DOI: https://doi.org/10.2298/SARH210426091S
UDC: 617.586-007.2-084-053.2:613.25; 613.25-053.2

ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Association between flat foot prevalence and nutritional status in schoolchildren

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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, sex, 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 obesity (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 flat feet 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 flat feet 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 feet and obesity in schoolchildren should be accepted as a warning sign, and many public health policies should be undertaken to solve these issues.

Keywords: children; flat feet; BMI; Vojvodina

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, 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, obese children produced higher forces altogether over all 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, Serbia.

Received • Примљено: April 26, 2021
Revised • Ревизија: November 2, 2021
Accepted • Прихваћено: November 4, 2021
Online first: November 8, 2021

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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 of 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 the Directive of the European Parliament on the protection of individuals with regard to the processing of personal data and on the free movement of such data (Directive 95/46/EC)] and specific legislation in Serbia. All interviewed members of households signed an informed consent, and parents/guardians 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 the 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), the respondents were classified into three socioeconomic 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, Chiba, Japan). Body height was measured to the nearest 0.1 cm using a stadiometer (Seca GmbH & Co. KG, Hamburg, 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 (< 5th percentile), normal weight (≥ 5th – < 85th percentile), overweight (≥ 85th – < 95th percentile), and obese (≥ 95th percentile) [8].

Statistical analysis was done using descriptive and inferential statistics. The results are given as mean ± 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 χ^2 tests and the Student's t-test. Then, to determine the impact of socio-demographic factors and nutritional status as independent variables on flat foot as a dependent variable, a multivariate logistic regression model was implemented. The dependent variable (flat foot) was transformed into dichotomous variables. The model was adjusted for age, sex, type of settlement, and material status. The 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 of $p < 0.05$ was taken as the minimum level of significance. All the statistical analyses were performed using IBM SPSS Statistics, Version 21.0 (IBM Corp., Armonk, NY, USA).

Table 1. Socio-demographic characteristics, nutritional status, and flat foot prevalence of children aged 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

RESULTS

A total of 1376 children, 7–14 years old, were voluntarily recruited into this study. Out of the total sample, 685 (49.8%) were boys, while 691 (50.2%) were girls. The 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 the children was 10.4 ± 2.3 years. The survey covered a larger number of children from the urban (56.8%) than from the rural areas (43.2%). The average weight recorded in this study amounted to 42.4 ± 15 kg in the boys and 42 ± 14.1 kg in the girls. The average BMI of the boys was 58.6 ± 30.9 percentiles and that of the girls was 58.2 ± 29.5 percentiles.

Most of the children in this study were with normal nutritional status (61.5%). Underweight was observed in 12% of the children, while overweight and obesity appeared in

14.3% and 12.2% of the cases, respectively. The sample sizes for children by sex, 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 aged 7–10 years (14.4%) and in 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 sex showed no significant relationship to the 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 had 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 feet 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 (8.2%) 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 the highest (13.6%) among rich participants and the lowest (5%) among the poor. The type of settlement showed no significant relationship to flat feet (Table 2).

Table 2. Association between socio-demographic characteristics, nutritional status, and prevalence of flat foot of children aged 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	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^2test

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

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

Nutritional status	Multivariate model*	
	OR (95% CI)	p*
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);
**$p < 0.05$

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 sex. The high prevalence of obesity in schoolchildren in Vojvodina is still lower than the reported rate from Vietnam for 2014 (19.1%), but is very similar to the reported data from a Montenegro study from 2013 (10.3%), Mexican study from 2012 (14.6%), Iranian study from 2011 (14.9%), and a Chinese study from 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 sex, although the percentage distribution of flat feet was higher in boys (10.8%) than in girls (8.7%). A few published studies also affirmed that the percentage distribution of flat feet in boys is marginally greater than that in girls, yet without any significant statistical difference [16, 17, 18].

Opposite to our results, a study on 6992 children in Poland aged 8–12 years reported a significant positive correlation between sex and incidence of flat feet, where flat feet were more frequent in boys (6.2%) than in girls (3.3%) [4]. Also, in a Taiwanese study implemented on 5–13-year-old children, boys (35%) had significantly higher frequency of flat feet than girls (20%) [19]. 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 greater than that in boys (10.3%) but without any statistically significant difference.

Similar to the results of other studies, we also detected a decreasing trend in the prevalence of childhood flat feet with increasing age [14, 16, 17]. Statistically significant differences in the prevalence of flat feet (greater number is present in earlier grades) were found between younger (11.3%) and older (8.2%) schoolchildren. Studies carried out in Spain reported different results – that no significant relationship was observed between the prevalence of flat foot and the 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 the highest in the obese (15.4%) group and the lowest in the underweight group (6.8%). Close to our findings, Sadeghi-Demneh et al. [20] reported the significantly highest prevalence of flat foot in the obese group (36.1%) and the lowest in the normal weight group (7.9%) of children aged 7–14 years from Iran. Essentially, Taiwanese examination of 1024 children 5–13 years old 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. These numbers are lower than those from the findings reported in 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 found to be 4.5 times more likely to have flat feet than those of normal weight.

CONCLUSION

The present study indicates 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. Children aged 7–10 years, obese, and children who belonged to the rich class have a significantly higher frequency of 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.

ACKNOWLEDGEMENT

This study is a part of the 2013 National Health Survey for the population of Serbia (excluding the Province of Kosovo and Metohija) carried out by the Ministry of Health of the Republic of Serbia with the professional support of the Dr. Milan Jovanović Batut Institute of Public Health of Serbia.

Conflict of interest: None declared.

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Повезаност преваленције равних стопала и нутритивног статуса код школске деце

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САЖЕТАК

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

Методе 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 социодемографских фактора и нутритивног статуса као независних променљивих на присуство равних стопала код школске деце, примењен је мултиваријантни модел логистичке регресије. Мултиваријантни 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