ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2022; 29(**1**): 5-11
ISSN 2299-9590
DOI: 10.23829/TSS.2022.29.1-1

The level of body posture, the flexibility of backbone and flat feet in competition fitness in 8-11year old girls

ALEXANDRA VEIS, JANKA KANÁSOVÁ, NORA HALMOVÁ

Abstract

Introduction. **Such sports as fitness have high demands on the motor system, mainly on the foot arch. Repeated movements can expose the ankle joint and the sole of children practicing fitness sports to high loading.** **Aim of Study.** **The aim of this study was to determine the incidence of incorrect body posture, flexibility and flatfoot in children attending competition fitness classes.** **Material and Methods.** **The study population was composed of 18 children aged 8.9 to 10.3 years of age. Body posture was assessed using the eye-viewing method according to Klein and Thomas. Backbone flexibility was measured using tests of Schober´s and Stibor´s symptoms, right and left backbone lateral flexibility, Thomayer´s symptom, Otto´s inclination and the reclination symptom. Podoscopy was used to assess flatfoot degrees. All indicators were evaluated individually and statistical significance of the relationship between individual dimensions of body posture and flat feet were assessed using the chi-square ($\chi 2$) test.** **Results.** **The highest proportion of incorrect body posture in all tested children was recorded in the dimension of hips and shoulders (78%), backbone curvature (61%) and shoulderblades (55.6%). Flat feet were diagnosed according to Kapandji in 27.8% and 11.2% cases according to Srdečný. When investigating the relationship of flat feet in the test of Kapandji and Srdečný to the dimension of body posture statistical significance was recorded between flat feet and the dimension of hips and shoulders and backbone curvature. In the test of Srdečný a significant relationship was observed between flat feet and the dimensions of head, shoulderblade and abdomen.** **Conclusions.** **This study focused on the verification of the impact of the training process in fitness sports practiced by children on their body posture and flatfoot incidence. We recommend observing children for flatfoot symptoms, which can negatively influence the postural function in young athletes.**

KEYWORDS: body posture, flatfoot, competitive fitness, spine flexibility.

Received: 7 March 2021
Accepted: 26 April 2021

Corresponding author: nhalmova@ukf.sk

Constantine the Philosopher University in Nitra, Department of Physical Education and Sports, Nitra, Slovak Republic

Introduction

Nowadays, motor system disorders are one of the most frequent problems in children practicing sports. Reasons for the development of motor system malfunctions need to be searched for already in childhood when the child is exposed to inadequate loads. Muscular imbalance then causes wrong body posture. The functional disorder of the motor system is manifested by changes in body shape. These changes can be eliminated by determined effort, in contrast to real deformities or orthopedic malfunctions [12].

An erect posture is characterized in humans as the particular manner of the postural stereotype of an individual [13]. Postural stereotypes are formed since the childhood based on optimal and adequate stimuli. The term stability is closely connected with the term posture. In the human motor system it is understood as the state, when least loaded joint structures, and the muscles work in closest cooperation and the motion is performed most efficiently [24].

Stabilization (or fixation of the backbone during all movements) is ensured by the coordination of the muscles in the deep stabilization backbone system and is considered to be a prerequisite of the axial skeleton, providing protection from overloading [19]. Engagement of muscles into the stabilization process is automatic. There are several muscles that participate in the stabilization of the backbone. As a result of muscular interconnection, it is the whole muscular chain [14]. Postural balance is the ability to hold the body in a balanced position and to regain it again after a shift of body segments. This elementary motor skill is learned in childhood and represents the fundament for everyday routine tasks and sports activities [3, 22].

