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Wpływ wybranych ćwiczeń korekcyjnych na kształtowanie się obniżonego sklepienia podłużnego stóp u dzieci w wieku od 3 do 6 lat

Influence of selected correction exercises for elongated formation of reduced feet in children aged 3-6 years

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Streszczenie:
Wstęp. celem pracy było określenie częstości występowania spłaszczonego lub obniżonego sklepienia podłużnego stóp u dzieci za pomocą badania podoskopowego, jak również uzyskanie informacji na temat wpływu wybranych ćwiczeń korekcyjnych na ukształtowanie stóp dzieci.
Materiał i metody. w pracy przedstawiono badania 211 dzieci w wieku przedszkolnym od 3 do 6 lat, które zostały wykonane trzykrotnie w trakcie trwania roku szkolnego 2011/2012. Do oceny stóp posłużono się metodą plantokonturograficzną, za pomocą której zmierzony został kąt Clarke'a charakteryzujący sklepienie łuku podłużnego stopy.
Wyniki. podjęta w pracy próba oceny sklepienia podłużnego stóp na podstawie kryterium średniej arytmetycznej oraz odchylenia standardowego, z zastosowaniem kąta Clarke'a wskazuje na fakt, iż płaskostopie podłużne zmienia się pozytywnie pod wpływem wybranych ćwiczeń korekcyjnych, co potwierdzono statystycznie. Dowodem tego są wyniki uzyskane podczas trzeciego badania stóp dzieci. Stopy z prawidłowym sklepieniem podłużnym posiadało 61% stóp prawych i 63% stóp lewych.
Wnioski. badania wykazały, iż występowanie obniżonego sklepienia podłużnego stóp jest deformacją powszechnie występującą wśród dzieci w wieku od 3 do 6 lat. Sklepienie podłużne stóp dzieci wzrasta do poziomu prawidłowego pod wpływem stosowania wybranych ćwiczeń korekcyjnych opierających się o metodę akcentującą docisk I głowy kości śródstopia do podłoża.

Słowa kluczowe:
sklepienie podłużne stopy, plantokonturografia

Abstract
Introduction. *The aim of this study was to determine the prevalence of a flattened or elongated formation of reduced feet among children with orthopaedic examination, as well as obtaining information on the impact of selected correction exercises on the shape of children's feet.*
Material and method. *The paper presents the research on 211 school children during their preschool period ranging from 3 to 6 year-old, which was accomplished three times during the school year 2011/2012. To assess the accurate state of children's feet the plantocontourographic method was used in which the measurement rate of Clarke angle was characterized by an elongated vaulted arch of the foot.*
Results. *Based on the arithmetic mean and standard deviation, proved statistically, , the evaluation of the flattened feet with Clarke's angle implies that corrective exercises have a positive effect on the condition of a longitudinal deformation of feet. The results obtained on the third examination of the children's feet confirm this statement. The feet with a correct elongated arch were found in 61% of the right feet and 63% of the left feet.*
Conclusion. *The study showed that the incidence of low foot arch longitudinal deformation of the feet is common among the children aged 3 to 6 years. The longitudinal foot arch over children rises to normal levels under the influence of some corrective exercises based on the method of accent pressure and metatarsal heads to the ground.*

Key words:
elongated formation feet, plantocontourographic method

Introduction

The foot is an important static-dynamic element of the human motor system. It acts as a support element and facilitates spatial bodily balance in static conditions; it also acts as a driving mechanism providing the propulsion to move [1]. The foot and the ankle joint comprise a complex mechanism of 26 bones and joints acting as a functional unity, with none of these elements being capable of functioning in an independent fashion [2]. The efficiency of the foot is affected by several factors including the efficacy of the musculoligament apparatus and the loads experienced upon everyday activities, such as locomotion [3]. The key structural element of the human foot is the longitudinal arch providing shock absorption upon walking as well as protecting nerves and vessels that provide the distal part of the foot from being crushed by the weight of the entire body [2].

The structure and function of the foot is studied by specialists in many fields, including anatomy, anthropometry, radiology, biomechanics, orthopedics, ergonomics and physiotherapy. The specialists in these fields characterize the developmental changes in a manner specific for their respective fields [4-6]. Each research method aimed at providing specific parameters and classification of results should be reliable, objective, accurate, standardized and normalized [7].

