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# Quantifying the functional diagnosis in the rehabilitation of postural problems of biomechanical junior female players in table tennis

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**Abstract**
We have lived in an era in sports history in which due to the intensity of the confrontations between athletes, disorders manifested by headaches, shoulder, pelvis and knee aches etc. appear more often. The performers during puberty require special attention on their morpho – functional development from the kynesiotherapist who is part of the multidisciplinary team, due to many transformations of the human body specific at this age category. 13 juniors female athletes have participated to the study, being assessed anthropometric, plantar pressures and posture with softwear FreeStep by Sensor Medica, biomechanical analysis and from technical & tactical point of view by 5 tests with DartFish 360S. Within the statistical – mathematical analysis, we have used Pearson correlation coefficient which favoured the identification of the strongest correlations resulted from the technical – tactical - anthropometric – plantar pressures and postural unbalances ($r > 1.00$ at test 1 and $r > 0.84$ at test 2). Assumption: It is assumed that by using established methods and means to assess postural deficiencies and to assess the level of consolidation of the topspin attack, we can identify the correlations between them which would facilitate the creation in the future of an efficient postural improvement program. The goal is to improve the quality of life and sports performance in junior female table tennis players. The conclusions of this study demonstrate the fact that the mobility of the spine in frontal plan, high thoracic elasticity and an increased lateral mobility on the opposite side of the active arm represent advantages intended to optimize the attack by topspin, while the supraponderability, the pain in lumber area and the shoulder's asymmetry constitute disruptive factors of attack's performance.
**Keywords:** *plantar pressures, postural unbalances, baropodometric platforms, topsin attack efficiency, dartfish 360s,*

## Introduction

In order to perform in table tennis, it is necessary for the debut in sports training to be made around the age of 6-8 years old, a context in which repetitive, speedy unilateral movements can create postural deficiencies over time. This limits the training process aimed at meeting the performance objectives, while the early identification and implementation of methods and means meant to improve their problems are a "*must have*" for continuity and for the optimization of the performance capacity.

According to the results obtained in a research conducted on the basis of an opinion survey applied to table tennis specialists dealing with sports training, a program for evaluating and improving incorrect body positions could bring benefits in improving the attack by topspin, aspect voted unanimously. By identifying the factors that can improve the performance in table tennis, such as biomechanics and posture, we will be able to provide information for the athletes involved in profile competitions, but also to provide guidance for a physical activity performed without repercussions on the osteo-articular and muscular level among the devotees practicing this discipline during free time [1].

By analyzing the hitting mode using the topspin technical-tactical element executed on both sides, the specialists observed that the forehand strokes mainly use the motion of trunk axial rotation, shoulder flexion, and shoulder internal rotation to produce racket linear velocities [2], while for backhand strokes, it primarily involves shoulder external rotation and flexion, elbow extension, forearm supination, and wrist extension [3]. In table tennis, the level of technical expression in the game is an essential factor for the athletes involved in high performance, an adequate execution technique translated by a high-performance biomechanics, meaning that you can perform coordinated physical actions, executed with adequate power and ability to imprint to the ball an effect and a speed adapted to the situation on the play field, according to the same authors, a high level of technical training implying an optimal orientation of the process in the context of the exchange of balls within a point disputed in the set's register, i.e. the adversary must not detect the intent of the technical expression [4].

The opponent has less opportunity to hit an offensive stroke against a ball with higher speed and greater spin

[5]. The topspin forehand is one of the most attacking shots in table tennis. In a recent study, Yoichi I. et al. found that it was used more often in winners than other stroke types, suggesting that mastering this shot is critical to winning matches [6].

An interesting aspect regarding the game tactics at the level of women's table tennis compared to the men's is given by the differences identified regarding the acceleration achieved at the execution of the attack using the topspin technical-tactical element from the ball with backspin effect, which highlights the fact that female tennis players use topspin on both hitting sides, while male tennis players look for opportunities to execute strong shots with the forehand topspin on the whole table [7].

Modern table tennis is a sports game that demands high speed in all forms of manifestation, variation, complexity and a quick response to various changing stimuli, the difficulty of this sports discipline being accentuated by the speed of movement and by the different effects imprinted on the ball. It is obvious that the forehand topspin is among the most used blows both in attack and in counter-attack, the speed of movement of the paddle when in contact with the ball reaching 20 m / s, after the hit, the ball will travel with 45m / s, the effect imprinted on it causing a rotation of 140 r / s, both theoreticians and practitioners considering that the forehand topspin is a complex hit involving a kinematic chain in which there is a cycle of elongation and muscle contraction, the speed with which the paddle hits the ball being initially influenced by the coxo-femoral joint and by the rotation of the trunk, followed by the flexion and adduction made at the scapulo-humeral joint level and the flexion of the forearm on the arm [8].

