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Body Mass Index and Triceps Skinfold Thickness in Prepubertal Children in Slovenia

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A B S T R A C T

The main aim of this study was to analyze overweight and obesity in children on the basis of body mass index (BMI) and triceps skinfold thickness (TSF). The sample included 5,613 children, aged 6 to12 years (X=9.23; SD=1.69) from Slovenia. Children were classified as non-overweight, overweight and obese according to age and sex specific BMI cut-off points. The results show that 18.3% of boys and 18.5% of girls are overweight and 6.5% of boys and 6.7% of girls are obese. The correlation between BMI and TSF in boys (r=0.785) and girls (r=0.783) are almost equal. Body weight has a lower correlation with TSF in boys (r=0.691) and in girls (r=0.631). The χ^2 test show that there is a significant difference ($p<0.001$) in TSF according to weight status. The results show that TSF and weight status of prepubertal children are closely related and that the criterion for the determination of weight status on the basis of BMI is well defined.

Key words: *obesity, overweight, triceps skinfold thickness, weight status, children*

Introduction

The worldwide epidemic of overweight and obesity in children represents a remarkable health problem[1,2]. In Europe, the prevalence of overweight and obese children varies considerably depending on the country: Latvia 2–3%, Slovakia 10%, the Netherlands 14%, Germany 16%, Denmark 18%, Sweden 18%, France 18%, Poland 19%, Spain 30%, Greece 31%, Malta 35% and Italy 36% [3,4].

Most children who are overweight or obese seem completely healthy. But numerous studies report that adverse levels of cardiovascular disease risk factors, such as total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides, fasting insulin, systolic blood pressure are associated with obesity in children[5,6]. Furthermore, psycho-social problems, especially low self-concept, lower self-esteem and social stigmatization are also more often in obese children[7].

Overweight and obesity are mostly estimated by using Quetelet's body mass index (BMI), especially in epidemiological studies[8,9]. Although there is a close correlation between the amount of body fat and BMI, it is not possible to make an exact prediction of the amount of body fat on the basis of BMI, because a higher BMI can be the result of a higher proportion of fat mass or muscle mass[10].

A good indicator of the amount of body fat is skinfold thickness[11], which shows the peripheral distribution of subcutaneous fat[12]. The distribution of body fat is quite disproportionate and depends on the age, sex and the amount of body mass[10]. In childhood and adolescence, girls' skinfold is a little thicker than that of the boys[13,14]. In girls, the skinfold thickness of the body and extremities increases evenly throughout the childhood to the end of puberty, whereas in boys, the skinfold thickness of extremities increases only to the age of 12, and the skinfold thickness of the body to the age of 13, and then they gradually decrease to the age of 18[15]. In childhood, the thickness of subcutaneous fat in the body is lower by half compared to the thickness of subcutaneous fat in the extremities[9]. Bandini, Vu, Must, et al.[16] observe that the triceps skinfold (TSF) predicts the amount of body fat in 68%, whereas BMI predicts it in 38%. TSF is closely associated with the overall quantity of body fat[17]. BMI and the sum of skinfolds are very similar criteria for determining obesity, as they correspond in 92% [18].

The first National Health and Nutrition Survey (NHANES I) stated that in the population of children and adults aged from 6 to 74, the Pearson correlations between BMI and TSF ranged from 0.6 to 0.9 and that there were no systematic differences in the correlation

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according to age[19]. Similar Pearson correlations between TSF and BMI, 0.76 in men and 0.64 in women, were found by Wang, Ho and Sabry[20]. Trudeau, et al.[12] reported that BMI and the sum of four skinfolds are closely related, as the correlation coefficient in men is 0.65, and in women 0.64. Zimmerman, Gubeli, Puntener, et al.[21] found that BMI and the proportion of body fat estimated on the basis of skinfolds are correlated both in boys and girls (r^2=0.74). A similarly close relation (r^2=0.61 to 0.75) between BMI and the percentage of body fat evaluated on the basis of skinfolds was also found by Eisenmann, Heelan and Welk[22]. A high correlation (r^2=0.85 to 0.90) between the percentage of body fat and BMI in children and adolescents was found by Freedman, Thornton, Mei et al.[23], who also found that there is a similar correlation between BMI and body weight, however, the closeness of the correlations decreases with age.

Body composition can be measured by a variety of methods. Eissenmann, Heelan and Welk[22] suggest that bioelectrical impedance analysis (BIA) has limited utility in estimating body composition, energy x-ray (DXA) is limited because of availability and cost, whereas BMI and skinfolds seem to be more useful in estimating body composition during adiposity rebound. Skinfolds offer good feasibility and cost and reasonable accuracy[24]. All methods significantly underestimated body fatness as determined by DXA[22].

