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OPTIMIZATION OF THE RETOPSPIN PERFORMANCE BIOMECHANICS IN FEMALE JUNIORS IN TABLE TENNIS

Mircea Mocanu (a)*, Ioan Negulescu (b), Petronel Moisescu (c)
*Corresponding author

(a) National University of Physical Education and Sports, 140 Constantin Noica St., Bucharest, Romania
(b) National University of Physical Education and Sports, 140 Constantin Noica St., Bucharest, Romania
(c) "Dunărea de Jos" University, 63-65 Gării St., Galați, Romania

Abstract

Increasing the efficiency of taking-over the most prolific technical-tactical element from the attack phase, i.e. topspin, by using the retopspin, represents a way of increasing the success rate in winning the points at stake within a game, the performance biomechanics playing an important role in the quality of returning the ball. Aim: to create a program for improving the retopspin attack, substantiated by optimizing the biomechanics and the execution time by adopting some methods and means for correction and biomechanical strategies. Objective: to outline the main aspects necessary for technical training in youth table tennis. Themes: to construe initial and final data in order to assess the efficiency of the program and to identify the top executions in order to create a model. The research included 20 Romanian women athletes involved in high performance table tennis, with ages between 13-15 years. For data collection, analysis and interpretation, we used Excel, IBM SPSS Statistics 23 and Dartfish 360s. Results: the efficiency of forehand retopspin is in a direct relation with the way the forehand topspin ($r = 0.801$, $p = 0.005$) and backhand retopspin are initiated, as well as with the execution speed of the latter, the execution speed of the forehand retopspin being around 0.28", as compared to the backhand one, of 0.23". The conclusions of the paper underline that program implementation has led to the optimization of the retopspin biomechanics, bringing 11% more in the execution speed.

Keywords: Biomechanics, retopspin, female juniors, table tennis. .

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1. Introduction

Forehand topspin is an attack hit commonly used in competitions (Negulescu, Mocanu, & Cristea, 2017), having a percentage of usage of 95.23% in the attack phase, as compared to its other specific elements, reason for which its counteracting technical-tactical method plays an important role in winning the ball exchange during a set, the retopspin being rated with 42.85% in winning a point in the game and with 50% in winning the "rally" (extended ball exchanges performed with high intensity). The importance of the retopspin has been validated by the fact that the European players had won against their Chinese opponents mainly due to the unpredictable technique of opposing topspin to retopspin (counter-looping), which has determined the analysis of the spin techniques and procedures (Qun, Zhifeng, Shaofa, & Enting, 1992).

Within the recently ended World Team Championships held in Sweden (29 April - 5 May 2018), out of the six female participants in the finals, Liu S., Ding N., Zhu Y., Kasumi I., Miu H. and Mima I. (ITTF, 2018a), in the competition between China and Japan, none used a defensive style, topspin and retopspin being ever-present in their game, their efficiency making the difference mostly on the scoreboard. This aspect has compelled and turned the training of female juniors into an aggressive game style, where the initiation of attack with topspin and its counteraction with retopspin becomes a "must have" for performance and especially for top performance area. Our interest in this biomechanical analysis was also generated by the conclusions related to the need for performance in this sport. According to Alexander & Honish (2009), table tennis is a sport that depends on finely crafted movements that occur very quickly and a precise execution of shots, and when training is at a high level, table tennis coaches and athletes must consider the concepts of reaction time, spin on the ball and stroke biomechanics.

Due to these aspects, we have considered that analysing the execution method of this element is important for both forehand and backhand areas in order to identify the most relevant aspects of the execution stages, with the purpose of designing an optimum model of technical expression in female table tennis at junior level. To fulfil this objective, we performed the biomechanical analysis of 120 video frames taken on 20 female junior athletes, using specialised analysis software; the recordings were processed for the ball hitting phase, the completion of the stroke and the time necessary to execute the element.