In the technical and physical context presented above, according to Dellaporta, et al., trunk flexion, extension, rotation and the time spent in the basic position, specific to the training and playing activity of table tennis players, facilitate a vulnerability of the lumbar area, causing pain [9].

Professional players focus on attack and most players who are participating in international competitions use the forehand topspin loop to create high spin and speeds on the ball. Moreover, because of making the size of the ball bigger for decreasing rate of the game, the force imposed on shoulder girdle muscles of table tennis players has been increased [10].

Muscle asymmetries, excessive curvatures of the spine and scoliosis are the factors that lead to painful syndromes, degenerative states, implicitly to disorders of motor functions, which can be disruptive factors in the efficiency of forehand and backhand topspin technical-tactical procedures mention that the dynamic stresses of the postural control require active contributions of the kinematic chain in order to develop a model of movement with greater coordination, reason for which the posture represents an important aspect for the efficient execution of the topspin attack, being related to it the capacity to train and to limit the pain of the sportswomen, appeared at the level of the spine in case of its deficiency, generated by the vicious positions and unilateral repetitive movements in speed regime [7][11]. According to Iordan, D.-A., et al., after applying the survey, 52% of the coaches interviewed and involved in the training of the female juniors mentioned that the topspin is responsible for the occurrence of pain in the lumbar spine [12].

According to Filipcic, et al., in tennis, the asymmetry of the body is present starting with the youngest age category, an aspect that creates problems at spine level [13]. In table tennis, over-training, improper execution of the first part of training, the incorrect posture, the lack of concentration and emotional instability favour the occurrence of injuries [14].

For a physical development, beneficial to children, it is necessary to individualize by using specific devices of physiotherapy and physiotherapy [15,16].

To turn a research in postural area to value, it is necessary to implement the baropodometric analysis according to Rosário, which recommends the use of plantar orthoses to improve the painful conditions related to the lower limbs and the spine [17-18].

The maximum pressure of the support base is found in three points: at the level of the first metatarsal (hallux), of the lateral edge of the plant and of the calcaneus [26].

According to Stan,. the positive correlations resulting from the study on “Relationships between the pressures exerted by the sole of the foot and the distribution of muscle forces at trunk level”, using the baropodometer and the Trunk Muscle Assessment System consisting of 4 components (a metal frame, a force transducer, a laptop and the software program for collecting, transmitting and processing the data collected by the translator), demonstrate the validity and efficiency of the system for measuring the muscle forces in the trunk, its every movement increasing the values of the pressure points at plantar level [19].

By using simple observation up to sophisticated analysis devices, we can evaluate lumbar lordosis and postural alignment, the services of a specialist had been used for the identification of these deviations [20,21,22]. Based on a study conducted by Negulescu, et al., the multiple twists of the trunk in high speed, specific to the topspin by forehand (the most prolific technical-tactical element, aspect scored by 50% of the surveyed coaches), create pain and disorders of the spine in the case of the female juniors involved in performance sports [23].

Following those mentioned in this introduction, it is necessary to monitor and evaluate athletes consistently [24] and we consider that anthropometric examination,

the plantar, postural analysis and the technical-tactical tests, along with the means associated to it, are determining factors in diagnosing the posture disorders and in creating programs to improve the quality of life of female athletes and to optimize the female junior table tennis players' performance [25].

**Material and method**

**Participants**

In this preliminary research, 13 junior female table tennis players involved in performance sports have been assessed (having experience in competitions of approximately 5.2 years, the average age being 12 years old, the height of 169.6 cm. and weight of 58 kg.), members of A.C.S. ACTIV Galați, L.P.S. Slatina, A.C.S.O.V. Bucharest Clubs. Within the previously mentioned club, the antropometic dimensions of the female players and the technical and tactical consolidation level of the attack by topspin had been measured, the postural assessment being made at the integralist medicine clinic named „Sănătate cu Ozon [Health by Ozone]" located in Galați City, 118 Domnească Street. The collected data had been processed and interpreted within the Kinetotherapy Research Centre of the Faculty of Physical Education and Sports within "Dunărea de Jos" University of Galati. In what concerns the participation to this study, we have selected only female subjects, performance junior players in table tennis with a good health state at the moment of performing the assessments which we are going to list below.

