7

TTP SHOT OUTCOME (%)

	WINNING	ERRORS
Top forehand	38,9	18,9
Top backhand	18,5	11,4
Push forehand	13,0	7,7
Top c. top forehand	9,3	18,0
Block backhand	5,6	18,9
Flick backhand	5,6	4,0
Block forehand	1,9	8,3
Flick forehand	1,9	4,0
Others	5,6	8,9
TOT	100,0	100,0

4.2 RESULTS

Considering the relationship between Footwork and Shot distribution, TTP used One step followed by Push-f (39.2%), Push-b (24.7%), Top-f (12.0%), flick-f (9.1%), flick-b (7.3%), etc. TTP performed a Chassè to play a Block-b (32.5%), Top-f (22.9%), Top-b (17.8%), Top c. top-f (7.3%), Block-f (6.1%), etc. No steps are followed by Top-b (34.0%), Block-b (30.9%), Top c. top-f (10.2%), Block-f (10.2%), top-f (8.3%), etc. Crossover is linked with Top c. top-f (44.4%), Top-f (30.8%), Block-f (5.9%), Top-b (5.9%), etc. Pivot step are directly linked with forehand shots: top (54.8), Top c. top (36.3%), etc.

5. CONCLUSIONS

The analysis of competitive performance may have important applications in table tennis, both when carried out in real time or after the match. Knowing the distributions of shot types, footwork types, and shot outcomes, as well as the relationships between these variables, would be of interest for coaches, players, and performance analysts. Analyzing the performance of a top-level player would allow to develop a technical/tactical reference model useful to plan appropriate training for players of all categories.

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FIFTY YEARS OF TOP-CLASS TABLE TENNIS WORLD RANKING

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XV. ITTF SPORTS SCIENCE CONGRESS

Düsseldorf 2017

INTRODUCTION

Recent reports suggest that 10–13% of the western population is left-handed [1]. In table tennis, an interactive sport characterized by indirect opposition, previous studies confirmed an overrepresentation of left-handed players [1] with a proportion higher, among top-level athletes, than in the other main racket sports [2].

AIM OF THE STUDY

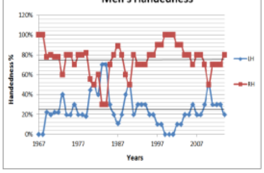
The aim of this study was to analyse the athletes' handedness distribution in the last fifty years of world table tennis rankings, linked to the grip, style of play, and nationality in order to better understand the historical and technical evolution of this sport.

METHODS

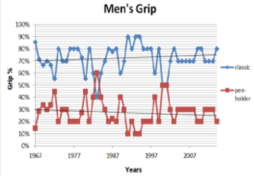
One world ranking for every year from 1967 to 2017 was examined by identifying the first 10 male (M) and female (F) players. For each player the handedness (left- or right-handed), grip (classic or pen-holder), style of play (offensive or defensive) and nationality were recorded.

- Handedness was established according to which hand was used to hold the racket, according to literature [3][4].
- Grip was established following the description of the ITTF manuals [5][6], distinguishing the European/classic and pen-hold grip.
- Style of play is based on different kind of racquet coverings. Players with long pimples rubber should be considered defenders. All the other players should be considered offensive players.
- Data collection about nationality is based on the official ITTF World Ranking.

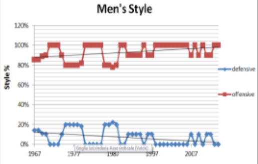
Men's Handedness



Men's Grip



Men's Style



RESULTS

All data are presented as percentages

HANDEDNESS

Left-handed are overrepresented (M: 25.4; F: 22.6) with respect to the normal population (10-13%).

GRIP

The classic grip is the most used (M: 72.8; F: 72.5). In M players, a slight increase was observed while in F since 1985 until today the classic grip showed an important increase.

STYLE

The predominant playing style is offensive (M: 93.4; F: 88.9) with an increasing trend in M and F.

NATIONALITY

In M the most represented nation is China (39.6) followed by Sweden (12.8), Japan (7.8), Korea (5.1), Germany (4.9), Yugoslavia (4.3).

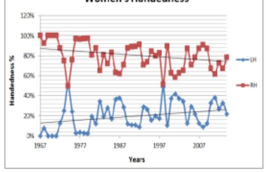
In F: China (50.4), Japan (8.8), Korea (7.3), PRK (4.6), USSR (3.1), Singapore (2.9), and Hungary (2.4).

In the last 50 years the Asian athletes have dominated the world rankings (M: 56.5; F: 50.4). This domination started in 2003 for M, after a period of substantial balance with Europeans and for F it constantly increases since 1971. Asians are followed by Europeans (M: 43.3; F: 18.8) and Americans (M: 0.2; F: 0.1).

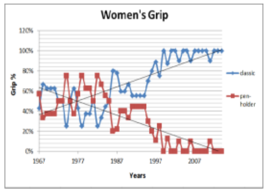
CONCLUSIONS

The study findings confirm an overrepresentation of left-handed players in top-class Table Tennis, both in men and women. Trends about the grip used by professional players suggest that the classical grip is the most used and the pen-hold grip is going to be less frequent especially between female players. The same result was observed concerning defensive style of play, with an increasing number of offensive players in both male and female top-level players. Observing 50 years of world ranking, Asian domination should be considered a recent trend in the history of Table Tennis.

