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**Association between flat foot prevalence and nutritional status
in schoolchildren**

Повезаност преваленције равних стопала и нутритивног статуса
код школске деце

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Повезаност преваленције равних стопала и нутритивног статуса код школске деце

SUMMARY

Introduction/Objective The aim of this study was to examine the association between flat feet and socio-demographic factors and nutritional status in children aged 7–14 years of the Province of Vojvodina, Serbia.

Methods The research was conducted as a cross-sectional study. The survey instrument was a questionnaire, and anthropometric measurements were done using standardized procedures. To determine the impact of socio-demographic factors and nutritional status as independent variables on the flat feet in schoolchildren as a dependent variable, a multivariate logistic regression model was implemented. A multivariate model was adjusted for age, gender, type of settlement, and material status.

Results This study included 1376 children (685 boys and 691 girls). Significant differences were observed in the frequency of flat feet between normal weight, overweight and obese ($p=0.006$), where obese children were rated highest in the flat foot category. Overweight children had a 1.76 times higher chance to have a flat foot than those with normal weight ($OR = 1.76$; 95% CI 1.08–2.88), while obese children were 1.88 times more likely to have a flat foot than those with normal weight ($OR = 1.88$; 95% CI 1.14–3.11).

Conclusion The research showed that nutritional status was significantly associated with the presence of flat feet in schoolchildren. The high prevalence of flat foot and obesity in schoolchildren should be accepted as a warning sign, and many public health policies should be taken to solve these issues.

Keywords: children; flat feet; BMI; Vojvodina

САЖЕТАК

Увод/Циљ Циљ рада је био да се испита повезаност преваленције равних стопала са социо-демографским факторима и нутритивним статусом деце узраста 7–14 година у Војводини, Србија.

Метод Истраживање је спроведено као студија пресека. Као инструмент истраживања коришћен је анкетни упитник, а антропометријска мерења су вршена стандардизованим поступцима. Да би се утврдио утицај социо-демографских фактора и нутритивног статуса као независних променљивих на присуство равних стопала код школске деце, примењен је мултиваријативни модел логистичке регресије. Мултиваријатни модел прилагођен је старости, полу, типу насеља и материјалном статусу.

Резултати Овом студијом обухваћено је 1376 деце (685 дечака и 691 девојчица). Истраживањем је утврђена значајна разлика у учесталости равних стопала између деце са нормалном телесном масом, прекомерном телесном масом и гојазне деце ($p = 0,006$), при чему су гојазна деца имала највећу учесталост равних стопала. Деца са прекомерном телесном масом су имала 1,76 пута већу шансу да имају равна стопала од деце са нормалном телесном масом ($OR = 1,76$; 95% CI 1,08–2,88), док су гојазна деца имала 1,88 пута већу вероватноћу да имају равна стопала од деце са нормалном телесном масом ($OR = 1,88$; 95% CI 1,14–3,11).

Закључак Истраживање је показало да је код деце школског узраста нутритивни статус значајно повезан са присуством равних стопала. Високу преваленцију равних стопала и гојазности код школске деце треба схватити као знак упозорења, за чије је решавање потребно унапређење постојећих и креирање нових јавноздравствених програма.

Кључне речи: деца, равна стопала; *BMI*; Војводина

INTRODUCTION

The most important factors shaping a child's foot are the beginnings of locomotion and increasing loading of the lower extremities. The foot has two longitudinal (medial and lateral)

arches and transverse arch. Among the arches of the foot, the medial arch plays a significant role in shock absorption upon contact with the ground. It achieves this by transmitting the vertical load on the foot through deflection of the arch, thereby lessening the impact on the foot as it hits the ground. For patients with flat feet, however, this arch stretches out to an abnormal limit, flattening out completely on the ground during gait and resulting in a postural deformity of the foot. Lowering of the foot arch in children and development of static flat foot is the result of muscle weakness and deficiency in the locomotors apparatus [1]. Obesity is one of the leading causes of flat feet and, excessive weight is a factor distorting the foot shape in children. Extreme body weight significantly contributes to abnormal motor development, agility, and overall coordination of movements, and may consequently result in postural defects [2].