**Procedures**

In order to reach the purpose of this scientific endeavour, we have used modern methods and means specific to kinesiotherapy, clinical medicine and table tennis, intended to highlight by assessment the most important aspects necessary for obtaining data of interest to the research team. They had been selected in accordance with the actual research level, their capacity to supply as many objective data as possible, the number of subjects, the time necessary for the assessment and the usage costs. At the assessment of the involved subjects, we had used the following methods, research means and technical and tactical assessment tests: *Anthropometric examination* – it has as purpose the assessment of the level of increasing the physical development degree [26]; *Schober Test* – it measures the muscular – articular mobility in flexion and extension movements of the trunk [19] ; *"Finger to floor" test* – it assesses both the degree of mobility of the spine through the flexion movement of the trunk, and the mobility of the coxofemoral joints and the suppleness of the hamstring and gastrocnemius muscles. (Cordun, 2009) [27]; *"The Laterality Test"* – it assesses the lateral mobility of the trunk [28]; *Dynamometry* – it is measured and recorded the maximum force (in kg) of the palmar flexors in the right and left hand [19,26], being performed with the Hydraulic Dynamometer of SH5001 type; *Computer software for analyzing the plantar pressures* (baropodometry freeMed) and the posture (images) – *FreeStep by Sensor Medica.*; *Computer software for biomechanical analysis*, *DartFish 360s*, being used for the biomechanical analysis of technical – tactical procedures used in the case of above mentions tests used for the assessment. This program was used in a scientific research by Mocanu & Negulescu, on the biomechanics of the attack by topspin in female junior table tennis players [29] in order to identify the efficiency of the movement, this being correlated with the execution technique [30].

For the evaluation of the level of consolidation of the attack by topspin, we have used a series of *5 technical – tactical tests*, performed both with forehand and backhand, both diagonally and in line, as follows:

*P.1. Topspin with diagonal forehand performed from blockage.* This test that we have used to evaluate the level of consolidation of the topspin attack in the female juniors involved in our scientific endeavour was performed by diagonal forehand topspin from the no-spin ball, from blocking the game partner. *The testing was performed using a number of 5 balls.

*P.2. Topspin with diagonal backhand performed from blockage.*This test that we have used to evaluate the level of consolidation of the topspin attack in the female juniors involved in our scientific endeavour was performed by topspin diagonal backhand from the no-spin ball, from blocking the game partner. * The testing was performed using a number of 5 balls, counting each success.

*P.3. Diagonal Butterfly performed from blockage.* The Butterfly test from the no-spin or spin ball is made by sending the ball diagonally or only in line, using a certain procedure or technical procedures, aspect established from the beginning of the theme (e.g. while one of the players performs topspin on both sides diagonally, the other player sends the ball back in line, with blockage). In the case of the assessment on the level of consolidation of the topspin attack in female juniors III, the forehand and backhand topspin executed from the no-spin ball sent diagonally was evaluated, the return being made from the blockage made by the game partner [31]. * We used a number of 5 balls, counting each successful ball exchange.

*P.4. Line Butterfly performed from blockage.* Regarding the level of consolidation of the topspin attack at this age category, we used the forehand and backhand topspin performed with no-spin ball sent in line, the return being made from the blockage made by the game partner [31]. * The testing was performed in a number of 5 series in which each successful ball exchange was counted.

*P. 5. Multiball (topspin with forehand + topspin with backhand performed diagonally from no-spin ball,*

*followed by the same technical procedures achieved from backspin ball).* According to Mocanu, multiball training is a modern training method similar to the "ball robot" which is performed by the coach and a female athlete, involving a large number of balls, performed in order to make more efficient the technical-tactical procedures and to optimize the specific motor skills [26]. The "box" (the popular name of the above-mentioned method, specific to table tennis) is made as follows: the player who performs the topspin attack will have to execute from both sides of the table the topspin with forehand and topspin with backhand, the hits being sent only diagonally, first from the no-spin ball, followed by the same technical procedures performed from the backspin ball. This test in our case aims to assess the level of consolidation of the forehand and backhand topspin attack from the no-spin ball and from the backspin ball. * We used for evaluation 10 series of 4 balls each (hit alternately with the forehand and then with the backhand) which were counted as successful only when the female athlete hit all 4 balls efficiently (they passed over the net, landing in the opponent's court).

