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Original Article

The condition of foot in students with functional disorders of posture under different types of physical load

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Abstract.
As a result of a comprehensive study were data obtained as a result of the comprehensive study characterize the state and functional readiness of the students' feet by measure of the flatness of arches of the foot without the physical load and after the static and dynamic physical load.
The weakening of the ligamentous - muscular foot apparatus was noted in students with a pathology of the musculoskeletal system – I grade dysplastic scoliosis (up to 7 ° S) under all physical load. Without a physical load, 27.9% of boys and 25.1% of surveyed girls with disorder of posture constitute the so-called risk group with the condition of the arch apparatus characterized as 'moderate' and 'flat' foot. Under static load, the flatness of the foot increased in 75.3% of boys and in 59.2% of girls with functional disorders of posture, and respectively, in 29.2% and 8.8% of boys and girls without postural disorder. Dynamic load on the foot with own body weight when jumping from the height of 1 m in 100.0% of students with functional posture disorders was characterized by deformities of the foot arch, while a qualitative assessment of "flat foot" was noted in 24.8%. In boys and girls without a posture disorder, these figures have constituted only 34.5% and 19.7%, respectively. The obtained data suggest that the physical impact on the foot depends on sex differences and the state of the spine. It was found out that young men, regardless of the state of the spine, have more significant changes in the structure and function of the foot than girls.
Keywords: an arch of the foot, physical load, risk group.

Introduction

In the process of evolution human foot has acquired a form that allows you to evenly distribute the load. The study of various forms of the foot allows to define a clear boundary between the extreme variants of the norm and the initial stages of its pathological deformation (Lagutin, & Samusev, 2009; Shchurov, Sazonova, & Shchurov, 2008; Wang, Jordan, & Newell, 2012). At the same time, such a distinction remains a rather difficult task due to the fact that the shape of the foot depends on many factors, and the support of its arch apparatus has its own sex and age peculiarities, which determine specific requirements to it (Lampropulos, 2018; Lagutin, Efremova, & Gavrikov, 2006; Mikhnovich, & Volotovsky, 2004). Meanwhile, its individual properties are due to the anatomical, physiological and biomechanical features (Deland, 2014; Kashuba, Sergienko, & Valikov, 2002; Newell, 2017). These factors affect the degree and range of functional safety of the joint and muscular component of the foot, and the violation of the proportionality of the human body helps to reduce the spring properties of the arch of the foot, which can lead to trauma of the musculoskeletal system or the development of various degrees of flatfoot (Gavrikov, Samusev, & Lagutin, 2006; Lagutin, & Samusev, 2009; Mikhnovich, & Volotovsky, 2004). The extreme complexity of the anatomical structure of the human foot, combined with the diversity of its functions, indicates the importance of knowing the influence of anthropometric parameters on its biomechanical properties (Gavrikov, Samusev, & Lagutin, 2006; Kashuba, Sergienko, & Valikov, 2002; Lagutin, Efremova, & Gavrikov, 2006).

Among the occurring abnormalities in the health condition and physical development of young people, functional and pathological changes in the musculoskeletal system, including various forms of impaired posture and static deformities of the arch of the foot, occupy a significant place. The most common deformity of the foot in the process of human ontogenesis is flatfoot, which is characterized by a decrease in the height of the longitudinal and transverse arches of the foot. In the process of flatfoot formation, the foot flattens, and as a result, a shock wave that occurs when walking, running and jumping, is not counterbalanced by the springy

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arches of the foot, but spreads up the skeleton and leads to deformation of the musculoskeletal system of the person overall (Lagutin, Efremova, & Gavrikov, 2006).

Analysis of the literature indicates a lack of comprehensive studies characterizing the condition, development, and preparedness of both the musculoskeletal system and the arch of the foot to physical loads of various intensity in order to establish the limits of the dynamics of changes in the arch of the foot as compensatory-adaptive ones (Newell, 2017). All the above determines the relevance, theoretical and practical significance of the presented work.

The purpose of the work is a comprehensive assessment of the morphofunctional parameters of the arch of the foot under different types of physical load for students with functional postural disorders.

