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Exploring anthropometric characteristics, weight status, and posture among preschool children in Serbia

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Abstract

The aim of this cross-sectional study was to determine the anthropometric characteristics, weight status, and posture of 6- and 7-year-old preschool-aged children. The sample of 922 children was divided by gender and age (monthly quartiles). Anthropometric characteristics were assessed using a battery of three variables: body height (BH), body mass (BM), and body mass index (BMI). BMI was categorized based on the World Health Organization (WHO) cutoff values, determining the degree of children's weight status. Postural status was assessed by evaluating the following postural parameters: foot status, scoliosis, and dropped shoulders. Independent samples t-test showed no differences in anthropometric characteristics between boys and girls. According to ANOVA test, all three older groups (III, IV, and V) had significantly higher values in body height than the first two younger groups. In terms of body mass, IV and V groups had higher values than group I, and V had higher values than group II. Normal-weight children constituted 73.5%, while 14.4% were overweight and 8.8% were obese. Chi-square test revealed no difference in the degree of weight status by gender. Regarding postural status, 24.1% of children had scoliosis, 75.4% had abnormal foot status, and 59.8% had dropped shoulders. Chi-square test showed no difference between gender and postural deviations, except for foot status where boys significantly had more deviations than girls. This study contributed to diagnosing the anthropometric characteristics and posture of children and can be considered significant as the first study in this part of Serbia, serving as a starting point for future practical and research steps.

Keywords: *morphological characteristics, BMI status, postural status, prevalence of obesity, preschoolers*

Introduction

Preschool age is considered a key phase in the holistic development of an individual (Bala, 2002). Children's participation in society is of exceptional importance, and monitoring their developmental process is crucial for analyzing health trends and formulating strategies (Sofi & Senthilvelan, 2021).

Children today engage in limited physical activity and spend most of their day sitting with screens (Colley et al., 2013). When inadequate physical activity (hypokinesia) and inadequate nutrition are added to this, all conditions leading to obesity are fulfilled (Mendonça & Anjos, 2004). Obesity is highly prevalent among children and is currently considered one of the most common public health problems (Kišić-Tepavčević et al., 2008; Kumar & Kaufman, 2018). The World Health Organization (WHO) highlights a significant increase in the proportion of obese children worldwide, from 4% in 1975 to over 18% in 2016 (World Health Organization, 2021). According to a recent comprehensive study by Spineli et al. (2021), 28.7% of boys and 26.5% of girls are overweight.

Today, the negative impacts of obesity on health are well-doc-

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umented, with particular emphasis on type 2 diabetes, asthma, hypertension, early atherosclerosis, as well as psychosocial and other health problems (Dikanović & Vignjević, 2009). With the aim of preventing and reducing the prevalence of obesity, especially in children, numerous health institutions have been involved in proposing guidelines on protocols for physical activity, nutrition, and sedentary behavior (Guan et al., 2020; WHO, 2021). It is not surprising, therefore, that an increasing number of studies are focusing on the anthropometric characteristics and prevalence of obesity in children (Cadenas Sánchez et al., 2015; Bjelica et al., 2021; Sofi & Senthilvelan, 2021; Katanic et al., 2023b).

In addition to optimal body composition, monitoring posture in children is exceptionally important as part of proper physical development (Pasichnyk et al., 2018). Recent studies suggest a consistent rise in the prevalence of spinal column postural deviations (Radaković et al., 2017; Vukićević, Čokorilo, Lukić, Miličković & Bjelica, 2018). Notably, foot abnormalities are detected in up to 60% of children (Romanov, Stupar, Međedović, & Brkin, 2014), while deviations from optimal spinal posture in both frontal and sagittal planes affect approximately 70% of participants, with boys exhibiting scoliotic posture more frequently (Romanov et al., 2014).

Although there are certain studies on this topic, there is no study that has comprehensively covered the detailed anthropometric, weight, and postural status of preschool children in Serbia. In this regard, the aim of this cross-sectional study was to determine the anthropometric characteristics, weight status, and posture of 6- and 7-year-old preschool-aged children in the territory of the municipality of Čačak. Secondary objectives included examining gender and age differences among children in these parameters. This study will contribute to the diagnosis of physical development in preschool-aged children and determine the level of weight and postural status, thus filling gaps in the literature, particularly related to this area.

