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Foot arches and physical fitness of 5-year-old children

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Abstract

Introduction Preschool age is a period of further changes in physical development, improvement of motor skills, and strengthening of the child's movement apparatus. At that time, especially between the ages of 4 and 7, morpho-functional changes in the feet are observed, leading to their longitudinal and transverse arches. **The aim** of the research was to try to assess the relationship between the curvature of the feet and the level of fitness and coordination abilities of children under the age of 5. **Material and methods** 414 children aged 5 participated in the study, including 178 girls and 236 boys. Podoscopic examination made it possible to assess the longitudinal arch of the feet using the Clarke's angle. The level of the child's motor development was characterized on the basis of the results of the tests of the Physical Fitness Test for Sekita's Preschoolers, and the Great Motility Test TGMD II was used to assess the coordination abilities. The results were statistically processed. Differences between the selected groups were estimated with the Student's t-test for independent groups. **Results** Based on our own research, it was found that preschoolers with flat feet are characterized by significantly lower body height and a higher BMI. On the other hand, such differences were not noted in body weight. On the other hand, the analysis of fitness abilities and motor predispositions proved the occurrence of small and insignificant differences between the described syndromes. **Conclusion** Therefore, it can be assumed that at this stage of ontogenesis, the level of the arched feet does not have a significant effect on the motor skills of the studied children.
Keywords: arching of feet, physical fitness, preschoolers

Introduction

Preschool age is a period of harmonious morphological development of a child, however, there are large inter-individual differences at this time regarding the level of development and growth rate. Improving the functioning of the central nervous system is conducive to improving sensorimotor integration and increasing motor efficiency. A preschool child is characterized by a biological need for movement, it perfects basic locomotive movements, and around the age of 5, harmony, rhythm and fluidity of movement begin to appear (Kielar-Turska 2012, Wolański 2012).

In a child at this age, there are dynamic processes of foot formation, closely related to the individual level and pace of the child's physical development. The thick layer of adipose tissue covering the arches of the feet gradually disappears. Under the influence of undertaken physical activity, the musculoskeletal apparatus of the lower limbs is strengthened, the longitudinal and transverse arches of the feet are shaped. There is no agreement in the literature regarding the period of appearance of the arches of the foot. According to Lizis (2000), the arch of the feet is formed in children between 3 and 6 years of age, according to Vergara-Amador et al. (2012) between 6 and 7 years of age. In turn, Carr et al. (2016), Sadeghi-Demneh et al. (2016), and Uden et al. (2017) believe that healthy preschool children have physiological flat feet. The lack of a characteristic arch may persist until about 8 years of age. The foot, despite being the smallest part of the human body, performs important static and kinetic functions due to its specific structure. It supports higher parts of the body, adapts to the ground during locomotive movements, and is an excellent shock absorber. The conducted research indicates that there is a relationship between the arching of children's feet and the level of their physical fitness (Górniak 2006). It was found that physical activity undertaken and sports practiced by children have a positive effect on the structure and formation of feet (Furgał and Adamczyk 2008, Piątek et al. 2015). The vast majority of research projects are carried out in the environment of school children and youth - from the age of 7. The shape of the dimensions and arches of the feet is most often analyzed in terms of somatic development, taking into account the age and sex of the respondents, without taking into account the level of physical fitness. However, there are no studies on the relationship between the quality of developmental changes and the formation of body posture and foot arches in preschool children. Therefore, the aim of the study was to assess the relationship between the arches of the feet and the level of motor development of five-year-old children, to assess the diversity of the level of fitness and coordination abilities.

Methods

Participans

The research was carried out as part of the DS statutory research project. 246, after obtaining a positive opinion of the Senate Research Ethics Committee of the Józef Pilsudski University of Physical Education in Warsaw (SKE 01-01/2014). All observations were conducted in accordance with the research ethics guidelines of the Declaration of Helsinki (Górniak 2017). The data obtained from the Education Department of the Biala Podlaska City Hall showed that in the school year 2015/2016 over 1,500 children aged 3-6 attended twelve pre-school facilities in Biala Podlaska. Pre-school education in the group of five-year-olds covered 576 children born in 2010 at that time. Parental consent for the child's participation in the research was obtained for 534 people, which constituted 93% of white five-year-olds. Of all the results collected in the research results of 414 children, including 178 girls and 236 boys, were used in the study. The mean calendar age of the subjects was 5.2 years, with a variation of 4.7 to 5.9 years.

