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# Monitoring and evaluation of flat-feet in children of pre-school age and younger school age

*Monitorowanie i ocena płaskostopia u dzieci w wieku przedszkolnym i młodszym wieku szkolnym*

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## Abstract

**Background.** The issue of flat-feet in children of pre-school and younger school age has been a frequently discussed issue in recent times. This issue has been addressed in particular with regard to the deteriorating physical fitness and general health of children. The lack of sensory stimuli from the foot causes incorrect development of the arch of the foot, which later becomes apparent in other parts of the support-movement system.

**Objective.** The aim of the study was to monitor the current condition of flat-feet in children.

**Method.** In our study we observed the occurrence of flat-feet in children of pre-school (n:37; age  $\bar{x}$ : 5,22) and younger school age (n:52; age  $\bar{x}$ : 7,45). The study enrolled children of pre-school and younger school age between five and nine years of age. We used the examination device Podoscope to examine the condition of the arch of the foot. We used the subjective method Chipaux - Šmířák (CSI) to evaluate the fingerprints. For each child, both feet were always compared. The results were evaluated with descriptive statistics.

**Results.** We found that 70.79% of all children have a normally shaped longitudinal arch on both feet. In the preschool year, the percentage of normal arch on both feet indicates 64.86% of all children. In primary school children, the figure is 73.08%. Among preschool and school age children, there was also a high foot, which was found on both feet in 8 out of 89 children. Flat-foot was found on both feet in 6.74% of the participants. 8.11% of kindergarten children had a flat-foot on both feet. In 5.77% of primary school pupils, a bipedal flat-foot was found.

**Conclusion.** The arch of the foot shapes with age. However, it cannot be said that it always shapes into a physiologically correct shape in every circumstance. In kindergarten children, flat-foot predominates because children attending this facility have not yet had time to fully form the arch. It is necessary to consider which year the children attend. In younger school age pupils, i.e. first to fourth grades, all three types of arch of the foot are present.

## Keywords

flat-foot, pre-school age, younger school age

## Streszczenie

**Wprowadzenie:** Kwestia płaskostopia u dzieci w wieku przedszkolnym i młodszym wieku szkolnym jest często omawianym zagadnieniem w ostatnim czasie. Problem ten jest szczególnie ważny w kontekście pogarszającej się sprawności fizycznej i ogólnego zdrowia dzieci. Brak właściwej stymulacji sensorycznej związanej z stopą może prowadzić do nieprawidłowego rozwoju sklepienia stopy, co później może mieć wpływ na inne elementy układu podpierająco-ruchowego.

**Cel:** Celem badania było monitorowanie aktualnego stanu płaskostopia u dzieci.

**Metoda:** W naszym badaniu obserwowaliśmy występowanie płaskostopia u dzieci w wieku przedszkolnym (n: 37; średni wiek: 5,22 lat) i w młodszym wieku szkolnym (n: 52; średni wiek: 7,45 lat). Badanie obejmowało dzieci w wieku od pięciu do dziewięciu lat.

Wykorzystaliśmy urządzenie badawcze o nazwie Podoscope do oceny stanu sklepienia stopy oraz zastosowaliśmy subiektywną metodę Chipaux - Šmířák (CSI) do oceny odcisków stóp. Dla każdego dziecka porównywano obie stopy. Wyniki oceniano za pomocą statystyki opisowej.

**Wyniki:** Stwierdziliśmy, że 70,79% wszystkich dzieci miało prawidłowo wykształcone podłużne sklepienie na obu stopach. W grupie dzieci przedszkolnych, odsetek prawidłowego sklepienia na obu stopach wynosił 64,86%, a wśród dzieci w wieku szkolnym było to 73,08%. Ponadto u 8 na 89 dzieci stwierdzono wysokie sklepienie na obu stopach, a płaskostopie na obu stopach wystąpiło u 6,74% uczestników badania. Wśród dzieci przedszkolnych 8,11% miało płaskostopie na obu stopach, a wśród uczniów szkół podstawowych płaskostopie obustronne wystąpiło u 5,77%.