***The statistical – mathematical analysis*** of the data obtained from the (topspin) technical – tactical and kinesiotherapeutic assessments had been interpreted by using *Microsoft Excel*.

The calculation formula for *Pearson* correlation coefficient achieved with the help of *Correl* function is:

$$Correl(X,Y)=\frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2\sum(y-\bar{y})^2}}$$

**Results**

The scientific research carried out was performed both technically - tactically and postural unbalances, due to the fact that we intend to identify a possible relationship between the performance of the topspin attack and the posture of the body of the female juniors in table tennis. For the evaluation of the biomechanics and the execution speed of the topspin we used modern analysis software, *DartFish 360s*, meant to evaluate the angles between the arm-forearm in the 3 stages of performing a procedure and its necessary execution time (Fig. 1).

From the usage of the above mentioned computer software, there resulted the times required to perform the procedures expressed in hundredths of a second and the average values of the topspin attack performed with the forehand and the backhand, both from the no-spin ball and from the backspin ball.

We present the following values obtained (Tables 1 and 2): FHD (Forehand) Topspin from no-spin ball (resulting from blockage). The time required to execute the procedure expressed in hundredths of a second: 33.3 ;BHD (Backhand) Topspin from no-spin ball. The time required to execute the procedure expressed in hundredths of a second: 29.5 ; FHD. Topspin from spin ball (backspin type). The time required to execute the procedure expressed in hundredths of a second: 48; BHD. Topspin from the spin ball. The time required to execute the procedure expressed in hundredths of a second: 38

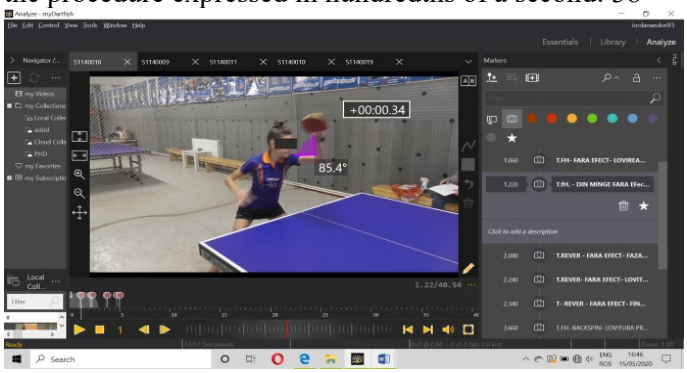



*Figure 1. Image during the technical – tactical assessment processed by biomechanical analysis software, DartFish 360s, during the test with diagonal forehand topspin – the end of movement from blockage*

| **The analysed feature** | **Average value** |
|---|---|
| FHD. Topspin – Hit's preparation <º | 124.5 |
| FHD. Topspin – Ball's hitting <º | 94.7 |
| FHD. Topspin – The end of movement <º | 74.3 |
| FHD. Topspin – Time necessary for the execution in hundreds of a second | 33.2 |
| BHD. Topspin – Hit's preparation <º | 102.76 |
| BHD. Topspin – Ball's hitting <º | 84.2 |
| BHD. Topspin – The end of movement <º | 129,75 |
| BHD. Topspin - Time necessary for the execution in hundreds of a second | 29,3 |

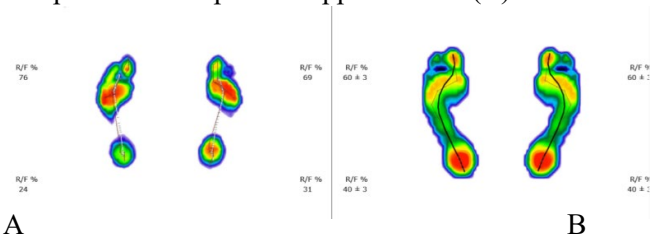
*Table 1. The average of the values of the biomechanical indicators for forehand diagonal topspin from no-spin ball*

| **The analysed feature** | **Average value** |
|---|---|
| FHD. Topspin – Hit's preparation <º | 138,5 |
| FHD. Topspin – Ball's hitting <º | 108,2 |
| FHD. Topspin – The end of movement <º | 75,9 |
| FHD. Topspin – Time necessary for the execution in hundreds of a second | 48 |
| BHD. Topspin – Hit's preparation <º | 114,5 |
| BHD. Topspin – Ball's hitting <º | 91,5 |
| BHD. Topspin – The end of movement <º | 137,6 |
| BHD. Topspin - Time necessary for the execution in hundreds of a second | 38 |

*Table 2. The average of the values of the biomechanical indicators for forehand diagonal topspin from backspin ball.*

Following the technical – tactical, anthropometric, plantar pressures and postural unbalances assessments, there have resulted multiple values and correlations, all favouring an overview of the connections between them. Table 3 highlights the above.