Researches in various countries showed posture disorders already in 29% of children and adolescents [4, 21, 27]. Moreover, the posture disorder is identified by visible changes in the posture, for example hyperlordosis, an increased frontal pelvic inclination or an anterior position of the head [17]. An incorrect posture is often connected with flat feet. The human foot is specialized for the performance of two different functions – static and dynamic. These aims are fulfilled by the series of bones forming various arches. The arches serve to dissipate forces applied to the plantar aspect of the foot. Changes in the height of the arch are related with the contraction or relaxation of tibial muscles [6]. Flatfoot (pes planus) is a relatively common phenomenon. For a majority of athletes flat feet do not cause any problems and have no impact on performance in sports. However, in certain sports disciplines flat feet can cause stiffness, inelasticity and pain. Baseball is the type of sport, which requires a long-lasting standing position and fast active movement. It is the sport, where flat feet can cause pain [29]. Some studies investigated posture and flatfoot in athletes. For example, Sharma and Upadhyaya studied the effect of flat feet on the running ability of track-and-fielders. In their study no difference was found in the degree of foot flatness in various athletes of different running (long or short distance) sports [25]. Fitness sports as competitive events for children were introduced in 2002. Children's fitness focuses on acrobatics, flexibility and power exercises, which ensure overall development of the child. The aim of the study was to determine the type of body posture, backbone flexibility and the incidence of flatfoot in children practicing competitive fitness sports.

Material and Methods

The analyzed sample was formed by 18 females (decimal age of 8.9 to 10.3 years), who are a part of the GymGol Nitra children's fitness club. Homogeneity of the sample population was reached by the single sex and age of the girls, as well as their identical performance level. The training units took place four times a week and lasted 90 minutes. All the girls performed them with the same strain in the same training unit.

All probands were placed in the first five places in the competitions in Slovakia. All probands have been practicing fitness sports since four years of age. To test the correct posture the standardized test of backbone curvature was applied using the plumb [5], the method by Klein and Thomas as modified by Mayer [20]. A total of six dimensions (head, thorax, backbone curvature, hips and shoulder lines, scapula and abdomen), were assessed visually. The examiners were two independent physiotherapists. Based on the assessment of the dimensions by marks from 1 through 4, where mark 4 is the worst, we assigned the girls to one of the four qualitative degrees: 1st degree – perfect posture, 2nd degree – good (almost perfect) posture, 3rd degree – wrong posture, and 4th degree – very bad posture.

Joint flexibility of the backbone was evaluated by means of five tests: the Schober test (Sch) – lumbar spine flexibility; the Stibor test (St) – flexibility of lumbar and thoracic segments; right and left backbone flexibility – lateral flexibility; the Thomayer test (Tho) – overall spine flexibility, and Otto inclination and reclination tests – flexibility of thoracic spine (Ot) [5].

Schober test (Sch)

From the 5th stem vertebra, mark upwards on the spine and mark the place.

Norm: when performing the maximum forward bend, this distance should be extended by 4-6 cm.

Stibor test (St)

While standing, we measure the distance from the projection of the 7th cervical vertebra to the 5th lumbar vertebra (C7–L5).

Norm: when forward, this distance is extended by 7.5--10 cm.

Otto inclination and reclination tests (Ot)

While standing, we mark the 1st thoracic vertebra on the spine (Th1) and apply 30 cm downwards and mark.

Norm: the distance is extended by 2-3 cm when bending forward and the distance is shortened by 2.5-3 cm when performing the inclination bend. The sum of deviations should be 6 cm.

Thomayer test (Tho)

In the standing position, a deep forward bend with reach is performed. The initial position is standing on a bench or elevated mat.

Norm: the hands touch the pad with their fingers.

Lateral flexion test
The depth of inclination to the right and left is measured after performing a maximum inclination of the torso. Physiological norm is 20-22 cm.
Reduced flexibility: if the elongation is less than the specified norm. Increased flexibility: if the elongation is greater than the specified norm.

LED Podoscope (02990) was used to test flatfoot signs.

The degree of flatfoot according to Kapandji
Healthy feet – standard; the 1st degree of flatfoot – slightly flat foot; the 2nd degree of flatfoot – markedy flat feet; the 3rd degree of flatfoot – the sole is markedly lowered, also when not loaded (Figure 1).

