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Review article

THE INFLUENCE OF SPORT ON THE DEVOLOPMENT OF POSTURAL DISORDERS IN ATHLETES

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Abstract. *The high incidence of postural disorders in certain branches of sport, especially among adolescents has questioned the influence of sports activities on the postural status of athletes. Although there is still no definite opinion about the connection between sports and postural disorders, researchers have established the existence of certain factors such as amenorrhea, weakness of the joints, highly repetitive activity of sports, muscle imbalance and others that could affect the occurrence or development of some postural disorders. These factors, along with the influence of the heritage of athletes, justify the thesis of certain authors, that scoliosis, kyphosis and lordosis are multifactorial disorders.*

Key words: *postural disorders, sport, physical activity, athletes.*

1. INTRODUCTION

Physiological spinal curvature is gradually formed in the earliest stages of posturogenesis. The degree of spinal curvatures depends on many factors such as gender, lifestyle, physical activity, etc. Physical activity affects the processes of ossification and muscle strength and is one of the important factors that affect posture. (Kutzner – Kozinska, 2001 to Lichota, Plandowska, & Patrycjusy, 2011).

The high incidence of postural disorders in certain branches of sport, especially among adolescents has questioned the influence of sports activities on the posture of athletes. Deviations from correct posture, as a result of a specific sport or excessive training loads can be found in the works of many authors (Grabara, & Hadzik, 2009; Grabara, & Hadzik, 2009a; Slawinska, Rozek, & Ignasiak, 2006). Some postural disorders are more

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common in certain sports fields, so it is assumed that the specific requirements of sport and training loads that occur during the execution of technical elements and prolonged repetition of these elements influenced the development of those postural disorders. Some female dominated sports, such as rhythmic gymnastics, figure skating and dancing are characterized by an extreme range of motion of the spinal column (Cirillo, & Jackson, 1985; Micheli 1983, Sward, Hellstrom, & Jacobsonn, 1990). Athletes who practice these types of sports have a higher risk of injury of the vertebral column and the abnormal development of the spinal column.

There is not a single sport nowadays where athletes do not have a disorder of the spinal column, whereas the level and the type of disorder depend on the nature of the sport. This is why the goal of this article is to review scientific research papers on the subject of postural disorders in athletes so that we can perform an analysis of the conclusions obtained by other authors.

2. POSTURAL DISORDERS IN DIFFERENT SPORTS

The most common postural abnormalities that occur in most sports are scoliosis and kyphosis, while lordosis occurs to a slightly smaller extent (Asghar & Imanzadeh, 2009). The appearance of such postural disorders in sport is usually associated with the highly repetitive nature of sports, amenorrhea, certain specific exercises that cause great stress on the still underdeveloped spine of professional or non-professional teenage athletes, weakness of the muscle joints that can occur during the adolescent period, etc. All these factors may influence the higher incidence of postural disorders and their further development. (Warren, Brooks-Gunn, Hamilton, Warren, & Hamilton, 1986; Becker, 1986; Tanchev, Dzherov, Parushev, Dikov, & Todorov, 2000).

Also, the early selection of certain sports entails involving children in the training process at a very early period in their childhood. In this period of development, the children's spinal column is affected by the influence of large loads that occur during the training process, which can lead to adaptive changes in skeletal and muscle systems and disrupt normal posturogenesis. This long-term exposure to such loads which affects the morphology of the bones that are still underdeveloped and the mechanical integrity of the bones can lead to the improper development of the spinal column (Wojtys, Ashton - Miller, Huston, & Moga, 2000).

2.1 Postural disorders in the sagittal plane in different sports

Kyphosis is the amplification of the physiological spinal curvatures in the sagittal plane with a thoracic convexity to the back (Bogdanović, 2008). Kyphosis, or "rump" as it is often called, can be found not only in the chest area and but in other areas as well. It can often occur in combination with lordosis, which is the amplification of spinal curvature in the sagittal plane, the convexity of which faces forward (Živković, 2000).

Kyphosis and lordosis are present in a number of sport athletes of many different branches. They are usually observed in gymnasts, wrestlers and water skiers who begin the training process very early. Wojtys et al., (2000) have noted in their research an increased curvature in the sagittal plane as well as the thoracic hyperkyphosis and lumbar hyperlordosis in adolescents participating in strong sports, which exceed 400 hours of

training per year. Intensive physical training combined with an immature spinal column, where loads are transferred from the upper to the lower extremities, lead to the formation of forces that influence the deformation of the spinal column. Athletes who are affected the most are gymnasts, footballers, hockey players, swimmers and wrestlers (Wojtys et al., 2000).

