



REVIEW PAPER

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Foot arch condition in comparison with the muscular balance of lower limbs in children at school age of 6–14 years

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ABSTRACT

Introduction. Foot arch condition plays an important role in correct setting of lower limbs joints, proper muscles tone and well-being [1]. More and more frequently foot arch deviations affect population of school age children [2, 3]. It is based on anatomic knowledge that abnormal foot arch is strongly connected with the disturbed muscle tone of lower limb. The aim of the presented study is to evaluate the relation between the foot arch condition and muscular balance of the lower limbs.

Material and methods. Children were assessed using the Clarke's angle and indicatory muscles length tests including: quadratus lumborum muscle, hamstring muscle, thigh adductors, piriformis muscle.

Results. Abnormal foot arch was showed by 70% of subject children. The greatest number of muscles length abnormality was observed in quadratus lumborum muscles. There was a statistically significant correlation between right hamstring muscle contraction and abnormal foot arch ($p = 0.011$).

Conclusions. Foot arch alternations increasingly more often appear in the greater number of school-age children. The assessment and therapy of abnormal foot arch should include the examination of muscular balance of the lower limbs.

Keywords: children, flat foot, muscular length, hamstring muscle.

Introduction

The human foot is made up of 26 bones and above 30 articulations. It ensures supporting, shock absorbing and weight-bearing functions [4]. The proper human foot condition has been the center of interest of many researches [5].

Postural abnormalities more frequently affect children and youth at school age [6, 7, 8]. Foot arch defects are ones of the most recognizable postural deviation among children and adolescents [2, 3]. They have differentiated etiologies and causes which are connected with school environment and behavioral habits [5, 9].

Low level of physical activity, leisure time spending passively, invalid nutritional habits, overweight and

obesity result in body posture defects [10, 11]. Postural abnormalities are inseparably associated with the changes of muscles length and laxity [12]. The muscular imbalance affects foot arches and results in foot abnormalities, mainly flat foot [13–15]. It should be emphasized that flat foot is the physiological stage during the first decade of life and does not need treatment. It is visible when children begin standing and walking and disappears spontaneously [15]. However, the progress of untreated abnormal foot condition may result in structural changes in the skeletal system, incorrect setting of lower limbs joints and escalating pain [15]. That is why the foot posture should be examined by a specialist in order to exclude pathological conditions.

Aim

The aim of the presented study is to evaluate the relation between the foot arch condition with muscular balance: the length of lower limbs indicatory muscles (quadratus lumborum muscle, hamstring muscle, thigh adductors, piriformis muscle) in children at the age between 6 and 14 years old from the primary school of the Mosina Community.

Material and methods

The study group consisted of 65 healthy school children (40 girls, 25 boys) attending the primary school in the area of the Mosina Community. The age of examined children ranged from 6 to 14 years and the average age was 9 years old and 4 months = 1 years and 7 months. Participants were divided according to age range into 4 groups: < 6 years old (5 children), 7–10 years old (37 children), 11–12 years old (19 children), 13–14 years old (4 children) [16].

Measurement

The pedograph footprints were used to evaluate foot arch of children. They was obtained by placing the child's foot covered with footprint ink on the stretched paper. Based on the obtained footprint, Clarke's angle was calculated as foot arching parameter. Clarke's angle assesses the longitudinal foot arch and is widely used in screening examination [17, 18]. It was constructed by drawing the first medial tangential line of the footprint and the line connecting the first metatarsal head and the acme of the medial longitudinal arch cavity [1, 19].

The results of the Clarke's angle were recorded as "normal" (the Clarke's angle between 42°–52°), "flattened" (the Clarke's angle between 31°–41°) and "flat" (the Clarke's angle below 30°) [19]. All footprints were evaluated by the same person.

Muscles of the lower limbs were assessed with indicatory muscles length tests including: quadratus

lumborum muscle, hamstring muscle, thigh adductors, piriformis muscle. The length of quadratus lumborum muscle was assessed while standing when the child slid his/her arm along the outer side of the thigh, without front or back bending. (Norm: The fingers of bending side reach the edge of the knee). Passive straight leg raise test was conducted to evaluate hamstring muscles (Norm: Hip flexion amounts to 80°) and Patrick's Test to evaluate tight adductors (Norm: The flexed knee reaches the level of the straight leg). Piriformis muscle was tested in pronation with flexed knees. The hips were laterally rotated. (Norm: Lateral rotation of hip amounts to 30°) [20].

Protocol and data analysis

Data were analyzed using Microsoft Excel by Microsoft Office 2007 and STATISTICA 8.1. Categorical variables were investigated using Chi² Pearson Test and Test Chi² Pearson Yates Test. Mann-Whitney U test was used for comparing two independent samples. The correlation coefficient was statistically significant when the p value was less than 0.05.

