

The evaluation of feet forms (shapes) in primary school children at 7–12 age

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Summary

Background. The very important condition of the normal (good) posture are correctly shaped feet. We can observe the most dynamic evolution of the feet in kindergarten and primary school children.

Material and methods. In 2008 and 2009 podoscopic research was carried out among schoolchildren at age 7 – 12 from Cracow and villages near Cracow. The aim of the research was the evaluation of feet shapes. Podoscopic method was used for the research and Sztriter - Godunow index (Ky) was evaluated.

Results. The right values of Ky index was observed in less than 30% of examined children, both city and rural areas inhabitants. The most common pathology of feet profile among the children was flat foot. Flat foot was observed in 10% of children from Cracow and 12,5% of children from villages near Cracow.

Conclusions. There was no statistical important differences between a number of feet defects in children from Cracow and children from villages near Cracow. Hollow foot is the most common pathology among the children from research group. The least common pathology of feet profile among the children was flat foot.

Key words: podoscopic research, flat foot, hollow foot

STATISTIC STATYSTYKA

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INTRODUCTION

The proper arching of a foot is one of the conditions of a good body posture and efficient gait. In the process of the evolution, an emergence of the erect posture resulted in a considerable modification in the structure and function of the foot. Although the development of the foot takes place during the whole period of childhood, its most dynamic phase coincides with the school-age period. Also, it is the time of the final formation of foot arches. Unfortunately, the fast pace of change that has been observed in the human environment in recent years results in the fact that adaptive mechanisms do not keep up with the dynamics of civilisation changes. Besides, such a situation has a detrimental effect on foot arching. The majority of people, including school-age children, have adopted a sedentary lifestyle, spending their spare time watching TV or using a computer, which subsequently leads to foot offloading. Thus the muscles supporting foot arches are not properly stimulated and become slack. This in turn leads to the lowering of the plantar arch. Other detrimental factors include an increase in the average body weight of children which is caused by a high calorie diet, as well as walking on hard surfaces with low shock absorption. [1, 2, 3, 4, 5, 6]

OBJECTIVE

The purpose of this research is to evaluate foot arching in a group of selected population of school-age children and to find an answer the following questions:

1. What is the value of Sztriter – Godunow index (Ky) in the examined groups of children with reference to gender and area of residence.
2. Which foot deformity is the most frequent in the groups examined.

INVESTIGATIVE MATERIAL

In the years 2008-2009 a podoscopic examination was carried out in a group of 1484 children aged 4 to 13 years, residents of Kraków and nearby villages. The group of 1091 children lived in Kraków and 393 lived in the villages. There were 743 girls which equalled 50.1% of the examined group and 741 boys (49.9%). The group consisted of 120 preschool children (aged 4-6 years) and 1364 school children (aged 7-13 years). In the group of preschool children there were 68 girls (56.7%) and 52 boys (43.3%). (see Tab. 1.)

The height of children ranged between 90.9 cm and 177 cm (average height equalled 138 cm). The body weight ranged between 12.9 kg to 106.5 kg (average body weight equalled 35.5 kg).

METHOD

In order to determine basic parameters of the examined group, the following measurements were taken: the height of children was measured by means of a Martin-type anthropometer, the weight was measured on the digital

weight scales and the three skin-fat folds (stomach, shoulder and arm) were measured by means of a calliper.

The remaining research parameters were collected on the basis of a podoscopic assessment of the foot arch using an equipment that consisted of an image scanner with built-in sensors and a computer with the original software for analysing the scanned images. The research equipment was the property of the Reh-As company based in Kraków. Both feet were measured simultaneously. A foot scan was taken twice for each child – the first scan was done in order to calibrate the device and the second one was the actual foot measurement. On the basis of the information acquired during the second scan, the parameters determining foot structure and the degree of foot arching were established. In foot evaluation, the following parameters were applied: Sztriter – Godunow index (Ky), α heel angle, α hallux valgity and α varus deformity of the fifth toe. The parameters were determined on the basis of the guidelines and norms presented in the publication by Tadeusz Kasperczyk “Wady postawy ciała” (Diagnosis of Body Posture Faults). [7]

The results obtained during the examination were further subjected to the statistical analysis.

