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Differences in postural disturbances between female adolescents handball players and nontraining peers

Razlike u posturalnim poremećajima između rukometašica i netreniranih adolescentkinja

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Abstract

Background/Aim. Physical activity and sport can influence the extent of the presence of the postural disturbances in children. The aim of this study was to investigate the occurrence of differences in the postural disturbances in female adolescents in relation to team handball training. **Methods.** This investigation involved 150 female adolescents with the average age of 13.2 ± 1.34 years divided into two groups (50 adolescents trained handball and 100 did non train it). **Results.** The study determined a statistically significant difference in the total number of postural disturbances between the two groups of adolescents ($p < 0.001$). The presence of the flat foot was statistically significantly higher in untrained adolescents ($p < 0.001$), but the presence of the scoliosis, kyphosis, lordosis, and *pes varus* was not found ($p > 0.05$). **Conclusion.** Handball adolescents players have less postural disturbances than untrained adolescents. Flat foot is significantly less frequent in female adolescents handball players than in untrained ones. Findings obtained in this investigation can help us in planning continuous prevention, observation and care for untrained and trained team handball female adolescents with postural disturbances.

Key words:
adolescent; athletes; female; spinal curvatures; scoliosis; kyphosis; foot deformities.

Apstrakt

Uvod/Cilj. Fizička aktivnost i sport mogu uticati na pojavu posturalnih poremećaja kod dece. Cilj studije bio je da se istraži postojanje razlika u posturalnim poremećajima kod adolescentkinja koje treniraju i njihovih vršnjakinja koje ne treniraju rukomet. **Metode.** U ovo istraživanje bilo je uključeno 150 adolescentkinja prosečne starosti 13,2 ± 1,34 godina, podeljenih u dve grupe (50 adolescentkinja koje su trenirale rukomet i 100 njihovih vršnjakinja koje nisu trenirale ovaj sport). **Rezultati.** Istraživanjem je utvrđena statistički značajna razlika u ukupnom broju posturalnih poremećaja između dve grupe adolescentkinja ($p < 0,001$). Ravno stopalo bilo je statistički značajno češće prisutno kod adolescentkinja koje ne treniraju ($p < 0,001$), nego kod adolescentkinja koje treniraju rukomet. Za skoliozu, kifozu, lordozu i *pes varus* razlika nije bila statistički značajna ($p > 0,05$). **Zaključak.** Adolescentkinje koje treniraju rukomet imaju manje posturalnih poremećaja od onih koje ne treniraju. Ravno stopalo je značajno ređe zastupljeno kod rukometašica nego kod njihovih vršnjakinja koje ne treniraju. Rezultati ovog istraživanja mogli bi pomoći u planiranju stalne prevencije, praćenja i lečenja adolescentkinja sa posturalnim poremećajima, bilo da one treniraju ili ne treniraju rukomet.

Ključne reči:
adolescenti; sportisti; žene; kičma, krivine; skolioza; kifoza; stopalo, deformacije.

Introduction

Postural disturbances can become more pronounced during the growth and development, especially in school children, under the influence of various internal and external factors.

Common postural disorders are postural disorders of the spine (scoliosis, kyphosis, lordosis) and postural disorders in the lower extremities. Principles for normal posture are optimal load on the skeletal system, balans between antagonistic muscle groups and optimal activity for internal body systems.

In postural disorders there is an imbalance in the loads imposed on different areas. Where loads exceed normal physiological limits consistently and over prolonged periods of time, structural changes occur in the skeletal bones. The damage of this type is usually irreversibile [1, 2]. Postural disorders can develop in variety of forms, but most types can be

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classified as either functional (flexible) [3] or structural (rigid) postural disorders [4]. Increase of the physiological thoracic kyphosis angle may be attributed to an alteration in the supporting anterior and posterior soft tissues and musculature. Lumbar lordosis is a key postural component. There is evidence that many individual factors, such as age, gender, muscular strength, activity, sport and flexibility of the spine and lower extremities [5] may affect the lumbar lordosis angle. It is worthy of consideration whether the degree of thoracic kyphosis and lumbar lordosis depends on one's style of life, for example, taking part in sports almost every day [6].

Several studies [7, 8] suggested that the pediatric flat foot as postural disorder in the lower extremities is a frequent presentation in clinical practice. Potential pain and disability are the reasons to discuss prevention and treatment of this problem. Although definition of flat foot varies under different classifications of this entity, it is widely accepted that the low medial arch, *valgus* heel position and the foot flexibility are consistent atributes [8].