The dynamic analysis of the female athlete's plantograms shows different ways of their movement, aspects that we want to highlight through the image represented by *Figure* 2, provided by the baropodometric device, which highlights the support mode of the assessed athlete (A) as compared to the optimal support mode. (B).

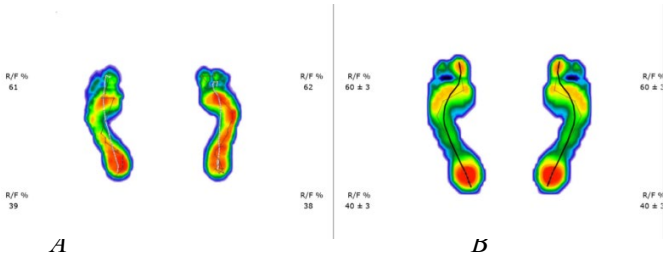


A B

*Figure 2. The value of the distribution of the plantar pressures versus the standard in the dynamic phase using the baropodometric platforms freeMed by Sensor Medica*

A = *The percentage distribution of plantar pressures specific to table tennis in the case of the subject with the highest performance at the technical – tactical assessment.*

*B = The general value or the standard of an optimum distribution of the plantar pressures exercised in normal conditions.*



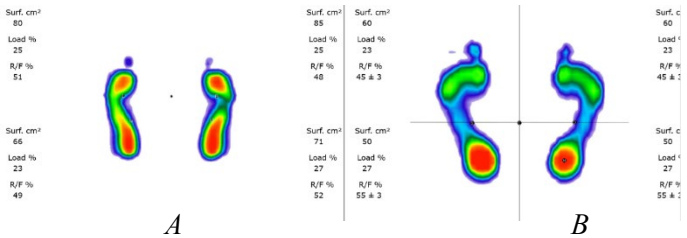
*A* *B*

*Figure 3. The value of the distribution of the plantar pressures of the subject vs. the general value in the dynamic phase using the baropodometric platforms freeMed by Sensor Medica*

A = *The percentage distribution of plantar pressures specific to table tennis in the case of the subject with the highest performance at the technical – tactical assessment.*

*B = The general value or the standard of an optimum distribution of the plantar pressures exercised in normal conditions.*

*From the dynamic assessment., a bilateral plane foot and a deficient way of movement as compared to the specificity of the table tennis (performed on the sole) are observed, with a negative influence at the level of the topspin attack, this comparison being achieved in relation to the other female athletes assessed, registering the lowest mean of the success.



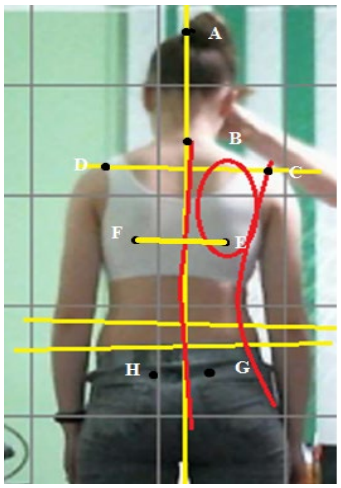
*A* *B*

*Figure 4. Distribution of the centre of gravity, as compared to the distribution of the centre of gravity in static phase result from using the baropodometric platforms freeMed by Sensor Medica*

*A = The Distribution of the centre of gravity specific to table tennis in the case of the female athletes assessed.*

*B = The Distribution of the centre of gravity or the standard.*

In Figure 4. - A, and in the case of the other athletes assessed, a forward projection of the centre of gravity is observed, aspect resulting from the fundamental position specific to current table tennis, in which the trunk is inclined forward and the support is made on the forefoot, the trunk moving often from the inclined to the bent position in the dynamics of the game, especially in attack. According to the data taken from the postural analysis using the images, the somatoscopic examination shows a scoliotic attitude (lumbar sinister-convex and thoracic dextro-convex) in the case of the female juniors assessed, according to the observations in Fig. 5. We consider that these scoliotic deficiency result from the motor skills specific to table tennis and the lack of timely notification by the coach and the sports doctor of this deficiency,




**A –** Subject's vertex
**B –** The prominence of C7 vertebra
**C –** Right shoulder
**D –** Left shoulder
**E –** The tip of right scapula
**F –** The tip of left scapula
**G** – Prominence of postero-superior iliac spine R.
**H -** Prominence of postero-superior iliac spine L.

implicitly the lack of a postural improvement protocol.