There are numerous studies corroborating harmful effect of increased body weight on foot loads and accompanying deformities [3, 4, 5]. As per Dowling et al. [6], while standing, the obese children created higher forces essentially over a larger foot area and experienced fundamentally higher plantar pressing factors contrasted with their nonobese counterparts. Likewise, while walking, the obese children produced higher forces altogether overall spaces of their feet, except the toes. The essentially lower plantar arch height found in the overweight and obese youngsters recommends that their flatter feet might be brought about by a bringing down of the medial longitudinal arch, most presumably brought about by their feet consistently bearing excess mass. Overweight and obesity can be associated with a generalized lack of foot functionality as a weight-bearing structure as a result of longitudinal medial arch collapse [5].

This study's objective was to identify and establish the prevalence of flat feet and its relationship with socio-demographic factors and nutritional status in schoolchildren aged 7–14 years from the Province of Vojvodina.

METHODS

The study was carried out on the schoolchildren population in the Province of Vojvodina, the northern part of Serbia, within the National study entitled “National Health Survey in Serbia” in 2013, conducted as a cross-sectional study on the representative population sample in the Republic of Serbia. The Ministry of Health of the Republic of Serbia allowed the use of

the National study database, therefore enabling the realization of this study. A specially created face-to-face questionnaire was used as a research instrument, and anthropometric measurements were done using standardized procedures.

Ethical standards applied in this study comply with the international standards (Helsinki Declaration - World Medical Association Declaration of Helsinki and Directive of the European Parliament on Protection of Individuals about the Processing of Personal Data (Directive 95/46/EC) and specific legislation in Serbia. All interviewed members of households signed informed consent, and parents signed for their children. The survey was conducted by trained interviewers whose work was supervised by licensed supervisors. The process of the data collection was standardized and performed by the methodological guidelines. Anthropometric measurements, including height and weight, were performed while the subjects were without shoes and in light clothing.

This study analyzed data on 1376 children aged 7–14 years, 685 boys (49.8%), and 691 girls (50.2%). Variables included socio-demographic characteristics (age, sex, type of settlement, material status (Wealth Index)), nutrition status, and foot deformities. According to the Wealth Index (Demographic and Health Survey Wealth Index), respondents were classified into three socio-economic groups or quintiles: rich (richer and the richest class), middle and poor class (poorest and poorer class) [7]. The children were divided into two age groups (7–10 years and 11–14 years). Body weight was measured to the nearest 0.1 kg using an electronic scale (Seca, Japan). Body height was measured to the nearest 0.1 cm using a stadiometer (Seca, Germany) as the child stood erect against a vertical wall. Body mass index (BMI) was calculated as the ratio of the body weight to the square of body height (kg/m^2) and was classified into four categories to assess nutritional status as underweight (< 5 th percentile), normal weight (≥ 5 th – < 85 th percentile), overweight (≥ 85 th – < 95 th percentile), and obese (≥ 95 th percentile) [8].

Statistical analysis was done using descriptive and inferential statistics. The results are given as mean \pm SD and proportion. Univariate and multivariate logistic regression analysis was used to assess the association of flat feet with nutritional status and socio-demographic factors. Selected socio-demographic factors and nutritional status among schoolchildren aged 7–14 years according to the prevalence of flat foot were first examined using chi-square tests and Student's t-test. Then to determine the impact of socio-demographic factors and nutritional

status as independent variables on the flat foot as a dependent variable multivariate logistic regression model was implemented. The dependent variable (flat foot) was transformed into dichotomous variables. The model was adjusted for age, gender, type of settlement, and material status. Data was weighted to be more representative of the Vojvodina population in 2013. We calculated the association through the odds ratio (OR) with 95% confidence intervals (95% CI). The probability, $p < 0.05$, was taken as the minimum level of significance. All the statistical analyses were performed with the SPSS, 21.0 statistical package (IBM Corp, New York).

RESULTS

A total of 1376 children, from 7 to 14 years old, had been voluntarily recruited in this study. Out of the total sample, 685 (49.8%) were boys, while 691 (50.2%) were girls. Participants were divided into two age groups, 7–10 years old ($n = 710$; 51.6%) and 11–14 years old ($n = 666$; 48.4%). The average age of children was 10.4 ± 2.3 years. The survey covered a larger number of children from urban areas (56.8%) than from other settlements (43.2%). The average weight recorded in this study equals 42.4 ± 15.0 kg in boys and 42.0 ± 14.1 kg in girls. The average BMI of boys was 58.6 ± 30.9 and of girls 58.2 ± 29.5 percentiles.

Most of the children in this study are with normal nutritional status (61.5%). Underweight is observed in 12.0% of children, while overweight and obesity appear in 14.3% and 12.2% of cases, respectively. The sample sizes for children by gender, age group, nutritional status, type of settlement, material status (Wealth Index), and flat foot prevalence are shown in Table 1.

