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Original research article

FREQUENCY OF THE SPINAL COLUMN POSTURAL DISORDERS AMONG ELITE SERBIAN SWIMMERS*

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Abstract. *The aim of the current research was to determine the frequency of the postural disorders of the spinal column among elite male and female swimmers, and to determine the causes and consequences of their occurrence. A sample of 30 male and female swimmers aged 13 to 26 ± 6 months was used to determine the postural status by means of the Spinal Mouse device, and their anthropometric measurements. The results of the measuring have indicated the presence of four postural disorders of the spinal column (flatback syndrome, scoliotc, kyphotic, and lordosis bad posture), where scoliotic bad posture is the most frequent postural disorder and can be found among all of the participants. The correlation between competitive disciplines and certain postural disorders has not been determined.*

Key words: *postural disorders, swimming, spinal column, elite swimmers.*

INTRODUCTION

The high frequency of the postural disorders of the spinal column in certain types of sports, especially among adolescents, has brought into question the influence of sports activities on the body posture of athletes. Deviations from proper body posture which occur as the consequence of extensive or sport-specific training load have been reported in the research of many authors (Grabara & Hadzik, 2009a; 2009b; Slawinska, Rożek & Ig-

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nasiak, 2006). Certain postural disorders are more frequent than others in certain types of sports, so it is assumed that the specific demands of sport and load which occur during the performance of technical elements and long-term repetition of these elements have influenced their development. Today there are almost no sports in which athletes do not show signs of postural disorders of the spinal column, and where the extent of the deformity and the type of disorder depend on the nature of the sport. The highly repetitive nature of sport, amenorrhea, specific exercises which cause great stress on the insufficiently developed spinal column of professional or non-professional adolescent athletes, and loose muscle joints which can occur during adolescence, are related to the increase in the frequency of postural disorders and their further increase (Warren, Brooks-Gunn, Hamilton, Warren & Hamilton, 1986; Becker, 1986; Tanchev, Dzherov, Parushev, Dikov & Todorov, 2000).

Becoming an elite athlete requires the performance of difficult physical exercises, which are repeated numerous times in unnatural positions related to static and dynamic load. Intense physical exercise leads not only to the adaptation of the passive elements of the spinal column but also the active elements, that is, the tendons which are responsible for their posture. (Schiller & Eberson, 2008; Janusz, Rutkowska & Markiewicz, 1998; Dziak & Tayara, 1997)

Swimming as a cyclical sport actually includes the repetition of a great number of the same movements. Its repetitive nature could represent one of the main factors in the occurrence of certain postural disorders of the spinal column, along with the specific nature of the movements being performed, as well as the environment in which the movements are made.

Considering the increasingly greater presence of postural disorders and their specific nature in the case of certain sports, the authors have decided to study their frequency of occurrence among swimmers and determine the causes and consequences of the relations between the disorders and the nature of the sport.

METHODS

The sample of participants consisted of 30 elite swimmers competing for Serbian National Swimming Team, aged 13 to 26 ± 6 months. The study was approved by the Ethics Committee of the Faculty of Sport and Physical Education, and which consisted of two phases: determining the postural status and determining the basic anthropometric measurements.

To determine the postural status of the swimmers, the non-invasive system of measuring, the Spinal – Mouse (Idiag, Fehraltdorf, Switzerland, www.idiag.ch) was used. The Spinal – Mouse is a computer-assisted device which determines postural status (thoracic and lumbar curvatures, pelvic inclinations, segmental angles and the length of the segmental parts) as well as mobility (the range of movement: flexion, extension and segmental). The Spinal – Mouse offers measuring with great precision and objectivity, while from the aspect of the participants, it represents a non-invasive method and does not require exposure to radioactivity. Its validity and reliability have been confirmed in the studies of Forster (2006); Mannion, Knecht, Balaban, Dvorak & Grob (2004); Post & Leferink (2004).