**Wnioski:** Kształt sklepienia stopy zmienia się wraz z wiekiem, ale nie zawsze jest to kształt fizjologicznie prawidłowy w każdym przypadku. W dzieciach przedszkolnych płaskostopie dominuje, ponieważ dzieci uczęszczające do tego rodzaju placówek nie miały jeszcze wystarczająco czasu na pełny rozwój sklepienia. Warto także wziąć pod uwagę, w którym roku szkolnym uczęszczają dzieci. W młodszym wieku szkolnym, tj. od pierwszej do czwartej klasy, występują wszystkie trzy rodzaje sklepienia stopy.

## Słowa kluczowe

płaskostopie, wiek przedszkolny, młodszy wiek szkolny

## Introduction

The foot represents an important segment of the musculoskeletal system, whose task is to create a solid base and an even distribution of the load while standing and moving [1]. The foot contains a number of proprioceptors, through which we can perceive the position and movement of individual body parts [2]. For good sensomotor perception, the correct shape of the arch of the foot is necessary, which has a direct influence on the position of the higher placed body parts [3, 4]. The development of the baby's foot begins at an early stage of pregnancy - at 8 weeks of the mother's pregnancy. Because the space for the baby in the womb is very limited, congenital deformities of the feet of the children occur. This type of deformity is reversible [5, 6]. The feet of newborns and infants do not yet have a formed arch of the foot, which begins to develop only by the loading of the foot. The foot begins to form by locomotion and verticalization of the child. The longitudinal arch is formed only at approximately the third year of life under conditions of healthy development [5, 7, 8]. Flat-feet are relatively common in infancy, affecting up to 14% of children [9]. Flexible flat-feet can be part of a normal developmental profile. Flexible flat-feet manifest in an overly flexible foot and usually include hypermobility of the subtalar joint. It usually occurs in childhood and can continue into adulthood [10]. The arch performs an important function, among other things, to cushion shocks and is therefore an important factor for walking flexibility. the so-called shock absorber [11]. The formation of the arch of the legs is completed around the age of 6. If the children grow, the leg does not change and remains flat, then we speak of the flat-feet as a deformity. The cause is the fallen arch. The muscles that make it are flaccid and will not keep it in the right shape. The incidence and prevalence of flat feet and defective posture in children is very common. Segmental posture disorders are present in both groups, both in children with pedes plani and in children with physiological arch of the leg [12]. Structural insufficiency and functional impairment of the leg are considered to predispose injuries to the locomotor apparatus, especially the lower limbs [13].

## Methods

We monitored 37 pre-school children and 52 children of a younger school age. A total of 178 feet were examined. To examine the condition of the leg arch, we used the diagnostic device Podoscope. To evaluate the condition of the leg arch, we used a subjective method of evaluation according to the Chipaux - Šmířák Index (CSI) [11], the essence of which is to identify the narrowest and widest point of the foot print. The foot index was calculated according to the formula: narrowest point/widest point×100. The resulting values of the index are given in percentages (%). Chipaux-Šmířák classifies the foot:

- normally arched foot: I. st. (0.1 – 25.0%); II. st. (25.01 – 40.0%); III. st. (40.01 – 45.0%)
- flat-foot: I. st. (45.01 – 50.0%); II. st. (50.01 – 60.0%); III. st. (60.01 – 100%)
- high arched foot: I. st. (0.1 – 1.5 cm); II. st. (1.6 – 3.0 cm); III. st. (3.1 cm and more)

For each child, both feet are always compared. Statistical processing of the data obtained was carried out by descriptive statistics using the Statistica program.