Because of their great effects on health, overweight and obesity occurring in children have to be treated seriously. In Slovenia, there has been no comprehensive analysis of the overweight and obesity of children up to date. Therefore the main purpose of the study was to analyze prevalence of overweight and obesity in children on the basis of BMI, and to analyze relations between BMI and TSF. The study also ascertains the differences in weight status according to gender, age and school environment.

Materials and Methods

Subjects. The study was carried out on a random group sample of children from Slovenia in 2006. The study included 5,613 children from the first to the sixth class of primary school, 2,601 of children were from city schools and 3,012 from rural schools. There were 2,841 boys and 2,772 girls, aged 6 to12 years (X=9.23; SD=1.69). Children and their parents agreed to participate in this research. Written consent was obtained from the children's parents.

Measurements. For measuring body height Martin's anthropometer was used, with the accuracy of 0.1 cm, for measuring weight SECA scale was used (to 0.1 kg; SECA, Birmingham, United Kingdom). On the basis of obtained measures BMI was calculated. Left TSF was measured in duplicate with a Lange skinfold caliper by standard procedure[25] and the mean of two recordings was used in analyses.

Criterion for definition of overweight and obesity. Weight status was defined using BMI in kilograms per square meters (kg/m^2). Children were classified as non-overweight, overweight and obese according to age and sex specific BMI cut-off points as proposed by Cole, Bellizzi, Flegal, et al.[26]. On that study the centile curves were drown that at age 18 years passed through the cut-off points of 25 kg/m^2 and 30 kg/m^2 for adults overweight and obese.

Statistics. SPSS 12.0 was used for statistical analysis. Descriptive statistics was computed for all variables (height, weight, BMI, TSF). χ^2 test was used to analyze differences between weight status, gender, age and school environment. Pearson's correlations coefficients were computed to identify relationship among height, weight, BMI and skinfold thickness. Statistical significance was set at an á level of 0.05.

Results

Table 1 shows the descriptive statistics for body height, body weight, BMI and TSF. The height increases from the first to the sixth class, the yearly increase of height in boys is between 5 and 7 cm, whereas in girls it is more gradual at about 6 cm. The weight of boys increases by approximately 4 kg a year, whereas in girls it is slightly less gradual and ranges from 3 to 5 kg a year. BMI also increases gradually from the first to the sixth class. Skinfold thickness in boys gradually increases from the first class (X=10.19) to the fifth class (X=12. 81), and is followed by a considerable increase in the sixth class (X=14.20). In girls, skinfold thickness gradually increases from the first class (X=11. 82) to the fourth class (X=14.35), and then it gradually starts to decrease.

Table 2 shows the results of the χ^2 test of the differences between the sexes, school environment and school class in relation to the weight status. The sample comprised 18.3% of overweight boys and 18.5% of girls, and 6.5% of obese boys and 6.7% of obese girls. The results show that there are no significant differences between boys and girls (p=0.930). The χ^2 test shows that there are no statistically significant differences in the weight status between children from urban schools and those from rural schools (p=0.775). Significant difference exist only between classes (p<0.001). The share of non-overweight children is highest in the first class (80.1%), and lowest (71.6%) in the fifth class. Conversely, the share of overweight children is lowest in the first class (14.5%) and highest in the fifth class (21.2%). The situation is slightly different with obese children, the proportion of whom is the lowest in the sixth class (4.6%) and the highest in the third class (8.0%).

Table 3 shows Pearson's correlation coefficients for height, weight, body mass index and TSF, separately for boys and girls. All the coefficients are at the level of statistical significance p<0.01. Height has the highest correlation with weight, in girls it is slightly higher (r=0.805) than in boys (r=0.795). Weight has the highest correlation with BMI, which is r=0.862 in boys and r=0.866 in girls. BMI has a slightly lower but still high correlation with TSF, which is almost equal in boys