Materials

Foot morphometry was carried out in 120 students aged 17-19 years old using the plantographic method according to E.A. Martirosov (Shchurov, Sazonova, & Shchurov, 2008) and methods of graphical and computational processing of plantograms (quantitative and qualitative ones) by calculating the index of the foot (according to A.V. Stritter) (Wang, Jordan, & Newell, 2012) under various types of physical load with own body weight: in a sitting position without a load (anatomical state of rest); in a standing position with a load of 100% of the mass of one's own body (static load); dynamic load of your own body with a jump from a height of 1 m (dynamic load).

According to the results of measurements, the dependence of linear and angular parameters, and the Friedland foot index have been determined (Shchurov, Sazonova, & Shchurov, 2008).

Statistical data processing was carried out using the package 'Statistica', 6.0 and tabular processor MS Office Excel.

All students were divided into 2 groups: the first group consisted of students with functional disorders of the musculoskeletal system (MSS) (up to 5 ° S), the second one – without postural disorders.

The quantitative composition of each examined group is 60 people, with 30 boys and 30 girls in each one.

Results

In the first group, the normal arch of the foot in the anatomical state of rest (without the load on the arch of the foot) is determined in 73.2% of boys and 70.9% of girls, in the second – 85.6% and 94.3% respectively.

Static load on the arch of the foot among students of the first group causes a quantitative redistribution of the 'norma' index of the arch of the foot to risk areas: 'moderately flattened' (detected in 76.9% of boys and 60.4% of girls) and 'flat' arch of the foot (8.6% of the examined boys and girls). Normally, only in 11.5% of boys and 28.0% of girls, the arch of the foot remained intact. In 3.0% of the examined young men of the first group, the qualitative characteristic 'distinctive flat foot' was noticed.

In the second group, with a static load, the normal arch of the foot was determined in 88.3% of boys and 95.6% of girls. 'Moderately flattened' arch of the foot in 29.2% of boys and 7.5% of girls, 'flat' arch of the foot was detected only in 2.5% of boys and 2.9% of girls. In this group, there were no students with 'distinctive flat foot'.

During the dynamic load on the feet of the students from the first group, all the examined irrespective of the sex were transferred to the risk group since the normal arch of the foot was not detected in this type of physical load. At the same time, in 14.7% of boys and 10.9% of girls, the plantogram indicators corresponded to the degree of disorder – 'distinctive flat foot'.

In the second group of students, under dynamic load, the 'normal' arch of the foot was determined in 88.3% of boys and 95.1% of girls. A small part of this sample of the examined students constituted a group (only 8.0% and 5.0%, respectively), in which the static deformity of the arch of the foot was noted, that is, the transition to the quality zones 'moderately flattened' and 'flat foot'. A flat arch of the foot in this group was found in 23.5% of boys and 3.5% of girls, therefore, the marked changes in boys cannot be characterized as compensatory and adaptive to this type of physical load.

Statistical data processing showed that at rest, the average value of the flattening index was: for young men – 34.9 ± 1.07 with a standard deviation – 7.6 and for girls - 30.8 ± 0.81 and 4.8, respectively (Tables 1, 2).

Table 1: Statistical analysis of the data on the index of the arch of the foot flattening in males under different physical load conditions

Physical load	The average value of the foot index	Standard deviation	Standard error	Confidence interval	
				lower	upper
Without load	34,9	7,6	1,07	33,4	37,7
Static	41,4	9,5	1,18	38,8	43,8
Dynamic	49,9	12,1	1,42	46,6	52,5

Table 2: Statistical analysis of the data on the index of the arch of the foot flattening in females under different physical load conditions

Physical load	The average value of the foot index	Standard deviation	Standard error	Confidence interval	
				lower	upper
Without load	30,8	4,8	0,81	29,4	31,7
Static	37,1	5,2	0,83	35,19	38,57
Dynamic	40,8	5,6	0,98	38,53	43,93

Static and dynamic load on the arch of the foot determined a corresponding increase in the flattening of the arch of the foot in boys to 49.9 ± 1.42 with a standard deviation of 12.1 and in girls, to 40.8 ± 0.98 and 5.6, respectively.

