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Age-Related, Sport-Specific Dysfunctions of the Shoulder and Pelvic Girdle in Athletes Table Tennis Players. Observational Study

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Abstract

Background: Postural skills are fundamental in motor activities, so far no evidence of a direct relationship has been found, it is therefore recommended to consider the following directions, the higher the level of sports competition, the better the body posture; or better athletes also have a better body posture. Around the age of 11-14 years, it is a period of aggressive development, if the rapid growth of the bone system is not associated and symmetrical with the development of soft tissues serious postural deficiencies may develop in table tennis players.
Methods: We used the web camera – photographic method (38) related to the Sensor Medica software that allows the acquisition of images in order to detect postural deficiencies and we considered it necessary to have a clear image of the level of technical-tactical training of female juniors III using 5 tests specific to topspin attack in order to assess the influence of body posture on such tests. Eighteen female juniors III (the mean ± SD age, height and weight were 11.1 ± 0.2 years, 147.7 ± 2.6 cm, 39.0 ± 2.0 kg). Descriptive statistical analysis was performed on the procedures for establishing the normality of data distribution, Levene's Test for Equality of Variances, the t test for independent samples. The confidence interval was set at 95% ($p < 0.05$),
Results and Conclusions: Since Sig. (2-tailed) or $p < \alpha = 0.001$ and taking into account that the confidence interval limits for the difference between the sample mean and the reference value (95% CI for the mean difference) do not contain the zero value, it is accepted that there are statistically significant differences between the shoulder inclination for the female athletes in the sample studied and the reference value. We identified that at the level of alignment between anatomical landmarks, the percentage of deficiency of the entire lot of female juniors III in the case of shoulders is 100% and at the level of PSIS is 66%, which validates several studies that stated that in this period of aggressive growth correlated with repetitive unilateral executions specific to the topspin attack lead to postural deficiencies. In terms of the influence of body posture on the quality level, we identified that Group 1 – (without PSIS imbalance) has a higher average overall efficiency of the 5 tests (11.33) compared to Group 2 (8.58), even if from a statistical point of view these differences are not significant.
Keywords: *Body posture, Asimmetry, Topspin attack, Table tennis, Sensor Medica,*

1. Introduction

Given that sports training begins during the period of aggressive growth and development of the body, the impact on the athlete is very strong, which is why it is necessary to study the relationship between body posture and sports performance (1).
Body posture is maintained by a low effort of the musculoskeletal system, without any discomfort (2, 3), also postural control involves the body's ability to maintain a state of balance in the orthostatic position – static posture and during movement – dynamic posture (4). Postural stability depends on a complex relationship between several systems such as the visual, vestibular, and peripheral somato-sensory (leg) to maintain the center of gravity of the body (5).
Functional disorders of body posture in school-age children are reported by (6, 7, 8) identifying the most common abnormalities of the musculoskeletal system (9) leading to its overload.
Around the age of 11-14 years, it is a period of aggressive development, if the rapid growth of the bone system is not associated and symmetrical with the development of soft tissues serious postural deficiencies may develop (10, 11). Another study by (12) states that in the tennis subject, the asymmetry of the muscular system starts at an early age, which creates problems in the spine.

The highest chances of changing body posture are mostly found in girls compared to boys, because this growth period is also influenced by the hormone called estrogen, which interacts with growth hormones and other specific factors, these potential etiological factors creating postural changes (13).
The most common deviations from a correct body posture are in the pelvis and shoulders, which are asymmetrical (14, 15). Following the same authors to state that if frontal scoliosis is present in athletes, this deficiency can cause a series of symptoms that are manifested in stress and fatigue in the tissues of the spine, negatively affecting sports performance in various ways.
A synthesis of specialized scientific articles addressing the evaluation and influence of postural control on performance athletes is made by the authors (16, 17, 18, 19, 20).
Table tennis is one of the most popular sports games, technical-tactical skills are very well recognized as the most important performance elements (21). The repetitive unilateral execution at high speed is performed every time the topspin attack is performed, which produces vicious body positions, implicitly the appearance of possible long-term pain in the spine, an aspect that may emphasize the fact that a correct posture indicates that athletes can support a higher intensity training without pain (22, 23). Positive results in competitions were obtained by high-level athletes due to good body posture and motor activities that reflected the level of athletic skills (24,25). For control and postural efficiency they require long-term specific training (26) to rebalance the bone and muscle-joint asymmetries. The most offensive shot in table tennis is topspin forehand, this procedure is extremely important for an aggressive player requiring correct biomechanics (27). For an efficient execution, an adjusted body position is required, a specific type of footwork, which modifies the kinematic chain of the body segments leading to a great variety and variability of movement (28, 29).