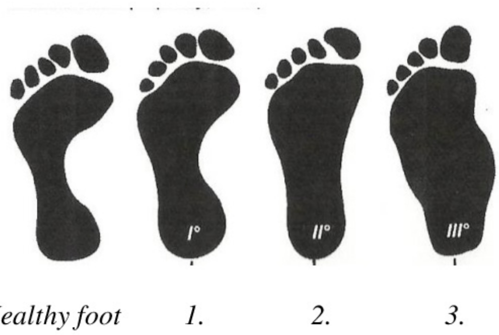

Figure 1. Visual scale according to Kapandji [11]

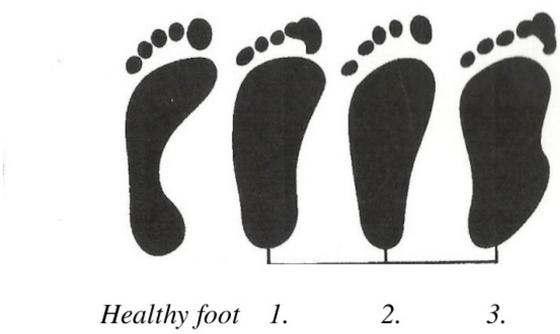

Figure 2. Visual scale according to Srdečný et al. [26]

The degree of flatfoot according to Srdečný et al.
Healthy feet standard, the sole is correct; the 1st degree of flatfoot – a more marked drop of the sole; 2nd degree of flatfoot – visually it is similar as in the 1st degree; the 3rd degree of flatfoot – the sole is markedly lowered, also when noy loaded (Figure 2).
When processing the data, arithmetic means, percentage and frequency analyses were used. In order to express the relationship between posture and the incidence of flatfoot the chi-square (χ^2) test was applied at the 1%, 5% and 10% level of statistical significance.

Results
When assessing posture in children attending fitness training, perfect posture was recorded in the dimension of the head (56% probands), good posture in 44%, while wrong posture and very bad head posture was not recorded. In the dimension of the thorax 89% of probands showed perfect posture and 11% good posture. Similarly as in the head posture, no cases of wrong and very bad posture were observed. In the backbone dimension 39% probands showed perfect posture, 50% good posture, 11% wrong posture, while no probands showed a very bad curvature of the backbone. In the dimension of the hips and shoulders 22% of probands showed perfect posture, while 78% good and wrong posture. No probands showed a very bad position of hips and shoulders. In the shoulder blade dimension 44% probands showed perfect posture, 39% good posture, 11% wrong posture, whereas one girl showed very bad posture, with protruding shoulder blades. In the abdomen dimension 56% of probands showed perfect posture, 39% good posture, one girl had the wrong posture, while no probands showed very bad posture (Table 1).
When assessing the overall posture we diagnosed one girl with perfect posture, 67% with good posture, 22% with the wrong posture and in one girl we recorded very bad posture.
The dimensions of the hips and shoulders with 78%, backbone curvature with 61% and shoulder blades with

Table 1. Qualitative degrees of posture

Degree/ dimensions	Head [%]	Thorax [%]	Backbone [%]	Hips and shoulders [%]	Shoulder blades [%]	Abdomen [%]
1st grade	56	89	39	22	44	56
2nd grade	44	11	50	78	39	39
3rd grade	0	0	11	0	11	5
4th grade	0	0	0	0	6	0

56% showed the percentages of probands with wrong body posture.

When comparing our results for evaluation of backbone curvature by means of the plumb line examination with the recommended values, we measured on average 2.1 cm in the case of cervical lordosis, while the recommended minimum is 2 cm and the maximal one is 2.5 cm. In the case of waist lordosis our value was 3.3 cm, while the recommended minimum is 3 cm and the recommended maximum is 3.5 cm. Joint flexibility of individual segments of the backbone was measured using 5 tests. In the case of Schober's test the probands reached 4.2 cm, which we evaluate as the norm according to the above-mentioned methodology. During the Stibor test we recorded a value of 8.4 cm, which we consider to be a norm.