Studies have shown different results which refer to the correlation between kyphosis and lordosis with the length of a training. Bagherian, Rahn, & Rajabi (2011) were researching whether the position in cycling affects the appearance of kyphosis in cyclists and noncyclists. The results of this research have shown that a professional cyclist has the highest degree of kyphosis, then amateur cyclists and noncyclists, and that the degree of kyphosis has been influenced by the years of training. Forster, Penka, Bosla & Schoffl, (2009) found, on a sample of 80 recreational male climbers, that the degree of kyphosis in the upright position with sport climbers was higher than with recreational climbers. Also the degree of lordosis was higher with sport climbers compared to recreational climbers, but not statistically significant. They also found that the degree of kyphosis was higher in elite sport climbers in relation to average sport climbers, and that the degree of kyphosis and postural adaptation depends on the level of training. Wojtys et al. (2000) have found that there is a correlation between an increase in the degree of curvature of the spine and the increase in the volume of training in children. On the other hand, Sainz de Baranda, Santonja Medina, & Rodriguez - Iniesta (2010) found no correlation between the volume of training and the degree of thoracic kyphosis, and noted that the degree of thoracic kyphosis is not associated with the years of training and the actual age they started their training at (Rajabi, Doherty, Goodarzi, & Hemayattalab, 2008).

Cebu, Czernicka & Durmala (2009) in their study noted the presence of thoracic hyperkyphosis of 72% with athletes and 70% with nonprofessional athletes. Lumbar hyperlordosis was observed in 43% of all examinees, in which non-athletes prevail with 67% comparing with 37% of athletes and 27% of swimmers.

Shahrokh, Daneshmand, Rahman, & Javaheri (2011) have found a statistically significant difference in kyphosis and lordosis with athletes compared to non athletes and noted that the best predictors of kyphosis and lordosis were the range of the arms and the length of the spinal column.

Rajabi et al. (2008) found that the highest degree of kyphosis is present in free-style wrestlers, followed by non-athletes and in the end Greco Roman style wrestlers.

Slezynski & Rottenmud (1991) found that volleyball players usually have kyphotic posture with expressed thoracic kyphosis.

In the study of Muyor, Alacid, Lopez - Minarro (2011), 68% of cyclists had hyperperkyphosis, while the majority had normal lumbar lordosis values. In contrast to the standing position, cyclists have shown a significant reduction of chest kyphosis while on the bicycle, so the thoracic hyperkyphosis is not directly linked to a position on the bicycle. Similar results were obtained in the research of Muyor, Lopez - Minarro & Alacid, (2011b) where thoracic hyperkypfosis was found in 58.3% of elite cyclists and 53.3% of master cyclists, while 88.3% of elite cyclists and 76.7% of master cyclists had normal values of the lumbar curve. The absence of a connection between lordosis and kyphosis and certain characteristic positions in sports is evident in canoeists, while the occurrence of thoracic hyperkyphosis in the standing position has emerged as a result of other factors, and not from the position and the movements in the canoe, whereas the occurrence of hyperlordosis in the basic position in a canoe was created due to the movements in the

water grab phase. However, this hyperlordosis does not affect the sagittal configuration of the lumbar spine in a standing position (Lopez - Minarro, Muyor & Alacid, 2011; Muyor, Alacid, & Lopez - Minarro, 2011).

Lopez - Minarro & Carcelas (2010) have estimated the frequency of functional kyphosis and lumbar kyphosis in adolescent kayakers. The results have shown that 63% of athletes have normal kyphotic values in a standing position, while in the maximum flexion of the trunk even 91.2% of athletes have expressed medium or slightly kyphotic posture. 68.5% of the athletes have normal values of the lumbar curvature in a standing position, while 83.9% of athletes have a lumbar kyphosis in a maximum flexion of the trunk.

Wodecki, Guigui, Hanotel, Cardinne & Deburge (2002) concluded that football players had a smaller thoracic kyphosis and more pronounced angle and pelvic inclination and lumbar lordosis compared to non athletes.

Grabara (2010) in her study has concluded that gymnastics training in early childhood can lead to postural changes, where these changes are reflected as more expressed symmetry in the frontal plane of the torso and the trunk of the body is pulled back compared to the girls who do not train. Lumbar lordosis was also less pronounced in female gymnasts aged 7 - 10 compared to untrained girls, while in the female gymnasts aged 11, lumbar lordosis was more pronounced than in their untrained peers. Kumsa, Ereline, Gapayeva, Paasuke & Vain (2007) in their study have found that rhythmic gymnasts have lower angle values of lumbar lordosis and thoracic kyphosis than the control group.

