Technical and tactical performance of top-class senior, junior and cadet table tennis players

Ivan Malagoli Lanzoni, Rocco Di Michele and Franco Merni
Department of Biomedical and Neuromotor Sciences, University of Bologna, Italy
(Mobile: +39 334 3769680; E-mail: ivan.malagoli@unibo.it)

Abstract: in the recent sports science literature, it is possible to notice that research branches related to performance analysis are widely developing [1]. The aim of this study was to analyze technical and tactical differences among male table tennis athletes of three categories: top-class world players (T), elite European juniors (J) and elite European cadets (C). 20 matches were randomly selected (T: 10, J: 5 and C: 5). Selected performance indicators were: stroke type, footwork type, and shot outcome. Selected matches have been watched in slow motion (0.2X) by an experienced table tennis coach, who collected the indicators of interest. The data were analyzed with the Excel software using contingency tables.

The strokes most used by T were top forehand (19 %), top counter top forehand (16 %) and block backhand (14 %). A similar distribution was observed for J: top forehand (21 %), top counter top forehand (15 %) and block backhand (15 %). Conversely, C showed the top forehand as the most used stroke (22 %), followed however by the push forehand (16 %). Concerning the footwork type, the most used one was the one step (T: 32 %, J: 28 % and C: 31 %). Differences among groups were observed for the chassè (T: 24 %, J: 15 % and C: 15 %), and stroke without step (T: 18 %, J: 29 % and C: 28 %). Strong associations were observed between stroke and footwork types, and between stroke types and shot outcome, with the top forehand and top counter top forehand being the most successful strokes in all the groups. By studying the relationships between strokes, footwork types and shot outcomes in table tennis athletes of three different categories, it is possible to detect differences in the play style among the three categories of players. This analysis can help to improve the technical and the tactical skills of players to obtain better competitive results.

Keywords: footwork technique, notational analysis, shot outcome.

1. INTRODUCTION

The analysis of competitive performance, known as performance analysis, has achieved a significant position among sports sciences. An important part of performance analysis is notational analysis, consisting of collecting specific aspects of the players' behaviour, and summarizing these aspects by means of appropriate performance indicators.

Hughes and 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 and 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]. Other authors presented specific methods for data collecting and statistical analysis [3-6].

In racket sports, performance analysis was used for the first time in studies on tennis, badminton and squash [7-9]. Subsequently, Hughes [10] and O'Donoghue [11] dedicated particular attention to racket sports, analyzing the evolution of match analysis in these disciplines and suggesting some methods to select appropriate performance indicators.

Previous notational analysis studies carried out on table tennis matches aimed to compare the performance of male and female players [12-13], considered also the nationality and age of the athletes [14-15]. Yuza et al. carried out a performance analysis study in which anthropometric characteristics and the physiological responses during games were considered as indicators [16]. Further studies considered the grip used to hold the racket, distinguishing the different play styles used by the examined players [17-18].

Therefore, several characteristics of table tennis players may be considered in a notational analysis context: gender, weight, height, handedness, grip (shake-hand, Chinese pen-hold, Korean pen-hold), playing style (offensive, defensive, all-round, etc.), and the position in the world ranking.

In table tennis, the playing technique is mostly characterized by the stroke used to hit the ball and the footwork used to move along the table. Some authors analyzed the stroke used during elite and top-level matches, with special focus on comparing forehand and backhand shots [15, 19].

The type of footwork is an important technical aspect, although it has received little attention to date. It is worth noting that a correct footwork technique enables the player to quickly move towards the direction of the ball, thus allowing to correctly execute the best possible shot in the given situation. Some authors proposed an international standard classification of footwork types [20-21]. Malagoli Lanzoni et al. identified five footwork types, differentiated by the technique of execution: one step, chassè, slide step, crossover and pivot [22].

A further class of indicators represents the tactical aspects of play. In particular, previous authors examined the shot outcome [23-24], the error type, the point/area

of the table in which the ball bounces [25-26], and the duration of rallies or various phases of play [27].

The main purpose of this study was to analyze technical and tactical differences among male table tennis athletes of three categories: top-class world players (T), elite European juniors (J) and elite European cadets (C). A second aim was to investigate the relationships among some of the most relevant performance indicators (stroke type, footwork type and shot outcome), in order to provide meaningful information to notational analysts, coaches, and players. Better knowledge in this field may contribute to improve the technical/tactical capacities of players, and thus the competitive results.

