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Research article

Comparative Study on the Topspin and Retopspin Execution Biomechanics in Female Cadets

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Abstract: Background: Many high-performance table tennis specialists and athletes may wonder if there are differences between the two most used technical-tactical elements in attack and which are these, given that their name and the biomechanical execution are characterized by approximately similar landmarks. Knowing the differences between the two technical elements, we will be able to understand and streamline the execution biomechanics. The biomechanical analysis of a large number of athletes on the three stages of execution and speed developed at the time of using topspin or retopspin (counter loop). Methods: The research engaged several 10 Romanian sportswomen involved in high-performance table tennis, with ages between 13-15 years old. Goal: Identify the distinctive biomechanical features between the two elements and the speed needed for execution optimization. Results: For data collection, analysis, and interpretation, we used Excel, IBM SPSS Statistics 23, analysis software Dartfish 360s, and for the technical-tactical expression level ''Topspin with crosswise retopspin, forehand, and backhand'', "Butterfly" and "Multiball training". Conclusions (4): The preparation of the forehand topspin hit requires an angle of 146.36 degrees(0) and 0.36 seconds(s) for the entire execution, while the forehand retopspin is 134.20 and 0.31 s, backhand topspin hit requires an angle of 920 and 0.32 s, while the retopspin 86,720 and 0.26 s for the entire execution.

Keywords: biomechanical features; forehand retopspin; backhand topspin; technical-tactical elements; tennis

1. Introduction

What do Liu Shiwen and Ma Long, the gold medalists at the latest World Championships from Budapest (24-28.04.2019) [1], have in common in what concerns the technical-tactical expression meat to bring victory? An analysis of the two finals in the singles matches whose stars are the great performers mentioned previously, will bring to light three ever-present elements consisting of service, topspin, and retopspin, these representing mainly the technical elements which put to difficulty their opponents and determined winning the points in the game and implicitly, the winning of the match.

Table tennis is one of the most popular sports in the world, with more than 300 million players in 1995, of which 40 million were playing high-performance sports at the Rio 2016 Olympic Games, which registered an audience of 552 million viewers [2,3]. The International Specialized Forum (ITTF) will have 219 federations in 2022, making it the largest organization of its kind compared to any other in world sport, which in this context gives both this discipline and the scientific research initiated for its development particular importance [4].

This discipline is related to tennis both in terms of origin (England) and period of appearance (19th century), specific means of play, technical-tactical baggage, competition events (singles and doubles), and the motor skills involved [5]. It has evolved into a sport that places greater emphasis than ever before on developing speed, coordination skills, endurance, strength, flexibility, and exceptional agility, a useful attitude in the context of the game played by high performers based on attack and counterattack [2]. The importance of our research is justified also by the high percentage, i.e. 95%, granted to forehand topspin as technical – tactical procedure, as compared to other procedures used by athletes during competitions, also, the most offensive hit meant to counterattack the loop is the counter-loop, a percentage of 42.85% among the Romanian specialists interviewed crediting the retopspin with an influence of 50% in winning the extended exchanges of balls within rallies, according to [6]. The identification of the differences in biomechanical nature, of execution time, the comparison with how the athletes hit the ball, actions which have been learned even since the junior period for the attack finalized with topspin and retopspin (counterattack loop), can represent an aspect meant to favor the performance. Interesting to mention that 'the differences in the values of maximal acceleration suggest that women could use both sides to perform a topspin attack against the retopspin ball, a slightly greater acceleration of maximum topspin backhand than forehand, while men should seek opportunities to make a stronger shot with a forehand topspin [7]. As in physical education lessons where it would be necessary to use information from the audio-visual environment to optimize this educational process, it would be advisable to proceed similarly in improving the biomechanics of topspin and retopspin execution [8].

Characterized by high speed and fast rotation, the mastery of the topspin forehand is also considered an important factor in differentiating elite athletes and to remain competitive and powerful, players need to increase the acceleration of their playing hand by optimizing their stroke skill and efficiency of the power chain transmission, which brings gains to the spin effect and flight speed of the ball during the topspin forehand [9].