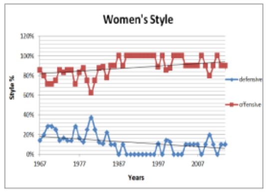
Women's Handedness



Women's Grip



Women's Style



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LIEBHERR WORLD TABLE TENNIS CHAMPIONSHIPS DÜSSELDORF 2017


Determinants for Table Tennis Performance in Elite Scottish Youth Players using a Multidimensional Approach: a Pilot Study
Sean Doherty, Guillaume Martinent, Amanda Martindale, Irene Faber
Why this study?
The purpose of the study was to explore whether a multidimensional profiling approach including training history, anthropometrics (biological age), motor skills and psychological factors can be useful in predicting table tennis player's performance.
What was done?
A purposive sample of 14 male Scottish junior table tennis players (15.3 years ± 1.2) ranked between 1 to 25 in the junior national ranking list were recruited.
Each player individually first completed questionnaires concerning their training history and the psychological skills (motivation, emotional regulation and self regulation in learning). Consecutively, anthropometrics and motor skill (eye-hand coordination and sprint test) data were gathered during a test session as part of their table tennis training.
Anthropometry
Eye hand coordination
Sprint
What were the outcomes?
Association between the significant multidimensional assessment outcomes and performance indicators.

		Rating 2016	Rating 2017	Progression 2016-2017
Maturity	APHV (years)	0.71*	0.45	-0.77*
Motor skills	Sprint (s)	-0.69*	-0.44	0.63*
Psychological skills	Positive refocusing	-0.58*	-0.58*	0.12
	Evaluation	0.57*	0.34	-0.58*
	Self-monitoring	-0.60*	-0.50ᵻ	0.69*
Training history	Number of years	0.84*	0.80*	-0.52ᵻ

Data are Spearman correlation coefficients. APHV: age to peak height velocity
ᵻP ≤ 0.09, *P < 0.05; significant association
What do we learn?
The primary determinants of development in this sample were physical maturation, sprint time, self-regulation and training history. The players were likely to improve their performance more over the course of the year if they were less physically mature, had a slower sprint time, and had practiced less at the initial time of testing.
Mapping these performance determining characteristics might be beneficial for talent development purposes.
THE UNIVERSITY of EDINBURGH
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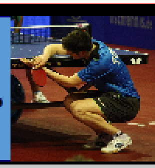
SCITT

How does Europe´s best table tennis player, Dimitrij Ovtcharov, hold his ground throughout the matches against the four best Chinese players?

The „Big Five Study" by Gunter STRAUB (straub@vdtt.de)



METHODS

A total of 18 singles matches against Fan Zhendong (FZ), Ma Long (ML), Xu Xin (XX), and Zhang Jike (ZJ) within the 2013-2016 Olympic cycle has been examined in terms of effectiveness, regarding partial skill indicators (Technique Effectiveness, TE) and a total outcome parameter (Competition Performance, CP) provided by the modern advancement of the three-phase method of performance diagnosis (Zhang, Liu, Hu, & Liu, 2013).

Pearson product-moment correlation coefficients have been calculated relating three partial – rally-stage based – skill indicators (TE) and the total outcome parameter CP (Zhang et al., 2013).

Results

CONCLUSION I: Ovtcharov at the head of the chasing pack

Taken on the whole, the playing strength of Fan Zhendong, Ma Long, Xu Xin, and Zhang Jike is very much superior to the performance of Dimitrij Ovtcharov.

But this does not mean that the German did not win any matches or that he was not able to keep up with his opponents in some situations or stages of the rallies (Table 1).

CONCLUSION II: Ovtcharov as a yardstick

This notion of keeping up with his opponents from China refers only to the matches against Fan Zhendong, Xu Xin, and Zhang Jike. Against this backdrop, Ma Long has proven himself as a league of his own (Table 2).

CONCLUSION III: Dima versus the "Tibetan Mastiff"

For Dimitrij Ovtcharov, the chance to win is not tremendously but comparatively high when encountering Zhang Jike. A decent serve-and-return play seems to be required, based either on an excellent serving or a superb receiving behavior (Table 1). In addition, the behavior in stalemate situations ($TE_{>4}$) of these two players seems to have a marked influence on their total match performance CP (Table 3).

CONCLUSION IV: Dima versus the "Cloudwalker"

In 2013, Dima played a total of three matches against Xu Xin. Scanning the entire year, a process of eliminating mistakes could be assumed regarding Ovtcharov's performance (Table 1).

CONCLUSION V: Starting over

In his matches against Zhang, Fan, and Xu, Ovtcharov usually shows an acceptable or even good serving behavior (Table 1). On the basis of the quality work already done in this respect, the receiving behavior of Dimitrij Ovtcharov probably has the strongest impact on his competition performance against the world's very best players, including the matches against Ma Long (Table 3).