Postural status is the result of earlier growth and development, but also of dominant physical activity or a sport and individual practices [9]. Systematic physical activity is a necessary element of normal development of a young human body [10]. From early childhood, people should participate in sports and recreational activities involving movement. However, organised and systematic learning of a given form of motor activity (physical training), particularly participation in sport competitions, may result in development of certain abnormalities connected with excessive physical load of a young body.

The guidelines of the International Scientific Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) recommend that sports are not prescribed as a treatment for idiopathic scoliosis. It is recommended that general sport activities are performed because of the specific benefits they offer to patients in terms of psychological, neuromotor and general organic well-being and that during all treatment phases physical education at school is continued. Based on the severity of the curve and progression of the deformity and the opinion of a clinician specialized in conservative treatment of spinal deformities, restrictions may be placed on practicing certain types of sport activities. It is recommended that sport activities are continued also during brace treatment because of the physical (aerobic capacity) and psychological benefits these activities provide. The SOSORT recommends that during brace treatment, contact or highly dynamic sport activities are performed with caution and that competitive activities that greatly mobilize the spine are avoided in patients with scoliosis at high risk of progression [11].

There are different results in the literature about the effect that various sports can have on the prevalence of postural disturbance in children. Sports associated with jumping and marked stress for the spine must be warned against in the Scheuermann's disease [12]. A high frequency of thoracic hyperkyphosis in the standing position was observed, whereas predominately neutral values were found in the lumbar spine [13]. Adolescent dancers are at significantly higher risk of developing scoliosis than nondancers of the same age (dancers were 12.4 times more likely to have scoliosis than nondancers of the same age) [14].

Different types of competitive sports exert different effects on the various subsystems of posture control [15]. Postural deformities of the locomotor apparatus among athletes from different sports were the subject matter of many studies [12–14, 16–19]. Postural disorders and asymmetry of the musculoskeletal system occur both in the general population and among athletes [20]. The studies were mostly conducted with the aim of comparatively analyzing posture in athletes and their non-athlete peers, or analyzing some of the postural disturbance among athletes (adolescents) from different sports.

The scientific knowledge regarding female adolescent handball team demands is limited. There are few data in the literature about the effect of the handball training on the occurrence of postural disturbance in female adolescents [16, 17]. In these investigations various samples, methods and parameters for assessment of postural disturbances were used, as well as for assessment of postural disturbances in athletes that trained various sport.

But, there are no investigations that analyzed the shape of the spine in the sagittal and frontal plane, together with assymetry of shoulder, scapulas, pelvic position, asymmetry of waist (Lorenz's triangle) and asymmetry of line of the Achilles tendon, or assessments of feet disturbance.

That's why the aim of this study was to investigate the occurrence of differences in the presence of postural disturbances, specifically in the spine and feet, in trained and untrained team handball female adolescents.

The findings obtained in this investigation could give us information about potential disturbances related to training handball and for planning continuous care for adolescents with postural disturbances, trained and untrained female adolescent team handball players. These findings could also show a total number of postural disturbances and which postural disturbances are less frequently seen in female handball players.

Methods

Subjects and design

In this investigation we included 150 female adolescents, average age 13.2 ± 1.34 years (range 12–13 years), divided into two groups. The group I included 50 female adolescents with the average age of 13.4 ± 1.5 years that participated in team handball training in local clubs for at least 2 years. The group II included 100 female school adolescents, average age 13.1 ± 1.7 years, that did not train team handball or any other sports, but were occupied with usual physical activities for that age. The groups were similar on all demographic characteristics.

Exclusion criteria were female adolescents with congenital musculoskeletal deformities, other deseases or injuries that resulted in deformities, disturbance of function of the musculoskeletal system and subjects with shoulder pain. All the participants underwent physical examination of the spine and feet. Estimate of the child conditions with spinal

and feet deformity included medical history, clinical physical, orthopaedic, pediatric, neurology examination and diagnostic tests.

The posture was examined visually and with special tests. Standardized physical examination of the spine to diagnose scoliosis included evaluation of patient posture in a standing position (inspection from behind, from the side, from the front and palpation). Physical assymmetry is examined in the following areas: shoulder height, scapulas position, chest area, pelvic and hip position, asymmetry of waist (Lorenz's triangle) and lateral deviation of the spinal column. Physical examination included examination of vertebral rotation (rib hump) with the Adam's forward bending test. The patients were in standing position, bending torso forward, legs are together, knees extended and shoulder relaxed. Practitioner made evaluation of imbalance or protuberance (hump) in the upper back area or prominence in the lumbar area.