Table tennis demands elaborate movements of the upper limb to manipulate racket angle, that is why coaches and players need to understand the basic biomechanical principles and how to apply them to the different components or phases of strokes (Qian, Zhang, Baker, & Gu, 2016); that is why our biomechanical analysis focused on the angles of the arm and forearm resulting during the execution phase; besides the lower part and the trunk, the upper limb had a decisive role in the successful execution.

The study performed by Zhou (2014) on the biomechanics of the topspin comes to support our research, stating that "the hand techniques are definitely considered as the most important, from a general point view" (pp. 589-590).

The female athletes belonging to the second junior category are in a period when the scientific, strategic and bodily elements, along with their personality attributes, are established; the customisation characteristics occur during this time, based on the abilities shown for a specific game profile; at the end of this category, the player should have a well-formed profile of the game (Doboşi, 2009). Also, for ages 12 to 14 (Baştiurea, Stan, Mihăilă, & Creţu, 2011), there are reported significant correlations in the extra

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rotation and flexion-extension of the arm, showing that the entire musculature of the trunk is involved in arm actions, and for ages 15 to 16, it can be observed a specialisation of the right arm for intra rotation only.

Taking into consideration the above-mentioned aspects, we would like to identify the angle values and the execution speed of retopspin, which would facilitate the creation of an optimum execution model, as well as the usage of a training methodology meant to consolidate and then to perfect this technical-tactical element specific to attack for this age category.

The following observations have underpinned the development of this investigation:

- There is no biomechanical analysis on this technical-tactical element for this age category;
- There is no efficient and acknowledged execution model;
- There is no execution model;
- There is no training program meant to optimize the execution on both striking zones, forehand and backhand, considering objective guiding marks, from a biomechanical point of view;
- The importance of viewing, acknowledging and analysing one's own executions, as compared to the optimum model, by coaches and female athletes;
- Knowing the best number of training sessions is required to strengthen the retopspin (counter-loop);
- The importance of knowing the execution speed and its influence on efficiency;
- Knowing the best way to execute the retopspin is essential;
- The opportunity of stroke consolidation for this age category, in order to attain the perfection level when reaching the age level.

2. Problem Statement

Reaching the performance objectives in a sports discipline is most times synonym to continuous training and the desire to repeat the performance or exceed it, to material rewards, notoriety and appreciation.

In table tennis, the attack phase, with its specific elements, represents the most prolific stage compared to the defence one, the efficiency of technical-tactical elements being a trump card in winning a game and winning a medal.

Topspin's counteraction, ranked with 60% in winning the point (Negulescu, Mocanu, & Cristea, 2017), put in the game through the retopspin, can be an action with visible influences on the scoreboard, but also on the financial, image prolificacy and the results obtained in important competitions, the high aggressiveness of the stroke, the quality of the response to topspin due to the speed and effect combination fostering success.

The Open Era in table tennis has increased the possibility of earning significant amounts of money and the notoriety of both this discipline and the participants in sports competitions that take place in 12 cities all over the world, starting from January up to November. These events have contests for the U-21 category, with the participation of female juniors and youth, even though some surprises occurred when the 13 and 16 years old players, Harimoto and Mima (ITTF, 2018b), won the senior competition, validating thus the "open" term. Our female juniors participate in these Opens, where the amounts of money obtained

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range between 5,000 and 48,000 USD (ITTF, 2017), the quality of the attack phase supported by retopspin being able to make the difference in both the ranking and financial registry even at this junior age.

In our opinion, the best possibilities to optimize the strikes of female junior athletes in the second category are the following (being reflected in all sportive, financial, continuity aspects connected to this topic):

- Creation of an effective execution model achieved following to biomechanical analysis;
- Identification of the execution speed for the counter-loop in top players and identification of the means and methods of achieving this objective;
- As for the speed/strength/coordination/versatility direction, athletic training should aim at their improvement;
- The retopspin and topspin strike can be strengthened through theoretical and practical aspects in each training session;
- The strike stage during actual games should be recorded, viewed and analysed;
- The athlete should be aware of how the strike phase is important during competitions and of the fact that they should use both topspin and retopspin elements during the competition.