2. Materials and methods

The aim of this preliminary research was to detect postural deficiencies in junior female athletes (10-12 years) and to know the relationship/influence of body posture on the qualitative level of topspin attack.
This preliminary study started from the finding that following the implementation of an opinion survey on the influence of body posture on the topspin attack addressed to female juniors III coaches within the Romanian Table Tennis Federation in 2020 (February-March), it turned out that postural deficiency negatively influences the biomechanics of topspin execution, and that pain occurs predominantly in the lumbar region due to the repetitive execution of the topspin attack (30).
H1: It is assumed that through postural assessment we will be able to identify and highlight the postural deficiencies encountered in this age category.
H2: The lot of subjects without deficiencies obtains significantly improved results in the tests for evaluating the qualitative level of the topspin attack, by comparison with the results of the lot with postural deficiencies.

2.1. Participants

The inclusion criteria were age between 10-12 years, girls and volunteers were found to participate in this scientific endeavor. Eighteen female juniors III (the mean ± SD age, height and weight were 11.1 ± 0.2 years, 147.7 ± 2.6 cm, 39.0 ± 2.0 kg). All players were right-handed, this being determined by the hand in which they held the racket (31).
The lot was divided into 2 groups. Group 1. consisted of 6 female athletes (mean seniority in performance sports is 4.1 ± 0.1 years) with a mean value of 0° inclination in PSIS (posterior superior iliac spine). Group 2. – 12 female athletes (mean seniority in performance sports is 4 ± 0.3 years) with a mean value of 3.33° inclination at the same level.
These were in the first 50 positions of the National Ranking and are part of 7 sports clubs from A.C.S.O.V Pantelimon, C.S.M. Buzău, C.S.S. Sfântul Gheorghe, L.P.S. Slatina, A.C.S. Activ Galați, F.C. Argeș and C.N.A.V. Râmnicu Sărat.
In the locations of the sports clubs where they carried out their trainings, the qualitative evaluation of the topspin attack was also performed.
Following the evaluation with modified Adams forward bending test – MAFBT (32) no subject involved had axial rotation of the vertebral plates in the spine.
The tested subjects and their legal guardians were informed in advance about the purpose and tasks of the research in which they participated voluntarily, expressing their agreement on our scientific approach. We have complied with international conventions aimed at personal data processing and ensuring anonymity (Helsinki Declaration).

2.2. The Organization of the Research

The subjects were evaluated during the period 18.08.2020 – 31.08.2020 (the female juniors were in the preparatory period and had 3-5 workouts per week and a duration of 2 h/session), we used the web camera – photographic method (38) related to the Sensor Medica software that allows the acquisition of images in order to detect postural deficiencies in frontal plane (rear view) and we focused on the alignment of the shoulder and pelvis (PSIS).
The data processing software called FreeStep by Sensor Medica, which is endorsed by the French Association of Posturology (33), the instructions for use are detailed in (34).

Figure 1 – The FreeStep software webcam

The Postural Assessment was performed near sports clubs and more precisely in cities with specific equipment in Bucharest, Galați, Brașov and Pitești.
The participants had the same distance from the webcam, which is mounted on a leveled tripod stand (figure 1), the clothing was scarce for better visibility of the anatomical landmarks and the hair in a bun so that the protrusion of the C7 vertebra could be seen. They were asked to adopt a normal, orthostatic position, with the arms close to the body, relaxed, looking forward, the head in a natural position and with the legs in extension parallel to each other.

