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Validity of Measured vs. Self-Reported Height, Weight and Body-Mass Index in Urban Croatian Adolescents

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Abstract

Objectives: The aim of this research was to estimate the validity of measured and self-reported height, weight and body-mass index (BMI) in Croatian adolescents.
Methods: In this cross-sectional study, participants were 286 urban secondary-school students (53% of girls) from the city of Zagreb, Croatia. To assess self-reported height, weight and sociodemographic characteristics of the participants, an in-person interview was carried out.
Results: Both boys and girls underestimated weight and height. Cohen's D effect showed that these differences were trivial. Pearson's coefficient of correlation between self-reported and measured values ranged from 0.95 to 0.97 in both boys and girls. The prevalence of underweight was overestimated, when using personal assessment of BMI, while overweight status was underestimated by both gender. Kappa statistics showed good (0.64 in girls) and excellent (0.89 in boys) agreement between the self-reported and measured BMI.
Conclusions: Our findings suggest, that there is the inaccuracy between measured and personal assessment of height and weight to determine the prevalence of overweight/obesity, especially in girls. However, self-reported height, weight and calculated BMI may be used as a valid assessment for large epidemiological studies, but not for intervention purposes.

Keywords: Validity, Effect, Agreement, Secondary-School Students, Croatia, Differences

1. Background

In the past several years, obesity has become one of the major public health problems in the world. World Health Organization (1), reports about around 2 billion adults aged $\geq$ 18 years old in the world were overweight and of these, 600 million were obese. Overweight and obesity represent independent risk factors for increased mortality and morbidity (2).

In children and youth, prevalence rates of overweight and obesity have doubled in the last few decades and have become an increasing epidemic problem (3). In childhood, overweight and obesity are often associated with health and psychosocial problems, like dyslipidemia and type II diabetes (4). Due to those negative consequences overweight and obesity have on physical and psychosocial health, several studies have concluded, that monitoring and tracking height and weight in childhood represents the need to detect any tendencies in the prevalence of body-mass index (BMI) (5-8). Although, self-reported height and weight have often been used in a large epidemiological researches, several studies have shown that self-reported weight is often underestimated, especially among girls (9, 10) and self-reported height is overestimated in boys (10). It is necessary to highlight, that while the relation between the measured and personal assessment of height and weight is high, it often fails to detect overweight and obese cases, who represent risk group for higher mortality (6).

In 2008, the prevalence of overweight and obesity in Croatia was around 58% and 24%in the population $\geq$ 18 years of age (11). In children and adolescents, the prevalence of overweight in 15 year olds is 23% for boys and 10% for girls (12). To authors knowledge, there has been only one study investigating the validity between the measured and personal assessment of height and weight, but only conducted in adolescent girls in Croatia (13). The relation between the self-reported and measured values were r > 0.9 and overweight girls underestimated their weight and overestimated their height (14). Since overweight and obesity is increasing in Croatia (11), especially in childhood and youth, it is important to use objective measures to monitor, track and correctly classify children and youth, accord-

ing to their BMI.

2. Objectives

The main purpose of this research was to assess the validity of measured and self-reported height, weight and calculated BMI in Croatian secondary-school boys and girls.

3. Methods

3.1. Participants

Sample of 286 secondary-school students from Zagreb participated in the study. For selection of secondary-schools we use random sampling approach. Basic categorical and numerical characteristics are presented in both Tables 1 and 2. Participants and their parents/guardians had given written consent to participate in the study before the study began. All the procedures performed in this research were approved by the Ethical Review Board of the Faculty of Kinesiology.

3.2. Testing Variables

The self-administrated questionnaire was used for the purpose of this study. The questionnaire consisted of sociodemographic characteristics of the participants. First, we asked about their subjective height and weight each by one-item question. Gender and grade were part of the first set of questions. Then, we asked about the frequency of weighting at home by one-item question. If the participant responded with yes, the next question was about the frequency of weighting. Nutrition was assessed by one item questions. Self-perceived socioeconomic status was assessed by one-item question. Finally, we asked about their current health assessed by one-item question (14). After the subjective data were obtained by each participant, a trained professional than measured participants' height and weight. A digital scale showed excellent reliability property before the study had begun (Cronbach $\alpha = 0.95$).