RESULTS

The calculated Sztriter – Godunow index (Ky) served as the basis for determining a number of children with hollow foot, properly arched foot and flat foot. Among all the children subjected to examination, the incidence of pes cavus was the highest: a left pes cavus deformity was observed in 58.8% and the right one in 68.1%. Pes planus of the left foot was observed in 11% of the children, whereas 9% of the group developed pes planus of the right foot.

With respect to gender, hollow foot occurred more frequently in a group of girls. However, it was the most common deformity of the longitudinal arch of the foot. Pes planus was more frequent in the group of boys, although the percentage of children with flat foot ranged between 10-20% and did not exceed the latter value. In the group of girls a lowered longitudinal arch was more frequent in the left foot (6.3%) rather than in the right one (3.9%).

Figure 1 illustrates the incidence of faulty foot arch with respect to area of residence.

No significant differences between the percentage of pes cavus among children from urban and rural areas were observed. In both groups, excessively high foot arch occurred more frequently in the right foot (69% of urban children and 66.4% of rural children).

The incidence of pes planus was more common in the group of rural children as opposed to the urban ones.

The comparison of both groups of girls, urban and rural ones, did not reflect any distinct differences in the number of foot deformities. The percentage of children with different types of foot arching was similar in all individual groups. Figures 2 and 3 illustrate the incidence of foot deformities. A higher percentage of rural girls

had normal foot arch. Pes cavus was observed more frequently among the urban girls, in 70% of the examined girls this deformity was detected in the left foot. A greater number of urban boys presented normal foot arch,

as opposed to those inhabiting rural areas. The percentage of pes cavus was higher in the group of rural boys than in urban ones. Flat foot was also more common among the boys from rural areas. (see Figure 2. and Figure 3.)

Tab. 1. Number of children in separate age groups

Age (years)	Girls		Boys	
	N	%	N	%
4-6	68	4,6	52	3,5
7	81	5,5	94	6,3
8	115	7,8	107	7,2
9	97	6,5	111	7,5
10	105	7,1	98	6,6
11	131	8,8	106	7,1
12	106	7,1	131	8,8
13	40	2,7	42	2,8
Σ	743	50,1	741	49,9

Fig. 1. Percentage distribution of foot deformities in examined children with reference to area of residence

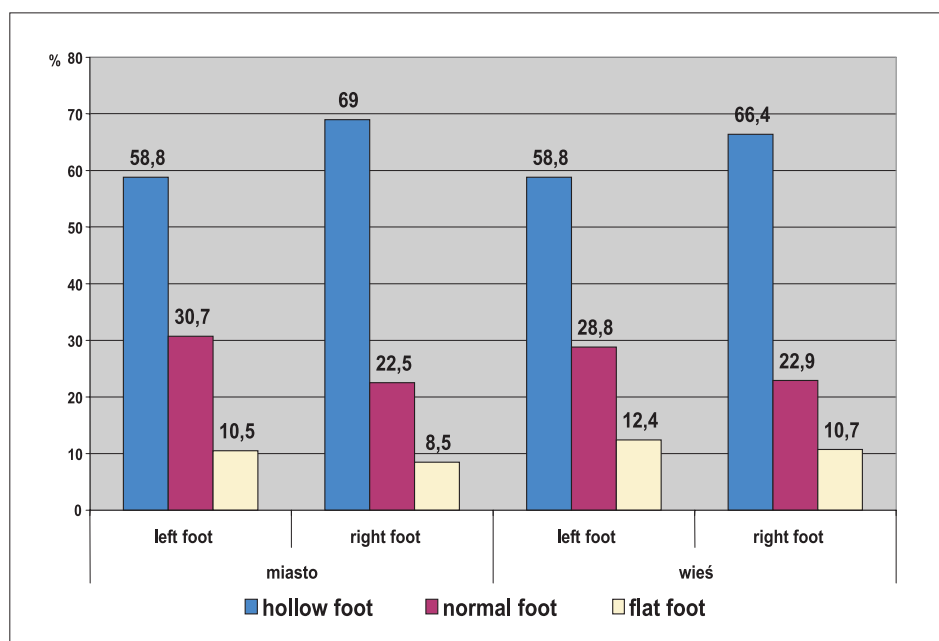
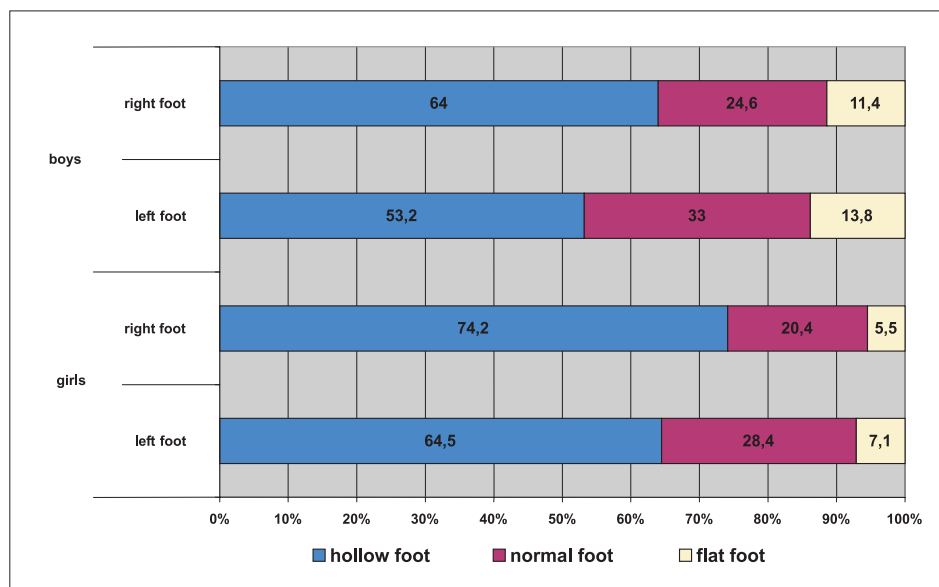