2.3. Tests related to topspin attack:

The tests were performed on an official table tennis court – called Donic (figure 2), Tibhar and Butterfly rackets (I.T.T.F. approved) and a set of 50 balls, with the size of 40.25 mm (I.T.T.F. approved);

Figure 2 – Completion of the execution of the topspin forehand attack

Before each evaluation session of each subject, a warm-up was performed with the game partner, which consisted of 5 minutes of executions with topspin forehand and backhand.
The technical-tactical tests specific to the topspin forehand and backhand attack were chosen because they were previously described and used by (35, 36, 37, 42). We considered it necessary to have a clear picture of the level of technical-tactical training of female juniors III using 5 tests specific to the topspin attack with the help of the game partner (coach):

1. Topspin with diagonal forehand performed from blockage*;*

* made of 5 series, counting in a series each success of the examined subject (the ball passed over the net, landing in the opponent's court, diagonally).

2. Topspin with diagonal backhand performed from blockage*;*

* made of 5 series, counting in a series each success of the examined subject (the ball passed over the net, landing in the opponent's court, diagonally).

3. Diagonal Butterfly performed from blockage*;*

* made of 5 series, counting in a series each success of the examined subject (the ball passed over the net, landing in the opponent's court, diagonally).

4. Line Butterfly performed from blockage*;*

* made of 5 series, counting in a series each success of the examined subject (the ball passed over the net, landing in the opponent's court, in line)

5. Multiball (topspin with forehand + topspin with backhand performed diagonally from no-spin ball, followed by the same technical procedures achieved from backspin ball)

* made of 10 series of 4 balls each. They were counted in a series as successful, only when the female athlete hit all 4 balls effectively (they passed over the net, landing in the opponent's court).

2.4. The statistical – mathematical analysis

It was performed using the IBM SPSS version 24 Software and procedures for determining the normality of data distribution, Levene's Test for Equality of Variances, t test for independent samples. The confidence interval was set at 95% ($p < 0.05$), according to (39, 40, 41).

3. Results

This preliminary study shows that the photography method with the help of the Sensor Medica software is reliable in detecting postural deficiencies.
Figure 3 shows the subject with scoliotic attitude, a model of body posture related to Group 1. The cause is in the thoracic region, which means that the dorsal convexity is on the left side, the inclination of the shoulder is 7° (table 1) to the right, the mean value being 2.5° inclination.

They are without pelvic imbalance, in the PSIS (posterior superior iliac spine) the angular value in the case of the subject is 0° and the mean angular value of the entire lot is also 0°.

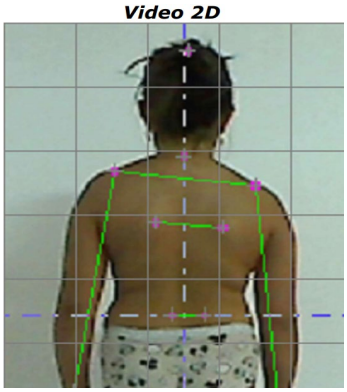

Figure 3 – Picture of one of the subjects of Group 1 in frontal plane (rear view)

Table 1 – The results of the postural measurements in frontal plane related to figure no. 3

Measurements

Results	Angle °
Shoulder tilt	7°LF^
Ground distance left shoulder mm	1206
Ground distance right shoulder mm	1235
Scapulae tilt	5° LF^
Sips tilt	0°

In figure 4 we present a body posture model related to Group 2, with scoliotic attitude, 3° imbalance of the PSIS (pelvis), the convexity at the lumbar level is on the right side, the mean value being 3.3°. The subject has a shoulder inclination of 2° (table 2) to the left, and the mean angular value of the entire lot is 2°.

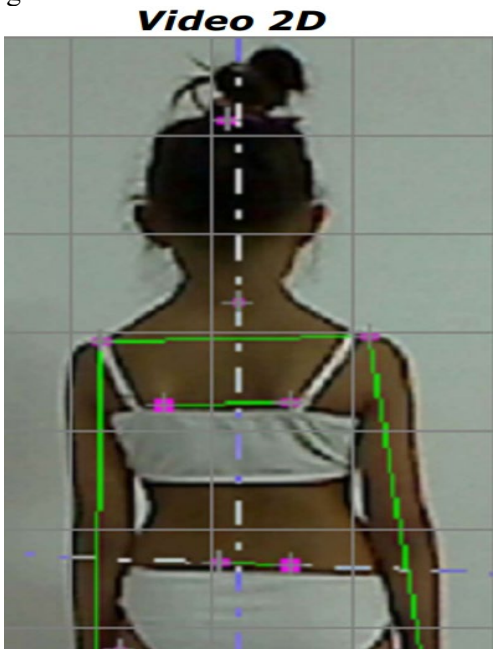

Figure 4 – Picture of one of the subjects of Group 2 in frontal plane (rear view)