The biomechanics of execution is also important in the context of being a one-handed racket sport and has been proven to have a bad effect on the symmetry of the trunk, and the imbalance of symmetry is one of the key factors leading to injuries, an incorrect technique would alter movement mechanics and thus joint loadings that are related to a potential risk of injury [9,10]. In twin sport, the ways in which tennis players perform better have a positive impact on their long-term health. Pluim et al., (2007) showed that tennis is associated with an increase in high-density lipoprotein (HDL) in blood plasma[11]. Matei et al., in 2022 demonstrated that HDL in higher concentrations is associated with a lower risk of cardiovascular disease implying that tennis players may have a reduced risk of cardiovascular events[12]. Topspin forehand is known as one of the most basic and aggressive strokes and for an elite offensive player, excellent forehand topspin skill is necessary, table tennis is a sport that requires open skills, flexibility in visual attention, quick decision-making and fast interceptive actions in response to an interactive opponent [13,14]. Also, the forehand loop is one of the most prolific shots, suggesting that optimizing this shot is critical to winning matches [15].

The importance of the biomechanics of these two technical-tactical elements specific to the attack in the sense of a high-performance execution is necessary in the context in which Table tennis players are required to hit the ball over 30 times per minute during rallies no longer than 4 s, with an average of 4-5 strokes per play, sometimes exceeding 20 strokes with resting times shorter than 15 s, with the ball traveling at high speed reaching 120

km/h, even exceeding 160 km/h, forcing players to respond in milliseconds, the knowledge of their intimate aspects being of great importance in the economy of the match as well as of the preparation as a whole [16,17].

According to Dobosi, (2009), in concerns this period specific to female cadets, when finishing this stage, the athlete must have a well-shaped game profile and that is the period when the physical, technical, and tactical elements are formed, as well as personality traits; during this period, the first aspects of individualization appear, based on the skills manifested for a certain game profile [18]. The quality of the attack finalized with topspin and retopspin, backhand topspin, and especially of the forehand topspin made the difference on the scoreboard in the international championships, its usage being a "sine qua non" condition for performance and especially for high performance [19].

Out of a study I had performed in 2018 using a social inquiry based on survey on the attack finalized with topspin and retopspin, where I had involved 22 coaches, it resulted that the two ingredients necessary to the success of the two elements specific to the attack are Execution speed (100%) and execution technique (76.19%), reason for which the identification of the execution speed and the analysis of the biomechanics of these procedures is a beneficial direction to approach at this age category and not only [20]. The players and coaches must understand the biomechanics of the executions of technical – tactical nature, this sport discipline requires elaborated actions from the upper limbs, according to Qian et al., (2016), in this context the usage of a computerized analysis software is indicated to improve the attack of the female juniors [21].

In another train of thoughts, the regulation changes meant to stimulate the commercial interest of this discipline in the televised media areas starting with the year 2000 such as increasing the diameter of the ball from 38 milimeter to 40mm [22] and then from 39,65mm to 40,25mm (40 to 40+) for the spectators to follow more easily the ball exchanges between players, the reduction of the number of points from a set from 21 to 11 and moving from the system 2 out of 3 to 3 out of 5 sets within a match [23] for a higher volume of publicity between sets and an increase in the intensity of the athletic confrontation and the improvement of the chromatics of the play space by color contrasts between the play table and the support area, with the purpose of increasing the pleasure to watch the development of the sports event, were capitalized by increasing the prizes received by the athletes, the attack finalized with topspin and retopspin being a technical – tactical means meant to bring the victory of the athletic competition and implicitly, financial profit which enhances it, starting with its consolidation since junior period [24]. The female cadet's category is optimum for the occurrence in the attack of the counter-loop together with an evolved topspin, which involves special attention to the development of the two technical-tactical elements [25].

2. Materials and Methods

2.1. Participants

Ten female cadets table tennis players (age: 13-15 yr, body weight: average 55,50 kg, and body height average 162,35 cm) were involved in performance sports and agreed to participate in the study. The research is being done during the competition schedule of the specialty federation. They had no previous upper or lower extremity diseases or deformities and were free from injury for at least six months before the test. All ten female cadets were right-handed. All the players signed written informed consent forms. The Ethics Committee of Elipetro Med Clinique gave its consent for the experimental procedure in this study with no: 230 of 2022-04-23.

2.2. Procedures

The experiment was conducted in the training rooms of the sports clubs participating in the study. All athletes used table tennis rackets approved by International Table Tennis Federation and 40+ balls.

For the collection of the data necessary for the scientific research, 4 tests have been used for the assessment of the technical-tactical level of the attach finalized with topspin and retopspin (Forehand diagonal topspin - retopspin; Backhand diagonal topspin - retopspin; Butterfly, and Multiball training), all having the role of highlighting numerical values and aspects of relational nature which would be capitalized in the interest of our undertaking of ameliorative type. After the 10-min warm-up, subjects were instructed to perform the tests to get to know and understand how the technical-tactical tests were carried out.