The effect of the presence of functional postural disorders and the magnitude of the physical load on the degree of flatness of the arch of the foot of girls was studied by the method of two-factor variance analysis. According to the data obtained, the presence of functional postural disorders in girls and the volume of the load reliably affect the flattening index of the arch of the foot both individually (Fisher's criterion is 34.7 and 16.9, respectively, at a significance level of less than 0.01) and with the combined effect of the factors (Fisher criterion of 22.8 at a significance level of less than 0.01) (Table 3). The presence of functional posture disorders and the volume of the load reliably affect the flattening of the arch of the foot in boys as separately (respectively, Fisher's criterion 11.8 and 25.4 with a significance level of $p \leq 0.05$) and with the combined effect of these two factors: Fisher 16.5 at a significance level of less than 0.05 (Table 4).

Table 3: The results of variance analysis of the effect of the physical load and the presence of functional postural disorders on the degree of flattening of the arch of the girls' feet

Factor	The number of degrees freedom	Sum of squares	Average square	Fisher criterion	Level of significance	The strength of the influence factor, %
Functional postural disorder	1	1883,0	1883,0	34,7	< 0,01	12,9
Load	2	1762,4	824,7	16,9	< 0,01	11,4
Joint action	2	55,7	27,8	22,8	< 0,01	11,1
Error	155	8451,5	51,2	–	–	59,3
Total	161	12781,7	–	–	–	–

Table 4: The results of variance analysis of the effect of the load mode and the presence of functional postural disorders on the degree of flattening of the arch of the boys' feet

Factor	The number of degrees freedom	Sum of squares	Average square	Fisher criterion	Level	The number of degrees freedom
Scoliosis	1	673,3	673,3	11,8	≤ 0,05	3,8
Load	2	5291,3	2315,2	25,4	≤ 0,05	20,3
Joint action	2	14,6	5,8	16,5	≤ 0,05	18,9
Error	186	18244,1	104,2	–	–	71,4
Total	191	23426,2	–	–	–	100,0

Discussion

The need to find ways to improve the process of physical education of students is due to the alarming trend of increasing deterioration of their health, as well as reduced levels of functionality and physical fitness (Gavrikov, Samusev, & Lagutin, 2006; Deland, 2014).

The disadvantages of the current practice of physical education of students are confirmed by statistics, which indicates that about 80.0% of them have deviations in the state of the musculoskeletal system (Kashuba, Sergienko, & Valikov, 2002). In recent years, the number of people suffering from flatfoot has significantly increased (Lampropulos, 2018). In most cases, this pathology of the foot is acquired, since the congenital flat foot is formed as a result of the disruption of the normal anatomical and physiological development of the fetus and is extremely rare (Mikhnovich & Volotovsky, 2004). And this cannot but alarm since it is in adolescence that the final formation of the musculoskeletal system takes place, the foundations for the harmonization of physical development and the functional capabilities of the human body are laid. The close connection between the state of the musculoskeletal system and the state of health has been proven by numerous studies (Shchurov, Sazonova, & Shchurov, 2008; Newell, 2017). Many authors (Wang, Jordan, & Newell, 2012; Sung & Yu, 2014;

Zhou, Tang, & Hardy, 2014) note that the absence of abnormalities in the state of the musculoskeletal system is an indispensable condition for the normal functioning of organs and systems, as well as the development of the body as a whole, and the improvement of physical performance and health.

The established quantitative data that characterise the arch of the foot in the anatomical state of rest in the first group of students indicate that the postural disorders are accompanied by an increase in the frequency of moderate flatness by 20.2% in boys and 10.9% in girls ($p < 0.05$).