Fig. 2. Percentage distribution of foot deformities among urban children with reference to gender



In order to verify a hypothesis for the existence of differences between the two groups, a test for the equality of two fractions was done. The analysis was carried out separately for the right and left foot and consisted in comparing the percentage of hollow, normal and flat feet. The analysis was performed in two gender groups and took into consideration rural versus urban area of residence of the examined children. The results obtained are presented in Table 2.

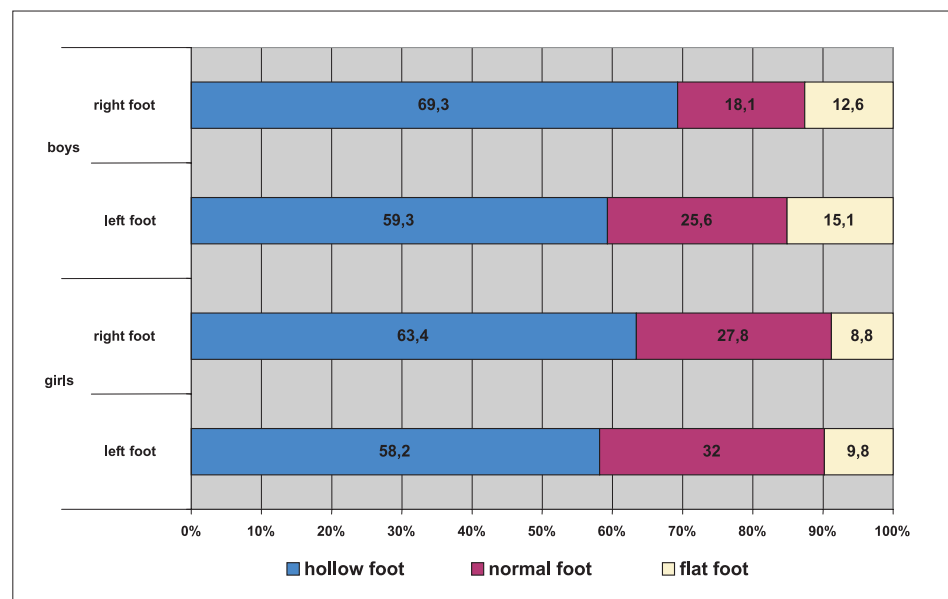
Among boys, the value of test verification (u) was significant and equalled $\hat{\alpha} = 0,05$ in the case of properly arched feet (left and right). More urban boys had proper foot arching in comparison with those inhabiting rural areas. In the case of pes cavus, the hypothesis for the equality of fractions can be dismissed on the significance level at $\hat{\alpha} = 0,1$. Hollow foot predominated in the group of rural boys. In the group of girls, the results reflected a difference between the left and right foot. As far as the left foot is concerned, the value of test verification had the significance level at $\hat{\alpha} = 0,1$ only in the case of pes cavus. The percentage of hollow foot was higher in the

group of urban girls. In the case of the right foot, test verification values for the fraction were statistically significant on the level of $\alpha = 0,01$ in hollow foot and in normal-arched foot. In the group of rural girls, properly arched feet were more common unlike in the group of urban girls where pes cavus was more frequent.

