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THE INFLUENCE OF ELITE SPORT ON ATHLETICS' POSTURE

(*Review article)*

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Abstract

The purpose of this report is literature review for influence of elite sport on athletes' posture. The aim of this literature review is to determine if there is an evidence that high performance sport affects athletes' posture, to highlight the relation between the training and body posture. The existence of numerous studies about the relation between sports and body posture represents the actuality of the problem. More studies that focus on younger children and elite athletes are needed. More higher quality researches are also needed. This includes intervention as well as longitudinal research. The effects of athletics involvement on early intermediate risk factors or mechanisms in the development of disorders need to be studied and followed over the time.

Keywords: *high performance training, body posture, posture deviations, sports training, younger children, elite athletes, school doctors, pediatricians, coaches, physical education teachers, general education teachers, parents, physical activity, scoliosis, kyphosis*

INTRODUCTION

Changes in body posture are common in children and adolescents. And what is the posture of children practicing sport on high performance level? Is high performance sport a healthy pursuit? Elite sports training are based on the constant repetition of some movements, which may lead to osteomyoarticular imbalance, causing changes in strength, flexibility, balance and motor coordination which can influence on posture among the children and adolescents practicing professional sports.

Modern elite sport must be viewed on the background of the idea of systematic progress. The Olympic motto, 'citius, altius, fortius' - faster, higher, stronger - gives a precise concentration of this idea. Modern sport is also influenced by the liberal idea of a free market where the actors can perform, compete and be rewarded according to performance. However, one may ask why and how the athletes are willing to risk their health and even their life on the free market of sport when they do the extreme: push the limits, break the records, set new standards, develop new events (Breivik, 1998). This paper discusses what may be the result on posture among the athletes as the sport moves toward the limits of human performance. The health focuses on development of the elite sport which should not be restricted to the individual athlete, but should also include the various systems that make up the elite sport. Other actors, like coaches, leaders, sponsors, medical personnel, service people, etc., are taking part in the same development.

High sports mastery is achieved with multiple repetitions of each element and many, many hours of training. Besides the continuity and specificity of the training, another feature of some sports is the early start. The early age is the period in which all the organs and systems are in continuous development and respectively carries the risks of abnormalities in their anatomical and physiological features (most it applies to musculoskeletal and digestive system). The listed characteristics are prerequisites for the development of body posture and spine deviations among the athletes.

The body posture and spine deviations were always subject of discussion and observation of orthopedists, pediatricians and parents. The problem has existed for many years and the experts never ceased to look for updates to the reasons and evolution as well as to their treatments, because the early diagnosis and timely treatment is important for the best prognosis (Raikov, (Райков), 2011).

The body posture is the position in which we hold our body upright against the gravity while standing, sitting or lying down.

The correct posture gives not only a smart appearance but also helps to prevent the injury and the spine abnormality.

Good posture is the state of muscular and skeletal balance that protects the body structures against the in-

jury or progressive deformity independent of the attitude (erect, lying, stooping, bent) in which these structures are working or resting. Under such conditions, muscles work more efficiently, and ideal positions are allocated to the thoracic and abdominal organs. (Kendall, McCreary, & Provance, 1995; Knoplich, 1986)

Good posture is the attitude which is assumed by body parts to maintain the stability and balance with minimum effort and least strain during supportive and non-supportive positions (Shimaa, 2012).

Good posture depends from many and different factors. There are intrinsic and extrinsic factors that can influence the subject's posture, such as heredity, the environment or physical conditions in which the subject lives, professional sport, socioeconomic level, emotional factors, and physiologic alterations due to human growth and development.

Factors that influence on the body posture:

- Aging - body gradually loses its capacity to absorb and transfer the forces
- Inactivity/sedentary living/reluctance to exercise - leads to loss of natural movement flow,
- Poor postural habits - eventually becomes structural,
- Biomechanical compensation - muscle imbalance, adaptive shortening, muscle weakness and instability,
- Body composition – increases load, stresses on spinal structure, leads to spinal deviation,
- Workspace – ergonomics,
- Poor movement technique/execution/training,
- Injury - leads to reduced loading capacity or elasticity,
- Others (McGill, 2007).