Methods

Participants

This cross-sectional study included children aged 6-7 from the municipality of Čačak, Serbia. The sample consisted of a total of 922 children (452 boys and 470 girls) from the preschool institution. Criteria for inclusion in the study implied that the participants should be healthy children, of both genders, aged 6 and 7 years. The sample was divided by gender and age. Age groups were created according to monthly quartiles (Table 1). Students participated voluntarily with parental consent, adhering to the ethical principles outlined in the Helsinki Declaration.

Table 1. Characteristics of sample population (n-922)

Gender (number, %)	
Boys	452 (49.02%)
Girls	470 (50.98%)
Aged (number, %)	
6.0-6.3	103 (11.17%)
6.4-6.6	252 (27.33%)
6.7-6.9	265 (28.74%)
6.10-7.0	233 (25.27%)
7.1-7.4	69 (7.48%)

Measurements

Anthropometric and weight parameters

The standard international biological procedure was used to determine morphological characteristics (Eston & Reilly, 2013). Anthropometric characteristics were assessed using a battery of three variables: body height (BH), and body weight (BW). Body mass index (BMI) was calculated based on the standard formula: BMI = BM (kg)/BH (m)2 (BM - body mass, BH - body height). BMI was categorized based on the World Health Organisation's (WHO) cut-offs to underweight, normal weight, overweight and obese individuals (Onis et al., 2007). The body mass index has a high correlation with the amount of body fat and for these reasons is used as an indicator of weight status in children (Wilmore, Costill, & Kenney, 2008).

Body posture parameters

The postural status was assessed by a specialist in physical medicine using a visual method of Napoleon Volanski (Vukićević, Čokorilo, Lukić, Miličković, & Bjelica, 2018; Aleksić Veljković, Peulić, Katanić, & Jovanović, 2023). The physiatrist holds a certificate and years of experience in assessing postural deviations using the given method, which is utilized as part of the systematic examination of children before starting school in the Republic of Serbia. During the postural examination, the physiatrist assessed the following postural parameters: foot status, scoliosis, and shoulder droop syndrome.

Statistics

Basic parameters of descriptive statistics were calculated: arithmetic mean, standard deviation, minimum, maximum, and percentages. Sex differences in anthropometric characteristics were calculated using independent samples t-tests, while differences between age groups were calculated using ANOVA and post-hoc tests. The Chi-square ($\chi 2$) test was used to determine the association between weight and postural status according to the gender. For all statistical analyses, significance was accepted at $p<0.05$. Data processing was performed using the statistical program SPSS 26 (Statistical Package for Social Sciences, v26.0, SPSS Inc., Chicago, IL, USA) and Microsoft Excel (version 13 of Microsoft Corporation, Redmond, WA, USA).

Results

Based on descriptive statistics (Table 2), it was determined that preschool boys had an average body height of 124.64±5.38 cm, body weight of 25.24±4.78 kg, and BMI of 16.09±2.24, while children from rural areas had an average body height of 124.02±5.57 cm, body weight of 24.79±5.01 kg, and BMI of 15.97±2.28.

Table 3 presents the descriptive anthropometric parameters according to age groups. A noticeable linear increase in both body height and weight values is observed among the groups.

Table 2. Descriptive statistics of anthropometric parameters in preschool children

		N	Mean	SD	Min	Max	Range
Boys	Age	452	6.63	0.27	6.00	7.42	1.42
	Body height	452	124.64	5.38	110.00	142.00	32.00
	Body weight	452	25.24	4.78	15.50	51.50	36.00
	BMI	452	16.09	2.24	11.52	28.80	17.28
Girls	Age	470	6.66	0.29	6.00	7.42	1.42
	Body height	470	124.02	5.57	104.50	144.00	39.50
	Body weight	470	24.79	5.01	15.50	47.00	31.50
	BMI	470	15.97	2.28	11.10	26.57	15.47
Total	Age	922	6.65	0.28	6.00	7.42	1.42
	Body height	922	124.32	5.48	104.50	144.00	39.50
	Body weight	922	25.01	4.90	15.50	51.50	36.00
	BMI	922	16.03	2.26	11.10	28.80	17.70