Table 2 – The results of the postural measurements in frontal plane related to figure no. 4

Measurements

Results	Angle °
Shoulder tilt	2°RG^
Ground distance left shoulder mm	1013
Ground distance right shoulder mm	1006
Scapulae tilt	2° RG^
Sips tilt	3° LF^

Table 3. - Results of the analysis of Mean, Std. Deviation and Std. Error Mean for the entire lot for postural assessment

Variables	N	Mean	Std. Deviation	Std. Error Mean
Shoulder inclination – angle (°)	18	2.28	1.526	0.360
PSIS inclination – angle (°)	18	2.33	2.029	0.478

*PSIS – posterior superior iliac spine.

Table 3 presents the data of the angular mean values of the entire lot of 18 subjects regarding the postural evaluation in frontal plane, the shoulder inclination is 2.2 ° and the PSIS inclination is 2.3°.

Table 4. - Results of the analysis of degrees of freedom, Sig.(2-tailed), Mean difference and 95% CI for the entire lot for postural assessment

Variables	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Shoulder inclination – angle (°)	6.331	17	0.000	2.278	1.52	3.04
PSIS inclination – angle (°)	4.879	17	0.000	2.333	1.32	3.34

Table 4 presents the results of degrees of freedom, Sig. (2-tailed), Mean difference and 95% CI of the entire lot for shoulder inclination: the mean value of the sample studied for shoulder inclination is 2.278°. The value of the t test = 6.331. The 95% confidence interval for the difference between the sample mean and the reference value is (1.52°, 3.04°). Since Sig. (2-tailed) or $p < \alpha = 0.001$ and taking into account that the confidence interval limits for the difference between the sample mean and the reference value (95% CI for the mean difference) do not contain the zero value it is accepted that there are statistically significant differences between the shoulder inclination for the female athletes in the sample studied and the reference value.

The percentage of female athletes for whom the shoulder inclination deviates from the reference value is 100%.

For the PSIS inclination, the mean value of the sample is 2.333. The calculated t test value = 4.879. The 95% confidence interval for the difference between the sample mean and the reference value is (1.32°, 3.34°). Since Sig. (2-tailed) or $p < \alpha = 0.001$ and since the confidence interval limits for the difference between the sample mean and the reference value do not contain the zero value, it turns out that there are statistically significant differences between the PSIS inclination for the female

athlete in the studied sample and the reference value.
The percentage of female athletes for whom the PSIS value deviates from the reference value is 66.66%.

Table 5. – The results of the 2 groups regarding the influence of body posture on the qualitative level of the topspin attack

Variables	Groups	N	Mean Rank	Sum of Ranks
Topspin with diagonal forehand performed from blockage	Group 1. (*without PSIS imbalance)*	6	**11.67**	70.00
	Group 2. (*with PSIS imbalance)*	12	8.42	101.00
	Total	18		
Topspin with diagonal backhand performed from blockage	Group 1. (*without PSIS imbalance)*	6	8.08	48.50
	Group 2. (*with PSIS imbalance)*	12	10.21	122.50
	Total	18		
Diagonal Butterfly performed from blockage	Group 1. (*without PSIS imbalance)*	6	**10.58**	63.50
	Group 2. (*with PSIS imbalance)*	12	8.96	107.50
	Total	18		
Line Butterfly performed from blockage	Group 1. (*without PSIS imbalance)*	6	**12.17**	73.00
	Group 2. (*with PSIS imbalance)*	12	8.17	98.00
	Total	18		
Multiball (topspin with forehand + topspin with backhand performed diagonally from no-spin ball, 56 followed by the same technical procedures achieved from backspin ball)	Group 1. (*without PSIS imbalance)*	6	8.42	50.50
	Group 2. (*with PSIS imbalance)*	12	10.04	120.50
	Total	18		
Total	Group 1. (*without PSIS imbalance)*	6	**11.33**	68.00
	Group 2. (*with PSIS imbalance)*	12	8.58	103.00
	Total	18		