3.3. Testing Protocol

Assessments took place in the physical education classroom. In a small group of four, participants approached to the examiner and first, they fulfilled the questionnaires. After that, each by each participant came to the second examiner, who measured their height and weight. Each participant was separately instructed how to be dressed for the purpose of the weight measurement. All the procedures were anonymous and it took about 5 minutes by each group to complete both questionnaire and objective measurement.

3.4. Data Analysis

Categorical variables are presented as percentages and frequencies. Chi-square test were used for gender differences in these variables. Numerical variables are presented as means and standard deviations. To determine differences between measured and personal assessment of height, weight and calculated BMI from those variables, paired sample *t*-test was used. The relations between two measures were assessed by using Pearson's coefficient of correlation. To determine the magnitude of the group differences in health-related physical fitness Cohen D effect sizes (ES) were also calculated. ES was classified as follows: $<$ 0.2 was defined as trivial; 0.2 - 0.6 was defined as small; 0.6 - 1.2 was defined as moderate; 1.2 - 2.0 was defined as large; $>$ 2.0 was defined as very large; and $>$ 4.0 was defined as extremely large (15). To assess the correct classification between self-reported and measured values, cross tabulation matrices were used. The relation between correct classification of underweight, normal and overweight self-reported and measured categories (we did not have a participant classified into the obesity category) was calculated by using Kappa statistics. Kappa values range between -1 (perfect disagreement) and +1 (perfect agreement). Kappa values $\leq$ 0.20, 0.21 to 0.40, 0.41 to 0.60, 0.61 to 0.80 and 0.81 to 1.00 represented poor, fair, moderate, good and excellent agreement. The diagnostic classification of underweight, normal and overweight category between measured and personal assessment of BMI was calculated by using the determination of sensitivity (the proportion of actual underweight, overweight or obese adolescents who are diagnosed correctly using the self-reported data) and specificity (the proportion of adolescents who are not underweight, overweight or obese and are also not diagnosed as such using the self-reported data). Mean proportional differences (self-reported value-measured value/measured value $\times$ 100) for height, weight and BMI between the different sociodemographic characteristics were determined by using one-way ANOVA. The associations between the differences in height, weight and BMI with socioeconomic characteristics were analyzed by using multiple regression analysis. All statistical procedures conducted in the study were performed in Statistical Package for Social Sciences version 22 (SPSS). Significance for all the analysis performed in the study was set up at $P \leq 0.05$. Two-sided significance was taken.

4. Results

Basic categorical characteristics of the participants are presented in Table 1. Interestingly, boys reported weigh themselves more often than girls. Most participants reported that they did not have a special diet, and boys

Table 1. Basic Categorical Characteristics of the Study Participants[a]

Categorical Study Variables	Total (N = 286)	Boys (N = 134)	Girls (N = 152)	P Value[b]
Grade				0.076
1st	60 (21.0)	26 (19.4)	34 (22.4)	
2nd	53 (18.5)	28 (20.9)	25 (16.4)	
3rd	76 (26.6)	43 (32.1)	33 (21.7)	
4th	97 (33.9)	37 (27.6)	60 (39.5)	
Do you weight yourself at home?				0.905
Yes	161 (56.3)	76 (56.7)	85 (55.9)	
No	125 (43.7)	58 (43.3)	67 (44.1)	
How often?				0.605
Daily	11(3.8)	6 (4.5)	5 (3.3)	
Weekly	30 (10.5)	17 (12.7)	13 (8.6)	
Monthly	75 (26.2)	34 (25.4)	41 (27.0)	
Less than monthly	45 (15.7)	19 (14.2)	26 (17.1)	
Total	161 (56.3)	76 (56.7)	85 (55.9)	
Special nutrition				0.998
Yes	14 (4.9)	7 (5.2)	7 (4.6)	
No	272 (95.1)	127 (94.8)	145 (95.4)	
Socioeconomic status				0.439
Low	3 (1.0)	2 (1.5)	1 (0.7)	
Middle	239 (83.6)	108 (80.6)	131 (86.2)	
High	44 (15.4)	24 (17.9)	20 (13.2)	
Self-rated health				0.220
Poor	26 (9.1)	9 (6.7)	17 (11.2)	
Good	260 (90.9)	125 (93.3)	135 (88.8)	