The measuring the postural status of the participants was carried out in three positions: the standing position, during maximal flexion, and during the maximal extension of the spinal column. The following parameters were noted both graphically and numerically: an inclination of the spinal column in the sagittal and frontal plane, the pelvic inclination in the frontal plane, scoliosis, lordosis and kyphosis, and segmentary angles.

With the aim of classifying the postural disorders according to category, we used the values determined by Cobb. The normal values of kyphosis were 20 – 40˚, while the normal values of lordosis were 15 – 30˚.

The collected data were processed using a program for statistical data analysis, SPSS 19. In order to determine the frequency of the postural disorders based on discipline, the non-parametric Chi-square test was used. For determination of correlation between postural disorders and discipline of swimming, Spearmen Correlation Test was used. The level of significance was defined as 0.05.

RESULTS

The average values (± SD and range) of body height, body weight and the body mass index (BMI) of the male and female swimmers are shown in table 1.

Table 1. The average values of (±SD, range) body height, body mass and the BMI

Gender	N	Body height (in cm)		Body mass (in kg)		BMI	
		AS±SD	MIN-MAX	AS±SD	MIN-MAX	AS±SD	MIN-MAX
Men	15	183.28±5.07	170 – 190	74.33±6.56	60 – 84	22.10±1.48	20.20 – 24.50
Women	15	167.73±7.42	157 – 184	54.76±9.11	38 – 73	19.34±2.12	15.20 – 23.60

The frequencies of the postural disorders among the male and female swimmers are shown in table 2. In the case of the male swimmers, a higher percentage of the postural disorder scoliotic bad posture was noted (33%), while in the case of the female swimmers, this percentage is somewhat smaller (27%). Contrary to that, in the case of the female swimmers, a higher percentage of two postural disorders (lordotic and kyphotic bad posture) was determined, 47% compared to 27% in the case of the men. The presence of kyphotic and scoliotic bad posture was noted in 20% of the female swimmers and in 13% of the male swimmers. Finally, in 27% of the male swimmers, all three postural disorders were noted, that is kyphotic, lordotic and scoliotic bad posture, while in the case of the females this percentage is much smaller and is 6%.

Table 2. The frequencies of the postural disorders of the male and female swimmers

Gender	Sco	X^2	Sig	Lor-Sco	X^2	Sig	Kyph-Lor	X^2	Sig	Kyph-Lor -Sco	X^2	Sig
Men	33%	1.06	0.81	27%	0.91	1.26	13%	0.11	0.99	27%	0.10	1.33
Women	27%			47%			20%			6%		

Legend: X^2 - Chi square test; Sig – the level of significance between the groups; Sco – Scoliotic bad posture; Lor – Lordotic bad posture, Kyph – Kyphotic bad posture

Table 3. shows the frequencies of postural disorders according to the competitive swimming disciplines. The most frequent postural disorder is scoliotic bad posture, which can be found among all of the participants competing in all of the disciplines. There was no correlation determined between the competitive disciplines and postural disorders of the spinal column (table 4).

Table 3. The frequencies of the postural disorders based on competitive disciplines.

Discipline	Postural deformities of the spinal column					
	N	Scoliotic	Kyphotic	Lordotic	Flatback	Kypho-Lordotic
Freestyle	15	15	1	4	3	3
Breast stroke	6	6	3	1	0	1
Butterfly	8	8	1	2	1	1
Back stroke	7	7	0	2	2	0
Overall	36	36	5	9	6	5

Table 4. The correlation between competitive disciplines and postural disorders.

Spearman's correlation		Disciplines	Disorders
Disciplines	Correlation Coeff.	1.000	-0.65
	Sig.		.621
Disorders	Correlation Coeff.	-0.65	1.000
	Sig.	.621	