In the case of lateral (right and left) flexibility of the backbone the recommended minimum and maximum for both right and left sides were 20-25 cm. The probands showed the values of 21 cm in the case of lateral flexibility to the right and 19.9 cm to the left. The standard value for Thomayer's test is that the fingertips should touch the ground, which was exceeded by our probands by 19.2 cm.

When comparing our probands' result of 3.8 cm in Otto's inclination symptom test with the maximum value of 2.5 cm and the minimum value of 2 cm, we can see that probands exceeded these values. In the case of Otto's reclination symptom test the recommended maximum value was 3 cm and the minimum value of 2.5 cm, while our probands recorded 2.8 cm.

The backbone flexibility indicators observed in our study were positive. The fitness sports probands in all tests reached the recommended standards of backbone flexibility with the exception of Otto's inclination symptom test, where we measured the value of 3.8 cm, while the recommended minimum is 2 and the maximum is 3 cm. Our probands exceeded the recommended maximum value by 0.8 cm (Table 2).

Out of the total number of probands, according to Kapandji [11] 94% of probands showed a healthy right leg and 72% probands a healthy left leg. The first degree of flatfoot in the right foot was diagnosed in one girl, while the first degree of flatfoot in the left leg was not diagnosed in any of the probands. No probands were diagnose with the second degree of flatfoot in the right foot and the left foot. The third degree was not diagnosed in any of the probands, whereas the third degree of flatfoot in the left foot was diagnosed in one girl. According to Srdečný et al. [26], the healthy left foot was diagnosed in all probands and the healthy right foot in 89% of probands. The first degree of flatfoot in the left foot was found in one girl, while the second degree of flatfoot in the left foot was not found in any of the probands. The third degree of flatfoot in the left foot was diagnosed in one girl.

When assessing the overall flatfoot incidence according to Kapandji healthy feet were diagnosed in 72% of probands. The first degree of flatfoot was diagnosed in 22% of probands, the second degree of flatfoot was not recorded in any of the probands, whereas the third degree was diagnosed in one of the probands. According to Srdečný et al., healthy feet were diagnosed in 89% of probands, while in one girl the first degree of flatfoot was observed. The second degree of flatfoot was not diagnosed at all, while the third degree was found in one girl.

When determining the relationship between flatfoot according to Kapandji and the types of body posture according to Klein and Thomas [20], we found a 10% statistical significance between flat feet and the dimension of the backbone, and 5% significance for the correlation between flat feet and the hips and shoulders dimension. In the case of other dimensions of posture no significance was found in their relationship to flat feet according to Kapandji. When determining the relationship of flatfoot according to Srdečný et al. with the dimensions of posture according to Klein

Table 2. Posture and backbone flexibility

Sample/test	Cervical lordosis (cm)	Waist lordosis (cm)	Schober's symptom (cm)	Stibor's symptom (cm)	Thomayer's test (cm)
SF	2.1 ± 0.63	3.3 ± 0.71	4.2 ± 1.12	8.4 ± 1.8	19.2 ± 6.29
Rmin	2	3	4.1	7.5	
Rmax	2.5	3.5	6	10	
Sample/ test	lateral backbone flexibility (right)	lateral backbone flexibility (left)	Otto´s inclination symptom	Otto´s reclination symptom	
SF	21 ± 2.4	19.9 ± 2.58	3.8 ± 1.67	2.8 ± 0.86	
Rmin	20	20	2	2.5	
Rmax	25	25	3	3	

Note: SF – the sample of fitness probands; Rmin – recommended minimum value; Rmax – recommended maximum value and Thomas, a statistically significant relationship was found at $p < 0.05$ between the sole and the dimensions of the head, shoulder blades and the abdomen. Statistical significance at $p < 0.01$ was confirmed between the sole and the dimensions of of the backbone and hips and shoulders (Table 3).