Table 5 identifies the mean value of the 2 groups regarding the influence of body posture on the quality level, listing part of them:
Test 1 – Topspin with diagonal forehand performed from blockage in the case of Group 1 (without PSIS imbalance) the mean value of successes is ***11.67*** and of Group 2 (with PSIS imbalance) is ***8.42***.
Test 3 – Diagonal Butterfly performed from blockage in the case of Group 1 (without PSIS imbalance) the mean value of successes is ***10.58*** and of Group 2 (with PSIS imbalance) is ***8.96***.
Test 4 – Line Butterfly performed from blockage in the case of Group 1 (without PSIS imbalance) the mean value of successes is ***12.17*** and of Group 2 (with PSIS imbalance) is ***8.17***.
From the total of the 5 tests it resulted that Group 1 (without PSIS imbalance) has a better quality level, of ***11.33*** points vs. Group 2 (with PSIS imbalance) which has a mean value of ***8.58***.
Table 6 presenting Levene's Test confirms the equality of the variances of the two groups for topspin with diagonal backhand performed from blockage ($F = 0.355$ and $p = 0.559 > \alpha = 0.05$), diagonal Butterfly performed from blockage ($F = 0.533$ and $p = 0.476 > \alpha = 0.05$), line Butterfly performed from blockage ($F = 1.362$ and $p = 0.260 > \alpha = 0.05$), multiball ($F = 2.197$ and $p = 0.158 > \alpha = 0.05$), total ($F = 0.239$ and $p = 0.632 > \alpha = 0.05$). Consequently, the result of the t test is read on the first line of the previous table (assumed equal variances) in these cases. The variances of the two groups are not equal for topspin with diagonal forehand performed from blockage ($F = 9.654$ and $p = 0.007 < \alpha = 0.05$).
The t test for two independent samples shows that the difference between the means of the two groups (with and without imbalances) is not statistically significant at the significance threshold $p < 0.05$ for any test: $t = 1.427$, $p = 0.208$ for topspin with diagonal forehand performed from blockage, $t = -0.985$, $p = 0.339$ for topspin with diagonal backhand performed from blockage, $t = 0.258$, $p = 0.800$ for diagonal Butterfly performed from blockage, $t = 1.941$, $p = 0.07$ for line Butterfly performed from blockage, $t = -0.662$, $p = 0.518$ for multiball, $t = 0{,}833$, $p = 0.417$ for the total. This conclusion is also supported by the fact that the 95% confidence interval of the difference between the means does not contain the zero value for any test.
The difference between the means of the two groups is 4.01667 for topspin with diagonal forehand performed from blockage, -1.88333 for topspin with diagonal backhand performed from blockage, 0.38333 for diagonal Butterfly performed from blockage, 1.83333 for line Butterfly performed from blockage, -0.583 for multiball, 4.29167 for the total.

Table 6. - Significance of differences between mean values in topspin-related tests (group 1 n=6 and group 2 n=12)

Variables	Groups	Mean	Mean Difference	Std. Deviation	Std. Error Mean	Levene's Test for Equality of Variances F	Levene's Test for Equality of Variances Sig.	t	Sig. (2-tailed)
Topspin with diagonal forehand performed from blockage	Group 1. (*without PSIS imbalance)*	9.1000	4.01667	6.74774	2.75475	9.654	0.007		
	Group 2. (*with PSIS imbalance)*	5.0833		1.99537	0.57601			1.427	0.208
Topspin with diagonal backhand performed from blockage	Group 1. (*without PSIS imbalance)*	5.8000	-1.88333	3.56651	1.45602	0.355	0.559	-0.985	0.339
	Group 2. (*with PSIS imbalance)*	7.6833		3.93350	1.13550				
Diagonal Butterfly performed from blockage	Group 1. (*without PSIS imbalance)*	5.6333	0.38333	2.30969	0.94293	0.533	0.476	0.258	0.800
	Group 2. (*with PSIS imbalance)*	5.2500		3.22392	0.93066				
Line Butterfly performed from blockage	Group 1. (*without PSIS imbalance)*	5.4667	1.83333	2.35514	0.96148	1.362	0.260	1.941	0.070
	Group 2. (*with PSIS imbalance)*	3.6333		1.63336	0.47151				
Multiball (topspin with forehand + topspin with backhand performed diagonally from no-spin ball, 56 followed by the same technical procedures achieved from backspin ball)	Group 1. (*without PSIS imbalance)*	1.83	-0.583	1.472	0.601	2.197	0.158	-0.662	0.518
	Group 2. (*with PSIS imbalance)*	2.42		1.881	0.543				
Total	Group 1. (*without PSIS imbalance)*	27.8333	4.29167	10.32001	4.21313	0.239	0.632	0.833	0.417
	Group 2. (*with PSIS imbalance)*	23.5417		10.29991	2.97333				