The prevalence of obesity was higher in children age 7–10 years (14.4%) and boys (14.5%) than in children aged 11–14 years (9.5%) and girls (9.9%), while overweight was higher in children aged 11–14 years (15.1%) and girls (14.5%) as compared to children age 7–10 years (13.4%) and boys (14.2%). There are significant differences in the nutritional status regarding age groups ($\chi^2 = 13.943$; $p = 0.003$), but gender showed no significant relationship to nutritional status ($\chi^2 = 6.726$; $p = 0.081$).

Flat foot prevalence in the study population was 9.8% ($n = 134$), and the children with flat feet have significantly higher mean values of BMI compared to children without flat feet (65.9 vs. 57.6 percentiles; $t = 3.019$; $p = 0.003$). The prevalence of flat foot among boys (10.8%) was not significantly different than among girls (8.7%). Age was found to have a significant relationship to flat feet ($p = 0.049$), where 7–10 years old children (11.3%) were rated higher than 11–14 years old children (8.6%) in the flat foot category. Significant differences were observed ($p = 0.007$) in the frequency of flat feet between underweight (6.8%), normal weight (8.4%), overweight (13.4%), and obese groups (15.4%). The participants who were more overweight had flatter feet. The material status was found to have a significant relationship to flat feet ($p < 0.001$). Flat foot prevalence was highest (13.6%) among rich participants and lowest (5.0%) among the poor. The type of settlement showed no significant relationship to flat feet (Table 2).

In the multivariate logistic regression model, as a predictor of the flat foot was singled out nutritional status. Overweight children had a 1.76 times higher chance to have flat feet to those with normal weight (OR = 1.76; 95% CI [1.08–2.88]; $p = 0.023$), while obese children were 1.88 times more likely to have flat feet to those with normal weight (OR = 1.88; 95% CI [1.14–3.11]; $p = 0.014$) (Table 3).

DISCUSSION

This study presented a high prevalence of overweight (14.3%) and obesity (12.2%) in children 7–14 years old, with significant differences in the nutritional status regarding age groups (greater number of obese is present in younger age group), but without significant differences regarding gender. The high prevalence of obesity in schoolchildren in Vojvodina is still lower than the reported rate for 2014 from Vietnam (19.1%), but is very similar to the reported data from a Montenegro study in 2013 (10.3%), Mexican study in 2012 (14.6%), Iranian in 2011 (14.9%), and a Chinese study in 2014–2017 (11.7%) [9–13].

The results showed significant differences in the prevalence of flat feet, depending on some socio-demographic variables (age and material status) and nutritional status. Alsancak et al. [14] and Yin et al. [15] showed that three variables had a significant relationship with the

prevalence of flat foot: age, sex, and weight. Our study demonstrates that the prevalence of flat feet in schoolchildren is not influenced by gender, although the percentage distribution of flat feet was higher in boys (10.8%) than girls (8.7%). A few published studies also affirmed that the commonness of level flat feet in boys is marginally more than girls, yet without any significant statistical difference [16, 17, 18].

Opposite to our results, a study on 6.992 Poland children aged 8–12 years reported a significant positive correlation between gender and incidence of a flat foot, where flat feet were more in boys (6.2%) than girls (3.3%) [4]. Also, in a Taiwanese study [19] implemented on 5–13-year-old children, boys (35%) had a significantly higher frequency for flat feet than girls (20%). On the other hand, according to Sadeghi-Demneh et al. [20], the prevalence of flat feet (children aged 7–14 years) in girls (11.3%) is slightly more than boys (10.3%) but without any significant statistical difference.

Similar to the results of other studies [14, 16, 17], we also detected a decreasing trend in the prevalence of childhood flat feet with increasing age. Between younger (11.3%) and older (8.2%) schoolchildren, were found statistically significant differences in the prevalence of flat foot (the greater number is present in earlier grades). Studies carried out in Spain have reported different results, that no significant relationship was observed between the prevalence of flat foot and age in a population of 6–12-year-old students [21].