The results were analysed with respect to gender. Both urban and rural groups of children were approached separately. The results are presented in Table 2. Comparing both gender groups of rural children subjected to examination, the differences between two fractions have significance level at $\alpha = 0,1$ in the case of pes planus and normal left foot. Pes planus was more common among the boys, whereas properly arched foot was more common among the girls. In the case of the right foot, the value of test verification for the fraction is statistically significant at $\alpha = 0,1$ only for the properly arched foot. It was more frequent in the group of boys.

In the group of urban children, the values of test verification are statistically significant in all the foot types when the analysis is carried out in the gender groups.

Fig. 3. Percentage distribution of foot deformities among rural children with reference to gender



Tab. 2. Test verification values (u) for fractions in gender groups with reference to area of residence

Boys village/town			Girls village/town	
u (left foot)	u (right foot)	foot	u (left foot)	u (right foot)
-1,927**	-1,878**	normal	0,932	2,170***
1,488*	1,364*	hollow	-1,545*	-2,865***
0,433	0,435	flat	1,201	1,610*

* $\alpha = 0,1$; ** $\alpha = 0,05$; *** $\alpha = 0,01$

Tab. 3. Test verification values (u) for fractions with reference to area of residence

Village girls/boys			Town girls/boys	
u (left foot)	u (right foot)	foot	u (left foot)	u (right foot)
1,386*	2,299**	normal	-1,650**	-1,717**
-0,211	-1,248	hollow	3,825***	3,683***
-1,585*	-1,219	flat	-3,658***	-3,538***

* $\alpha = 0,1$; ** $\alpha = 0,05$; *** $\alpha = 0,01$

Statistical significance of the differences at $\alpha = 0,05$ is registered in both right and left normal feet. Properly arched feet are more common among the boys rather than girls. In the case of pes planus and pes cavus, the values of test verification for the fraction are statistically significant on the level of $\alpha = 0,01$. Pes planus was more prevalent among the boys and excessive foot arch was more frequent among the girls. (see Tab. 3.)

Table 4 illustrates the percentage of hollow, normal and flat feet among all the examined children with respect to gender and age.

In the case of all age groups subjected to examination, with the exception of 12-year-children and 13-year-old girls, the percentage of excessively arched feet was the highest. Pes cavus was diagnosed in 60% of children. The

highest percentage of hollow feet was registered among 8-year-old girls. This deformity was observed in over 80% of children. In each age group, the percentage of an excessively high longitudinal foot arch is higher in the left foot.

Flat foot was observed with similar frequency in both feet in the group of boys. It was only among the 12-year-old children that pes planus was more frequent in the left foot (18.5%) than in the right one (8.4%). In the case of girls pes planus dominated in the right foot in the groups of 12- and 13-year-olds. In the remaining groups pes planus prevailed in the left foot.

The highest percentage of children with properly arched feet was registered among older children and was more common among the girls than the boys. The normal left foot was less frequent than the right one.

Tab. 4. Percentage distribution of foot arch types among examined children

Boys						Age	Girls					
Ky L			Ky P				Ky L			Ky P		
% h	% n	% f	% h	% n	% f		% h	% n	% f	% h	% n	% f
62,8	18,1	19,1	69,1	14,9	16	7	64,2	24,7	11,1	75,3	16	8,6
65,4	23,4	12,4	73,8	14	12,1	8	84,3	11,3	4,4	88,7	7,8	3,5
59,3	35,4	5,3	71,4	23,2	5,4	9	63,9	25,8	10,3	66	27,8	6,2
61,6	22,2	15,2	63,3	22,2	14,5	10	64,8	26,7	8,5	77,1	15,2	7,6
61	28,6	10,4	67,6	21,9	10,5	11	66,4	29	4,6	67,7	29,2	3,1
32,3	49,2	18,5	60,8	30,8	8,4	12	35,8	59,4	4,7	62,3	31,1	6,6
47,7	40,9	11,4	52,4	35,7	11,9	13	42,5	52,5	5	51,3	43,6	5,1