4. Discussion In the specialized literature, we do not find much scientific research in our direction of interest that highlight the reality in the table tennis subject in this age category.
Thus, body asymmetry is possible to result from the practice of table tennis, however, according to knowledge (42), the effect of table tennis on body asymmetries has not yet been assessed and further attention is required.
In another study (43) the coaches of junior high-performance table tennis female athletes state that more than 50% say that the topspin attack is directly responsible for the pain in the lumbar region. Being also confirmed by the fact that the unilateral executions specific to table tennis resulted in slight asymmetries in the shoulders and pelvis causing musculoskeletal imbalances/deficiencies, aspects reported by (44).
The authors (45) assume that a negative influence of a

vicious position in bipedalism on body health is expressed especially in primary school age. However, even if postural skills are fundamental in motor activities, so far no evidence of a direct relationship has been found, and it is recommended that the following directions be considered, the higher the level of sports competition, the better the body posture; or better athletes also have a better body posture (1) in children and adolescent athletes.

Hypertrophy in the hitting upper limb is evident and is due to systematic involvement in specific training since the age of 5-6 in tennis (47), a subject related to table tennis, in which unilateral motor executions are performed, which is why muscle imbalances are inevitable materializing in postural deficiencies that, if not treated in time, will consolidate and pain will appear at the level of the entire musculoskeletal system.

In order to regain postural control, relatively short periods are needed by introducing specific motor programs, thus favoring and accelerating the body's ability to recover and adapt, which is stated by (48).

The percentage of female juniors III assessed, for which the PSIS deviates from the reference value is 66.66%, thus detecting imbalances in the pelvis, therefore, the authors consider it appropriate (49) to pay special attention to children and adolescents, because a correct body posture in adulthood is based on those stages of growth.

In the profile materials found, for a correct posture all the angular values between the anatomical landmarks must be equal to 0° otherwise, the postural problems must be marked (50).

A study (46) on 83 top table tennis, tennis and badminton Slovenian players, it has been found that the most vulnerable regions are at the ankle joint and the spine, which is why they have stated that improvement programs need to be included because they are essential for the well-being of the body and for optimal health (51, 52).

5. CONCLUSIONS We believe that this scientific research should be of real interest and useful to researchers in the field, performance coaches/analysts and especially physiotherapists, in order to give importance to the assessment and early detection of postural deficiencies in order to implement an individualized program to compensate for the imbalances encountered in the muscle-joint system and with possible beneficial implications on the topspin attack.

We found that at the level of alignment between anatomical landmarks, the percentage of deficiency of the entire lot of female juniors III in the case of shoulders is 100% and at the level of PSIS is 66%, which validates several studies that have stated that in this period of aggressive growth correlated with repetitive unilateral executions specific to topspin attack lead to postural deficiencies (hypothesis no. 1 is confirmed).

From the point of view of the influence of body posture on the quality level, we found that Group 1 - (without PSIS imbalance) has a higher average total efficiency of the 5 tests (11.33) compared to Group 2 (8.58), even if from from a statistical point of view these differences are not significant (hypothesis no. 2 is not confirmed).

The highest score and efficiency was at test no. 4 called *Line Butterfly performed from blockage* (in which the game partner sent the ball diagonally and the subject sent it in line from forehand and backhand) in the case of Group 1.

Limitations The results recorded cannot be universal, due to the limited number of subjects investigated, due to the fact that it is an individual sport and a limited age category. Another limitation of the study is that the analysis of postural imbalances in the sagittal plane implicitly on those of the knees were not analyzed.

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

Informed consent

The investigated subjects and their legal guardians were informed about the purpose and methodology of this study, expressing their agreement to the processing and publication of the results of this scientific approach, in compliance with the rules on personal data protection.

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