## Results

### Normally arched foot

The results show that 64.86% of all pre-school children belong to the bilateral normal arch foot index (Table 1). The measured values represent the average of the foot index for left DK CSI: 29.08% and for right DK CSI: 31.52%, which means the ideal arch foot at this age. One-sided normally arched foot was found on the left in 28 children with the average value of the foot index CSI: 29.60%. One-sided standard of arch foot on the right was present in 27 children (ø CSI: 30.58%). Normally arched feet of 2nd grade were the most common. Normally arched foot on both sides in this group of pre-school children was found in 73.08% of children. The foot index in the bilateral normally arched foot group was on the left CSI: 28.11%, on the right CSI: 29.99%. Left-sided normally arched foot was in 42 cases with the average of the foot index CSI: 28.78%, right-sided standard of arch foot was in 41 cases with the average of the index CSI: 30.8%. In all cases, Grade 2 of normally arched leg was found the most.

**Table 1. Norm – Average value CSI (%)**

	n	CSI	1. degree		2. degree		3. degree		
			n	CSI	n	CSI	n	CSI	
<b>Preschool age – norm</b>									
L+R	24 (64.86%)	L	29.08	6 (16.22%)	14.42	15 (40.54%)	32.95	3 (8.11%)	39.08
		R	31.52	7 (18.92%)	19.08	14 (37.84%)	35.42	3 (8.11%)	42.35
L	28 (75.67%)	29.60	7 (18.92%)	17.34	18 (48.65%)	32.33	3 (8.11%)	41.83	
R	27 (72.97)	30.58	10 (27.03%)	19.80	15 (40.54%)	35.76	2 (5.41%)	43.29	
<b>School age – norm</b>									
L+R	38 (73.08%)	L	28.11	8 (15.38%)	16.41	28 (53.85%)	30.44	2 (3.85%)	42.22
		R	29.99	8 (15.38%)	17.43	24 (46.15%)	32.28	6 (11.54%)	37.55
L	42 (80.76%)	28.78	9 (17.31%)	16.00	28 (53.85%)	30.44	5 (9.62%)	42.25	
R	41 (78.85%)	30.8	9 (17.31%)	16.50	24 (46.15%)	32.28	8 (15.38%)	38.77	

Legend: L – left foot; R- right foot; n-total; ø- average; CSI - Chipaux-Schmirak Index

**Flat-foot**

In a group of preschoolers, we found bilaterally a 3rd grade flat-foot in 3 cases (8.11%) with a foot index on the left CSI: 62%, which means strongly flat-foot, on the right CSI: 48.26%, which means slightly flat-foot (Table 2). The one-sided flat-foot on the left occurred in 4 cases (10.81%), the average foot index was CSI: 58.11% (moderately flat-foot). On the right, the one-sided flat-foot was found in 5 cases (13.51%) with a mean CSI

index: 47.17% (moderately flat-foot). The flat-foot occurred bilaterally in 3 cases (8.11%) in pupils with a mean foot index on the left CSI: 57.32%, which means moderately flat-foot, and on the right CSI: 48.26%, which means moderately flat-foot. The one-sided flat-foot was on the left in 5 cases with a mean CSI index: 54.78%, which means moderately flat-foot, on the right there was unilaterally flat-foot in 6 cases with a mean foot index for moderately flat-foot CSI: 53.27%.