TABLE 1
DESCRIPTIVE STATISTICS OF BODY HEIGHT, BODY WEIGHT, BMI AND TSF

Class	Gender	Age (years)		Height (cm)		Weight (kg)		BMI (kg/m²)		TSF (mm)	
		X	SD	X	SD	X	SD	X	SD	X	SD
1. Class (n=951)	Boys	6.82	0.38	123.59	5.29	25.02	4.63	16.32	2.50	10.19	4.8
	Girls	6.84	0.35	123.76	5.49	24.64	4.47	16.03	2.28	11.82	4.34
2. Class (n=1026)	Boys	7.82	0.37	130.31	5.96	29.57	6.41	17.29	2.77	11.77	5.34
	Girls	7.85	0.35	129.27	5.95	28.38	6.63	16.83	2.83	12.65	5.25
3. Class (n=965)	Boys	8.86	0.34	135.56	6.54	32.84	7.18	17.74	2.90	12.11	5.06
	Girls	8.88	0.32	135.62	6.72	33.10	7.77	17.87	3.31	13.93	6.01
4. Class (n=1097)	Boys	9.89	0.30	141.55	7.05	36.48	8.65	18.05	3.21	12.87	6.40
	Girls	9.87	0.32	141.62	7.71	36.45	8.68	18.03	3.32	14.35	6.79
5. Class (n=944)	Boys	10.95	0.20	146.05	6.66	40.24	9.27	18.73	3.46	12.81	6.14
	Girls	10.96	0.19	147.05	7.66	41.85	10.53	19.17	3.77	14.24	5.91
6. Class (n=630)	Boys	11.89	0.30	151.93	6.39	45.28	10.56	19.49	3.72	14.20	6.62
	Girls	11.91	0.27	152.89	6.72	45.15	10.23	19.18	3.53	13.97	5.88

BMI – body mass index, TSF – triceps skinfold thickness

TABLE 2
PREVALENCE OF NON-OVERWEIGHT, OVERWEIGHT AND OBESITY ACCORDING TO GENDER, SCHOOL ENVIRONMENT, AND CLASS

Variables		Non-overweight		Overweight		Obesity		p
		n	n%	n	n%	n	n%	
Gender	Boys (n=2,841)	2,136	75.2	520	18.3	185	6.5	0.930
	Girls (n=2,772)	2,073	74.8	513	18.5	186	6.7	
School	Urban (n=2,601)	1,957	75.2	469	18.0	175	6.7	0.775
	Rural (n=3,012)	2,252	74.8	564	18.7	196	6.5	
Class	1. Class (n=951)	762	80.1	138	14.5	51	5.4	0.001
	2. Class (n=1,026)	762	74.3	185	18.0	79	7.7	
	3. Class (n=965)	702	72.7	186	19.3	77	8.0	
	4. Class (n=1,097)	839	76.5	192	17.5	66	6.0	
	5. Class (n=944)	676	71.6	200	21.2	68	7.2	
	6. Class (n=630)	468	74.3	132	21.0	30	4.8	

(r=0.785) and girls (r=0.783). The correlations between weight and skinfold thickness are lower, in boys it is r=0.691 and in girls r=0.631.

Table 4 shows the results of the χ^2 test according to weight status and the skinfold thickness of children. For this purpose, the participants were divided according to TSF into six groups with a 5 mm span. The χ^2 test show that there is a significant difference ($p<0.001$) in skinfold thickness according to weight status. Skinfold thickness lower than 5 mm is only present in non-overweight children. The percentage of the non-overweight children decreases with the increased skinfold thickness, so it is only 0,2% when the skinfold thickness is higher than 26 mm. Conversely, the majority of obese children (35.45%) belong to the group with skinfold thickness over 26 mm, a lot of them (31.3%) also to the group with skinfold

TABLE 3
CORRELATIONS BETWEEN BODY HEIGHT, BODY WEIGHT, BMI AND TSF

Variables	Gender	Height	Weight	BMI	TSF
Height	Boys	1			
	Girls	1			
Weight	Boys	0.795*	1		
	Girls	0.805*	1		
BMI	Boys	0.396*	0.862*	1	
	Girls	0.418*	0.866*	1	
TSF	Boys	0.337*	0.691*	0.785*	1
	Girls	0.252*	0.631*	0.783*	1

* $p<0.01$

TABLE 4
DIFFERENCES IN TSF ACCORDING TO WEIGHT STATUS

TSF (mm)	Non-overweight		Overweight		Obesity	
	n	n%	n	n%	n	n%
< 5 mm	247	6.04	0	0	0	0
6–10 mm	2,062	50.40	42	3.77	6	1.46
11–15 mm	1,375	33.61	315	28.30	33	8.07
16–20 mm	341	8.33	449	40.34	97	23.72
21–25 mm	58	1.42	224	20.13	128	31.30
> 26 mm	8	0.20	83	7.46	145	35.45
χ^2=2398.02; p=0.001; V=0.543						

thickness between 21 and 25 mm. The majority of overweight children (40.34%) belong to the group with skinfold thickness between 16 and 20 mm.