Results

Foot arch was assessed as normal in 30% of children, flattened in 30% of children, flat in 40% of children (Figure 1). In the group of boys flattened and flat foot

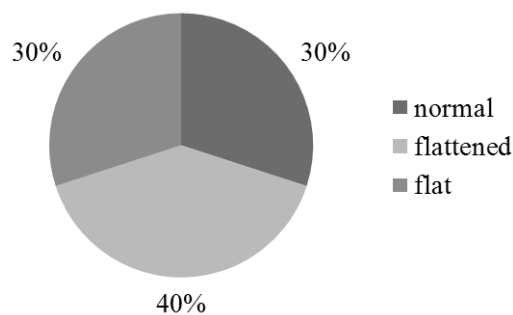


Figure 1. Results of the Clarke's angle

Table 1. The number of shortened indicatory muscles, including the right and left side

	Quadratus lumborum muscle		Hamstring muscles		Tight adductors		Piriformis muscle	
	Left	Right	Left	Right	Left	Right	Left	Right
The number of children	38%	29%	28%	31%	14%	9%	6%	11%

Table 2. The number of correct muscles length, including the right and left side

	Quadratus lumborum muscle		Hamstring muscles		Tight adductors		Piriformis muscle	
	Left	Right	Left	Right	Left	Right	Left	Right
The number of children	62%	71%	72%	69%	86%	91%	94%	89%

Table 3. The relationship between the results of the evaluation of lower limbs muscles tonicity and foot arch

	Quadratus lumborum muscle		Hamstring muscles		Tight adductors		Piriformis muscle	
	Left	Right	Left	Right	Left	Right	Left	Right
The number of children with abnormal foot arch	16	14	17	14	2	5	3	3
p	NS*	NS*	NS*	r**	NS*	NS*	NS*	NS*

* – not significant;

** – correlation coefficient

was presented more often (84%) than in the group of girls (63%).

Tables 1 and **2** illustrate the results of muscle tonicity evaluation.

The measurement of muscles flexibility shows that quadratus lumborum muscles were the most often shortened muscles. In contrast piriformis muscles had the least often tendency to shorten.

Relationship between foot arch and lower limbs muscles tonicity

Comparative analyses were conducted between the results of indicatory muscles length tests (quadratus lumborum muscle, hamstring muscle, thigh adductors, piriformis muscle) and the results of Clarke Index. The obtained results are presented in **Table 3**.

There was a statistically significant correlation between right hamstring muscle contraction and abnormal foot arch ($p = 0.011$). However, there was no significant correlation between left hamstring muscle length and foot arch alterations ($p = 0.10796$).

Discussion

In the past decade flat foot has been an object of many studies and it seems to be a very common postural problem in children [21, 22]. In the present study deviation of proper foot condition occurred in 70% of children. This is consistent with previously study of foot arches condition among children at school age [23, 24]. In the study done by Janiszewska et al., foot arches malformation occurred in more than half of the children [25]. The significantly higher results obtained Brzeska et al, the frequency of flat foot was observed in 78.4% of the research group [26].

Flat foot was more frequent among the group of 7–10-year-old children in the presented research. Literature suggests that the majority of preschool children commonly present abnormality in foot arches [27, 28]. Different results in the presented study can result from very small number of children in the research group who were in preschool age. Walczak and Napiontek have suggested that the occurrence of abnormal

foot arches condition among preschool children is connected with a layer of fat tissue covering foot arches which is physiological for this period of the ontogenesis [29]. The foot arches development change over time in close relation to ontogenesis [27]. It is noteworthy that the frequency of flat foot decreases in children over 10 years old. Similar observations were made by Kania – Gudzio and Wiernicka [30]. The age above 10 years refers to improvements in forming foot arches or development of increased foot arches during puberty. The foot spontaneously evolves to the proper physiological shape of the adult's foot at around 10 years of age [27]. In the study performed on the group of children from the Hausa ethnic group of Nigeria, Umar and Tafida diagnosed flatfoot significantly more often in the group of girls than in the group of boys [31]. Opposite to the research by Umar and Talida, in the presented study flatfoot was more common postural alteration among boys than girls. This is consistent with data published by other researchers [15, 32, 33]. The literature suggests that higher incidence of flat foot in boys may be results of the general process of foot morphology and development. The intensive period of the growth of boys feet begins later and last longer [34]. It occurs between 13 and 15 years of age [35].

There are a lot of factors contributing to the development of foot flat, such as BMI, gender, and age [36]. Only few authors take into consideration flat foot and muscular imbalance in their analyses [37, 38]. That is why the main aim of the presented study was to make comparative analysis of length of lower limbs muscles with foot arches condition. The presented study found that there was a significant correlation between right hamstring muscle contraction and abnormal flat foot. This is consistent with the other studies and anatomy of myofascial system [37–40]. There is exists skeletal-myofascial connection between two tapes of: the Spiral and the Lateral Tape, through two tendons: peroneus longus muscle tendon and peroneus brevis muscle tendon. The Spiral Tape passes under the foot arch, creating a loop (stirrup), which is a connection between tibialis anterior muscle and peroneus longus muscle. It joins the foot arch with upper part of a calf.

Myofascial structures of peroneus longus muscle passes through external part of a shank to the caput fibulae, where there is located Connection between peroneus longus muscle with biceps femoris muscle (lateral side of hamstrings muscle group). There is a pronounced fascial connection between caput fibulae and peroneus longus muscle [39]. That is why there is a relationship between contraction of hamstring muscle and flat foot which was presented by Ippalito et al. [40]. They showed in Volumetric magnetic resonance imaging that postero-medial muscular compartments of the leg with flat foot are thinner and shorter than those of the normal leg [40].

It should be noted that, in the future untreated defects in foot arches condition such as flatfoot may play an important role in the development of pain and pathologic conditions of lower limbs [1, 15, 21].

Conclusions

Based on the observation and analysis of the presented study we proposed the following conclusions:

1. Many children at school age suffer from foot arches defects.
2. The assessment and therapy of children with foot arch alterations should consider the examination of muscle tonicity of lower limbs.

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Conflict of interest statement

The authors declare that there is no conflict of interest in the authorship or publication of contribution.

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