**Table 2. Flat-foot – average value CSI (%)**

			1. degree		2. degree		3. degree	
	n	CSI	n	CSI	n	CSI	n	CSI
<b>Preschool age – flat-foot</b>								
L+R	3 (8.11%)	L	2 (5.41%)	58.00	0	-	1 (2.70%)	69.77
		R	1 (2.70%)	46.67	1 (2.70%)	52.17	1 (2.70%)	45.95
L	4 (10.81%)	L	3 (8.11%)	54.00	0	-	1 (2.70%)	69.77
		R	3 (8.11%)	45.91	1 (2.70%)	52.17	1 (2.70%)	45.95
R	5 (13.51%)	L	2 (5.41%)	47.17	1 (2.70%)	52.17	1 (2.70%)	45.95
		R	3 (8.11%)	45.91	1 (2.70%)	52.17	1 (2.70%)	45.95
<b>School age – flat-foot</b>								
L+R	3 (5.77%)	L	1 (1.92%)	48.89	1 (1.92%)	56.41	1 (1.92%)	66.67
		R	0	-	2 (3.85%)	56.82	1 (1.92%)	62.22
L	5 (9.62%)	L	2 (3.85%)	47.45	2 (3.85%)	56.17	1 (1.92%)	66.67
		R	3 (5.77%)	47.91	2 (3.85%)	56.82	1 (1.92%)	62.22
R	6 (11.54%)	L	2 (3.85%)	47.45	2 (3.85%)	56.17	1 (1.92%)	66.67
		R	3 (5.77%)	47.91	2 (3.85%)	56.82	1 (1.92%)	62.22

Legend: L – left foot; R – right foot; n-total; ø- average; CSI – Chipaux–Schmirak Index

**Hight vault**

Double-sided high vaulting occurred in 4 cases (10.81%) with an average length of free space of the foot on the left 1.975 cm, on the right 2.175 cm. Both average values are relevant for a medium-high foot. Single-sided high left vaulting was found in 5 cases (13.51%) with an average length of free space of the foot 1.92 cm, on the right high vaulting occurred in 5 cases (13.51%) with an average length of free space of 1.98 cm (medium-high foot).

In this group we found high vaulting of the foot bilaterally in 4 cases on the left the diameter of free space of the foot was 2.6 cm, on the right 2.8 cm, which represents a medium-high vaulting of the foot. Single-sided high left vaulting was 2.24 cm in 5 cases with an average size of free space of the foot and high-arched right foot was also 2.42 cm in 5 cases where the diameter of free space was 2.42 cm, i.e. both cases a medium-high arched foot.

**Table 3. Hight vault – average value CSI (cm)**

			1. degree		2. degree		3. degree	
	n	CSI	n	CSI	n	CSI	n	CSI
<b>Preschool age – hight vault</b>								
L+R	4 (10.81%)	L	1 (2.70%)	1.5	3 (8.11%)	2.133	0	-
		R	1 (2.70%)	0.5	2 (5.41%)	2.5	1 (2.70%)	3.2
L	5 (13.51%)	L	1 (2.70%)	1.5	4 (10.81%)	2.025	0	-
		R	2 (5.41%)	0.85	2 (5.41%)	2.5	1 (2.70%)	3.5
R	5 (13.51%)	L	1 (2.70%)	1.5	4 (10.81%)	2.025	0	-
		R	2 (5.41%)	0.85	2 (5.41%)	2.5	1 (2.70%)	3.5
<b>School age – hight vault</b>								
L+R	4 (7.69%)	L	1 (1.92%)	1.0	2 (3.85%)	2.65	1 (1.92%)	4.1
		R	0	-	2 (3.85%)	2.3	2 (3.85%)	3.3
L	5 (9.62%)	L	2 (3.85%)	0.9	2 (3.85%)	2.65	1 (1.92%)	4.1
		R	1 (1.92%)	0.9	2 (3.85%)	2.3	2 (3.85%)	3.3
R	5 (9.62%)	L	2 (3.85%)	0.9	2 (3.85%)	2.65	1 (1.92%)	4.1
		R	1 (1.92%)	0.9	2 (3.85%)	2.3	2 (3.85%)	3.3

Legend: L – left foot; R – right foot; n-total; ø- average; CSI – Chipaux–Schmirak Index

## Discussion

Multiple factors influence the arching of the foot. These can be the physiological development of the individual, genetic predisposition, congenital locomotor defects, incorrect posture and external influences. Analysis of the occurrence of posture errors in the population showed statistically significant variables for the curvature of the spine in the frontal plane, the occurrence of the flat-foot and the valgosity of the knee [14]. In our study, we found normal arching of the foot on both feet in 25 pre-school aged children (67.56%). 3 children had a flat-foot on both feet. In pre-school aged children, the examination was dominated by the one-sided normal arching leg on the left (75.67%) and the bilaterally normal arching leg (64.86%), while the one-sided normal arching leg on the right was found in 72.97%. The results in younger school aged children do not differ much from those in pre-school aged children. We found a two-sided standard in 73.08%, a one-sided standard on the left in 80.76% and on the right in 78.85% of children. In four pupils, a high arching of both feet was found. All types of arch of the foot are found in younger pupils.