Children's posture undergoes many adjustments and adaptations due to body changes, effect of psychosocial factors and environment. Build and maintaining good posture in childhood is important for maintaining good health in adolescent and adulthood.

During the growth it is significantly important to look after and detect any deviation from the norms of physical development for appropriate age, in order successfully to take preventive measures and treatment. Posture deviations can have a progressive evaluation. This can lead to significant health problems - cardiovascular and respiratory diseases, early wear of the joints, severe spinal deformities, impair the function of internal organs, reduce the performance and sometimes lead to invalidity. Therefore such studies are of timeless relevance and are significantly important for the health and the future of each population (Karaneshev, Chernogorova & Markova (Каранешев, Черногорова, & Маркова), 1982; Langova, Stoikova, & Gradinarova (Лангова, Стойкова, & Градинарова), 1999; Mancheva (Манчева), 1971).

The identification of the postural habits adopted by children and the postural alterations that often result is important (a) for prevention (Knoplich, 1986; Pereira, 2001) (b) to encourage a healthier posture for children, and (c) to prevent resulting of painful syndromes and deformities.

Problems with posture should be well known from the school doctors, pediatricians, coaches, physical education and general education teachers, parents and society.

The most common postural deviations are:

- in sagittal plane – cervical and lumbar hyperlordosis, kyphosis, flat back,
- in frontal plane – scoliosis.

Posture alterations can be found both in sedentary individuals, due to their physical inactivity, and in physical activity practitioners (Neto, Pastre, & Monteiro, 2004). The posture is correlated with the sports modality and presents its own characteristics which the body has to adapt to and can cause postural disorders. Cyclic and repetitive sports activities can trigger posture problems due to the automatization of gestures.

The high incidence of postural disorders in certain branches of sport, especially among the adolescents has questioned the influence of sports activities on the postural status of athletes (Stošić, Milenković, & Živković, 2011).

Purpose

It is necessary to discuss the health problems in elite sport nowadays as it gets closer to the human performance limit. There is no a single sport where the athletes do not have a posture and spine disorder, 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.

METHODS

Literature review

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 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 the teenage athletes, weakness of the muscle and 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).

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 the normal postural genesis. This long-term exposure to such loads 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).

The posture deviation, as a result of a specific sport or excessive training loads can be found in many studies (Grabara & Hadzik, 2009a, 2009b; Slawinska, Rożek, & Ignasiak, 2006). Some postural disorders are more 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, Nyman, & Peterson, 1990). Athletes who practice these types of sports have a higher risk of the abnormal development of the spinal column.

Few accessible Bulgarian studies discuss the posture deviation among the rhythmic gymnastics athletes (Zaharieva, 2015, Zaharieva, 2015a, 2015b, Zaharieva & Gencheva, 2014 and Tanchev, Dzherov, Parushev, Dikov, & Todorov, 2000).

In international literature there are studies which explore the health problem among the rhythmic gymnastics including posture alteration (Radaš & Bobić, 2011; Kums, Ereline, Gapeyeva, Pääsuke,& Vain, 2007; Bosso & Golias, 2012), treatment methods and prevention of abnormal posture in rhythmic gymnasts (Popa & Dobrescu, 2013).

Ballet dancers and Rhythmic female gymnastics are thought to suffer from hypoestrogenism because they tend to over exercise (train too much) and keep low the body weights, conditions that can cause low estrogen levels, delayed menarche, fractures and scoliosis. Low estrogen levels have been linked to scoliosis in a variety of studies (Lau, 2011).

Kyphosis and lordosis is the amplification of the physiological spinal curvatures in the sagittal plane. Kyphosis or lordosis can be found not only separately but it can often occur in combination as well. 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.

In their study Wojtys, Ashton-Miller, Huston, & Moga, (2000), present an increased the 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. The most affected athletes are gymnasts, footballers, hockey players, swimmers and wrestlers (Wojtys et al., 2000).

Grabara (2010) in her study 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, the lumbar lordosis was more pronounced than in their untrained peers.

The study of Kumsa, et al. (2007,) shown that rhythmic gymnasts have lower angle values of lumbar lordosis and thoracic kyphosis than the control group.