Physical examination of the spine to diagnose kyphosis and lordosis included evaluation of patients posture in a standing position. We asked the patients to stand and looked at the the spine from the side. Although normal posture is difficult to define, we made assessment of the thoracic and lumbar curvatures, noting whether the curve is quite regular or apparently increased.

Physical examination of the feet was performed visually and with special tests. We estimated medial arch, *valgus* heel position and the foot flexibility. We asked patients to try to arch the foot. In mobile flat foot the arch can often be restored voluntarily. In estimate of posture we looked at the foot from behind, paying particular attention to the slope of the heels. Valgus heels are associated with *pes planus* [7].

Testing procedures

Modified original physical activity and postural disturbance test which was developed from the classification of musculoskeletal disturbance was used. The original physical activity and postural disturbance test contains also the part with questions about physical activity, which we did not study in this work.

Postural disturbance test contains information about age, gender and 10 sections. Five sections are for assessment of the body asymmetry and degree of disappearance when child actively corrected: asymmetry of the scapulae, shoulder girdle, waistline (Lorenz's triangles), pelvic alignment in the frontal plane-anterior superior iliac spine (ASIS) and asymmetry of line of the Achilles tendon. Three sections are intended for assessment of spine postural disturbances and flexibility (scoliosis, kyphosis and lordosis) and 2 sections for assessment of of feet disturbance and flexibility (flat feet and *pes varus*) [5–7] using a rating on the scale from 0 to 2. "0" estimate normal findings, "1" mild degree and flexible postural disturbance an "2" clear, nonflexible deformity.

In a spontaneous standing position obvious asymmetries were noted along the contour of the back: elevation of a shoulder, prominence of a scapula, uneven waistline, levels of the anterior superior iliac spines or a rib hump, asymmetry of the line of the Achilles tendon and the degree of disappearance when a child actively corrected [3, 21]. Visual (scaled) observations [8] and the test of contraction of plantar flexor muscles were performed for physical examination of the feet (if an arch is reconstituted on toe standing, then it is termed a flexible flat foot) [21]. A pedoscope was used to see the pattern of weight distribution in the foot. We registred an increase in the area of central part of sole taking part in weight-bearing.

For assessment of spine postural disturbances and flexibility we performed tests for assessment of spine flexibility: test of lying in a prone position, test of hanging position [22], the Adam's forward bending test [3, 4, 11]. Children were classified as having normal findings (estimated „0"), flexible postural disturbance or mild asymmetry (grade „1") or structural, clear, nonflexible deformity or asymmetry (grade „2").

Informed consent was obtained from all the subjects. All parameters that were collected, age, clinical examination and testing procedures are the part of the regular clinical and ethical procedures in medical practice.

Statistical analyses

To assess the occurrence of differences in postural disturbances and symmetries between team handball trained and nontrained female adolescents, χ^2 test and Student *t*-test were used. Statistical significance of differences was on the level of $p < 0.05$.

Results

The characteristics of the study participants are shown in Table 1. The female handball players had 64 (27.8%) and untrained 166 (72.2%) of the total number of disturbances in the total sample of participants. As we can see, there was a statistically significant diference in the total number of postural disturbances in trained *vs* nontrained female athletes ($p < 0.001$). The presence of the flat foot was statistically significantly higher in untrained adolescents ($p < 0.001$). Difference between groups regarding scoliosis, kyphosis, lordosis, and *pes varus* was not statistically significant ($p > 0.05$).

Table 2 presents the results obtained by Student *t*-test. As we can see, there is a significantly higher asymmetry of the prominence of the scapula in the handball female adolescent players ($p < 0.05$), but not in the shoulder girdle ($p > 0.05$). Compared to the untrained peers, there is a statistically significantly higher asymmetry of the pelvic alignment in the frontal plane ($p < 0.05$) and the line of the Achilles tendon in the control group of adolescents compared to the handball players ($p < 0.05$).

Discussion

Modern life style has reduced physical activity in children. The various sports have an influence on the musculoskeletal system. There is evidence that school children who are not actively involved in sport activities have significantly higher probability of poor posture than children performing sports [23], which is in accordance with our findings.