The increasing number of children with postural defects contributes to the increased interest in prophylaxis and analysis of the incidence of postural defects. The human posture is subject to changes during lifetime, being affected by a complex development process and a large number of related factors [16]. Of note is the fact that postural defects in children may develop very rapidly, sometimes over as little as few weeks. Therefore, it is very important that any abnormalities in children's posture are noticed as early as possible [8].

The objective of this study was to determine the incidence of flattened or reduced longitudinal arch of foot in children aged 3 to 6 by means of podoscopic examination as well as to obtain information in the effect of selected corrective exercises on the shape of children's feet.

Material and Methods

The study was conducted in Public Pre-School no. 214 in Warsaw. The clinical material consisted of 211 subjects, accounting for a total of 422 feet, aged 3 to 6 years. Based on the results of the first podoscopic measurements, children were divided into the study group (n=147) and the control group (n=64).

The research method consisted of plantoconturographic assessment of feet in static conditions, with even load being placed on both feet while standing. In all subjects, plantoconturograms were obtained using a CQ-ST3D digital podoscope. Digital podoscopy is an extension and improvement of the well-know podoscopic examination. Despite the accurate footprint (plantoconturogram), the method was also capable of providing information on spatial formation of the foot.

Plantoconturograms provided information on Clarke's angle values as well as on changes in these values over the course of

the study. The Clarke's angle values are classified as follows: flat foot, x-30º; reduced arch, 31º-41º; normal foot, 42º-54º; elevated arch, 55º-x [9].
Main characteristics of the CQ-ST apparatus:
• an accurate PODOSCOPE;
• line projector to determine the longitudinal arch in load and relief conditions;
• analysis of loads by means of colored visualization of pressure loads;
• observation of heel position (varus/vagus) by means of an extra camera;
• analysis of actual projection of the center of gravity by a platform equipped with four sensors;
• dynamic recording of measurements in motion.
Examinations were performed three times (September 2011, February 2012, June 2012). The parents/guardians of children diagnosed with foot deformity were provided with a dedicated set of exercises for systematic training at home. Having analyzed the available literature on corrective exercises to address abnormal foot arch formation, we selected a method putting a particular stress on the pressure of the head of the first metatarsal bone against the ground surface. The concept consists in the head of the first metatarsal bone being actively pressed to the ground while the exercises highlight the strengthening of the long peroneal and posterior tibial muscles while maintaining full mobility of all joints [10]. Children with normal longitudinal arch values were classified into the control group.
The material was processed using the SPSS (Statistical Package for the Social Sciences) software.

Results

Podoscopic examination of subjects' feet followed by a statistical analysis of results revealed that the Clarke's angles in the study group were lower than those in the control group, as evidenced by mean values obtained in all measurements and presented by descriptive statistical parameters in Tables 1, 2, and 3.
The statistical analysis of Pearson's correlation revealed a strong correlation of Clarke's angles in all measurements. High Clarke's angles measured in the first measurement were very frequently accompanied by high values measured in subsequent runs while low Clarke's angles measured in earlier runs coexisted with low values measured in later runs (Fig. 1).
Statistically significant differences were observed between average Clarke's angles for all measurement pairs in the study group. Comparison of individual measurements using the dependent samples t-test with 95% confidence interval revealed statistically significant differences in Clarke's angle values from measurements 1-2, 1-3, and 2-3. This suggests that the corrective exercises based on putting a particular stress on the pressure of the head of the first metatarsal bone against the ground surface significantly increased the Clarke's angle, both in the right and the left feet (Table 4)
In the control group, significant differences consisting in increasing Clarke's angle values were observed for the right feet and measurement pairs 1-2 and 1-3 only.