L – left foot; P – right foot; %h – percentage of hollow feet; %n – percentage of normal feet; %f – percentage of flat feet

Tab. 5. Percentage distribution of foot arch types among rural children

Boys						Age	Girls					
Ky L			Ky P				Ky L			Ky P		
% h	% n	% f	% h	% n	% f		% h	% n	% f	% h	% n	% f
58,1	19,4	22,5	67,8	16,1	16,1	7	62,1	31	6,9	83,3	10	6,6
72,2	13,9	13,9	80,5	5,6	13,9	8	70	20	10	80	10	10
77,4	19,4	3,2	87,1	12,9	0	9	56,7	23,3	20	53,4	36,6	10
71,8	17,9	10,2	74,4	15,4	10,2	10	54,5	33,3	12,2	66,6	27,3	9,1
50	33,3	16,7	63,3	20	16,7	11	65,8	23,7	10,5	60,5	34,2	5,3
22,6	54,8	22,6	38,7	45,2	16,1	12	39,4	60,6	0	42,4	45,5	12,1

L – left foot; P – right foot; %h – percentage of hollow feet; %n – percentage of normal feet; %f – percentage of flat feet

Tab. 6. Percentage distribution of foot arch types among urban children

Boys						Age	Girls					
Ky L			Ky P				Ky L			Ky P		
% h	% n	% f	% h	% n	% f		% h	% n	% f	% h	% n	% f
66	0	34	73,1	0	26,9	4-6	67,6	14,7	17,7	69,1	17,7	13,2
65,1	17,5	17,4	69,8	14,3	15,9	7	64,7	21,6	13,7	70,6	19,6	9,8
62	28,2	9,9	70,4	18,3	11,3	8	89,4	8,2	2,4	91,8	7,1	1,1
51,9	42	6,1	65	27,5	7,5	9	67,1	26,9	6	71,6	23,9	4,5
55,9	25,4	18,7	54,2	28,8	17	10	69,4	23,6	7	83,3	9,7	7
65,8	26,3	7,9	69,7	22,4	7,9	11	66,7	31,2	2,1	70,7	27,2	2,1
35,4	47,5	17,1	67,7	26,3	6	12	34,2	58,9	6,8	71,2	24,7	4,1
47,6	42,9	9,5	52,5	37,5	10	13	42,5	52,5	5	51,3	43,6	5,1

L – left foot; P – right foot; %h – percentage of hollow feet; %n – percentage of normal feet; %f – percentage of flat feet

The percentage distribution of foot deformities was analysed within age groups with respect to the area of residence. The results are shown in Tables 5 and 6.

The highest percentage of properly arched feet is observed among rural children in the group of 12-year-olds. Over 60% of girls had a properly arched left foot.

Pes cavus was the most frequently observed deformity in the age groups of 7-11 years. The percentage of hollow feet is lower only in the group of 12-year olds. Among 8-, 9- and 10-year-old boys excessive foot arching is predominant in the right foot and equals almost 90% in the group of 9 year-olds. Over 80% of instances of an excessively high longitudinal arch were observed in the right foot in the group of girls aged 7 and 8. Pes planus was more frequent among the boys. A low occurrence of flat feet was registered only among 9-year-old boys, and no instance of pes planus was observed in the right foot. The percentage of flat feet reached the highest value in the group of 9-year-old girls among all the examined age groups. The most instances of pes planus were diagnosed among 7- and 12-year-olds.

As far as the urban children are concerned, the examination was also carried out among preschool children. Owing to their number they were combined into an age group of 4-6 years. In this age group, no instances of properly arched feet were observed among the boys, neither in the right nor in the left foot. Approximately 1/3 of preschool boys were diagnosed with pes planus and the remaining 2/3 with pes cavus. The percentage of flat feet in this age group was the highest among all the age groups subjected to examination.

An overly-high arched foot was the most common among the urban boys, with the exception of the left foot in the group of 12-year-olds, in which the percentage of properly arched feet was the highest. An excessively high foot arch was more frequently observed in the right foot.

Pes cavus was also the most frequent affliction in the group of urban girls. A normal arch was observed only in the left foot in the group of 12- and 13-year-old girls. The highest percentage of girls with hollow feet was in the group of 8-year-olds. Nearly 90% of girls aged 8 have an excessive longitudinal foot arch. Pes planus was more common in the preschool group (aged 4-6) and among 7-year-old girls. In the remaining age groups only a small percentage of children had flat feet. The highest percentage of normal-arched feet was observed in the group of 13-year-old girls and in the group of 12-year-old girls in the left foot.