Analysing the data obtained, it can be assumed that higher loads on the arch of the feet of students of the first group can cause a decrease or exhaustion of the physiological reserves of the joint and muscular arch of the foot: spring, support, and locomotor. As a result, the 'shock wave' that occurs during various locomotions (walking, running or jumping) will not be absorbed by the springing properties of the arch of the foot, but spread up to the skeleton bones, leading to a rather rapid wear of not only the joints of the lower limbs, but also the spine overall. The transition of a part of the second group of students (8.0% of boys and 5.0% of girls) to the 'flat foot' quality zone under dynamic load indicates a low compensatory and adaptive ability of the foot arches to this physical load in this group of patients.

In the context of this problem, the formation of supporting and spring properties of the foot deserves special attention. The foot is an important structural element of the human musculoskeletal system, which ensures its locomotor function and represents an integral morphofunctional object on which the motor function of a person depends (Laputin, 2003; Mandrikov, Krayushkin, & Perepelkin, 2012). The structural-functional dependence in the system of the 'vertebral pillar – foot' biokinematic chain is specified in the studies by V.A. Kashuba et al., (2002). Researchers also note that changes in one of the biolinks lead to an adaptation adjustment in another one, and can lead to the spread of a destructive process and a damage of the entire musculoskeletal system. A large number of deviations in the state of the musculoskeletal system of the students examined convinces that the current organizational and methodological approaches to the use of physical education facilities do not fully ensure the prevention of deformities of the arches of their feet. In the literature, special data on the dynamics of the formation of morphobiomechanical properties of the foot of students are mentioned. Despite the exceptional importance of the function of the foot in the formation of the musculoskeletal system in the process of physical education of students, not enough attention is paid to the correct development of this part of the body, which leads to the development of flatfoot.

Therefore, the problem of preventing disorders of the support-spring properties of the foot, the strengthening of its arches in students remains relevant and is still far from its final solution.

Findings:

1. The presence of the pathology of the musculoskeletal system in students is characterized by a decrease in the adaptive capacities of the arch of the foot to the physical load. Thus, in a neutral anatomical state of rest (without load) in students with functional postural disorders, the normal arch of the foot was determined in 73.2% of boys and 70.9% of girls. At the same time, in the second group, a normal arch of the foot was noted in 88.3% of boys and 95.6% of girls.

2. Under static load, the normal arch of the foot was defined only in 11.5% of examined boys and in 28.0% of girls with functional postural disorders and without them. While 76.9% of boys and 60.4% of girls move into the risk zone with a 'moderately flattened' arch of the foot, in other 8.6% of the examined boys and girls, a 'flat' arch of the foot is revealed.

3. Dynamic load on the foot leads to the transition of all students with functional postural disorders to the risk group since the normal arch of the foot at this physical load was not identified. Among students without postural disorders with a similar load, the normal arch of the foot was determined in 88.3% of boys and 95.1% of girls, which indicates a significant stock of biomechanical strength of the foot arch apparatus.

4. Static and dynamic load on the arch of the foot determined a corresponding increase in the flattening parameter of the arch of the foot to 49.9 ± 1.42 in boys and to 40.8 ± 0.98 in girls.

Prospects for further research consist in the study of the asymmetry of muscle tone in students with functional postural disorders and various degrees of flattening of the foot arch apparatus in order to objectify control of the effectiveness of corrective measures.

References

Kashuba, V.A., Sergienko, K.N., & Valikov, D.P. (2002). Computer diagnostics of the support-spring function of the human foot. *Fiz. education of students of creative specialties:* Sat. scientific tr. Kharkov: Kharkov publishing house. art.-prom. Inst., 1, 11–16.

Lagutin, M.P., Efremova, G.V., & Gavrikov KV. (2006). *Efficiency of the computer plantography method for assessing the state of the arch of the foot during cyclic physical loads:* Materials of the I All-Russia. from Intern. participation, conf. traffic management. Great Luke: Publisher Velikoluksk. state Academy of Phys. culture, 16–17.

Newell, M. (2017). Stage II Adult Acquired Flatfoot Deformity: Treatment Options and Indications. Orthopaedic Knowledge Online Journal, 33(2), 44–50. https://doi.org/10.5435/okoj-15-7-1

Shchurov, V.A., Sazonova, N.V.