Tab. 1. Clarke's angle values in the children in three examinations

Groups	Examination	Number of feet (n)	Min	Max	$\bar{X}$	SD
			Right foot			
Examined group	1	147	4,70	61.30	26.72	10.18
	2	147	6,40	55.90	32.33	11.91
	3	147	8,50	60.00	36.93	11.94
Control group	1	64	38,00	55.90	45.26	4.50
	2	64	27,10	65.80	47.77	6.41
	3	64	22,40	77.70	47.73	6.73
			Left foot			
Examined group	1	147	1.40	68.70	29.57	11.88
	2	147	7.20	57.70	33.22	12.77
	3	147	10.00	59.00	37.25	11.24
Control group	1	64	38.30	68.50	46.83	6.15
	2	64	9.20	67.10	46.88	8.42
	3	64	31.30	67.60	47.92	5.36

Tab. 2. The elongated formation of reduced feet in 211 children by Clarke's angle

	Right foot			Left foot		
	Exam. 1	Exam. 2	Exam. 3	Exam. 1	Exam. 2	Exam. 3
Flat foot (Clarke's angle ≥30º)	42%	29%	21%	34%	30%	18%
Reduced foot (30º > Clarke's angle ≤41º)	27%	25%	14%	29%	18%	17%
Normal foot (41st > Clarke's angle ≤54º)	27%	42%	61%	34%	47%	63%
Cavus foot (Clarke's angle >54º)	3%	4%	4%	3%	5%	3%

In the comparison of average values from measurements 2 and 3, the difference was not statistically significant, i.e. might be attributed solely to the random error. For the left foot, the differences between the mean values were statistically insignificant for each analyzed measurement pair (1-2, 1-3, 2-3). Table 4 presents the results of the dependent samples t-test.

Tab. 3. The elongated formation of reduced feet in the children by Clarke's angle

	Right foot			Left foot		
	Exam. 1	Exam. 2	Exam. 3	Exam. 1	Exam. 2	Exam. 3
Examinated Group n=147						
Flat foot (Clarke's angle ≥30º)	61%	41%	29%	49%	42%	26%
Reduced foot (30º > Clarke's angle ≤41º)	33%	32%	18%	37%	21%	22%
Normal foot (41st > Clarke's angle ≤54º)	5%	26%	52%	14%	36%	51%
Cavus foot (Clarke's angle >54º)	1%	1%	1%	1%	1%	1%
Control Group n=164						
Flat foot (Clarke's angle ≥30º)	0%	2%	2%	0%	3%	0%
Reduced foot (30º > Clarke's angle ≤41º)	14%	9%	6%	11%	13%	5%
Normal foot (41st > Clarke's angle ≤54º)	80%	80%	81%	81%	72%	89%
Cavus foot (Clarke's angle >54º)	6%	9%	11%	8%	13%	6%

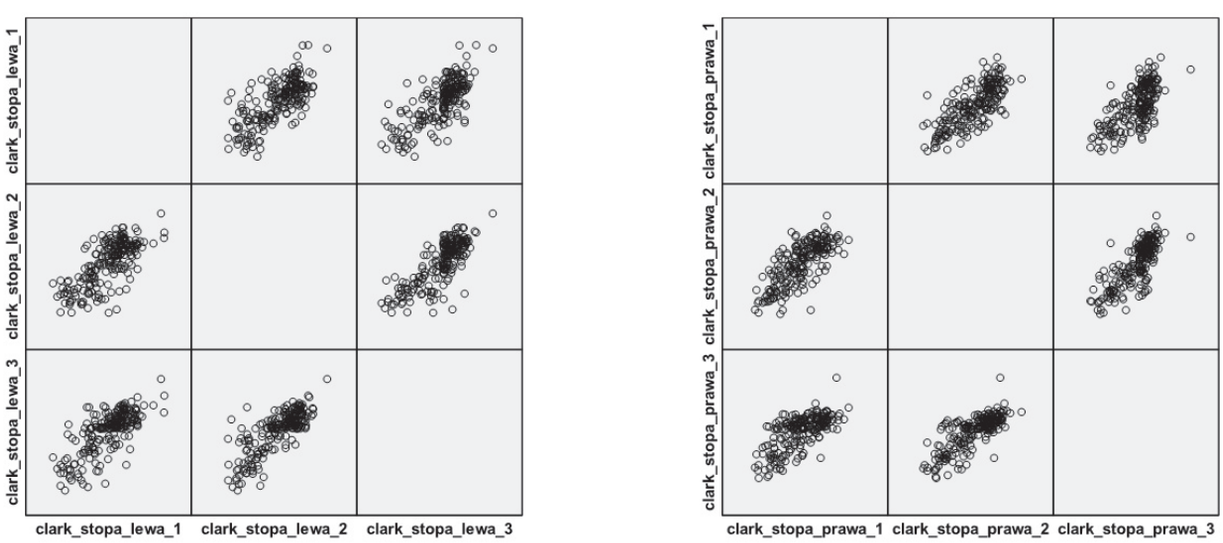

Fig. 1. The dispersion graph of Clarke's angle by right and left feet in three examinations with Pearson's correlation coefficient.