A similar issue of the development of arch of the foot in younger pupils was dealt with in the Canas et al study. [15]. Using a sub-scope, they monitored the arch of the foot and determined its degree according to the Kapandji scale and the Heartfelt scale. The Kapandji results show that in their measured group of 113 boys, flat-foot occurs in a large proportion. The first stage of flat-foot occurs in 22.12% and the second stage in 61.06%, i.e. in more than half of boys. While a healthy foot occurs in only 16.81% of all boys measured. In girls who were examined in 108, a healthy foot occurs in a percentage of 23.15%. The first stage of flat-foot was found in 29.63% of girls and the second stage in 47.22% of girls. In our study, we did not address the effect of shoes on the condition of the feet of children, although the condition of the feet can demonstrably affect not only the condition of the feet, but also the postural quality of the individual. This fact is pointed out by the authors of Gajdoš et al. [16], who state that wearing some types of inappropriate shoes leads to changes in the step cycle and incoordination muscles. Among other things, the poorly chosen shoe prevents the transmission of information from the external environment to other parts of the musculoskeletal system, which results in a negative effect on the statics and muscle dynamics of the arch of the foot, especially during the development of the foot in childhood [17]. Through exercise and modification of shoes, we can slow the progression of such developing pathological condition [18]. These changes can cause overloading of the lower limbs, but also vertebrogenic problems. A survey developed by Shtin-Bañarová [19] demonstrates the negative effect of the disorder of the

longitudinal arch of the foot, as well as on the position of the ankle joints and the shape of the transverse arch of the foot. The aim of the study was to analyze the characteristics of the foot structure in girls and boys in the final stages of early childhood, taking into account half-yearly age ranges. The study was conducted among 800 children aged 3 years. The research tool was the CQ-ST sub-scope. In each of the identified age groups, statistically significant gender differences were found in the length of the right and left legs, the width of the right and left legs, and the Clark angle of the right and left legs. Several studies suggest an association with the development of the arch of the foot, anthropometric characteristics or motor abilities of children [20]. Chang et al. [21] study evaluating the occurrence of flat-feet in 572 children and physical fitness while comparing the results between flat-footed children who developed arch feet and children who did not develop arch feet within 1.5 years. The study points out that out of 263 flat-footed children, CSI significantly changed in 70 children and at the same time improved performance in the equilibrium standing test on one lower limb was observed in these children in boys and at the same time a smaller increase in height in children. The weight of a child has a significant influence on the development of the foot. Mikuláková et al. [22] states in their study that underweight children have thinner and flatter feet than children of normal weight. The results of the Glovacké study [23] in which 30 children participated indicate that body weight and BMI have a significant influence on the longitudinal and transverse arch of the foot. A similar study [24] to evaluate the quality of the arch of the foot and the occurrence of finger deformities in 104 physiotherapy students using the CQ-ST sub-scope. Most students had a physiologically arched longitudinal arch of the foot, but also noted an increased incidence of flat transverse arch of the foot and toe deformities, especially in women. Recent recent studies point to the fact that changes in one's own foot also affect higher segments that contribute to postural imbalances [25].

## Conclusion

The arch of the foot is shaped together with the lid. However, it cannot be said that it is always shaped into a physiologically correct shape at all times. Different factors may have influenced the fact that we noticed a normally arched foot already in pre-school children – which gives room for further scientific research.

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