2. METHODS

At the beginning of the study, 20 international table tennis matches were randomly selected (T: 10, J: 5 and C: 5). The matches were played between 2008 and 2013 in some of the most important international tournaments. The videos of the matches were taken from television footage.

The examined players were 20 top-level male players belonging to the best players of the world, 10 elite male European junior (under 18) players, and 10 elite cadet (under 15) male European players. When the examined matches were played, all top-level players were in the first 41 positions of the world ranking, whereas all the junior players were in the first 9 positions of the European junior ranking, and the 10 cadet players were in the first 18 positions of the European cadet ranking.

Tables 1-2-3 provide a summary of the players' characteristics. All the junior and cadet players were right-handed and used a shake-hand grip. In contrast, there were five left-handed and six pen-holders among the top-level players.

The examined performance indicators were the stroke type, the footwork type, and the shot outcome. The stroke type classification was based on a general technical model associated to an internationally shared terminology [20-21], considering the following stroke categories: serve, push, flick, topspin, topspin counter topspin, block, drive, lob, and smash. For each shot, the forehand/backhand execution was also analysed. The classification of footwork types included the following categories [22]: one step, chassè, slide, pivot, crossover and stroke without step, i.e. when the player hits the ball without executing an observable footwork.

Table 1 Characteristics of top-level players

Player	World ranking at time of the competition	Association	Handedness	Grip
1	1	CHN	Right handed	Pen holder
2	2	CHN	Right handed	Shake-hand holder
3	3	CHN	Right handed	Pen holder
4	3	GER	Left handed	Shake-hand holder
5	4	CHN	Right handed	Shake-hand holder
6	5	CHN	Right handed	Shake-hand holder
7	6	BLR	Right handed	Shake-hand holder
8	7	CHN	Left handed	Shake-hand holder
9	9	CHN	Left handed	Shake-hand holder
10	10	KOR	Right handed	Shake-hand holder
11	11	JPN	Left handed	Shake-hand holder
12	13	GER	Right handed	Shake-hand holder
13	15	AUT	Right handed	Shake-hand holder
14	19	JPN	Right handed	Pen holder
15	20	HKG	Left handed	Shake-hand holder
16	22	JPN	Right handed	Pen holder
17	24	GER	Right handed	Shake-hand holder
18	29	RUS	Right handed	Shake-hand holder
19	30	TPE	Right handed	Pen holder
20	41	HKG	Right handed	Pen holder

The shot outcome (Table 4) was defined as in a previous study [28].

Selected matches have been watched in slow motion (0.2X) by an experienced table tennis coach, who collected the indicators of interest. Data collection was carried out through a dedicated Visual Basic-based application with a panel allowing creating a set of data in the Microsoft Excel software. A very good intra- and inter-operator reliability has been shown for the considered performance indicators, as assessed using a classification and methodology similar to the present one [28].

The associations between pairs of the considered variables were assessed using chi-square tests. The significance was set at $p < 0.05$.

Table 2 Characteristics of junior players

Player	European J ranking at time of the competition	Association	Handedness	Grip
1	1	GER	Right handed	Shake-hand holder
2	1	FRA	Right handed	Shake-hand holder
3	1	FRA	Right handed	Shake-hand holder
4	2	CZE	Right handed	Shake-hand holder
5	4	FRA	Right handed	Shake-hand holder
6	5	ENG	Right handed	Shake-hand holder
7	6	SRB	Right handed	Shake-hand holder
8	7	FRA	Right handed	Shake-hand holder
9	8	FRA	Right handed	Shake-hand holder
10	9	SWE	Right handed	Shake-hand holder

Table 3 Characteristics of cadet players

Player	European C ranking at time of the competition	Association	Handedness	Grip
1	1	FRA	Right handed	Shake-hand holder
2	2	POL	Right handed	Shake-hand holder
3	2	FRA	Right handed	Shake-hand holder
4	2	FRA	Right handed	Shake-hand holder
5	7	RUS	Right handed	Shake-hand holder
6	6	SWE	Right handed	Shake-hand holder
7	8	POL	Right handed	Shake-hand holder
8	11	POR	Right handed	Shake-hand holder
9	15	GER	Right handed	Shake-hand holder
10	18	CRO	Right handed	Shake-hand holder

Table 4 Shot outcome classification

Symbols	Outcome description
#	winner, perfect execution, winning stroke, assigns the point
0	return, neutral stroke, transition action, without advantages
=	error, mistake, losing stroke (out, net, etc.), assigns the point to the opponent

3. RESULTS

Table 5 displays the distributions of shot types, in which forehand and backhand executions are not distinguished.