[a] Values are expressed as No. (%).
[b] Chi-square test.

showed a higher percentage of good self-assessment of health than girls. Overall, no gender differences occurred between categorical variables.

Basic numerical characteristics of the researched participants are presented in Table 2. Boys overestimated their height, underestimated their weight and BMI. Girls also overestimated their height, but underestimated their weight and BMI. Cohen's D revealed that the effect between measured and personal assessment of height, weight and BMI was trivial in both boys and girls. The relations between self-reported and measured variables ranged between 0.95 - 0.97 in both boys and girls.

Table 3 shows the agreement between self-reported and measured BMI, according to gender. In general, Kappa statistics showed good agreement in girls and excellent agreement in boys between underweight, normal and overweight categories. The lowest sensitivity values were for overweight status in both boys and girls. Specificity values ranged between 88.9% - 100% in boys and between 50.0% - 93.0% in girls.

The proportional differences for height, weight and BMI, according to the socio-demographic characteristics of the study participants are presented in Table 4. Both boys and girls overestimated their height. Girls significantly underestimated their weight and body-mass index, opposed to boys. It is worthwhile to mention, that those differences occurred only because of underestimated weight, since differences between genders in height were not statistically significant. Students from higher grades overestimated their height, especially students from the 4th grade (P = 0.013). Students who did not measure themselves at home had higher proportional differences in weight and body-mass index. Interestingly, students who reported having poor self-rated health also had higher proportional differ-

Table 2. Basic Numerical Characteristics of the Study Participants

Numerical Study Variables	Self-Reported Value, AM ± SD	Measured Value, AM ± SD	Mean Difference (Self-Reported-Measured Value), Difference ± SD	P Value[a]	Cohen's D	Pearson's Correlation Coefficient r
Boys (N = 134)						
Age, y	16.45 ± 1.22	-	-	-	-	-
Body height, cm	178.84 ± 6.25	177.90 ± 6.46	0.94 ± 1.67	< 0.001[b]	0.15	0.97
Body weight, kg	70.22 ± 8.38	70.56 ± 9.08	-0.34 ± 2.41	0.105	-0.04	0.96
Body-mass index, kg/m^2	21.95 ± 2.38	22.28 ± 2.54	-0.33 ± 0.80	< 0.001[b]	-0.13	0.95
Girls (N = 152)						
Age, y	16.50 ± 1.21	-	-	-	-	-
Body height, cm	166.21 ± 5.79	165.45 ± 5.86	0.75 ± 1.60	< 0.001[b]	0.13	0.96
Body weight, kg	58.31 ± 9.37	59.59 ± 9.70	-1.28 ± 2.22	< 0.001[b]	-0.13	0.97
Body-mass index, kg/m^2	21.05 ± 2.79	21.72 ± 2.70	-0.67 ± 0.96	< 0.001[b]	-0.24	0.95
Total (N = 286)						
Age, y	16.48 ± 1.21	-	-	-	-	-
Body height, cm	172.13 ± 8.71	171.29 ± 8.74	0.84 ± 1.63	< 0.001[b]	0.10	0.98
Body weight, kg	63.89 ± 10.71	64.73 ± 10.88	-0.84 ± 2.35	< 0.001[b]	-0.08	0.98
Body-mass index, kg/m^2	21.47 ± 2.64	21.98 ± 2.78	-0.51 ± 0.90	< 0.001[b]	-0.19	0.95

[a] Paired sample *t*-test.
[b] $P \leq 0.05$.