DISCUSSION

Nowadays, posture-related afflictions, including foot arch deformities, pose serious health problems in many societies. Fast changes that happen in the environment have a detrimental influence on human organisms and their defence and adaptive mechanisms cannot keep pace with the dynamics of civilisation changes. This in consequence leads to posture problems. The development of civilisation has the most crucial influence on a child's

organism that is in the process of constant transformation. [3, 5]

Kasperczyk and Ślężyński [8] define a proper posture as the one that occurs frequently enough to be considered typical for a given population and which is representative of healthy people characterized by normal physical and mental development. A faulty posture is defined as a deviation from generally accepted characteristics of a good posture, typical for a given age group, gender and body type. [7]

Foot deformities are one of the most commonly observed afflictions, particularly in the case of children. According to Lizis [9] the development of foot is complete by 11 years of age. Therefore, the research conducted among preschool children illustrates the dynamism of foot development in the best way and allows an early diagnosis of any emerging foot problems.

Although there are frequent examinations carried out in order to determine the type and range of foot deformities in children, there is a big discrepancy in the obtained results which, among other reasons, may be caused by the application of different research methods. [10, 11] According to Gawron [12], approximately 50% of 118 examined children suffered from pes planus. Quite a high percentage of lowered arch was observed by Borzęcki [3] – 19.4% and Demczuk [13] – 16.7%, and the value registered for hollow foot was only 1.6%. Another study by the same author [14] that was based on the examination of 210 children establishes the percentage of pes planus at 27.2% and pes cavus at 21.4%. Gołębowska [4] also points out that in comparison with pes cavus, pes planus is decidedly a more commonly observed foot deformity.

The distinctly lower values of pes planus were registered by Krishan [15] – 1.54% and Garcia – Rodriguez et al. [16] – 2.7%. The research conducted by Woźniacka et al. [17] in the group of 250 children aged 7-12 revealed 2.8% of lower foot arch and 60.4% of hollow foot. In the examined group of 361 preschool and early school children, Bac [18] also observes a remarkably higher percentage of hollow feet in comparison with flat feet.

The above data confirm the results of the presented research and show that in the group consisting of 1484 children the most frequently observed foot pathology was pes cavus, whereas pes planus was lower than 10%.

On the basis of her research Kurkiewicz – Witkaczowa [19] indicates the fact that a foot arch is greatly influenced by gender and she states that girls aged 11-14 lat present better foot arching than boys. This relation is perceived differently by Demczuk [13] who reports that the percentage of flat feet with respect to the gender reaches 30% among the boys and 13.4% among the girls. The research conducted by Gołębowska et al. [4] shows that foot arching in both genders is on a similar level, although a slightly higher percentage of pes planus of the right foot was observed among the girls, whereas pes cavus of the left foot was diagnosed among the boys.

Gawron and Janiszewski [12] prove that flat foot is more common among the boys (60%) than the girls (40%).

The results of the above research confirmed the observations of many authors that the majority of flat feet were more common among the examined boys, whereas hollow feet were more frequent in the group of girls.

Lizis and Nowobilski [9] show that the average values of the Ky index of the feet examined among 220 randomly chosen girls aged 8–11 decrease gradually with age. The authors point out that the condition of longitudinal foot arch improves, which is concordant with the ontogenetic development of the plantar surface of the foot. Trzcińska [20] maintains that the condition of the longitudinal foot improves with children's age, unlike the transverse arch in the case of which she observed an inverse tendency. Those results find proof in the presented research. The percentage of flat feet and hollow feet diminishes significantly with increasing age of the chil-

dren examined, which allows for an inverse correlation between the age and the number of normally arched feet.

CONCLUSIONS

On the basis of the conducted research the following conclusions have been formed:

1. Pes cavus was the most frequent foot deformity in the group of examined children.
2. With reference to the gender, pes cavus was more common among the girls, whereas pes planus was more frequently observed in the group of boys.
3. In the group of examined children, older children had a lower percentage of foot deformities in comparison with younger ones.
4. No significant differences were observed between the percentage of hollow feet among urban and rural children.
5. In the group examined, pes planus was more common among rural children than among urban ones.

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