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

In their study Cebula, Czernicki, & Durmala, (2009) presented thoracic hyperkyphosis in 72% of athletes and 70% in nonprofessional athletes. Lumbar hyperlordosis was observed in 43% of all examinees, in which the non-athletes prevail with 67% comparing with 37% of athletes.

Rajabi, Doherty, Goodarzi, & Hemayattalab, (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.

Shahrokh, Daneshmandi, Rahmani, & 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.

Also there are studies that have shown different results which refer to the correlation between kyphosis and lordosis with the length of a training.

The results of Bagherian, Rahnama, & Rajabi, (2011) 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.

In the study of Muyor, Alacid, & Lopez-Minarro, (2011a), 68% of cyclists had hyperkyphosis, 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 hyperkyphosis 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. However, this hyperlordosis does not affect the sagittal configuration of the lumbar spine in a standing position (Lopez-Minarro, Muyor, & Alacid, 2011; Muyor et al., 2011a).

Lopez-Minarro & Carcelas, (2010) have estimated the frequency of functional kyphosis and lumbar kyphosis in adolescent kayakers - 63% of athletes have normal kyphotic values in a standing position, while in the maximum flexion of the trunk 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.

Forster, Penka, Bosl, & Schoffl, (2009) found, 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.

There are the studies that have shown different results which refer to the correlation between volume of training and the degree of spine curvature.

Wojtys et al. (2000) have found that there is a correlation between the 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, (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.

Hasan, Hematinezhad & Saghebjoo (2002) 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.

Scoliosis can be defined as a lateral curvature of the spinal column or deviation in frontal plane by one or more vertebral segments.

Female athletes in general have high rates of scoliosis. A likely reason for this is because the women, who train excessively, like professional dancers and athletes, may stop menstruating, which lowers their estrogen levels and makes them at risk for osteoporosis, a condition closely linked to scoliosis.

Most authors have reported a higher incidence of scoliosis in dance, ballet, the javelin throw, table tennis, tennis, hurling, gymnastics and rhythmic gymnastics.

Tanchev, et.al, (2000) present a 10-fold higher incidence of scoliosis was found in rhythmic gymnastics trainers (12%) compared to a control group (1.1%). 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.

The high level of incidence of scoliosis was noticed in the dancers. It is shown in the study of Warren, Brooks-Gunn, Hamilton, Warren, & Hamilton (1986). In their study, which was based on a sample of 75 classical ballet dancers, scoliosis was noted in 24% of the cases.

Becker (1986) in his preliminary study reported that 6.9% of the assessed adolescents who participate in competitive swimming programs 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.

The research conducted by Modi et al., (2008) present the existence of a significant scoliotic curve where the dominant hand is associated with the direction of the curve on the volleyball players sample. The curves were either thoracic or thoraco-lumbar. Cobb's angle was not statistically significantly associated with the length of the training.

The study of Yoo et al., (2001) present that 51.7% of volleyball players (players who had been involved in volleyball for more than one year) 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%). According to the authors 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.

The opinion of the existence of a genetic predisposition towards the development of idiopathic scoliosis is widely accepted, but according to the research there is a discrepancy in terms of the development of scoliosis. Potoupnis, Kenanidis, Papavasiliou, & Kapetanos (2008) examined the monozygotic twins aged 13.5 who were top athletes in synchronized swimming. One of them suffered from idiopathic scoliosis and the other was not. 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 the 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, et al., (1990) reported 2 to 3 times higher incidence of scoliosis in thoraco-lumbar part in athletes than within the non athletes. Scoliosis is significantly more present in male gymnasts than in soccer players.

In their research Kenanidis, Potoupnis, Papavasiliou & Kapetanos (2008) 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.

However the all presented studies 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).

CONCLUSION

The existence of numerous studies whether the sports activities were associated with the development of posture deviations show the actuality of the problem. The posture deviations can have a progressive evaluation and can lead to significant health problems - cardiovascular and respiratory diseases, early wear of the joints, severe spinal deformities, impair the function of internal organs, reduce performance and sometimes lead to invalidity. Therefore, such studies are of timeless relevance and are significant important for the health and future of each population.