The following inclusion criteria were adopted: a healthy child, born in 2010, written consent of parents for their child's participation in the project and the use of research results for publication purposes, child's participation in all fitness tests, correctly made image of the plantar side of the feet.

The exclusion criteria were: poor health or absence of the child during the trials, a different year of birth, lack of parental consent to participate in the research or to use the results for scientific purposes, incorrect plantographic image.

All observations were made in the morning hours. General pediatric examination and assessment of foot arches were conducted in the posture laboratory of the Regional Center for Research and Development, Branch of the University of Physical Education in Biala Podlaska. The assessment of physical fitness took place in the athletics hall of the university in Biala Podlaska, after a positive opinion of the doctor. This guaranteed equal research conditions for all participants of the observation.

Measurement

Foot arches were characterized on the basis of podoscopic examinations (Świerc 2012). Data were collected using the CQ Elektronik System St6 podoscope, serial number: CQST-vUSB-1212, model 2012. On the basis of Clarke's angle (1959), the longitudinal arch of the right and left foot was assessed, and on this basis a group of children with properly arched feet and flat feet was distinguished. The first group included cases in which the values of the Clarke angle were:

- feet with an elevated arch (550 and more)
- normal alloys (420 – 540)

and for the group of children with flat feet:

- feet with a lowered arch (310 - 410)
- flat feet (300 and less)

While characterizing the level of the child's motor development, tests were carried out to assess both fitness and coordination abilities. Physical fitness (PF) was assessed according to the Polish Physical Fitness Test for preschoolers (Sekita, 1988). For each attempt, the maximum number of points to be scored is given in

parentheses. It consisted of four trials:

- explosive strength of the legs – standing broad jump (SBJ);
- agility – 4x5m shuttle run with carrying blocks (4x5mSR);
- speed of locomotion - 20m dash (20mR);
- dynamic force of the torso and shoulder girdle – throwing a 1 kg medicine ball with both hands from above the head (1kgTB).

The Gross Motor Skills Test (TGMD II) (Urlich, 2000) was used to assess motor skills, in which the examiner rated the technique of performing exercises. This test allows the assessment of mobility capabilities with the help of 6 tests

- run (8 points)
- forward gallop and forward delivery steps (8 points)
- jumping on one leg (10 points)
- jumping over an obstacle (8 points)
- slides - side-loading steps (8 points)
- long jump from place (8 points)

Six trials with the use of sports equipment were carried out:

- hitting the ball in place (10 points)
- dribbling in place (8 points)
- catching the ball (6 points)
- kicking the ball (8 points)
- throwing the ball with a swing (8 points)
- ball rolling on the floor (8 points).

Date analysis

Arithmetic means and standard deviation were calculated for all trials of both fitness tests. Statistically significant differences between the results were calculated using the Student's t-test for independent samples. The statistical characteristics did not take into account the division of the group by gender, because there are no significant differences between these teams, both in the Sekita test and the TGMD II test (Saczuk, Wasiluk 2021).

Due to the fact that the scores of the Gross Motor Skills tests do not equal the maximum number of points obtained, both in locomotion skills and in control over devices, the results were calculated as percentages of the maximum possible number of points. In order to standardize the units of the physical fitness test, the obtained results were normalized in the T scale to mean and dissemination measures of all subjects. The overall efficiency was also calculated as the average of all obtained points. It should be emphasized that this is not a biological but a statistical concept (Przewęda, Dobosz 2005).

Results

The results of podoscopic examinations indicate a varied situation in the development of the feet of five-year-old children. Girls at this age were characterized by a better situation in terms of foot development. High instep and properly arched feet were found in more than 70% of girls and 50% of boys. In the remaining cases there were flattened and flat feet.

Irrespective of gender, the correct arch of the feet and slight changes in the form of lowering the medial arch more often affected the right foot. On the other hand, flat feet with varying degrees of severity of changes - the left foot (Table 1).