Tab. 4. The t-test of dependent samples from three values of Clarke's angle in the studied children's feet

	$\bar{X}$	SD	SEM	Dependent samples 95% CI Limes inferior	Limes superior	t	df	p
Examinated Group - right foot								
Exam. 1-2	-5.61	9.31	0.77	-7.13	-4.09	-7.30	146	0.00
Exam. 1-3	-10.21	9.66	0.80	-11.79	-8.63	-12.81	146	0.00
Exam. 2-3	-4,60	8.12	0.67	-5.92	-3.28	-6.87	146	0.00
Control Group - right foot								
Exam. 1-2	-2.51	7.24	0.90	-4.32	-.70	-2.78	63	0.01
Exam. 1-3	-2.47	6.99	0.87	-4.22	-.73	-2.83	63	0.01
Exam. 2-3	0.04	7.33	0.92	-1.80	1.87	0.04	63	0.97
Examinated Group - left foot								
Exam. 1-2	-3.65	9.83	0.81	-5.25	-2.05	-4.50	146	0.00
Exam. 1-3	-7.68	9.22	0.76	-9.19	-6.18	-10.10	146	0.00
Exam. 2-3	-4.03	8.20	0.68	-5.37	-2.70	-5.96	146	0.00
Control Group - left foot								
Exam. 1-2	-0.05	9.11	1.14	-2.32	2.23	-0.04	63	0.97
Exam. 1-3	-1.09	6.49	0.81	-2.71	0.53	-1.34	63	0.18
Exam. 2-3	-1.04	7.15	0.89	-2.83	0.75	-1.16	63	0.25

Discussion

The posture of a human is a reflection of their physical and mental condition while being also affected by environmental and cultural factors such as free time activities or parent's education and occupation [11]. The incidence of postural defects among children in Poland is assessed at up to several dozen percent, possibly due to the diversity of research methods being used [12,13,14]. The diversity of research methods combined with the lack of objective standards and the studies being conducted in different populations of different age make it difficult to unambiguously and accurately diagnose and predict the foot arch status. The problem is particularly evident in case of a reduced longitudinal arch affecting between 10% and 90% of population, according to different authors [1]. Studies assessing the development of the longitudinal arch in ontogenesis as well as objective standards for Clarke's angles are known in the literature [3, 15].

Lizis [3] pointed out that the preschool age is of key importance for future health and efficiency of feet as it allows prophylactic measures being taken, whereas at the age of 11-13, the Clarke's angle is stabilized and corresponds to the future value in adulthood.

The results of digital podometry examinations facilitated the comparison of foot arches in children in whom reduced longitudinal arch was diagnosed on the basis of Clarke's angle measurements with the foot arches in children with normal arch profiles.
In the first measurement run, the problem of reduced arch was found to affect 69% of right feet and 63% of left feet with 27% and 34% of the right and left feet, respectively, being characterized by normal profiles. According to the results of the second measurement run, a total of 54% of right feet and 48% of left feet maintained improper arch profiles while 42% and 47% or the right and left feet, respectively, were correctly formed.
The assessment of longitudinal arch on the basis of arithmetic means and standard deviations of Clarke's angle values as attempted in this study suggests that fallen longitudinal arch undergoes positive changes upon selected corrective exercises as confirmed by statistical analyses. That was evidenced by the results obtained in the third measurement run. Normal longitudinal arch was measured in 61% of right feet and 63% of left feet.

Conclusions

1. Reduced longitudinal arch of feet is a common deformity in children between the age of 3 and 6 years.
2. The longitudinal arch of children's feet can be increased to the normal level as measured by the Clarke's angle by means of selected corrective exercises putting a particular stress on the pressure of the head of the first metatarsal bone against the ground surface.

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