There are a small number of studies that examine the athletes between the ages of 6 and 18 years for posture deviations, age in which all organs and systems are in continuous development. According to this, the influence of specificity of the training, diet, very early begins the influence on the development of the skeleton (particularly in adolescence) deserves further investigation.

However all presented studies has not yet been proven that a particular branch of sport causes or contributes to the development and the occurrence of posture deviations in sagittal or frontal plane. 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.

Also the studies show different results which refer to the correlation between posture deviations with the length of training.

Studies presented the existence of a significant connection between the dominant hand and posture asymmetry, due to repetitive sports activities with dominant hand and asymmetrical muscle development can lead to mild scoliosis.

Postural disorders are more common in some certain sports fields like gymnastic, ballet and etc. 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).

We can conclude on the basis of previous research that scoliosis, kyphosis and lordosis are multifactorial deformities occurring under the influence of different environmental factors and genetic predispositions.

There are great differences in the methodological procedures of different studies, defining the conditions and age of athletes and sports experience, these 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 which would establish or reject a link between a particular sport and posture deviation.

REFERENCES

Asghari, A., & Imanzadeh, M. (2009). Relationship between kyphosis and depression anxiety in athlete and non athlete male students in selected universities of Tehran. *World Applied Sciences Journal,* 7(10), 1311-1316.

Becker, T. (1986). Scoliosis in Swimmers. *Clinics in Sports Medicine, 5*(1), 149-158.

Bagherian, S., Rahnama, N., & Rajabi, R. (2011). Comparison of thoracic kyphosis in two groups of professional and amateur cyclist. *Electronic Physician, 3*(3), 353-353.

Bosso, L., & Golias, A. (2012). Rhythmic gymnastics athletes posture: analysis through photometry. *Rev Bras Med Esporte*, *18*(5) - Set/Out, 2012; 333-337.

Breivik, G. (1998). Limits to Growth in Elite Sport - Some Ethical Considerations, *Twentieth World Congress of Philosophy, Boston* /on-line/. Rretrieved May 7, 2014 from: www.bu.edu/wcp/Papers/Spor/SporBrei.htm

Cebula, M., Czernicki, K., & Durmala, J. (2009). Posture in youth practising oriented training activity. *Scoliosis,* (4 Suppl., 1): O23-10.1186/1748-7161-4-S1-O23.

Cirillo, J., & Jackson, D. (1985). Pars interarticularis stress reaction, spondylosis, and spondylolisthesis in gymnasts. *Clincs in Sports Medicine*, 4(1), 95-110.

Forster, R., Penka, G., Bosl, T. & Schoffl, V. (2009). Climber's back - form and mobility of the thoraco–lumbar spine leading to postural adaptations in male high ability rock climbers. *International Journal of Sports Medicine,* 30(1), 53–59.

Gielen, J., & Van den Eede, E. (2008). Scoliosis and sports participation. *International Sport Med Journal, 9*(3), 131-140.

Grabara, M., & Hadzik, A. (2009a). The body posture in young athletes compared to their peers. *Medycyna Sportowa, 25*(2), 115 -124.

Grabara, M., & Hadzik, A. (2009b). Postural variables in girls

practicing volleyball. *Biomedical Human Kinetics, 1*(1), 67-71.

Grabara, M. (2010). Postural variables in girls practicing sport gymnastics. *Biomedical Human Kinetics, 2*(2), 74-77.

Green, B., Johnson, C., & Moreau, W. (2009). Is physical activity contraindicated for individuals with scoliosis? A systematic literature review. *Journal of Chiropractic Medicine, 8*(1), *25-37.*

Hasan, D., Hematinezhad, M., & Saghebjoo, M. (2002). Spinal abnormalities in former athletes. *Spring, 1*(1), 51- 64.

Hellstrom, M., Jacobson, B., Sward, L., & Peterson, L. (1990). Radiologic abnormalities of the thoraco-lumbar spine in athletes. *Acta Radiologica*, *31*(2), 127-132.

Каранешев, Г., Черногорова, Е., & Маркова, Г. (1982), *Изправителна гимнастика* [Corrective gymnastics. In Bulgarian.] София: Медицина и спорт.