*Figure 5. – Image highlighting the* scoliosis*, resulting from the postural assessment of the junior female athlete resulting from using softwear FreeStep By Sensor Medica*

**DISCUSSION**

The aim of this study is to assess postural deficiencies and to assess the level of consolidation of the topspin attack, we can identify the correlations between them which would facilitate the creation in the future of an efficient postural improvement program.

The two findings were: all juniors' players have postural deficiencies and plantar imbalances, and a high weight of the athlete, she will have a flat leg and a low efficiency in the attack phase. And we consider that personalized plantar supports are very important in this age category and a recovery protocol through exercises performed asymmetrically, depending on the concavity of the spine.

From the statistical – mathematical analysis applied to the data obtained from the assessment, many strong correlations have resulted, as compared to the other specific levels (without correlation, poor correlation, moderate correlation and strong correlation).

In the case of strong and moderate correlations at Test 1, the correlations related to the arrows of the lumbar spine (r= 1.00) and (r= -0.99) of the force of the palmar flexors were highlighted. In the first case we have a correlation directly proportional from which it results that a better technical – tactical success involves a higher value of the spine arrows in lumber area (a highlighted lumbar curve), and at the second correlation we have an inverse ratio with the following significance: a success superior to the topspin attack involves a low force of the palmar flexors.

In the case of strong and moderate correlations at Test 4, the correlations related to the thorax elasticity (r= 0.97) and (r= - 1.00) of the bust have been highlighted. In the first case we have a directly proportional correlation from which it results that a better technical – tactical success involves a higher value of the thorax elasticity, and in the second correlation we have an inverse ratio with the following significance: a success superior to the topspin attack involves a lower value of the bust.

In the case of strong and moderate correlations at Test 5, the correlations related to Schober Test on flexion (r = 1.00) and (r = - 0.78) the lateral mobility of the unhandy arm have been highlighted. In the first case we have a directly proportional correlations from which it results that a better technical-tactical success involves a higher value at Schober Test on flexion, and for the second correlation, we have an inverse ratio with the following significance: a success superior to the topspin attack involves a lower lateral mobility on the unhandy arm.

From the dynamic assessment of the female junior athlete (Fig. 2, variant A), it is observed a hollow (scooped) foot and a movement mode specific to table tennis, performed on the forefoot (sore) with beneficial implications at the level of the topspin attack (registering the best performance) as compared to the other athletes assessed.

**CONCLUSIONS**

In the case of the means of the technical – tactical tests and the posture examination within the scientific research assessment, the following strong correlations have resulted, intended to guide the specialists for the optimization of the capacity and performance objectives. The strong correlation resulting from the technical – tactical assessment in relation to the weight (r= - 0.78) signifies a reverse proportionality, demonstrating the fact that a superior success in technical – tactical area involves a smaller weight of the female athletes. In the case of the strong correlation resulting from the technical – tactical assessment in relation to the waist (r= 0.64) signifies a directly proportional ratio demonstrating the fact that a better success in the topspin attack involves a larger waist of the female athletes. The strong correlation resulting from the technical – tactical assessment in relation to the bust (r= - 1.00) signifies a reverse proportionality demonstrating the fact that a superior success in the technical –tactical area involves a smaller bust of the female athletes. The strong correlation resulting from the technical – tactical assessment in relation to the thorax elasticity (r= 0.96) signifies a direct proportionality demonstrating the fact that a better success in the topspin attack involves a higher thorax elasticity of the female athletes. The strong correlation resulting from the technical – tactical assessment in relation to the plantar pressure of the left foot (r= 0.84) signifies a direct proportionality demonstrating the fact that a higher pressure exercised on the sole left foot involves a superior success in the technical – tactical tests (at the hit with forehand in the case of right-handed female players).

The lateral mobility of the spine is much higher on the unhandy arm side, being explained by the fact that in the adopted play tactic, both in female and male players, the positioning, initiation and finalization of the forehand attack predominate, reason for which the flexion of the trunk in the side of the handy part causes a muscular – articular elongation higher on the diametrically opposite side (unhandy arm).