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Association of German Table Tennis Coaches

Verband Deutscher TischtennisTrainer

www.vdtt.de

Photos by courtesy of the ITTF (3) and Mr. Markus Reiter

Data

Meanings of the coloured markings with respect to the grading system:
- 0.000 = Excellent (Excellent numerical relation between scoring shots and faulty shots in the respective phase of the rally)
- 0.000 = Good
- 0.000 = Fair (Acceptable)
- 0.000 = Poor (Failed)

Table 1. Technique effectiveness (TE) and competition performance (CP) values for Dimitrij Ovtcharov (Grading according to Zhang et al., 2013)

Match	Result (seen from Ovtcharov's perspective)	Technique Effectiveness of Serve + 3rd Ball ($TE_{1,3}$)	Technique Effectiveness of Receive + 4th Ball ($TE_{2,4}$)	Technique Effectiveness of Stalemate after 4th Ball ($TE_{>4}$)	Competition Performance (CP)
FZ_1/2013	1-4	0.682	0.435	0.358	7.878
ML_1/2013	1-4	0.483	0.446	0.419	7.222
ML_1/2014	0-3	0.424	0.436	0.416	6.088
ML_2/2014	0-3	0.500	0.521	0.366	7.543
ML_1/2015	2-4	0.513	0.463	0.422	7.586
ML_2/2015	0-4	0.444	0.366	0.408	4.160
ML_3/2015	0-4	0.519	0.436	0.380	6.581
ML_1/2016	1-4	0.451	0.463	0.444	7.094
XX_1/2013	1-4	0.553	0.436	0.379	6.861
XX_2/2013	1-4	0.567	0.481	0.407	8.584
XX_3/2013	3-4	0.538	0.479	0.447	8.918
ZJ_1/2013	0-3	0.526	0.370	0.426	6.031
ZJ_2/2013	1-3	0.667	0.443	0.462	9.165
ZJ_1/2014	3-0	0.534	0.588	0.479	14.233
ZJ_2/2014	1-3	0.473	0.485	0.414	7.380
ZJ_3/2014	2-3	0.567	0.484	0.462	11.119
ZJ_1/2016	3-4	0.529	0.510	0.414	9.144
ZJ_2/2016	4-1	0.680	0.539	0.450	11.960
All Matches (Games)	2-16 (24-58)	0.519	0.466	0.423	8.126

Table 2. Technique effectiveness (TE) and competition performance (CP) values for the four Chinese opponents of Dimitrij Ovtcharov (Grading according to Zhang et al., 2013)

Match	Result (seen from the opponents' perspective)	Technique Effectiveness of Serve + 3rd Ball ($TE_{1,3}$)	Technique Effectiveness of Receive + 4th Ball ($TE_{2,4}$)	Technique Effectiveness of Stalemate after 4th Ball ($TE_{>4}$)	Competition Performance (CP)
FZ_1/2013	4-1	0.681	0.465	0.513	12.325
ML_1/2013	4-0	0.689	0.573	0.486	13.706
ML_1/2014	3-0	0.630	0.662	0.439	16.545
ML_2/2014	3-0	0.644	0.662	0.621	14.106
ML_1/2015	4-2	0.682	0.531	0.484	12.899
ML_2/2015	4-0	0.672	0.606	0.600	17.390
ML_3/2015	4-0	0.683	0.573	0.482	14.876
ML_1/2016	4-1	0.683	0.611	0.443	14.013
XX_1/2013	4-1	0.667	0.514	0.629	14.126
XX_2/2013	4-1	0.539	0.632	0.483	12.879
XX_3/2013	4-3	0.664	0.611	0.473	10.724
ZJ_1/2013	3-0	0.649	0.518	0.512	14.853
ZJ_2/2013	3-1	0.686	0.600	0.433	10.622
ZJ_1/2014	0-3	0.467	0.600	0.429	7.613
ZJ_2/2014	3-1	0.518	0.586	0.600	13.689
ZJ_3/2014	3-2	0.660	0.446	0.453	9.256
ZJ_1/2016	4-3	0.540	0.605	0.486	11.878
ZJ_2/2016	1-4	0.515	0.473	0.451	8.834
All Matches (Games)	16-2 (59-24)	0.670	0.538	0.480	12.744

Table 3. Product-moment correlation coefficient r on the relationships between TE and CP regarding D. Ovtcharov and his Chinese opponents

	$TE_{1,3}$ and CP	$TE_{2,4}$ and CP	$TE_{>4}$ and CP
Ovtcharov against all (N = 18)	0.586*	0.640**	0.664**
All against Ovtcharov (N = 18)	0.763**	0.767**	0.508*
D. Ovtcharov against Ma Long (N = 7)	0.762*	0.836*	-0.065
Ma Long against D. Ovtcharov (N = 7)	0.860*	0.676+	-0.096
D. Ovtcharov against Zhang Jike (N = 7)	0.476	0.872*	0.746+
Zhang Jike against D. Ovtcharov (N = 7)	0.671	0.624	0.902**

+P < 0.1; *P < 0.05; **P < 0.01

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