Kenanidis, E., Potoupnis, M., Papavasiliou, K., & Kapetanos, G. (2008). Adolescent idiopathic scoliosis and exercising: is there truly a liaison?. *Spine,* 33(20), 2160-2165.

Kendall, F., McCreary, E., & Provance, P. (1995). *Músculos provas e funções*. 4a. ed, São Paulo: Editora Manole.

Knoplich, J. (1986). *Enfermidades da Coluna Vertebral.* 2ª ed. São Paulo: Panamed Editorial.

Kums, T., Ereline, J., Gapeyeva, H., Pääsuke, M., & Vain, A. (2007). Spinal curvature and trunk muscle tone in rhythmic gymnasts and untrained girls. *Journal of Back and Musculoskeletal Rehabilitation, 20*(2007) 87-95.

Лангова, М., Стойкова, Р., & Градинарова, А. (1999). Превилната стойка е във вашите ръце [Proper posture is in your hands. In Bulgarian.] София: SD "Elite Lang".

Lopoz-Minarro, P., & Carceles, F. (2010). Functional kyphosis and lumbar kyphosis in adolescent paddlers. éRetos: Nuevas Pesperctivas de Educacion Fisica. *Deporte y Recreacion,* 17, 5 - 9.

Lopez–Minarro, P., Muyor, J., & Alacid, F. (2011). Sagittal spinal and pelvic postures of highly-trained young canoeists. *Journal of Human Kinetics, 29*, 41- 48.

Манчева, Н., (1971). *Лечебна физкултура* [Remedial gymnastics. In Bulgarian.] София: Медицина и Спорт.

McGill, S. (2007). *Low Back Disorders-Evidence Based Prevention and Rehabilitation.* Champaign, IL.: Human Kinetics.

Micheli, L., (1983). Back injuries in dancers. *Clinics in Sports Medicine, 2*(3), 473- 484.

Modi, H., Srinivasalu, S., SMehta, S., Yang, J., Song, H., & Woo Suh, S. (2008). Muscle imabalance in volleyball players initiates scoliosis in immature spine: A screening analysis. *Asian Spine Journal, 2*(1), 38 - 43.

Muyor, J., Alacid, F., & Lopez-Minarro, P. (2011a). Valoracion del morfotipo raquideo en el plano sagital en ciclistas de categoria master 40. *International Journal of of Morphology, 29*(3), 727 - 732.

Muyor, J., Lopez-Minarro, P., & Alacid, F. (2011b). Spinal posture of thoracic and lumbar spine and pelvic tilt in highly trained cyclists. *Journal of Sports Science and Medicine,* (10), 355 - 361.

Neto, J., Pastre, C., & Monteiro, R. (2004). Alterações posturais em atletas brasileiros do sexo masculino que participaram de provas de potência muscular em competições internacionais. *Rev Bras Med Esporte,* (3):195-198.

Pereira, A., Sousa, L., & Sampaio, R. (2001). Back School: Um Artigo de Revisão. *Rev Bras Fisioter, 5*(1),1-8.

Popa, C., & Dobrescua, T. (2013). Improving the Symptoms of Compensating Hyperlordosis in Female Gymnasts Through the Use of Postural Reeducation Programs. *Procedia Social and Behavioral Sciences*, *117,* 603-609.

Potoupnis, M., Kenanidis, E., Papavasiliou, K., & Kapetanos, G. (2008). The role of exercising in a pair of female monozygotic (high class athletes) twins discordant for adolescent idipathic scoliosis. *Spine, 33*(17), 607-610.

Райков, Д. (2011). *Гръбначните изкривявания са необратими* [Spinal deformities are irreversible. In Bulgarian.] /on-line/. Rretrieved June 14, 2014 from: vnews.bg, http://vnews.bg/news/26320.

Radaš, J., & Trošt, B. (2011). Posture in top-level Croatian rhythmic gymnasts and non-trainees. In Croatian.] *Kinesiology, 43*(1), 64-73.

Rajabi, R., Doherty, P., Goodarzi, M., & Hemayattalab, R. (2008). Comparison of thoracic kyphosis in two groups of elite Greco-Roman and freestyle wrestlers and a group of non-athletic participants. *British Journal of Sports Medicine, 42*(3), 229 - 232.