From technical – tactical point of view, the results obtained with the help of the biomechanical analysis software highlight a difference between the execution time of the topspin with forehand and with the backhand from backspin ball, as compared to the no-spin ball resulted from the blockage. The times necessary for the execution of the procedures in the case of backspin balls are higher due to the spin of the ball, aspect involving a larger span of the execution angles and trunk twists (e.g.: topspin with forehand from backspin ball, *0.48 seconds,* as compared to topspin with forehand from no-spin ball *0.33 seconds).* The angle value between the arm and forearm for the execution of topspin forehand procedure on the preparatory part of the hit, in the case of backspin balls are higher (e.g.: 138.5 from spin ball vs. 124.5 from no-spin ball), due to the spin of the ball, aspect which involves a larger span of the execution and trunk twist angles (e.g.: from backspin ball, *0.38 seconds*, as compared to no-spin ball, *0.29 seconds).*

A good processing of the main muscle and articular groups involved, specific to the motor skills in table tennis, mainly oriented on the shoulder, trunk and lower

limbs area, will facilitate the optimization of the topspin attack by preventing and reducing accidents.

Also, the implementation of customised plantar supports will represent another means of optimization of the attack in female junior players.

For the continuation of this scientific research, we would like to involve in the future a greater number of subjects (approximately 20 female junior players) for a picture at macro level on the topspin attack and the problems generated by it at the level of body posture. From the accumulated experience and data collected from the above mentioned scientific research, we would like to create an assessment system and an efficient amelioration program achieved with the help of the actual methods and means in order to optimise the performance capacity and to improve the life quality in female junior players in table tennis.

**Declaration of conflict of interests**

There is no conflict of interest for any of the authors regarding this paper.

**Informed consent**

Parental consent was obtained for each child after explaining the nature of the assessments, while ensuring that they were strictly anonymous and confidential. They were informed that they had the right to stop the experiment without prejudice. This study was conducted with the consent of the table tennis coaches.

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*Table 3. – Correlations between the (topspin) technical – tactical - anthropometric – plantar pressures and postural unbalances assessments*