Table 3. Descriptive statistics of anthropometric parameters in children according to the age groups

		N	Mean	SD	Min	Max	Range
6.0-6.3 (Group I)	Age	103	6.21	0.08	6.00	6.50	0.50
	Body height	103	121.60	4.53	112.50	133.00	20.50
	Body weight	103	23.99	3.73	17.00	35.00	18.00
	BMI	103	16.15	1.94	12.53	22.00	9.47
6.4-6.6 (Group II)	Age	252	6.43	0.10	6.17	7.25	1.08
	Body height	252	123.20	5.39	104.50	138.50	34.00
	Body weight	252	24.21	4.78	15.50	48.00	32.50
	BMI	252	15.83	2.24	11.52	25.20	13.68
6.7-6.9 (Group III)	Age	265	6.66	0.08	6.00	6.83	0.83
	Body height	265	124.56	5.33	112.00	140.00	28.00
	Body weight	265	25.27	4.94	16.50	51.50	35.00
	BMI	265	16.11	2.26	12.40	26.00	13.60
6.10-7.0 (Group IV)	Age	233	6.91	0.08	6.25	7.00	0.75
	Body height	233	125.55	5.07	110.50	140.50	30.00
	Body weight	233	25.59	4.93	16.00	47.00	31.00
	BMI	233	16.08	2.36	11.10	28.80	17.70
7.1-7.4 (Group V)	Age	69	7.14	0.12	6.58	7.42	0.84
	Body height	69	127.45	0.33	112.50	144.00	31.50
	Body weight	69	26.55	5.88	19.00	46.50	27.50
	BMI	69	16.07	2.44	12.20	24.70	12.50

Table 4. Sex differences in anthropometric characteristics (t-test)

	Boys	Girls	t	p
Age	6.63±0.27	6.66±0.29	-1.167	0.244
Body height	124.64±5.38	124.02±5.57	1.706	0.088
Body weight	25.24±4.78	24.79±5.01	1.379	0.168
BMI	16.09±2.24	15.97±2.28	0.788	0.431

Based on an independent samples t-test (Table 4), it was determined that there are no significant differences between the groups of boys and girls in any anthropometric parameter.

Based on ANOVA analysis (table 5), differences were observed among the groups regarding age categories in body height ($p<0.0001$) and body weight ($p<0.0001$). However, there were no differences among the groups in BMI. By applying post-hoc tests, it was determined that Group III, IV, and V significantly exceeded Group I and II, as well as Group V exceeded Group III in terms of body height. The same test showed that concerning body weight, Groups IV and V achieved higher values than Groups I and II.

Table 5. Differences in anthropometric characteristics across age categories (ANOVA)

	6-6.3	6.4-6.6	6.7-6.9	6.10-7	7.1-7.4	p	Post-hoc
Age	6.21±0.08	6.43±0.10	6.66±0.08	6.91±0.08	7.14±0.12	-	-
Body height	121.60±4.53	123.20±5.39	124.56±5.33	125.55±5.07	127.45±6.33	<0.0001*	III>I IV>I V>I III>II IV>II V>II V>III
Body weight	23.99±3.73	24.21±4.78	25.27±4.94	25.59±4.93	26.55±5.88	<0.0001*	IV>I V>I IV>II V>II
BMI	16.15±1.94	15.83±2.24	16.11±2.26	16.08±2.36	16.07±2.44	0.593	/

Figure 1 shows the prevalence of obesity among boys and girls. Among boys, 73.5% are normal weight, 14.6% are overweight, and 9.3% are obese, while only 2.7% are underweight. A similar distribution is observed among girls, with 73.2% being normal weight, 14.3% overweight, and 8.3% obese, while 4.3% are underweight. It should be noted that based on the Chi-square test, there is no association between the degree of nourishment and gender.