Our opinion is that only through attack consolidation by retopspin, by using the solutions mentioned above, the game performance can be increased, turning into incentives for training and monetary gain.

3. Research Questions

Hypothesis: Analysing the execution method, from a biomechanical point of view and as regards the speed of the playing upper limb in female junior athletes, we will be able to create an optimum hitting model, which would consolidate the attack phase.

Premise: The analysis of the importance and development of the retopspin by means of an investigation tool that consists in a dedicated biomechanical analysis software program is what makes our investigation beneficial and attractive.

In our study, we have investigated the following purposeful contemporary aspects aimed at complementing the performance training of athletes:

- Is there any relation between the angle of the arm and forearm in the ball hitting phase, the one from the moment the hit is completed, and the success of the execution?
- Is the strengthening of the retopspin attack advisable for this category?
- Does the attack phase become more efficient by using the recording method and the biomechanical analysis of the execution method?
- Can evaluation of the execution speed of the counter-loop performed with forehand and backhand highlight certain correlations responsible for success?
- Is the usage of retopspin, during each training, an efficient consolidation method of the technical-tactical element and, implicitly, of the attack phase?
- Can the comparison between the execution of female juniors II and female juniors I, through analysis and visualisation, be a stimulus to improve execution and its optimum usage for this age category?

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- Can the visualisation of own biomechanical efficiency, as compared to the designated optimum model, influence the adaptation and success of athletes at the moment this technical element is used?
- How important is the physical, technical and tactical training in the phase of strengthening the attack?
- Are the technicians having different insights on how to execute the topspin and counter-topspin?

4. Purpose of the Study

We aim to increase the efficiency of the attack phase in female junior athletes by optimizing the retopspin execution following the biomechanical analysis performed for the playing upper limb (skilful hand), which would lead to create a hitting model and the optimum training methodology on this direction.

We believe that our scientific endeavour can create an objective analysis and execution model by using audio-video recordings, computerised biomechanical analysis and statistical-mathematical analysis, which would provide coaches with an effective evaluation system that could be applied and extended to other technical-tactical elements submitted to consolidation and perfecting.

From a theoretical point of view, the obtained results are meant to fill the existing gap for this age category (similar studies are applied to seniors), the trunk and lower limbs being targeted by this research.

Details related to the action of the arm and forearm in different stages of retopspin execution can make the difference between being effective and not succeeding in reaching the performance objectives.

Our second purpose is to highlight the importance of our investigation and to have a good grip on an audience willing to develop the retopspin attack.

5. Research Methods

Our scientific endeavour was directed towards the consolidation of the attack phase through the recording, refinement and analysis of many executions during the games and of the technical-tactical themes in which the research subjects participated, the collected data being important, in our opinion, for the improvement of the retopspin executed on both sides (forehand and backhand).

The research was conducted on a group of 20 female table tennis players, all right-handed, ranked between the 8th and the 133rd place in female juniors II (out of which two players were members of the national team) and one female junior I, who was part of the national team in her age category.

They were split into two samples, the experimental and control ones, with 10 subjects each, which constituted the object of the testing; the strategy for optimizing the attack, from the biomechanical and technical-tactical points of view, is applied only in the case of subjects belonging to the first sample.

In order to be efficient, from the standpoint of the proper research and in financial terms, we established the experimental group with female junior athletes from both our own team (which we have trained and led to contests) and the areas next to our sports club, the position in the leaderboard not being a determining factor in their selection.

The following methods were used in this research: informational-bibliographic study, pedagogical observation, audio-video recording, anthropometric measurements, psycho-pedagogical experiment of

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verification and improvement, logical method, black-box, statistical-mathematical method and computer graphics method.

For data collection, analysis and interpretation, we used the latest IT software and devices, for example a Panasonic audio-video recording camera - HC-V380 Full HD Wireless model, a G850 computer model from Lenovo, Dartfish 360s biomechanics analysis software and the IBM SPSS Statistics analysis program, version 23.