Hasan, Hematinezhad & Saghebjoo (2002) have found that 58.04% of athletes in the sample have normal posture as opposed to 43.43% of former athletes who have normal posture. The authors also found that training of 1-3 times per week is better than training of 4 - 6 times per week for athletes. This emphasizes the importance of applying corrective exercises during one's lifetime and that these exercises need to be sport specific in order to maintain a normal development of the spinal column.

2.2 Postural disorders in the frontal plane in different sports

Scoliosis can be defined as a lateral curvature of the spinal column or an angular deviation of the normal position by one or more vertebral segments (Živković, 2009) where the angle of the curvature is at least 10 degrees (Cobb's angle) and often results in a visible rib crest when a patient performs a deep forward bend. (Weinstein, 1989 by Green, Johnson, & Moreau, 2009).

Most authors have reported a higher incidence of scoliosis in dance, ballet, the javelin throw, table tennis, tennis, hurling, gymnastics and rhythmic gymnastics. However, it has not yet been proven that a particular branch of sport causes or contributes to the development and the occurrence of scoliosis. (Green, Johnson, & Moreau, 2009; Gielen & Van den Eede, 2008). It has been determined that most athletes diagnosed with scoliosis have an idiopathic scoliosis. (Schiller & Eberson, 2008)

Becker (1986) conducted a preliminary study which assessed the occurrence of scoliosis in a group of adolescents who participated in competitive swimming programs. The author reported that 6.9% of the subjects had idiopathic structural signs in each group. Also, in each group he reported the incidence of mild functional scoliosis of 16%. Becker also found that in 16% of the participants who had mild functional scoliosis, the lateral curvature of the scoliosis towards the more dominant hand occurred in 100% of the cases.

This high incidence of scoliosis with a curve towards the dominant hand he attributed to muscle imbalance and the increased power of the dominant hand, which is often considered as a causal factor in the development of scoliosis, taking into account the high repetitive swimming activity and the subsequent adaptation of the vertebrae.

The high level of incidence of scoliosis was noticed in the dancers. In the study by Warren et al. (1986), which was based on a sample of 75 classical ballet dancers, scoliosis was noted in 24% of the cases, with 15 out of 18 (83%) dancers, in whom scoliosis was noted, had delayed menarche, compared to 31 out of 57 dancers (54%) in whom there was no scoliosis. Also, the dancers who had scoliosis had a higher percentage of secondary amenorrhea (44% compared to 31%) that lasted longer than the group without scoliosis. The incidence of scoliosis in families of dancers with scoliosis was 28% compared to 4% in families of dancers without scoliosis. In the author's opinion, dancers with delayed menarche are at risk of developing scoliosis and the development of fractures, and this risk increases with age. Delayed menarche and secondary amenorrhea are associated with hypoestrogenism and slowed bone growth. Considering the fact that ballet training begins very early as well as the application of a diet in order to maintain proper body weight, ballet dancers as a group may be subject to the residual effects of sexual maturation of bone growth. The influence of heredity and the environment, and also the specificity of sport, which involves the use of appropriate exercises and postural positions that affect the spinal column that is in the process of development, may have an effect on those with a predisposition for developing scoliosis. According to the authors, the influence of hormonal and nutritional factors on the development of the skeleton (particularly in adolescence) deserves further investigation.

The research conducted by Tanchev, Dzherov, Parushev, Dikov, & Todorov (2000), was aimed at determining the frequency of scoliosis in rhythmic gymnasts, analyzing its specific characteristics, and trying to present some etiological explanations for this specific form of scoliosis. Out of the overall sample of participants, scoliotic curves over 10 degrees (range of 10 - 30 degrees) occurred in 12% of gymnasts, which represents a large share compared to 1.1% of scoliosis that occurs in normal children of the same age, determined in the examination of 4800 children in Sofia by the same medical team. In their study the authors suggest three major factors that distinguish rhythmic gymnasts from their peers who do not participate in sports and that most likely contribute to the increased incidence of scoliosis among them: 1. general joint laxity as a hereditary factor; 2. slow growth and maturation as a result of physical, dietary and psychological stress, 3. continuous asymmetric loading of the spinal column. According to them, these three factors contribute the etiology of this scoliotic form and they are named a dangerous triad. Extended hypoestrogenism, that occurs as a complication of a weight loss, diet and physical training among young girls and women, leads to a delay of menarche, which together with the slow maturation leads to an increase in so-called "vulnerable years of development." This abnormality, together with the asymmetric load of the spine that is a characteristic of the rhythmic gymnastics, exhibits an epiphyseal plate to longer undesirable effects of mechanical forces (pressure, stroke, microtrauma).