Table 3. Relationship of flatfoot according to Kapandji [11] and Srdečný et al. [26] with dimensions of posture

	Kapandji		Srdečný	
Dimensions	p-value	chí	p-value	chí
Head	0.4360	2.725	0.0497*	7.829
Thorax	0.7719	1.977	0.7213	1.333
Backbone	0.0813(*)	6.723	0.0048**	12.922
Hips and shoulders	0.0101*	11.32	0.0002**	19.467
Shoulder blades	0.2605	4.009	0.0271*	9.167
Abdomen	0.3605	3.209	0.0484*	7.885

* $p < 0.05$; ** $p < 0.01$; (*) $p < 0.10$

Discussion

Based on the fulfilled aims of the study we are presenting the part of the results, being the subject of further research. The presented results may not be generalized. It is necessary to understand them as partial ones with regard to further research. Our results are in line with the previous conclusions of the works [8, 9], where wrong posture was found in 100% of children aged 11 years attending general schools. The dimensions of hips and shoulders followed by backbone curvature and shoulder blades were the ones observed with the highest incidence of wrong posture in all probands. These results correspond with the findings in the school non-sporting population [9, 15]. Our findings of the relationship between flatfoot and posture correspond with the findings by Kanásová, who assumed that flat feet can to a high degree influence also the wrong body posture [10].

In our reference sample good posture was diagnosed in a majority of probands (67%), which according to the method of evaluation is considered to be a slight deviation from the standard. Healthy feet (assessed according to the quality of the sole) were recorded according to both methods in 72 up to 89% of probands. The sole represents one of the most important proprioceptive areas of the human body. It is not by chance that it is closely connected with postural functions. In terms of afferentation mainly the receptors in the area of the sole, hips and the neck play a crucial role in the erect body posture [7]. If the information from various receptors differs, they become the source of motor insecurities [28]. According to several authors [2], improper functional loading of the leg has a highly negative impact on overloading and the incidence of chronic changes not only in the area of the ankle joint and leg, but also in more proximal segments of the body within the whole kinematic chain. Many studies describe the connection between the sole, the deep stabilization system and posture [16, 18]. Both high and low arched feet have been reported to be factors making the foot more prone to injury during physical activities [23].

In our study these interconnections between the sole and posture were found in individual dimensions of posture. The activity of the deep stabilization system was not observed. When observing the impact of an intervention program on backbone flexibility in 136 female pupils of 4th grade in secondary schools (without any connection with flatfoot) it was found that the backbone, in terms of the overall dynamic function, after a 3-month aimed motor program with compensation focus in the sagittal and lateral planes became more dynamic and flexible. These results were supported by the statistically significant results ($p < 0.01$) of Thomayer's, Schober's, Stibor's and Otto's inclination and reclination tests and lateral flexibility, as well as the statistically significant improvement ($p < 0.01$) in overall muscular balance [1].

With regard to the evaluation of the results for individual indicators this study has several basic limitations. The first one is the deliberate selection of probands. This selection was based on the fact that there were probands closely focused on fitness sports and met the criterion of age, sex and performance homogeneity. The second limitation was the size of the research sample. The results obtained from the improbable selection cannot be considered representative and therefore we cannot generalize the results.

There is a probability of personal physical error, since measurements were not computerized.

Even though all the girls have been through the training process at the same time and with the same workload, we cannot avoid individual differences based on the degree of maturation and physical preoccupation.

Conclusions

When evaluating posture, we found that at least 22% of the subjects had excellent posture in all dimensions and only one subject (in the scapula dimension) had very poor posture. When evaluating overall posture, we diagnosed one subject with excellent posture, more than half with good posture, 22% with incorrect posture and in one subject we recorded very poor posture. The dimensions of the hips and shoulders (uneven position of the hips and shoulders) contributed most to the incorrect posture of all probands.

In all the tests for the detection of articular spinal motility we measured values within the norm, except for Otto's inclination test. As for the results of flatfoot measurements, we can also talk about positive results in the case of the right foot. In one subject we recorded the first degree of flatfoot in the right leg and in one case the third degree of flatfoot in the left leg. Overall, we recorded better results for the right than the left leg. We found different results when looking at the relationship between the sole of the foot and the individual dimensions of posture according to Klein and Thomas. Based on Kapandji's assessment we found a relationship between flatfoot and the spine dimension and between flatfoot and the hips and shoulders dimension. According to Srdečný et al., we found a relationship between the sole of the foot and the dimensions of the head, shoulder blades and abdomen. Statistical significance was also confirmed for the relationship between the sole of the foot and the dimensions of the spine, as well as the hips and shoulders. We can state that the probands most often showed a slight deviation from the individual standards of posture and also the quality of the sole.