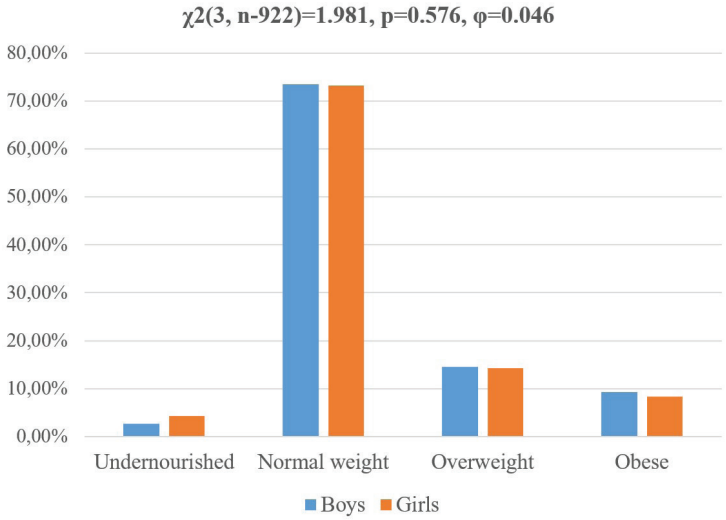

FIGURE 1. The association between the weight status and the gender in children

Table 6. Association between scoliosis and gender in children

	No deviation	Has deviation	Total
Boys	341 75.4%	111 24.6%	452 100%
Girls	359 76.4%	111 23.6%	470 100%
Total	700 75.9%	222 24.1%	922 100%
χ^2(1, n-922)=0.066, p=0.797, φ=-0.011			

When it comes to deviations, Table 6 shows a similar distribution of scoliosis among boys and girls (24.6% and 23.6%, respectively). Additionally, the same table indicates that there is no association between scoliosis and gender.

Table 7 indicates that as many as 82.1% of boys have foot deviations, while the number is lower among girls (68.9%). The chi-square test confirmed an association between foot status and gender (p<0.0001), indicating differences between genders in foot status.

Dropped shoulder is present in 61.9% of boys and slightly fewer (57.7%) girls (Table 8). From the table, it can be seen that there is no association between the prevalence of dropped shoulder deviation and gender.

Table 7. Association between foot status and gender in children

	No deviation	Has deviation	Total
Boys	81 17.9%	371 82.1%	452 100%
Girls	146 31.1%	324 68.9%	470 100%
Total	227 24.6%	695 75.4%	922 100%
χ^2(1, n-922)=20.745, p<0.0001, φ=-0.153			

Table 8. The association between dropped shoulders and gender in children

	No deviation	Has deviation	Total
Boys	172 38.1%	280 61.9%	452 100%
Girls	199 42.3%	271 57.7%	470 100%
Total	371 40.2%	551 59.8%	922 100%
$\chi^2(1, n\text{-}922)=1.587, p=0.208, \varphi=-0.044$			

Discussion

The aim of this cross-sectional study was to determine the anthropometric characteristics, weight status, and posture of 6- and 7-year-old preschool-aged children. Secondary objectives included examining gender and age differences among children in these parameters. This study had several significant findings. The prevalence of weight status was established, with 73.5% of boys being normal weight, 14.6% overweight, and 9.3% obese, while only 2.7% were underweight. A similar distribution was observed among girls, with 73.2% being normal weight, 14.3% overweight, and 8.3% obese, while 4.3% were underweight. It should be noted that there is no association between weight status and gender. Additionally, there were no differences in anthropometric characteristics between genders. Regarding differences in age categories, differences were found in body height and body weight. However, there were no differences among the groups in BMI. When it comes to deviations, almost every fourth child has scoliosis, while as many as 60% of children have dropped shoulders. There is no association between these deviations and gender. The only difference between genders was observed in foot deviation, with this deviation being more common in boys (82%) compared to girls (69%).

Our results indicate that every fourth child is overweight. Compared to previous research, there are variations in data regarding different European countries. For example, some countries have a similar percentage of childhood obesity (26-31%) as observed in Montenegro (Katanic et al., 2021; Katanic et al., 2023b), while a slightly higher percentage of obesity compared to our study was noted in Greece (33%) and Italy (36%), and in some countries a lower percentage compared to our results, such as 13% in Finland, and 16% obese in the Czech Republic (Cali & Caprio, 2008).