The study carried out by Meyer, Cammarata, Haumont, Deviterne, Gauchard et al. (2006) aimed to determine whether physical and sports activities have an influence on the development of idiopathic scoliosis. The experimental group (201 adolescents with idiopathic scoliosis), and the control group (192 adolescents without scoliosis) completed the epidemiologic questionnaire. Those adolescents who trained gymnastics were mainly in

the experimental group. In these adolescents, idiopathic scoliosis was diagnosed when they were just starting their gymnastics training. Since the laxity of the joints is considered one of the factors that influence the development of scoliosis, it has been tested on 42 girls with idiopathic scoliosis and in 21 girls in the control group. Adolescents with scoliosis, whether they were involved in gymnastics or not, showed a greater degree of joint laxity compared to adolescents from the control group who practiced gymnastics or not. The groups that were involved in gymnastics did not show higher values of joint laxity compared to other groups. Children with higher joint laxity may be attracted by the selection because of their ability to adapt to the specific demands of this sport. A girl with higher joint laxity may be more prone to idiopathic scoliosis.

Modi, Srinivasalu, Smehta, Yang, Song, & Woo Suh (2008) determined the existence of a significant scoliotic curve where the dominant hand is associated with the direction of the curve on the sample volleyball players. Cobb's angle was not statistically significantly associated with the length of the training. The curves were either thoracic or thoraco-lumbar.

To determine the incidence of scoliosis in volleyball players Yoo, Suh, Jung Hur, Chae et al. (2001) carried out a research on a sample of 116 volleyball players who had been involved in volleyball for more than one year. Out of the total number of participants, 60 of the participants (51.7%) had a trunk rotation angle greater than 5 degrees, while the control group recorded 2.5%. The number of athletes with an angle greater than 10 degrees (Cobb) was 6 (5.17%), while the value in the control group was 465 (1%). In the author's opinion, the volleyball team had a higher incidence of scoliosis and trunk asymmetry than the control group. The authors also concluded that asymmetrical muscle development can lead to mild scoliosis, but that it also has a potential for significant progress to be found in some cases of idiopathic scoliosis.

Potoupnis, Kenanidis, Papavasiliou, & Kapetanos (2008) investigated the case of female monozygotic twins of whom one suffered from idiopathic scoliosis and the other was not. The opinion of the existence of a genetic predisposition towards the development of idiopathic scoliosis is widely accepted. According to the research, this case is unique because of the pair of female monozygotic twins who are top athletes, with whom there is a discrepancy in terms of the development of scoliosis. The twins, aged 13.5 who were top athletes in synchronized swimming, were clinically tested in a medical school check-up. Both girls were tested in a standing position in order to determine lateral contour asymmetry, trunk, shoulders and shoulder blades while also measuring limb length. The deep forward bend test (forward bending test) was performed to determine the existence of rib hump asymmetry. The measurement results showed the existence of doubt whether one of the girls had developed scoliosis. Radiological assessment determined the existence of adolescent idiopathic scoliosis with Cobb's angle of the left thoraco-lumbar curve of 32 degrees. The clinical and radiological assessment of her sister did not show the existence of any spinal deformity. Given that the twins share the same genetic basis, and that both of them were exposed to the identical factors of synchronized swimming training, it could have been expected that both of them would have the same evaluation results for scoliosis. Since this was not the case, the authors concluded that adolescent idiopathic scoliosis was a multifactorial skeletal deformity, and that several factors (heredity, environment, etc.), which act together or separately might be involved in its development.

Hellstrom, Jacobson, Sward, & Peterson (1990) in their study radiographically evaluated the thoraco-lumbar part of the spine in 117 men and 26 female athletes and 30 non-

athletes who comprised the control group. The authors reported 2 to 3 times higher incidence of scoliosis in athletes than in the control group. Scoliosis is significantly more present in male gymnasts than in soccer players.

The research of Kenanidis, Potoupnis, Papavasiliou, Sayegh et al. (2008) was aimed at evaluating and comparing the frequency of adolescent idiopathic scoliosis between two groups (athletes and non athletes) to determine whether the sports activities were associated with the development of adolescent idiopathic scoliosis. The results showed that in 99 cases (48 athletes and 51 non-athletes) adolescent idiopathic scoliosis was radiographically confirmed (Cobb's angle was greater than 10 degrees). There was no statistically significant difference between the groups of athletes and non-athletes and male sports groups and male non-athletes groups as well as female athletes and non-athletes groups regarding the frequency of adolescent idiopathic scoliosis. Based on these results, the authors concluded that systematic training was most likely not related to the development of adolescent idiopathic scoliosis and that active participation in sports did not seem to affect the level of the main scoliotic curve.