Table 1. Clarke's foot arches for boys and girls

	N	Feet with a raised arch		Feet properly arched		Feet with a lowered arch		Flat feet	
		L foot	P foot	L foot	P foot	L foot	P foot	L foot	P foot
boys	236	34	37	98	100	55	63	49	36
	%	14.40	15.70	41.50	42.40	23.30	26.70	20.80	15,20
girls	178	48	47	78	82	31	33	21	16
	%	27.00	26.40	43.80	46.10	17.40	18.50	11.80	9.00
Σ	414	82	84	176	182	86	96	70	52
	%	19.80	20.30	42.50	44.00	20.80	23.20	16.90	12.50

Source: own study

The qualitative assessment included the arches of both feet. The group of children with properly arched feet included those cases in which both feet were found to be elevated and/or properly arched. The group of flat feet included those children with reduced arches and/or flat feet in one or both feet (Table 2). The correct

situation regarding the formation of feet concerned 53.9% of the examined five-year-olds and was definitely more common in girls (65.2%) than in boys (45.3%), which is undoubtedly one of the manifestations of sexual dimorphism in the child's development.

Table 2. Qualitative assessment of the arches of both feet of the examined children

	N	Feet properly arched		Feet flattened and flat	
		N	%	N	%
boys	236	107	45.30	129	54.70
girls	178	116	65.20	62	34.80
Σ	414	223	53.90	191	46.10

Source: own study

To assess the level of somatic features and motor skills of girls and boys, the subjects were divided into teams with properly arched feet (SP) and incorrectly arched feet (SN). From the information in Table 3, it can be concluded that statistically significant differences occurred only in body height and BMI values. Higher values of this somatic feature were found in preschoolers whose feet were properly arched. It should be emphasized that a tendency could be observed according to which children with abnormal arches of the feet were characterized by slightly higher values of body weight compared to their peers. Thus, higher BMI values were characteristic of the syndrome with abnormal foot arches.

During the analysis of motor skills, there were also no significant distances between the assessed teams. However, also here a tendency can be observed in which preschoolers with abnormal foot arches obtained slightly better results in the explosive power of the lower limbs, locomotive speed and agility. On the other hand, they are weaker in the dynamic strength of the trunk and shoulder girdle. Taking into account the general physical fitness (PF) of the examined children, a tendency to a higher level of motor skills can be stated in the group of children with abnormal foot arches.

Table 3. The results of somatic features and motor skills of white five-year-olds with normal (SP) and abnormal (SN) foot arches

	Feet properly arched (SP)		Feet flat and flattened (SN)		Test value t Student
	x	SD	x	SD	
Body height	114.67	4.71	113.46	4.82	2.58*
Body weight	20.40	2.86	20.47	3.62	0.21
BMI	15.47	1.49	15.82	1.98	2.05*
4x5mSR	10.43	1.30	10.42	1.17	0.03
1 kg TB	206.86	57.58	202.90	55.01	0.71
20mR	5.85	0.85	5.72	0.70	1.76
SBJ	91.97	23.02	93.54	21.88	0.71
PF	49.81	7.47	50.19	6.71	0.25

** statistically significant difference at p≤ 0.05 Source: own study*

On the basis of the sum of locomotion points of gross motor skills, a tendency of better results was found in children characterized by normal arching of the feet (Table 4). Only in the assessment of slip, worse results were recorded in the group mentioned. However, these differences were small and statistically insignificant.

Table 4. Results of locomotion skills of white five-year-olds with normal (SP) and abnormal (SN) foot arches

	Feet properly arched (SP)		Feet flat and flattened (SN)		Test value t Student
	x	SD	x	SD	
run	6.53	1.73	6.38	1.84	0.86
gallop	5.33	2.28	5.26	2.22	0.30
jump	5.97	2.29	5.87	2.45	0.44
jump	4.70	1.50	4.57	1.58	0.87
long jump	6.10	2.18	5.87	2.21	1.08
shoe	5.47	2.14	5.50	2.02	0.15
sum	34.10	7.27	33.45	7.65	0.89

Source: own study

In the skills of controlling the devices, better results were obtained by preschoolers with normal foot arches (Table 5). This is confirmed both by the sum of the points obtained from all the analyzed trials and the point values obtained in individual exercises.