We recommend in young girls to observe signs of flatfoot using podoscopy, which is a practical aid, thanks to which we can visually assess unilateral and bilateral flat feet. If the problem linking functional disorders in the motor system was not found in the area of the sole, this can be manifested in wrong posture and insufficient flexibility of the backbone. Flat feet can seriously impact overall body posture, which can lead to pain and injuries manifested not only in feet, but also elsewhere. In the case of flatfoot diagnosed in children participating in fitness training it is inevitable to immediately incorporate aimed exercises to form the arch of the sole and exercises promoting stabilization and regeneration of the backbone as secondary prevention measures.

Based on research concerning the supporting function of the leg, experts do not recommend long-term walking barefoot on a hard surface, since the child's leg could be overloaded and damaged.

We recommend including spinal mobilization exercises in the training unit to improve spine flexibility and core exercises to strengthen the corset muscles. We recommend exercises for spiral stabilization – the SM system, which by activating the muscle spiral through the arch of the foot improves the tone of the abdominal muscles and affects posture, the quality of the position of the lower limbs and the sole of the foot.

Conflict of Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Bendíková E, Stackeová D. Vplyv pohybového programu s kompenzačným zameraním na pohyblivosť chrbtice u žiačok stredných škôl (Effect of exercise programme with compensatory aim targeting on spine mobility in school probands of secondary high school). Hygiena: časopis pro ochranu a podporu zdraví. 2018;60(1):4-9.
2. Coplan JA. Ballet dancers turn out and its relationship to self-reported injury. J Orthop Sports Phys Ther. 2002;32(11):579-584.
3. De Kegel A, Dhooge I, Peersman W, et al. Construct validity of the assessment of balance in children who are developing typically and in children with hearing impairments. Phys Ther. 2010;90:1783-1794.
4. Girish S, Raja K, Kamath A. Prevalence of developmental coordination disorder among mainstream school children in India. J Pediatr Rehabil Med. 2016;9:107-116. https://doi.org/10.3233/PRM-160371.
5. Haladová E, Nechvátalová L. Vyšetřovací metody hybného systému (Assessment methods of motor system). Brno: NCO NZO; 2010.
6. Hawke F, Rome K, Evans AM. The relationship between foot posture, body mass, age and ankle, lower-limb and whole-body flexibility in healthy children aged 7 to 15 years. Retrieved Feb 4, 2018, from: https://www.researchgate.net/publication/301705125_The_relationship_between_foot_posture_body_mass_age_and_ankle_lower-limb_and_whole-body_flexibility_in_healthy_children_aged_7_to_15_years.
7. Jančová L. Prístrojové vyšetrenie nožnej klenby a postury (Instrumental examination of the arch of the foot and postures). Rehabilitácia. 2013;50(2):89-103.
8. Kanásová J. Držanie tela u 10 až 12 ročných žiakov a jeho ovplyvnenie v rámci školskej telesnej výchovy (Body posture of pupils aged 10-12 and and the impact of school Physical Education on it). Bratislava: Peter Mačura – PEEM; 2006.
9. Kanásová J. Evolution changes in the gait of boys aged 11-15. Saarbrücken: LAP Lambert Academic Publishing; 2015.
10. Kanásová J. Zdravotná telesná výchova (Health Physical Education). In: Šimonek J. Metodika telesnej výchovy