Discussion and Conclusion

On the basis of BMI and skinfold thickness we analyzed the weight status in pre-pubertal children and observed the differences according to sex, age and school environment. The results show that 18.3% of boys and 18.5% of girls are overweight and that 6.5% of boys and 6.7% of girls are obese, which is more than reported by Planinšec, Fošnarič and Pišot[27]. They found that 14% of boys and 12.5% of girls are overweight and 4.7% of boys and 5.1% of girls are obese. These findings show that the prevalence of overweight and obesity in Slovenia increased within short time period. The comparison of the results of our study with other European countries shows that the prevalence of overweight and obesity is smaller in Latvia, Germany, France, Slovakia, Finland, the Netherlands, Denmark, Sweden and Poland, approximately equal in Norway, Great Britain and Croatia, and higher particularly in the Mediterranean countries[3,4].

The prevalence of overweight and obesity differs according to the school class, even by up to 8.5% if we compare the children of the first class (19.9%) and of the fifth class (28.4%). We found that the trend of change is irregular, which is contrary to our previous findings according to which the proportion of children who are overweight and obese gradually decreases from the age of six to the age of eleven[3]. The results also showed that there are no significant differences according to prevalence of overweight and obesity from urban and rural schools. The results of researches are quite different in this respect. Some find that there are more overweight children in rural areas[28], which is explained by a more modest choice of food and less possibility for physical activities. In other studies, on the contrary, it is found that the percentage of overweight children is higher in urban areas[27,29], which is explained as the consequence of modern lifestyle, involving less physical activity for urban children. In numerous studies, the comparison between boys and girls shows that the prevalence of overweight and obesity is approximately the same for boys and girls and that there are no significant differences[21,27,30], which was also the finding of our study.

The results of the present study showed that TSF increases in boys from the first to the sixth class, or to the age of twelve, which is in accordance with the previous findings[15]. In girls, TSF increases to the age of ten, and than starts to decrease gradually, which is in part contrary to the previous findings claiming that there is a continued increase in the skinfold thickness of girls till the end of puberty[15]. In our study, the comparison between the sexes shows that in the period from the first to the fifth class, TSF is substantially greater in girls, which is in accordance with the previous findings[13,14,18]. It is somewhat surprising that in the sixth class the differences are not significant.

The correlations between TSF and other anthropometric variables are interesting. As anticipated, the correlation between TSF and BMI is high. Similar correlations between TSF and BMI are reported in other studies [19,20]. The correlations in our study are also similar to those from other studies[12,21], but it has to be noted that these correlations are between BMI and different skinfold thicknesses, not just the triceps. Lower than correlations between TSF and BMI, but still moderately high, are the correlations between TSF and body weight.

There are significant differences in TSF of children according to weight status. All the children that have TSF lower than 5 mm belong to the group of normal body weight. Similarly, 97.8% of the children with TSF from 5 to 10 mm belong to the group of normal body weight. Conversely, the group of TSF over 26 mm contains 96.5% of the children who are overweight or obese. The children with TSF from 16 to 20 mm and 21 and 25 mm mostly belong to the group of overweight children. The results clearly show that TSF and weight status are closely related and that the criterion for the determination of weight status on the basis of BMI is well defined, as it adequately classifies children according to the fat mass measured by TSF.

Promoting healthy lifestyle in children will have a significant role in prevention of obesity. Preventive efforts focused on physical activity and nutrition in childhood will have long-life health benefits[31]. A realistic approach to the prevention of physical inactivity and obesity requires incorporation of environmental, behavioral, psychological and cultural factors. A health educational intervention needs to be given in educational and health institutions, local communities and families.

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INDEKS TJELESNE MASE I DEBLJINA KOŽNOG NABORA TRICEPSA KOD DJECE PRETPUBERTALNE DOBI U SLOVENIJI

SAŽETAK

Glavni cilj ove studije bio je analizirati prekomjernu težinu i gojaznost kod djece na temelju indeksa tjelesne mase (BMI) i debljine kožnog nabora tricepsa (TSF). Uzorak je uključivao 5.613 djece u dobi od 6 do 12 godina (X=9,23; SD=1,69) iz Slovenije. Djeca su klasificirana kao normalna, prekomjerna i gojazna ovisno o dobnim i spolnim specifičnim BMI standardima. Rezultati pokazuju da 18.3% dječaka i 18,5 % djevojčica ima prekomjernu težinu, a 6,5 % dječaka i 6,7% djevojčica su gojazni. Korelacije između BMI i TSF kod dječaka (r=0,785) i djevojčica (r=0,783) su skoro podjednake. Tjelesna težina manje korelira sa TSF kod dječaka (r=0,691) i djevojčica (r=0,631). χ^2 test pokazuje značajnu razliku u ($p<0,001$) TSF u odnosu na status težine. Rezultati pokazuju da su TSF status i status težine usko povezani te da je kriterij za određivanje statusa tjelesne težine na temelju BMI dobro definiran.