Table 5. The results of device control skills of white five-year-olds with correct (SP) and incorrect (SN) foot arches

	Feet properly arched (SP)		Feet flat and flattened (SN)		Test value t Student
	x	*SD*	*x*	*SD*	
hit	7.17	2.08	7.01	2.20	0.76
dribbling	4.28	2.79	3.75	2.78	1.95
grip	4.45	1.42	4.38	1.52	0.48
digging	5.86	1.72	5.67	1.84	1.09
throw	5.73	1.56	5.59	1.48	0.96
turning	4.83	1.67	4.68	1.74	0.91
sum	32.32	6.06	31.07	6.70	1.94

Source: own study

Discussion

Our research shows that over 60% of five-year-old children were characterized by a properly shaped dynamic arch of the feet, and this situation more often concerned girls than boys. Feet with reduced arches were present in more than 20%, and flat feet in more than 10% of the subjects. Both boys and girls had better arched right feet. The observed situation is reflected in the studies of other authors, who indicate that flat feet affect over 40-70% of children aged 3-4, and among 6-7 year-olds it covers about 20-40% of cases. They also find that preschoolers have better arched right feet than left feet (Echarri and Forriol 2003, Arizmendi et al. 2004, Pfeiffer et al. 2006, Chang et al. 2010, Chen et al. 2011, Evans and Rome 2011, Jankowicz-Szymańska and Pociecha 2012, Matsuda et al. 2012, Gijon-Nogueron et al. 2019).

Previous studies conducted in the Biala Podlaska community show that school children and adolescents with flat feet were characterized by greater body weight, were more muscular and fat, with a higher level of skeletal strength. Girls with flattened and flat feet obtained worse results in endurance and explosive strength, and in the younger school age also in measurements of flexibility, speed of hand movements and functional strength compared to their peers with properly arched feet. Boys with flat feet were worse in the balance test, and in adolescence also in the test of flexibility, speed, trunk strength, explosive strength and cardiorespiratory endurance, than their peers with properly arched feet (Górniak 2006). The current study of preschool children showed that in the group with abnormal foot arches, there was a trend of slightly better results in the explosive power of the lower limbs, locomotive speed and agility. On the other hand, they are weaker in the dynamic strength of the trunk and shoulder girdle. Taking into account the general physical fitness (PF) of the examined children, a tendency to a higher level of motor skills can be stated in the group of children with abnormal foot arches. Opposite observations were presented by Jagucka-Mętel et al. (2013), indicating that children with flat feet obtained worse results in physical fitness tests compared to their peers with properly shaped feet. Statistically significant differences were noted by the authors in the 20 m run and the ball throw. Similar conclusions were presented by Kojić et. al (2021) based on research on Serbian children. In addition, our observations on gross motor skills show that there were no statistically significant differences between the assessed groups, both in locomotion skills and in control of devices. However, a tendency to higher scores was found in preschoolers with normal foot arches.

The feet of a small child are very delicate and susceptible to the negative influences of endogenous and exogenous factors. Therefore, a very important measure in the aspect of flat feet prevention from the earliest age of a child's life is to create opportunities for physical activity, preferably barefoot in various terrain conditions, avoiding excessive static workload on the lower limbs, shaping proper foot loading habits, as well as the appropriate selection of footwear. The correct shape and functioning of the feet creates the conditions for the correct positioning of the lower limbs and pelvis, which in turn ensures the correct positioning of the spine. Early prevention of disorders in the developing motor apparatus of a child enables proper psychomotor development, as well as protects against health consequences in adult life (Sobera 2010). It should be remembered that a 5-year-old child is at the beginning of his motor development path, hence the differences in the level of motor skills, locomotion skills and the ability to control devices in individual groups of foot arches may be small. However, Barros et al. (2022) proved that incorrect physique in childhood may have an adverse effect on motor development.

The analysis of the processes taking place in the body while monitoring individual aspects of the child's life can support his psychophysical development. This is important because, according to many experts, it is up to the age of five that a child shapes its habits and perception of the world to the greatest extent. Appropriately directing it during this period may contribute to better functioning in later periods of life (Šišková et al. 2020, Timpel et al. 2021). It can therefore be assumed that the 5th year of life is still too early a period in ontogenesis to search for significant relationships between motor skills and physical fitness and body posture.

Conclusions

1. There were no statistically significant differences between white 5-year-olds with normal and abnormal foot arches. On the other hand, there was a tendency to a higher level of general fitness in the group of children with abnormal foot arches.
2. Also in gross motor skills there were no significant differences between the assessed groups.
3. The results presented in the paper indicate that the age of 5 is still too early to observe real differences in children's motor skills.

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