2.3 Postural disorders and their association with sports injuries

Physical deformities are closely associated with other injuries (Watson, 1995). Knee injury in football is associated with lumbar lordosis. Participants who had a pulled muscle had a higher incidence of lumbar lordosis and hyperlordosis. Back injuries are also associated with kyphosis, lordosis and scoliosis. Only 26.5% of football players, rugby players and American football athletes had a preserved lumbar part of the spine, while 51.9% of the players had lumbar lordosis. Also, 67% of these players suffer from muscle injuries, while in the group without these postural disorders only 36% had the same injury. Similar results were obtained by Ribeiro, Akashi, Sacco, & Pedrinelli (2003) who noted the existence of hyperlordosis (63%) and thoraco-lumbar hyperlordosis (22.2%) in players who played futsal, who had some injuries, while players who did not have such injuries had 60.9% of hyperlordosis and 17.4% of thoracohiperlordosis.

3. CONCLUSION

Despite the fact that in certain studies and literature we may find results that speak of changes in the spinal cord in athletes of different sports that involve large rotations, such as gymnastics, ballet, swimming, wrestling, javelin throwing, etc., it has not yet been determined that these activities lead to a direct acceleration or worsening of postural disorders (Wood, 2002).

Achieving the highest level of performance of certain sports require performing heavy physical exercises that are repeated many times in unnatural positions associated with static - dynamic loading, which causes muscle imbalances. Intense physical exercise leads to adaptations not only of passive elements of the spinal column but also of active elements, or the muscles and tendons responsible for their proper posture (Schiller, & Eberson, 2008; Janusz, Rutkowska, & Markiewicz, 1998; Dziak, & Tayar, 1997). Tight muscles of the hip and thigh flexors are often associated with hiperlordosis. (Sammarco, 1983) Hormonal, hereditary and nutritional factors are an important part of influencing the development of the skeleton, especially in girls. Training in physiological terms leads

to an anabolic response of the bone density. However, overtraining can lead to a catabolic response of the body (Arendt, 2000). Hypoestrogenism that occurs as a result of a weight loss, diet and physical training among young girls and women leads to a delayed menarche and reduced bone growth. In this way the skeletal system is subject to residual effects of sexual maturation allowing greater adverse effects of mechanical forces (microtrauma, force, shock etc.) for a longer period, thus creating more space for the emergence of some of the postural disorders. A certain level of physical activity is essential for a proper development of the spinal column, whereas excessive physical exercise can have a negative effect on an immature bone morphology and its mechanical integrity. This is the reason why in highly competitive sports, the spine of young athletes is in a very vulnerable stage of development and the planning of the training process should be approached with care with respect to the principles of growth and development.

These factors along with the genetic predisposition for the development of postural disturbance and environmental impacts may lead to the appearance of postural disorders. However, not a single study is able to confirm this with great certainty. What we can conclude on the basis of previous research is that scoliosis, kyphosis and lordosis are multifactorial deformities occurring under the influence of different environmental factors and genetic predispositions. On the other hand, great differences in the methodological procedures of different studies, defining the terms athletes and sports experience, different samples of participants, are just some of the problems which makes it impossible to determine the cause and effect of the relationship of sports and postural disorders fully, which is exactly the reason why there must be further controlled studies conducted that would establish or reject a link between a particular sport and scoliosis.

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UTICAJ SPORTA NA RAZVOJ POSTURALNIH POREMEĆAJA KOD SPORTISTA

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Visoka stopa učestalosti poremećaja u držanju tela u određenim vrstama sporta, naročito među adolescentima je dovela u pitanje uticaj sportskih aktivnosti na držanje sportista. Iako i dalje ne postoji jasno izražen stav o vezama između sporta i poremećaja u držanju tela, istraživači su utvrdili postojanje određenih faktora kao što su amenoreja, slabost u zglobovima, veliki broj ponovljenih pokreta u sportu, disbalans u mišićima i drugi koji bi mogli da utiču na učestalost ili razvoj nekih poremećaja u držanju tela. Ovi faktori, zajedno sa uticajem naslednih faktora sportista, opravdavaju tezu određenih autora da su skolioza, kifoza i lordoza multifaktorijalni poremećaji.

Ključne reči: *poremećaji u držanju tela, sport, fizička aktivnost, sportisti.*