For the technical-tactical and physical capabilities, two tests were used to evaluate speed and coordination abilities ("Wall Toss" and "Shuttle Run"), and for the technical-tactical expression level (topspin with crosswise retopspin, forehand and backhand, the "Butterfly" and "Multi-Ball" tests), all aimed to highlight relational values and aspects used in our experimental-ameliorative research.

As for the bibliographic study, we studied the materials of interest in international and national literature, which has helped us better understand the aspects and importance of the topic addressed.

The female junior's participation in competitions such as the Romanian Cup, Championships – Division A and team and singles contests has shown how the above elements are used; also, our presence in these contents gave us the possibility to discuss with the athletes' coaches about the above-mentioned elements.

The audio-video shots were recorded in different positions, such as frontally, from the side (past the net) of the table and behind it, with the purpose of capturing the most representative angles.

Besides the desire to identify the moment, area and biomechanics of the skilful arm, we wanted to highlight the possibility of correlating the physical abilities specific to this discipline (coordination abilities in speed conditions) with the success level of forehand and backhand retopspin, as well as the connection between them.

Pearson (r) correlation coefficient and Sigma (p) associated probability were calculated for identifying possible correlations.

Exercises were executed based on the "Multi-Ball" method (Figure 01), using, for each evaluation, 40 balls, and for the other test themes - 5 balls each, for the "Wall Toss Wall Test" - a field tennis ball, and for the "Shuttle Run", 2 table tennis boards placed 3 meters away.

Figure 01. Multi-Ball Test

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6. Findings

The efficiency of this attack hit is in direct relation with the way the forehand topspin and backhand retopspin are initiated, as well as with the execution speed of the latter. It is recorded a correlation with specific coordination abilities, but not one which is highly important:

- The average execution speed of forehand retopspin for the experimental group is around 0.28 seconds, and for backhand, 0.23 seconds, compared to the speed of an athlete from the next category, who executes these two procedures in 0.28 seconds for forehand retopspin and 0.20 seconds for backhand retopspin, thus recording a percentage with almost 10% higher in favour of juniors I, as against the experimental group, and almost 10% higher than the control group.
- After applying the training methodology during the competitive season, for the experimental group, the efficiency of executing this technical-tactical element recorded an improvement of almost 10% compared to the control group, from both the biomechanical and execution speed standpoints, nearing to the optimum technical expression model of female juniors I. (Table 01)

Table 01. Existing correlations between forehand retopspin and backhand retopspin

Forehand retopspin	**Pearson Correlation coefficient**	**Sigma Associated probability**
Forehand topspin – Hit preparation <º	0.801	0.005
Backhand retopspin – Ball hitting	0.689	0.028
Backhand topspin – Ball hitting	0.634	0.049
Weight of the female juniors	-0.636	0.048
Backhand retopspin	**Pearson Correlation coefficient**	**Sigma Associated probability**
Hit preparation - Length of the right hand	0.656	0.040
Hit preparation - Width of the arms	0.674	0.033
Forehand topspin at <º ball's strike	0.642	0.045
Forehand retopspin - Time necessary for execution, hundredths of a second	0.669	0.035

6.1. A training model for improving the attack with retopspin in female juniors II

- The average execution speed of forehand retopspin should not exceed 0.28 seconds, and for backhand, 0.24 seconds;
- The hit will be initiated on the forehand part, at an angle of around 1300-1350, and for backhand, at an angle of around 650- 800 between the arm and forearm;
- In the case of forehand retopspin, the ball should be hit at an angle of about 900-1060 between the arm and forearm for the dexterous upper limb, and in the case of backhand, for the same limb, at an angle of around 850-950;
- Hit completion will describe an angle of around 600-750 between the arm and forearm for the execution from the dexterous part and 1200-1300 for the backhand one;
- The daily practice of the element, on the basis of the multi-ball method, making use of the topspin and backspin effects;
- Technical exercises for retopspin consolidation with male partners;
- Sets - exercises where the athlete creates the opportunity for the opponent to initiate the topspin attack and has the responsibility (obligation) to respond with retopspin on both sides;