We are witnessing a constant increase in the prevalence of obesity worldwide over the last 2-3 decades (Lobstein & Frelut, 2003; World Health Organization, 2021). There are numerous potential reasons for childhood obesity, with sedentary lifestyle, insufficient physical activity (PA), and improper nutrition being considered the main contributors (Mendonca et al., 2024). In any case, it is essential to detect and treat obesity in childhood promptly to prevent later consequences.

When it comes to postural deviations, similar findings have been obtained in other studies. For example, in one study conducted in Novi Sad, 71.5% of girls of the same age had foot deviations (Mihajlović, Smajić, & Sente, 2010), while in another study in the same area, this percentage was slightly lower - 60% (Romanov, Stupar, Međedović, & Brkin, 2014). Regarding scoliosis, one study showed that a significantly smaller number of children had scoliosis compared to our results (Simov, Minić, & Stojanović 2011). In contrast, another study found a much higher percentage of children with scoliosis (Vukićević et al., 2018). However, these results should be interpreted with caution due to differences in measurement methodology.

It should also be noted that numerous studies have shown that obese children engage in less physical activity (Elmesmari, Martin, Reilly, & Paton, 2018), have poorer motor skills (Barnett et al., 2016; Banjević et al., 2022), and more frequently have postural problems (Shapouri et al., 2019) compared to normal-weight children. This is why the World Health Organization adopted the Global Strategy on Diet, Physical Activity, and Health to support health and proper physical and motor development (WHO, 2021). Monitoring body weight and postural status in early childhood may be the first step in preventing obesity, reducing health risks, and addressing posture problems (Noorwali, Aljaadi, & Al-Otaibi, 2023). Furthermore, it is important for each country to conduct national surveys and implement strategies in line with WHO guidelines to address the global problem of childhood obesity, as these factors play an important role in assessing quality of life and future health (Pokos, Lauš, & Badrov, 2014).

These results indicate the need to influence policies to promote physical activity and healthy lifestyles in children, which implies that we all need to get involved and take necessary steps. It is also crucial to highlight the role of the family, particularly the key role of parents, especially considering that parental physical inactivity strongly influences children's inactivity which leads to impaired physical development (Sothern, 2004). Therefore, it is important to urge parents to set an example by being physically more active themselves to encourage children to adopt a more active lifestyle (Katanic et al., 2023a). Certainly, these results can be helpful for healthcare workers and experts dealing with the problem of obesity and physical development in general. In line with the authors' plea (Bubanja, Katanic, & Bjelica, 2023), it is necessary to promptly identify the current situation and refer obese children for urgent intervention, not only in terms of treatment but also with a strong emphasis on prevention.

The main strength of this study lies in the fact that a large sample of participants was provided from the population of preschool-aged children, aged 6 and 7 years, making the results highly generalizable. Additionally, the strength of the study is reflected in the detailed analysis by gender and age categories, and primarily in the fact that this is the first study of weight and postural status in this part of Serbia.

Despite the significance of this study, like any research, it has certain limitations. The primary limitation of this study concerns the assessment of postural status using the Volansky method, therefore future research should consider incorporating modern measuring instruments for posture assessment. Additionally, a broader system of variables should be included for examining anthropometric status.

Conclusion

In this study, it was found that almost every fourth child is overweight. The highest prevalence of foot deviations and dropped shoulders in children is 60-80%, while every fourth child has scoliosis. There was no association between weight status and gender, and no difference in anthropometric characteristics between genders. The only association between body deviations and

gender was found in the prevalence of foot deviations, while there was no association between other deviations and gender.

The practical significance of this research lies in diagnosing the current weight and postural status of preschool-aged children and taking subsequent steps in the prevention and treatment of obesity and postural deviations in children. This information can be useful for physical education teachers and physiotherapists in assessing the current physical condition of children and creating appropriate exercise protocols aimed at reducing the percentage of obesity and improving the postural status of children. Further research is also necessary to gain a more comprehensive understanding of children's physical development through a thorough analysis of anthropometric and postural parameters.

Conflict of Interest

The author declares that there is no conflict of interest.

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