pre stredné odborné školy. Bratislava: Slovenské pedagogické nakladateľstvo; 2004. pp. 132-150.
11. Kapandji IA. The Physiology of the Joints. Vol. 2: The Lower Limb. Edinburgh: Churchill Livingstone; 1987.
12. Kolář P. Vertebrogenní obtíže a stabilizační funkce svalů – diagnostika (Vertebrogenic difficulties and stabilization function of muscles – diagnosis). Rehabilitace a fyzikální lékařství. 2007;13(4):155-170.
13. Kolář P, et al. Rehabilitace v klinické praxi (Rehabilitation in clinical practice). Praha: Galén; 2009.
14. Kolář P, Lewit K. Význam hloubokého stabilizačního systému v rámci vertebrogenních obtíží (The importance of deep stabilization system related to vertebrogenic difficulties). Neurologie pro praxi. 2005;5:270-275.
15. Kováčová E. Stav svalovej nerovnováhy a chybného držania tela u školskej populácie a možnosti ich ovplyvňovania u mladších žiakov (The state of muscular imbalance and defective posture in the school population and the possibility of influencing them in younger pupils). Unpublished dissertation. FTVŠ UK Bratislava; 2003.
16. Kulašíková M, Čolláková K. Oporná funkcia nohy (Support leg function). Rehabilitácia. 2018;55(1):19-30.
17. Lee JH. Effects of forward head posture on static and dynamic balance control. J Phy Ther Sci. 2016;28:274--277. https://doi.org/10.1589/jpts.28.274.
18. Lewit K, Lepšíková M. Chodidlo – významná část stabilizačního system (Foot – significant part of the stabilization system). Rehabilitace a fyzikální lékařství. 2008;3:99-104.
19. Malátová R, Markesová J, Kanásová J. Vliv cílené pohybové aktivity na utváření návyku správného držení těla u dětí staršího školního věku (Impact of an aimed intervention programme on shapinng the body posture of teenagers). In: Šport a rekreácia; zborník vedeckých prác. CD-ROM. Nitra: UKF; 2014. pp. 106-112.
20. Mayer K. Hodnocení držení těla mládeže metodou postojových standardů a výsledky její aplikace v tělovýchovné praxi (Assessment of body posture of adolescents using the method of attitude standards and the results of its application in physical education practice). Acta Chir Orthop Traumat. 1978;3:108-202.
21. Nikolić SJ, Ilić-Stosović DD. Detection and prevalence of motor skill disorders. Res Dev Disabil. 2009;30:1281--1287. https://doi.org/10.1016/j.ridd.2009.05.003.
22. Peterka RJ, Loughlin PJ. Dynamic regulation of sensorimotor integration in human postural control. Neurophysiol. 2004;91:410-423. https://doi.org/10.1152/jn.00516.2003.
23. Razeghi M, Batt ME. Foot type classification: a critical review of current methods. Gait Posture. 2002;15:282--291. https://doi.org/10.1016/S0966-6362(01)00151-5.
24. Richardson C, Jull G, Hodges PW, Hides J. Therapeutic Exercise for Lumbopelvic Stabilization. A Motor Control Approach for the Treatment and Prevention of Low Back Pain. Edinburgh: Churchill Livingstone; 2004.
25. Sharma J, Upadhyaya P. Effect of flat foot on the running ability of an athlete. Indian J Orthop Surg. 2016;2(1):119--123. https://doi.org/10.5958/2395-1362.2016.00017.7.
26. Srdečný V, Osvaldová V, Srdečná H. Ploché nohy (Flat feet). Praha: Nakladatelství Onyx; 1997.
27. Tsui KW, Lai KY, Lee MM, Shea CK, Tong LC. Prevalence of motor problems in children with attention deficit hyperactivity disorder in Hong Kong. Hong Kong Med J. 2016;22(2):98-105. doi:10.12809/hkmj154591.
28. Véle F. Kineziologie: přehled klinické kineziologie a patokineziologie pro diagnostiku a terapii poruch pohybové soustavy (Kinesiology: review of clinical and pathokinesiology for the diagnosis and treatment of musculoskeletal disorders). Praha: Triton; 2006.
29. Zehr M. Flat Feet and Sports. Retrieved Feb 21, 2018, from: https://www.livestrong.com/article/344040-flat-feet-sports/.