Table 1

Characteristics of the study participants (n = 150; 50 female handball players and 100 female untrained adolescents)

Parameter	Group	Score			Total	Statistical analysis χ^2 test
		0	1	2		
Age (years), $\bar{x} \pm SD$	handball		13.4 ± 1.5		13.2 ± 1.3	
	control		13.1 ± 1.7			
Scoliosis, n (%)	handball	34 (68)	12 (24)	4 (8)	50 (100)	$p > 0.05$
	control	70 (70)	29 (29)	1 (1)	100 (100)	
Kyphosis, n (%)	handball	40 (80)	8 (16)	2 (4)	50 (100)	$p > 0.05$
	control	80 (80)	19 (19)	1 (1)	100 (100)	
Lordosis, n (%)	handball	40 (80)	8 (16)	2 (4)	50 (100)	$p > 0.05$
	control	72 (72)	25 (25)	3 (3)	100 (100)	
Flat foot, n (%)	handball	24 (48)	16 (32)	10 (20)	50 (100)	$p < 0.001$
	control	16 (16)	67 (67)	17 (17)	100 (100)	
Pes varus, n (%)	handball	48 (96)	2 (4)	0 (0)	50 (100)	$p > 0.05$
	control	96 (96)	4 (4)	0 (0)	100 (100)	
Total of postural disturbances, n (%)	handball		46 (71.9)	18 (28.1)	64 (27.8)	$p < 0.001$
	control		144 (86.7)	22 (13.3)	166 (72.2)	
Total, n (%)			190 (82.6)	40 (17.4)	230 (100)	

$\bar{x}$ ± mean value; SD – standard deviation.

Table 2

Assessment of symmetry of the scapulas, shoulders, pelvis and Achilles tendon of the handball players and untraining peers (score from 0–2, where 0 is a normal finding)

Symetries	No trained female adolescents	Adolescent handball players	*t* (Student's *t*-test)	*p* value
	Average score (± SD)	Average score (± SD)		
Scapula	0.24 (0.52)	0.56 (0.77)	-1.89	< 0.05
Shoulder girdle	0.22 (0.51)	0.12 (0.33)	0.39	> 0.05
Waistline (Lorenz's triangle)	0.08 (0.28)	0.08 (0.27)	0	> 0.05
Pelvic alignment in the frontal plane-ASIS	0.06 (0.24)	0 (0)	1.77	< 0.05
Line of the Achilles tendon	0.48 (0.77)	0.12 (0.44)	2.38	< 0.05

ASIS – anterior superior iliac spine; SD – standard deviation.

A total number of postural disturbances in female handball adolescents was significantly lower than in the control group in our research. This could be explained by involvement of various muscle groups, as well as by higher spine mobility during team handball training. The total sample contained a lower percentage of lordosis and kyphosis in our investigation compared to previous study [23]. These differences could be explained by differences in the samples.

Scoliosis has been found in up to 80% of athletes with an asymmetric load on the trunk and shoulders, such as javelin throwers and tennis players [24]. A 10-fold higher incidence of scoliosis was found in rhythmic gymnastic trainees [25]. But, research that investigated the prevalence of kyphosis, hyperlordosis and back asymmetry in children playing and not playing sports reported that the incidence of back asymmetry was higher in girls playing basketball. Tennis was found not to be a suitable sport for either male or female prepuberal children. In females the incidence of hyperlordosis did not correlate with any of the sports [26].

Scoliosis was found in 32% of the female handball players in our research (24% flexible and 8% nonflexible) and in 30% of adolescents in the control group (29% flexible and 1% nonflexible). Nonflexible scoliosis was found in a higher percentage (8%) of female handball players in our research than in non-training peers (1%). An overall prevalence of adolescent idiopathic scoliosis (AIS) is 0.47–5.2% in the current literature [27]. These results may be because of the size of the samples, other factors or potentially related to the overheadthrowing motion that is a highly repetitive skilled motion performed at high velocities.

We did not find a statistically significant diference in the number of scoliosis in female adolescent players in relation to nontraining peers that is in accordance with other report, showing that systematic exercising is probably not associated with the development of AIS [28].

Young athletes may have a spinal deformity that might have been incidental or potentially related to their sport [29]. Excessive mechanical loading and the frequency of training

could lead to an increase in kyphosis in the immature athlete [30]. There is the lack of prospective, controlled trials addressing this issue.