Table 5 Distribution of stroke types

Stroke type	T	J	C
top	25%	27%	27%
serve	19%	20%	20%
push	16%	14%	19%
top counter top	15%	14%	11%
block	14%	14%	15%
flick	7%	8%	5%
lob	2%	2%	2%
smash	1%	0%	0%
drive	0%	1%	1%
Total	100%	100%	100%

The strokes most frequently used by all the groups of players were the top spin and the serve. The third most used stroke was the push, especially used by C, followed by T, and J. The top counter top was used especially by T. The block was used with similar percentage by the three groups. Finally, the flick was used more often by J.

Significant differences between the examined categories of players were noticed with respect to the serve. Indeed, the backhand serve showed a higher percentage in C (C: 22 %, T: 5 % and J: 0 %). Anyway, the majority of serves were executed forehand in all categories.

Table 6 displays the distribution of stroke types (excluding the serve) when forehand and backhand shots are considered as different categories. The strokes more frequently executed by top-level players were the top forehand, the top counter top forehand and the block backhand. A similar distribution was observed for junior players. Conversely, cadet players showed the top forehand as the most used stroke. When considering only if the shot was forehand or backhand (i.e. ignoring the stroke type), it was noticed that forehand shots were prevalent in all the groups (T: 56 %, J: 59 % and C: 59 %)

The distribution of footwork types is reported in Table 7. The most used footwork was the one step in top-level players and cadets, while it was the stroke W. Step in junior players. Differences between groups were noticed for the other footwork types, especially the chassè (T: 24 %, J: 15 % and C: 15 %), and the stroke without step (T: 18 %, J: 29 % and C: 28 %).

Table 6 Distribution of stroke types
(with distinction of forehand and backhand shots)

Stroke type	T	J	C
top forehand	19%	21%	22%
top c. top forehand	16%	15%	13%
block backhand	14%	15%	13%
top backhand	13%	13%	11%
push forehand	13%	14%	16%
push backhand	7%	4%	8%
flick backhand	4%	6%	4%
flick forehand	4%	4%	2%
top c. top backhand	3%	2%	1%
block forehand	3%	3%	5%
lob backhand	3%	2%	2%
other shots	5%	4%	4%
Total	100%	100%	100%

Table 7 Distribution of footwork types

Footwork type	T	J	C
one-step	32%	28%	31%
chassè	24%	15%	15%
str. W. ste.	18%	29%	28%
pivot	13%	14%	13%
crossover	10%	13%	12%
slide	3%	1%	2%
Total	100%	100%	100%

Regarding the stroke/footwork relationship, the one-step was followed more frequently by the push forehand in all the categories (T: 39 %, J: 50 % and C: 49 %) and by the push backhand in T (20 %), and C (25 %). In junior players, the stroke showing the highest frequency after the one-step was the flick backhand (17 %). The chassè footwork was used by top-level players especially to execute the block backhand (26 %) and the top forehand (21 %). Junior and cadet players used a chassè mainly to execute a top forehand (28 %), or a block backhand (25 % and 23 %, respectively). The stroke without step was most frequently linked to the block backhand (T: 37 %, J: 33 %, and C: 30 %) and to the top backhand (T: 33 %, J: 30 %, and C: 27 %). The crossover was mainly related to the top forehand in top-level athletes (42 %), and to the top counter top forehand for the other two groups (J: 42 %, and C: 40 %). Finally, the pivot was directly linked to the top forehand (T: 46 %, J: 58 % and C: 75 %), and to the top counter top forehand (T: 43 %, J: 33 %, and C: 13 %).

The shot outcome distribution was similar in all the groups. The return was the prevalent outcome (T: 75 %, J: 76 % and C: 75 %), followed by the error (T: 22 %, J: 21 % and C: 22 %), and the winner (T: 3 %, J: 4 % and C: 3 %).