In our study, increasing weight status was also significantly associated with a higher prevalence of flat foot. The prevalence of flat foot was highest in the obese (15.4%) group and lowest in the underweight group (6.8%). Close to our findings, Sadeghi-Demneh et al. [20] reported a significantly highest prevalence of flat foot in the obese group (36.1%) and lowest in the normal weight group (7.9%) of children aged 7–14 years old from Iran. Essentially, Taiwanese examination in 1.024 children matured five to 13 years tracked down a huge expansion in the commonness of flat foot in overweight and obese children [19]. Several published studies in the same context showed similar findings [15, 22, 23]. As per Dowling et al. [6], obese children showed fundamentally lower footprint angles contrasted with their non-obese counterparts. They proposed that these underlying foot changes were related to contrasts in plantar pressures between obese and normal weight children.

Our research results indicate that overweight children had a 1.76 times higher chance to have flat feet than those with normal weight, while obese children were 1.88 times more likely to have flat feet than those with normal weight. It is lower than the findings that have been reported from an Ethiopian study in which children who were overweight or obese were found to be 3.77 and 4.16 times more likely to have flat feet than those underweight [23]. As per Suciati et al. [24], overweight/obese children were 4.5 times bound to have flat feet contrasted with those of normal weight.

CONCLUSION

The present study has indicated that the overall prevalence of obesity in the whole sample was 26.5%, of which 14.3% were overweight, and 12.2% were obese schoolchildren. Flat foot prevalence in the study population was 9.8%, and the children with flat feet have statistically significantly higher BMI values than children without flat feet. The children aged 7–10 years, obese, and children who belonged to the rich class have a significantly higher frequency for flat feet. The research showed that nutritional status was significantly associated with the presence of flat feet. The high prevalence of flat foot and obesity in schoolchildren should be accepted as a warning sign, and strategies that promote healthy weight and physical activity among children should be adequately developed and applied.

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Table 1. Socio-demographic characteristics, nutritional status, and flat foot prevalence of children age 7–14 years

Variable	Sex				Total	
	Male		Female		n	%
	n	%	n	%		
Age (years)						
7–10	352	51.4	358	51.8	710	51.6
11–14	333	48.6	333	48.2	666	48.4
Nutritional status						
Underweight	82	12.2	80	11.8	162	12
Normal weight	400	59.2	433	63.9	833	61.5
Overweight	96	14.2	98	14.5	194	14.3
Obese	98	14.5	67	9.9	165	12.2
Type of residence						
Urban	386	56.4	396	57.3	782	56.8
Rural	299	43.6	295	42.7	594	43.2
Material status						
Poor	256	37.4	230	33.3	486	35.3
Middle	152	22.2	138	20	290	21.1
Rich	277	40.4	323	46.7	600	43.6
Flat foot						
Yes	75	11	59	8.6	134	9.8
No	609	89	631	91.4	1240	90.2
Age (years), M ± SD	10.5 ± 2.3		10.3 ± 2.3		10.4 ± 2.3	
Height (cm), M ± SD	147.6 ± 15.6		146.9 ± 15.6		147.2 ± 15.6	
Weight (kg), M ± SD	42.4 ± 15		42.0 ± 14.1		42.2 ± 14.5	
BMI (percentiles), M ± SD	58.6 ± 30.9		58.2 ± 29.5		58.4 ± 30.2	

M ± SD – mean ± standard deviation

Table 2. Association between socio-demographic characteristics, nutritional status, and prevalence of flat foot of children age 7–14 years

Variable	Flat foot				p*
	Yes		No		
	n	%	n	%	
Sex					
Male	76	10.8	630	89.2	0.193
Female	58	8.7	610	91.3	
Age (years)					
7–10	78	11.3	611	88.7	0.049
11–14	56	8.2	629	91.8	
Nutritional status					
Underweight	11	6.8	150	93.2	
Normal weight	70	8.4	767	91.6	0.007
Overweight	26	13.4	168	86.6	
Obese	25	15.4	137	84.6	
Type of residence					
Urban	88	10.8	727	89.2	0.113
Rural	46	8.2	514	91.8	
Material status					
Poor	24	5.0	454	95.0	
Middle	28	9.6	264	90.4	< 0.001
Rich	82	13.6	522	86.4	

Data is presented in frequency and percentages;

* χ^2 test

Table 3. Odds ratios (OR) and 95% confidence intervals (CI) for the presence of flat feet depending on socio-demographic factors and nutritional status

Variables	Multivariate model*	
	OR (95% CI)	p*
Nutritional status		
Normal weight	1	
Overweight	1.76 (1.08–2.88)	0.023**
Obese	1.88 (1.14–3.11)	0.014**

*Model adjusted for sex, age, material status, type of residence; dependent variable: flat foot (ref. children with flat foot);

**p < 0.05