To assess the execution speed and the angles achieved by the arm and forearm during the three hitting stages corresponding to forehand and backhand procedures, I used the com-puterized analysis software Dartfish 360s.

Figure 1. Imagine with time necessary for execution and the angle of the end of movement of backhand(rever) counter-loop

2.3. Statistics Analysis

The collected data were processed in Excel software, then, the data were statistically analyzed by IBM SPSS Statistics 23 software, following the Pearson correlation coefficient, showing us if a dependency relation does exist or does not between two phenomena, as well as the correlation degree. The latter (noted with r) can take values between +1 and -1. As the value of the coefficient comes closer and closer to +1 or -1, the correlation is more and more accentuated, either in the same sense (+) or in the opposite sense (-). As the value of the coefficient comes closer to zero, the correlation between the two series of variations is weaker. If r = 0, there is no correlation. In case the resulting probability is lower than the significance limit (α = 0.05), it results that the two variables are correlated. If p > α = 0.05 we will decide that the two variables are not correlated [26].

3. Results

Table 1. The values of the biomechanical indicators of topspin(loop) and retopspin(counter-loop)

Characteristics under analysis	Average of initial values	Average of final values	Percentage difference
FOREHAND Topspin. Hit's preparation <^{0}	146.36	139.45	-4.721%
FOREHAND Topspin. Ball hitting <^{0}	117.46	120.02	2.179%
FOREHAND Topspin. End of movement <^{0}	83.08	87.18	4.935%
FOREHAND Topspin. Time necessary for the execution: hundredths of a second.	36.00	32.00	-11.111%
BACKHAND Topspin. Hit's preparation <^{0}	115.95	115.00	-0.819%
BACKHAND Topspin. Ball hitting <^{0}	92.00	95.00	3.261%
BACKHAND Topspin. End of movement <^{0}	132.930	122.91	-7.538%
BACKHAND Topspin. Time necessary for the execution: hundredths of a second	32.60	28.00	-14.110%
FOREHAND Retopspin. Hit's preparation <^{0}	134.20	132.56	-1.222%
FOREHAND Retopspin. Ball's hitting <^{0}	105.51	106.71	1.137%
FOREHAND Retopspin. End of movement <^{0}	68.750	75.17	9.338%
FOREHAND Retopspin. Time necessary for the execution: hundredths of a second	31.00	27.40	-11.613%
BACKHAND Retopspin. Hit's preparation <^{0}	86.72	79.79	-7.991%
BACKHAND Retopspin. Ball's hitting <^{0}	84.09	85.19	1.308%
BACKHAND Retopspin. End of movement <^{0}	136.48	129.95	-4.785%
BACKHAND Retopspin. Time necessary for the execution: hundredths of a second	26.00	23.00	-11.538%

<^{0}- represents the angle formed by the forearm and arm on the 3 moments of the execution

Negative percentage values on the initiation and finalization parts of the technical – tactical procedure and positive in the case of the proper hit are considered improved effectiveness of execution biomechanics.

Table 2. The existing correlations (which influence efficiency) between the retopspin(counter loop) and different aspects of technical nature (hitting angles,execution speed or topspin)

RETOPSPIN FORHAND	Pearson correlation coefficient r	Associated probability p
Retopspin FHD. Hits preparation <^{0} – Topspin FHD. Hits preparation <^{0}	0.801	0.005
Retopspin FHD. Hits preparation <^{0} – Retopspin FHD. Time necessary for the execution: hundredths of a second	0.824	0.003
Retopspin FHD.Hits preparation <^{0} – Retopspin REV.Ball's hitting <^{0}	0.689	0.028
Retopspin FHD. Ball's hitting <^{0} – Topspin REV. Ball's hitting <^{0}	0.634	0.049
Retopspin FHD. Ball's hitting <^{0} – Retopspin FHD. End of movement <^{0}	–0.689	0.028
Retopspin FHD. Time necessary for the execution: hundredths of a second – Body weight-kg.	–0.636	0.048
Retopspin FHD. Time necessary for the execution: hundredths of a second. – BIACROMIAL DIAMETER- CM.	–0.715	0,020
Retopspin FHD. Time necessary for the execution: hundredths of a second – BITROHANTERIAN DIAMETER-CM	–0.721	0.019
Retopspin FHD. Time necessary for the execution: hundredths of a second – Retopspin REV. Ball's hitting <^{0}	0.669	0.035

<^{0}- represents the angle formed by the forearm and arm on the 3 moments of the execution Retopspin (Counterloop) - technical-tactic element specific to the attack phase of topspin's takeover.