The analysis of the relationship between stroke types and outcomes revealed that the top forehand was the stroke that, more than others, involved a neutral outcome (T: 19 %, J: 22 % and C: 24 %). The push forehand, frequently used to counter the serve, showed, in all the groups, the second highest percentage of returns (T: 15 %, J: 17 % and C: 19 %). The most successful stroke types were the top forehand (T, J and C: 31 % of winners) and top counter top forehand (T: 26 %, J: 19 % and C: 26 %). The main difference between the groups was about the winning block backhands (T: 7 %, J: 15 % and C: 13 %). Finally, the strokes involving the highest number of errors were the top counter top forehand (T: 21 %, J: 23 % and C: 20 %), the block backhand (T: 21 %, J: 17 % and C: 18 %), and the top forehand (T: 15 %, J: 17 % and C: 17 %).

4. DISCUSSION

This study examined the distribution of some relevant performance indicators, and their relationships, in table tennis matches played in different categories.

First and foremost, the present results highlight the importance of three actions performed in the first phases of the rally: serving, countering the serve, and attacking.

The serve represents a key shot in table tennis, because it may allow a player to effectively start the rally, thus avoiding an immediate attack by the opponent. Forehand serves are definitely predominant among the examined categories of players. The different percentage of backhand serves in the three groups is attributable to the individual behavior of players when serving. Indeed, among cadets, players 4 and 5 executed a backhand serve in 100 % and 63 % of cases, respectively, whereas 77 % of serves showed backhand executions in the top-player 12. The serve is usually countered by performing a one-step and a push forehand. The subsequent shot normally shows a pivot, chassè or crossover footwork and a top forehand stroke, which is the most used stroke by all the three categories. Subsequently, if no point is scored, the rally may continue with either a defensive shot (block) or a counterattack (top counter top).

Some differences may be noticed between the examined groups. Indeed, on average, junior players counter the serve in a more offensive way than the other players, that is, execute a one-step followed by a flick backhand. In contrast, top-level players counter the serve with a one-step mainly followed by a less offensive push, executed either forehand or backhand. In the subsequent shot, all the players perform either a pivot to execute a top forehand, or no footwork (stroke without step) to attack with a top backhand.

In the central phase of the rally, top level players show a higher offensiveness as they perform more often a counterattack (top counter top forehand), usually following a crossover or a pivot. Anyway, it seems fundamental for all the players the capacity to counter

the first attack, also with a passive shot (e.g. block backhand) and without performing a footwork (stroke without step).

The analysis of shot outcomes revealed that the majority of shots are neutral (returns). In particular, the rally tend to continue after the players counter the serve with a push forehand, and after the first attack, often performed using a top forehand. The top forehand and top counter top forehand were the strokes that, more than others involved a winning outcome. However, the top counter top forehand often lead to mistakes and thus to lose the point. The top counter top forehand can be considered therefore as a risky stroke, related to a specific offensive technique in top-level players, or to the need of risking in situations of difficulty in junior and cadet players.

A limit of this study was that the grip and the hand used by the players to hold the racket were not considered in the analysis for the sake of brevity. These variables could however be linked to the stroke type distribution. For example, a player using a traditional pen-hold grip is likely to execute more forehand shots than a shake-hand holder. It will be a matter for future studies to analyze how the players' handedness and their grip affect the shooting behavior.

5. CONCLUSION

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 stroke 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 top-level players would allow developing a technical/tactical reference model useful to plan appropriate training for players of all categories.

REFERENCES

[1] Hughes, M. and Franks, I.M. *The Essentials of Performance Analysis*, London: Routledge, 2008.

[2] Hughes, M. and Barlett, R. The use of performance indicators in performance analysis. *Journal of Sports Sciences*, 20, 739-754, 2003.

[3] Wilson, K. and Barnes, C.A. Reliability and validity of a computer based notational analysis system for competitive table tennis. In A. Lees, I. Maynard, M. Hughes & T. Reilly (Eds.), *Science and Racket Sports II* (pp. 265-268), London: E & FN Spon, Routledge, 1998.

[4] Atkinson, G. and Nevill, A. Selected issues in the design and analysis of sport performance research. *Journal of Sports Sciences*, 19, 811-827, 2001.

[5] Hughes, M., Cooper S.M. and Nevill, A. Analysis procedures for non-parametric data from performance analysis. *International Journal of Performance Analysis of Sport*, 2, 6-20, 2002.

[6] Hughes, M., Hughes, M.T. and Behan, H. The evaluation of computerised notational analysis through the example of racket sports.

[7] Downey, J.C. *The Singles Game*. London: EP Publications, 1973.

[8] Sanderson, F.H. A notational system for analyzing squash. *Physical Education Review*, 6, 19-23, 1983.