| NO. | S. | Correlations | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | W. | WS. | B. | SP. | B.D. | T.E. | SHB. | | D.-S. | LAT. | | PAL. FLEX. FORCE | | SPINE ARROWS | | AREA (cm²) DYNAMIC ANALYSIS | | P. P. (%) STATIC ANALYSIS | | P. P. MAX. (gr/cm²) | |
| | | | | | | | | FL. | EXT. | | H.A. | U.A. | H.A. | U.A. | CVL. | LB. | L. | R. | L. | R. | L. | R. |
| 1 | BA | 48 | 171 | 79.5 | 166 | 29 | 12 | 11 | 5.5 | 11 | 39 | 43 | 14.5 | 8 | 69 | 69 | 142 | 132 | 51 | 49 | 563 | 561 |
| 2 | PD | 54.3 | 168 | 83.5 | 160 | 28.5 | 8 | 10.5 | 7 | 9 | 42.5 | 44 | 20 | 10 | 48 | 30 | 142 | 136 | 49 | 51 | 479 | 434 |
| 3 | PR | 78.5 | 170 | 84.5 | 167 | 34 | 5 | 11 | 10 | 0 | 27 | 32 | 18 | 20 | 117 | 40 | 146 | 141 | 48 | 52 | 523 | 531 |
| 4 | GD | 56 | 170 | 82.3 | 174 | 30 | -4 | 10 | 9 | 2 | 25 | 27 | 30 | 20 | 23 | 23 | 134 | 143 | 43 | 57 | 544 | 543 |
| 5 | RD | 54 | 165 | 80 | 168 | 32 | 3 | 3 | 6 | 4 | 32 | 34 | 25 | 30 | 45 | 34 | 154 | 143 | 56 | 44 | 476 | 425 |
| 6 | DS | 52 | 160 | 76 | 160 | 32 | 10 | 6 | 4 | 6 | 43 | 41 | 10 | 20 | 45 | 89 | 134 | 123 | 49 | 51 | 476 | 486 |
| 7 | AB | 34 | 152 | 80 | 157 | 26 | 5 | 4 | 6 | 0 | 43 | 35 | 25 | 10 | 45 | 65 | 134 | 135 | 52 | 48 | 500 | 400 |
| 8 | GL | 47 | 169 | 78.5 | 165 | 25 | 10 | 10 | 5 | 4 | 35 | 40 | 13 | 10 | 45 | 45 | 135 | 142 | 49 | 51 | 400 | 503 |
| 9 | AD | 75 | 172 | 86 | 168 | 33 | 3 | 12 | 6 | 3 | 24 | 27 | 20 | 20 | 100 | 50 | 150 | 155 | 52 | 48 | 540 | 545 |
| 10 | TF | 45 | 165 | 76 | 159 | 28 | 10 | 6 | 6 | 8 | 35 | 40 | 5 | 10 | 56 | 65 | 165 | 160 | 49 | 51 | 512 | 532 |
| 11 | IG | 65 | 160 | 73 | 170 | 27 | 7 | 12 | 5 | 0 | 27 | 30 | 20 | 25 | 15 | 20 | 131 | 145 | 51 | 49 | 563 | 521 |
| 12 | EV | 70 | 169 | 81.5 | 159 | 28 | 6 | 12 | 9 | 0 | 30 | 35 | 25 | 30 | 34 | 54 | 145 | 135 | 48 | 52 | 476 | 432 |
| 13 | PA | 76 | 172 | U0 | 167 | 34 | 5 | 11 | 10 | 5 | 27 | 32 | 15 | 20 | 11 | 3 | 140 | 145 | 48 | 52 | 523 | 531 |
| CORREL T.1 | | -0.46 | 0.89 | -0.91 | 0.59 | -0.20 | 0.78 | 0.69 | -0.58 | 0.44 | 0.30 | -0.15 | -0.99 | -0.42 | 0.02 | 1.00 | 0.53 | -0.47 | 0.84 | -0.84 | 0.99 | 0.99 |
| CORREL T.2 | | -1.00 | 0.05 | -0.82 | -0.40 | -0.95 | 0.93 | -0.28 | -1.00 | 1.00 | 0.98 | 0.78 | -0.39 | -1.00 | 0.02 | 0.49 | -0.47 | -1.00 | 0.89 | -0.89 | 0.64 | 0.61 |
| CORREL T.3 | | -0.86 | 0.51 | -0.99 | 0.07 | -0.69 | 0.99 | 0.21 | -0.92 | 0.76 | 0.40 | 0.40 | -0.78 | -0.84 | -0.51 | 0.84 | -0.87 | -0.87 | 1.00 | -1.00 | 0.92 | 0.91 |
| CORREL T.4 | | -0.80 | 0.61 | -1.00 | 0.19 | -0.60 | 0.97 | 0.32 | -0.87 | 0.78 | 0.68 | 0.29 | -0.84 | -0.77 | -0.41 | 0.90 | 0.11 | -0.81 | 0.99 | -0.99 | 0.96 | 0.71 |
| CORREL T.5 | | 0.32 | 0.94 | -0.33 | 0.99 | 0.57 | 0.08 | 1.00 | 0.19 | -0.34 | -0.67 | -0.78 | -0.78 | 0.36 | 0.73 | 0.70 | 0.31 | 0.31 | 0.19 | -0.19 | 0.88 | 0.84 |
| CORREL M | | -0.78 | 0.64 | -1.00 | 0.22 | -0.57 | 0.96 | 0.35 | -0.85 | 0.76 | 0.46 | 0.58 | -0.86 | -0.75 | -0.38 | 0.91 | -0.64 | -0.91 | 0.99 | -0.99 | 0.75 | 0.55 |

***SP**– Span; **HA** – Handy arm; **UA** – Unhandy arm; **B** - Bust; **C** – Correl; **CVL** – Cervical; **S**– Spine; **BD** - Biacromial Diameter; **DS** – Distance fingers – floor; **R** – Right**; TE** – Thorax elasticity; **EX** – Example; **EXT** – Extension; **FL** – Flexion**; Fig.** – Figure; **FHD** – Forehand; **PAL FLEX. FORCE** – Palmar flexor force; **W** - Weight; **LAT** - Laterality Test; **LB** – Lumbar; **T.1-5** – Test 1-5; **PP (%)** – Plantar Pressure (load %); **BHD** – Backhand; **S. ARROWS** – Arrows of the spine; **SHB** - Schober Test; **L** – left; **WS**– Waist; **TH-TC** – Technical-tactic.

*Table 4. – Legend*

| | |
|---|---|
| -0.25 < **r** < 0.25 | Without correlation |
| -0.5 < **r** < -0.25 or 0.25 < **r** < 0.5 | Poor correlation |
| -0.75 < **r** < -0.5 or 0.5 < **r** < 0.75 | Moderate correlation |
| **r** < -0.75 or **r** > 0.75 | Strong correlation |