4. Discussion

The value differences in biomechanical nature and the execution speed between topspin and retopspin are the following:

- forehand topspin 0.32 s / forehand retopspin 0.27 s.;

- backhand topspin 0.28 s / backhand retopspin 0.23 s.;

From the values collected, it can be observed that retopspin as a technical–tactical element, requires an execution speed higher than topspin by 0.05 s in the case of both procedures.

- Preparation of the hit for forehand topspin < 139.45^0 / forehand retopspin < 132.56^0;

- Ball's hitting for topspin forehand < 120.02^0 / forehand retopspin < 106.71^0;

- End of movement for forehand topspin < 87.18^0 / forehand retopspin < 75.17^0.

The amplitude of the forehand topspin on the preparation part is higher by approximately 70 as compared with retopspin, while the end of the hit is shorter at topspin than at retopspin by approximately 120.

- Preparation of the hit for backhand topspin < 115^0 / backhand retopspin < 79.79^0 ;

- Ball's hitting for backhand topspin < 95^0 / backhand retopspin < 85.19^0;

- The end of movement for backhand topspin < 122.91^0 / backhand retopspin < 129.95^0.

The amplitude of the backhand topspin on the preparation part is higher by approximately 35^0 as compared to retopspin, while the end of the hit is shorter at topspin than at retopspin by approximately 7^0.

Out of the scientific analysis performed, the following general conclusions result: the execution speed of retopspin is sensibly higher than that of topspin, while the amplitude of the angle between arm and forearm in the topspin's preparation phase is higher than that of retopspin and lower at the end of the hit, as compared to retopspin, both for forehand and for the backhand procedures.

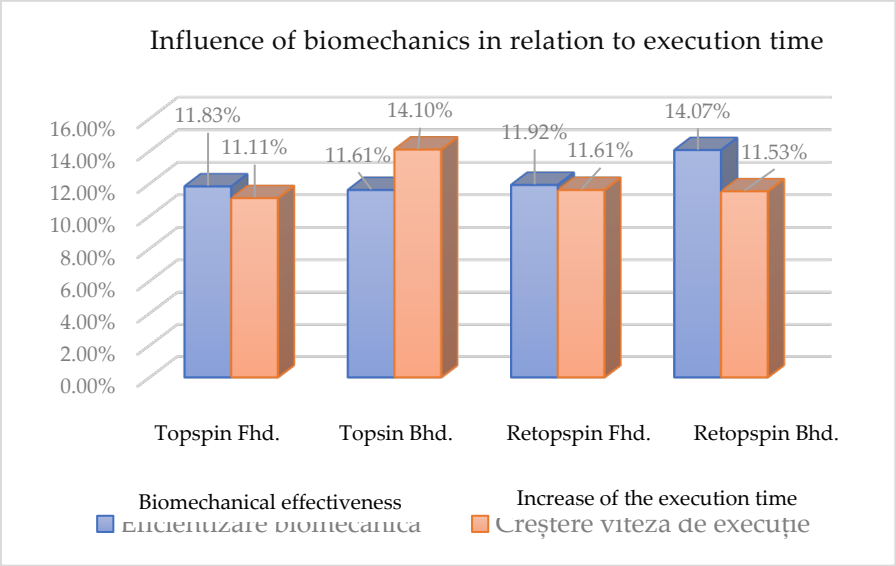

Figure 2. Influence of biomechanics in relation to execution time

5. Conclusions

The following important conclusions result from the mathematical statistics analysis, meant to guide the training of junior female athletes and to highlight some differences between the two technical–tactical elements from the attack area:

(I) the efficiency of retopspin during attack is in direct relation with the three execution stages of the procedure which influence each other, in the case of execution speed existing an inverse ratio with the weight of the female juniors, with the bitrochanteric and biacromial diameter as compared to forehand topspin, at which it is important to observe the fact that the level of muscular development of the lower body influences the efficiency of this attack procedure, aspect which highlights the importance of physical training in the methodological preparation strategies of female juniors, and at the same time, the coordination of the visual analyzer with the upper limbs has relevance in making the attack more effective;

(II) in the case of the comparison between backhand topspin and backhand retopspin: at the first procedure, the execution speed, the preparation, as well as hitting the ball are correlated with the dimensions of the action arm, the ball's hitting angle in the case of forehand retopspin having an influence on the same stage as at the backhand topspin, while for the second technical and tactical procedure specific to the attack, it is directly influenced by the anthropometric values of the upper limbs (length and span) of the female athletes, being correlated with the ball's hitting angle in the case of the execution speed.

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