Sainz de Baranda, P., Santonja Medina, F., & Rodriguez-Iniesta, M. (2010). Tiempo de entrenamiento y plano sagital del raquis en gimnastas de trampolín [Training time and sagittal curvature of the spine in trampolin gymnasts. In Spanish.] *Rev.int.med.cienc.act.fis.deporte, 10*(40), 521 -536.

Shahrokhi, H., Daneshmandi, H., Rahmani, P., & Javaheri, A. (2011). The study of predictor's anthropometric parameters with trunk anatomical alignment in athletes. *Electronis Physician, 3*(3), 358-358.

Shimaa, E. (2012). *Lecturer of physical therapy (lesson 1), faculty of community, King Khalid University,* /on-line/. Rretrieved June 6, 2014 from: http://www.slideshare.net/shimaa2022/planes-axes.

Slawinska, T., Rożek, K., & Ignasiak, A. (2006). Body asymmetry within trunk at children of early sports specialization. *Medycyna Sportowa*, *22 ,* 97-100.

Slezyenski, J., & Rottermund, J. (1991). Somatic indicators, body posture and foot arch of volleyball players. *Wych. Fiz. Sport*, *35*(4), 59-65.

Stošić, D., Milenković, S., Živković, D., (2011). Uticaj sporta na razvoj posturalnih poremećaja kod sportista [The influence of sport on the development of postural disorders in athletes. In Serbian.] *Physical Education and Sport, 9*(4, Special Issue), 375-384.

Sward, L., Hellstrom, M., & Jacobsonn, B., Nyman, R., & Peterson, L. (1990). Acute injury to the vertebral ring apophysis and intervertebral disc in adolescent gymnasts. *Spine, 15,* 144-148.

Tanchev, P., Dzherov, A., Parushev, A., Dikov, D., & Todorov, M. (2000). Scoliosis in rhythmic gymnasts. *Spine, 25*(11), 1367-1372.

Warren, M., Brooks-Gunn, J., Hamilton, L., Warren, L., & Hamilton, W. (1986). Scoliosis and fractures in young ballet dancers – Relation to Delayed Menarche and Secondary Amenorrhea. *The New England Journal of Medicine, 314*(21), 1348-1353.

Wodecki, P., Guigui, P., Hanotel, M., Cardinne, L., & Deburge, A. (2002). Sagittal alignment of the spine: comparison between soccer players and subjects without sports activities. *Revue de chirurgie orthopedique et reparatrice de l'appareil moteur, 88(*4), 328- 36.

Wojtys, E., Ashton-Miller, J., Huston, L., & Moga, P. (2000). The association between athletic training time and the sagittal curvature of the immature spine. *The American Jounal of Sports Medicine, 28*(4), 490-498.

Yoo, J., Suh, S., Jung, B., Hur, C., Chae, I., Kang, C., Wang, J., Moon, W., & Cheon, E. (2001). Asymmetric Exercise and

Scoliosis: A Study of Volleyball Athletes. *The Journal of the Korean Orthopaedic Association, 36*(5), 455-460.

Wood, K. (2002). Spinal deformity in the adolescent athlete. *Clinical Journal of Sports Medicine, 21*, 77-92.

Zaharieva, D., & Gencheva, N. (2014). Effect of Schroth method on posture and spine deviation on rhythmic gymnasts. *Proceedings, International scientific conference effects of physical activity application to anthropological status with children, youth and adults, Belgrade, 2014,* (pp.222-234). Belgrade: University of Belgrade, Faculty of Sport and Physical Education.

Zaharieva, D. (2015a). Posture among rhythmic gymnastics. *Proceedings, International Scientific Conference in the field of physical education "Fundamentals of motorical literacy in early childhood development", 10th International Balkan Education and Science Congress* (pp.9-10). Skopje: Journal "Pedagogical Magazine".

Zaharieva, D. (2015b). The influence of elite sport on children's health, *Proceedings, XVIII International Scientific Conference "FIS COMMUNICATIONS 2015" in physical education, sport and recreation and III International Scientific Conference* (pp.155-159). Niš. Fakultet sporta i fizičkog vaspitanja.

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