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- Monthly evaluation of the progress recorded as execution method, but also as efficiency in the game, using measurement objectives;
- Developing movement near the tennis table for covering, by the forehand, the largest possible area to initiate the retopspin attack, this hit imprinting the ball with a combination of speed and effect higher than the hit using the backhand, the pressure upon the opponent being due to the higher amplitude of the hit;
- Developing motor abilities of the entire muscle system towards speed-strength coordination;
- High-speed execution of elements in front of the trunk with well-chosen timing near the table and sending the ball across and in line;
- Examining the audio-video records of the executions using at a HD-type resolution and the Dartfish 360s software;
- Convergence in executions to the values expressed by the top players from the next category, the biomechanical analysis being performed with images caught during the games they are playing at important contents, in their final stages (semi-finals, finals);
- Using the latest equipment (video camera, computer software specialised in biomechanical analysis, computer, bats, tables, rubbery support areas);
- Performing exercises to strengthen the retopspin near the table and at midway, because the strikes are more efficient this way.

The influence of biomechanics on the execution speed is shown in Table 02.

Table 02. The influence of biomechanics on the execution speed

	Technical-tactical element/ Hit stage	**Initial value**	**Final value**	**Percentage increase**
1	Forehand retopspin Preparing the hit <º	134.20	132.56	
2	Hitting the ball <º	105.51	106.71	
3	End of movement <º	68.75	75.17	
4	Time required for the execution in hundredths of a second	31.0	27.4	11.61%
5	Backhand retopspin Preparing the hit <º	86.70	79.79	
6	Hitting the ball <º	84.09	85.19	
7	End of movement <º	136.48	129.95	
8	Time required for the execution in hundredths of a second	26	23	11.54%

A model for analysing the execution time for the counter-loop performed with backhand and forehand is shown in Figure 02.

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Figure 02. Model for analysing the execution time for the counter-loop performed with backhand and forehand

7. Conclusion

For our goal to be successful, the above-mentioned components must be intertwined with the best execution, from a biomechanical perspective, and the daily performance of the retopspin during training, along with the training for developing the movement abilities of the whole muscle system. The female juniors II is the best time when the retopspin, together with the refined topspin, should occur in the game, which means that special attention must be paid to the development of these technical and tactical aspects.

The importance of the topspin counts for 60% according to coach feedback as regards gaining a round within a game, with votes from 42.85% of coaches, and the same percentage of specialists declare a 50% influence of the retopspin in this respect, the efficiency of the execution, from a biomechanical point of view, increasing extensively the chances of winning a game, especially against an offensive player.

The above technical and tactical aspects (retopspin and topspin), particularly in the strike stage, practically condition the athletes at this level, their importance being unanimously appraised by coaches.

If we compare the two elements, mainly in the strike stage, only 4.78% is in their favour, considering that there is a difference between how the topspin and retopspin are executed; in our opinion, the retopspin requires higher speed and strength coordination than the topspin, even though the basic movement is not quite distinct, which is also underlined by the retopspin or counter topspin designation; thus, the average execution speed in the case of the forehand retopspin and topspin is 0.30 seconds, and in the case of the backhand, a difference of 0.24 seconds is recorded for the retopspin and 0.28 seconds for the backhand topspin.

Following to the methodology applied for the optimization of the attack phase by improving the execution of retopspin (technical-tactical element), an improvement with 11% (rank 46 in February vs 41 in May) of the position occupied by the athletes from the experimental group in the leaderboard occurred between February and May, as against an increase of 8.88% (rank 50 in February vs 46 in May) in the case of the control group.

Designing a program to improve the attack using the retopspin might be the best solution for a contemporary match, thus increasing the chances for female juniors II to achieve performance at the highest level; the audio and video recording, as well as the biomechanical analysis comparing the top players' executions performed by specialised software, are universally agreed to help the athletes improve their performance and evolution.

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