DISCUSSION

The results of this research indicate the presence of four postural disorders among the participants: flatback syndrome, kyphotic, lordotic, scoliotic bad posture and its combination. Scoliotic bad posture can be found in all of the participants, while the remaining three deformities are present to a smaller or greater extent, depending on the discipline. Becker (1986) carried out a preliminary study in which he evaluated the frequency of occurrence of scoliosis in a group of adolescents who participated in swimming competitions. The sample of participants included 336 athletes (193 women and 173 men) who were studied by means of somatoscopy, both in a standing position and during hyperextensions. The author reported that 6.9 % of the participants in each group showed signs of structural idiopathic scoliosis. In addition, each group showed signs of a mild functional scoliosis (16%). In our research, scoliotic bad posture was determined in all of the swimmers, irrespective of the discipline, so that we can conclude that a certain discipline does not cause scoliosis but that the occurrence of this postural disorder depends on other factors Tanchev et al. (2000) named three of the main factors which they consider have the greatest influence on the onset of scoliosis: general joint mobility, slow growth and the development and maturation due to physical, dietary and physiological stress and the constant asymmetric load on the spinal column. Namely, even though the load in all of the joints in an aquatic environment is significantly smaller, a great number of movements which are repeated due to the cyclical nature of swimming cause great load on all the joints and thus the spinal column itself. If we were to take into consideration the great number of training sessions during one microcycle, it is clear that for swimmers who are still in the process of maturing, this represents a great burden which could have a negative influence on the formation of physiological curvatures. Puberty and the pre-adolescent period for ages starting from 10 to 18 are considered a period of rapid growth of all the segments of the spinal column (Akbarnia, Yazici & Thompson, 2010). It is precisely during this period that a great number of children take part in the intense training process and begin their active swimming career, which leads to the possibility of forming a pos-

tural disorder of the spinal column. In addition, certain disciplines, such as the back stroke, require great flexibility of the shoulder belt so that the stroke are of the arm could lead to the most optimal position and allow the unhindered passage of the second arm which is in the return phase. A study carried out by Meyer et al. (2006) has shown that young females with loose joints can be more prone to the development of idiopathic scoliosis. Even though swimming is a cyclical sport, poor technique or the great strain on the muscles of the dominant arm for the purpose of achieving a more effective stroke in the propulsion phase can lead to asymmetric load on the musculature. Considering that with an increase in speed and the surface of the body we increase resistance in the water, through the application of various drag forces or through poor technique or greater strength in the dominant arm, various types resistance are created which after a long time can cause muscular disbalance. Becker (1986) in his study determined that within 16% of the participants who have functionally mild scoliosis, the lateral curvature of the scoliosis which faces the dominant arm occurs in 100% of the cases. He ascribed this high frequency of scoliosis with a curvature toward the dominant arm to muscular disbalance and the greater strength of the dominant arm, which is often considered the cause of the occurrence of scoliosis, considering the high repetitive nature of swimming and the later adaptation of the spinal vertebra. Yoo et al. (2001) have also confirmed that asymmetric muscular development can lead to mild scoliosis. Opposite results can be found in the work of Cebula, Czernicki & Durmala (2009), who have determined that the symmetry of the swimmers in the frontal plane is significantly better in comparison to the general population.

If the average number of strokes of swimmers swimming freestyle is approximately 5000, and if they breathe on every third stroke, in which case there are approximately 1667 rotations of the head during a training session, it is clear just how much load the swimmer's body is exposed to during just one training session. In addition, if the swimmers apply unilateral breathing, and the rotation of the head is only to one side, it is clear that this can lead to a muscular disbalance which can lead to the occurrence of a postural disorder or injury (Pollard & Fernandez, 2004). Similar results were obtained by Meliscki, Monterio, Maman, Medeiros & Giglico (2010) who have determined that there is a connection between the changes in the spinal column and the type of breathing during swimming, as well as that hyperextension and hyperkyphosis of the chest are the main postural disorders among swimmers.