[9] Sanderson, F.H. and Way, K.I.M. The development of an objective method of game analysis in squash rackets. *British Journal of Sports Medicine*, 11, 188, 1977.

[10] Hughes, M. The application of notational analysis to racket sports. In A. Lees, I. Maynard, M. Hughes & T. Reilly (Eds.), *Science and Racket Sports II* (pp. 211-220). London: E & FN Spon, 1998.

[11] O'Donoghue, P. Principal components analysis in the selection of key performance indicators in sport. *International Journal of Performance Analysis of Sport*, 8, 3, 145-155, 2008.

[12] Barchukova, G. Competitive activity of the best table tennis players. *International Journal of Table Tennis Sciences*, 1, 135-137, 1992.

[13] Katsikadelis, M., Pilianidis, T. and Aikaterini, V. Real play time in table tennis matches in the XXVIII Olympic Games "Athens 2004". *Proceedings of the 10th ITTF Sport Science Congress*, 94-98, 2007.

[14] Takeuchi, T., Kobayashi, Y., Hiruta, S. and Yuza, N. The effect of the 40 mm diameter ball on table tennis rallies by elite players. *Table Tennis Sciences*, 5, 267-277, 2002.

[15] Otcheva, G. and Drianovsky, Y. Comparative analysis of the games of the finalists from the biggest international and Bulgarian table tennis competition 2000. *Table Tennis Sciences*, 5, 155-166, 2002.

[16] Yuza, N., Sasaoka, K., Nishioka, N., Matsui, Y., Yamanaka, N., Ogimura, I., Takashima, N. and Miyashita, M. Game analysis of table tennis in top Japanese players of different playing styles. *International Journal of Table Tennis Sciences*, 1, 79-89, 1992.

[17] Hao, Z., Tian, Z., Hao, Y. and Song, J. Analysis on technique and tactics of Lin Ma and Hao Wang in the men's single table tennis final in the 29th Olympic Games. *International Journal of Table Tennis Sciences*, 6, 74-78, 2010.

[18] Hsu, M.H. A study on the technical analysis and attack-defence performance of men's top four single players in 2008 Olympic Games. *International Journal of Table Tennis Sciences*, 6, 248-260, 2010.

[19] Hao, Z., Cai, X.L., He, F. and Hao, Y.J. Analysis on technique and tactics of Ryu Seung-Min in men's singles table tennis final and semi final of the 28th Olympic Games in Athens. *Proceedings of the 10th ITTF Sport Science Congress*, 374-382, 2007.

[6] International Journal of Sport Science and Engineering, 1, 3-28, 2007.

[20] Tepper, G. *ITTF Level 1 Coaching Manual*, ITTF, 2003.

[21] Molodzoff, P. *ITTF Advanced Coaching Manual*, ITTF, 2008

[22] Malagoli Lanzoni, I., Lobietti, R. and Merni, F. Footwork techniques used in table tennis: a qualitative analysis. *Proceedings of the 10th ITTF Sport Science Congress*, 401-408, 2007.

[23] Malagoli Lanzoni, I. and Lobietti, R. A pilot study to compare footwork techniques used in Table tennis. In A. Hokelmann, K. Witte & P. O'Donoghue (Eds.), *Current trends in Performance Analysis: World Congress of Performance Analysis of Sport VIII*, Aachen: Shaker Verlag, 78-82, 2009.

[24] Malagoli Lanzoni, I., Lobietti, R. and Merni, F. Footwork in relationship with strokes and efficacy during the 29th Olympic Games table tennis final. *International Journal of Table Tennis Sciences,* 6, 60-63, 2010.

[25] Wu, X.Z. and Escobar Vargas, J. Notational analysis for competition in table tennis (part I): based format analysis. *Proceedings of the 10th ITTF Sport Science Congress*, 104-108, 2007.

[26] Wu, X.Z. and Escobar Vargas, J. Notational analysis for competition in table tennis (part II): non-format method. *Proceedings of the 10th ITTF Sport Science Congress*, 109-118, 2007.

[27] Katsikadelis, M., Pilianidis, T. and Misihroni, A. Comparison of rally time in XXIX Beijing (2008) and XXVII Athens (2004) Olympic table tennis tournament. *International Journal of Table Tennis Sciences,* 6, 55-59, 2010.

[28] Malagoli Lanzoni, I., Di Michele, R. and Merni F. Reliability of selected performance indicators in table tennis. *International Journal of Table Tennis Sciences,* 7, 62-65, 2012.