To assess the shape of anteroposterior vertebral curvatures in adolescents who practice team sports, recently reported investigation analyzed 57 females and 104 males aged 14–17 years, playing volleyball, basketball or handball, and 63 females and 99 males as a control group [16]. The author found that female athletes had lower thoracic kyphosis than the control group ($p < 0.01$). The percentage of functional (flexible) kyphosis and lordosis in our research was lower in the trained handball (16% and 16% respectively) than in female untrained adolescents (19% and 25%, respectively). The presence of the unflexible kyphosis was higher for 3% in handball trained. But, there was no statistically significant difference in the presence of kyphosis and lordosis in the two groups of adolescents. These differences could be the result of selection of the sample and of the applied method.

Poor posture and loss of muscle tone were contributory to lumbar lordosis in untrained adolescents. It is also reasonable to postulate that lower physical activity in female in relationship to male adolescents [31] may decrease the tone of the spinal ligaments and muscles in untrained female. There is a report that the relationship between kyphosis and lordosis decreased in girls but not in boys [32, 33].

Karski et al. [34] reported favorable influence of some sports on the development of children skeleton. In the classification of sports, team handball presents sports activity with modest statics and high dynamics [35]. Several recent studies in the prevalence of postural disturbances in children suggest problems with foot being one of the most common [7, 8]. There is no standardized framework from which to evaluate the pediatric flat foot [7]. The prevalence of flat foot estimates are vastly variable and range from 0.6–77.9% [7]. We find that 73.3% of female adolescents have flat feet. Of course, these differences could be the result of selection of the sample, sex and age of participants, diagnostics and cultural habits. Our results showed that asymmetry of the line of the Achilles tendon were statistical significantly lower in trained than in untrained female.

The results of our study show significantly lower number of flat feet and asymmetry of the line of the Achilles tendon in team handball players. These results could be explained by the fact that handball training requires endurance and maintenance of the foot arch which needs involvement of sole arch muscles. There are reports that the formation of foot arches probably end at late school age [36].

There is a significantly higher asymmetry of the prominence of scapula in the handball female adolescent players in our research, that is in accordance with the results of a recently report [17]. Asymmetric scapular posture is often associated with abnormalities of the shoulder complex joint. We did not find a difference in the shoulder girdle between female handball adolescent players and untraining peers. However, shoulder asymmetries may also be related to adaptations to sports practice [18]. It was noted in previous studies that in handball athletes, the dominant scapula was more anteriorly tilted than in non-athletes groups. The authors concluded that a certain degree of scapular asymmetry may be normal in some athletes. It should not be considered automatically as a pathological sign but rather an adaptation to sports practice and extensive use of upper limb [18].

We did not find a statistically significant difference in the presence of waistline (Lorenz's triangle) between trained and untrained females. This result may be explained by low percentage of non-flexible scoliosis in both groups of adolescents.

There is a report that states that correct pelvic alignment in the frontal plane was more common in handball players than in untraining young females [17]. It is in accordance with our results showing no asymmetry of the pelvic alignment in the frontal plane in female adolescents handball players in any case. We found a significantly higher asymmetry of the pelvic alignment in the frontal plane in the control group of adolescents. This result can be explained by the fact that handball training contributes to and maintains elasticity of hip muscles.

Conclusion

The results of this investigation show that postural disturbances are less frequent in 13-year female team handball players than in untrained adolescents of the same age. Flat foot is significantly less frequent in female adolescents handball players than in untrained ones.

We did not find a statistically significant difference in the presence of scoliosis, kyphosis, lordosis and *pes varus* between young female handball players and untraining peers.

The obtained results show that asymmetry of the line of the Achilles tendon and asymmetry of pelvic alignment in the frontal plane-anterior superior iliac spine were statistically significantly lower in female handball trained than in untrained adolescents, but asymmetry of the waistline and the shoulder girdle were not. There is a significantly higher asymmetry of the prominence of the scapula in the handball female adolescent players than in the untrained adolescents.

The findings obtained in this investigation can help in planning continuous prevention, observation and care for trained and untrained team handball female adolescents with postural disturbances.

Understanding of what we know (and do not know) about team handball trained differences in female adolescents is important for improving quality of care for musculoskeletal development of children. The findings of this study could be useful in practice and further investigation. These may be the strengths of this study. The primary limitation of this study was that we could not include emotional and mental health domains and pretraining physical shape. Further studies are required to confirm these results in other sets of adolescents.

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