Kyphosis and lordosis have been determined among swimmers in the studies of other authors. Cebula et al. (2009) have determined that there is a thoracic hyperkyphosis among 70% of the athletes. Reduced values of thoracic kyphosis were not determined among swimmers, while lumbar kyphosis was noticed in 27%. The muscles which are most responsible for propulsion in swimming are the pectoralis, latissimuus dorsi, biceps brachi, rectus abdominis and gluteus maximus (Mc Leod, 2010). The pectoralis, with the help of the latissimus dorsi generates the greatest segment of force during the propulsion phase of the stroke in all of the competitive disciplines except for the back stroke, so that we can assume that these muscles are especially developed and reduced among swimmers. The shortening of the muscles of the front side of the chest and shoulder belt, as well as the repetitions of a position which is counter indicated by kyphothic posture, such as the moment of inhaling when the body is in a slightly bent position with the upper arm close to the body immediately prior to the lift during the retroactive phase, can be considered to be contributing factors to the development and increase of kyphotic posture.

Leg work in freestyle and back stroke is almost identical, where in the back stroke leg work is primarily in the opposite direction. The muscles which are most active at that time are the iliopsoas, rectus femoris and quadriceps during the propulsion phase and the gluteus muscles as well as the muscles of the region femoris posteriori (biceps femoris, semitendinosus, semimembranosus). The reduction in the regio femoris posteriori along with the reduction in the muscles of the lumbar part of the back can lead to lordosis. In addition, leg work during butterfly includes a wave-like motion which begins from the lower back and continues downwards, which makes this leg work technique counter indicated with the lordotic body posture.

CONCLUSION

On the basis of the obtained results from the male and female swimmers from the representative sample, we were able to determine the existence of postural disorders of the spinal column in a greater percentage than expected. Considering the fact that swimming, irrespective of the style, is a sport of cyclical movement which is performed in an aquatic environment and which gravity affects differently in comparison to sports carried out on dry land, the existence of one, two or three postural deformities requires certain analysis. Bad scoliotic posture is more frequent among men, as is the existence of more postural deformities (kyph-lor-scoliotic bad posture). Among women there is a higher percentage of the simultaneous existence of two postural disorders. It is important to place special emphasis on the styles of swimming. On the basis of the obtained data it is easy to note that among the swimmers of the breast stroke technique, there are the fewest occurrences of scoliotic bad posture, lordotic bad posture, the flatback syndrome and kypho-lordotic bad posture. We can analyze body position, the movements of the upper and lower extremities, the position of the torso, head and pelvis, and conclude that the position of the body during the breast stroke is very natural and does not require any twisting turns to the side. In that case, engaging the deep muscles of the spinal column and the lateral flexors and rotators of the torso is avoided, and thus the creation of a disbalance between the agonists and antagonists of the aforementioned muscle groups, which could lead to the occurrence of disorders of the spinal column in the frontal plane (scoliotic posture). In the end we should mention that for all the participants we had to take into consideration the acquired habits of body posture outside the training process, the way in which they sit, lie, carry their bags and so on. What we cannot know is the condition of their body status and possible existence of postural disorders prior to their active inclusion in the swimming training process. We can conclude that in the case of our elite male and female swimmers, there is a presence of postural disorders in the functional stage, and in some cases combined disorders in the sagittal and frontal plane, but we should not and must not ascribe responsibility for the determined state to the structure and character of movement during swimming.

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UČESTALOST POSTURALNIH POREMEĆAJA KIČMENOG STUBA KOD VRHUNSKIH SRPSKIH PLIVAČA

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Cilj aktuelnog istraživanja bio je da se utvrdi učestalost posturalnih poremećaja kičmenog stuba kod vrhunskih plivača i plivačica i utvrde uzročno posledične veze njihovog nastanka. Na uzorku od 30 plivača i plivačica uzrasta od 13 do 26 godina ± šest meseci, utvrđivan je posturalni status, uređajem Spinal Mouse i primenom antropometrije. Rezultati merenja pokazali su prisutnost četiri posturalna poremećaja kičmenost stuba (ravna leđa, skoliotično, kifotično i lordotično loše držanje), pri čemu je skoliotično loše držanje najučestaliji posturalni poremećaj prisutan kod svih ispitanika. Povezanost takmičarskih disciplina sa određenim posturalnim poremećajima nije utvrđena.

Ključne reči: *posturalni poremećaji, plivanje, kičmeni stub, vrhunski plivači.*