Table 3. Diagnostic Table for Correct Classification of Body-Mass Index Categories[a]

	Self-Reported Body-Mass Index	Measured Body-Mass Index	Sensitivity, %	Specificity, %
Boys (N = 134)				
Underweight	9 (6.7)	8 (6.0)	100.0	88.9
Normal	107 (79.9)	104 (77.6)	99.0	96.3
Overweight	18 (13.4)	22 (16.4)	81.8	100.0
Kappa statistics	0.89[b]			
Girls (N = 152)				
Underweight	24 (15.8)	14 (9.2)	85.7	50.0
Normal	114 (75.0)	119 (78.3)	89.1	93.0
Overweight	14 (9.2)	19 (12.5)	68.4	92.9
Kappa statistics	0.64[b]			
Total (N = 286)				
Underweight	33 (11.5)	22 (7.7)	90.9	60.6
Normal	221 (77.3)	223 (78.0)	93.7	94.6
Overweight	32 (11.2)	41 (14.3)	75.6	96.9
Kappa statistics	0.76[b]			

[a] Values are expressed as No. (%) unless otherwise indicated.
[b] $P < 0.001$.

ences in weight and body-mass index and those differences were statistically significant.

Linear regression results (data not presented) showed that, from the socioeconomic variables entered into the

Table 4. Proportional Differences in Height, Weight and Body-Mass Index Between the Different Socio-Demographic Variables[a]

Categorical Study Variables	Difference in Height	P Value[b]	Difference in Weight	P Value[b]	Difference in Body-Mass Index	P Value[b]
Gender		0.509		< 0.001		< 0.001
Boys	0.54 ± 0.96		-0.30 ± 3.43		-1.35 ± 3.53	
Girls	0.46 ± 0.98		-2.06 ± 3.56		-2.93 ± 4.16	
Grade		0.013		0.564		0.198
1st	0.30 ± 1.03		-0.84 ± 3.61		-1.42 ± 3.88	
2nd	0.39 ± 0.88		-1.75 ± 4.09		-2.48 ± 4.57	
3rd	0.49 ± 0.91		-1.33 ± 3.00		-2.27 ± 3.51	
4th	0.81 ± 0.99		-1.19 ± 3.96		-2.75 ± 4.03	
Do you weigh yourself at home?		0.410		0.017		0.013
Yes	0.45 ± 0.85		-0.77 ± 3.06		-1.65 ± 3.23	
No	0.55 ± 1.11		-1.83 ± 4.14		-2.87 ± 4.64	
How often?		0.913		0.400		0.339
Daily	0.34 ± 0.42		-0.63 ± 1.97		-1.31 ± 2.07	
Weekly	0.52 ± 0.84		0.04 ± 2.08		-0.97 ± 2.26	
Monthly	0.47 ± 0.79		-1.10 ± 3.36		-2.00 ± 3.94	
Less than monthly	0.41 ± 1.02		-0.80 ± 3.29		-1.61 ± 2.63	
Special nutrition		0.663		0.659		0.573
Yes	0.39 ± 0.81		-0.82 ± 3.98		-1.61 ± 3.02	
No	0.50 ± 0.98		-1.26 ± 3.59		-2.22 ± 3.99	
Socioeconomic status		0.151		0.983		0.679
Low	1.58 ± 0.51		-1.14 ± 1.15		-4.18 ± 2.09	
Middle	0.49 ± 0.99		-1.22 ± 3.70		-2.16 ± 3.97	
High	0.46 ± 0.86		-1.33 ± 3.19		-2.20 ± 3.94	
Self-rated health		0.881		0.003		0.009
Poor	0.47 ± 1.08		-2.90 ± 3.83		-3.78 ± 4.37	
Good	0.50 ± 0.96		-1.00 ± 3.52		-1.96 ± 3.84	

[a] Values are expressed as difference ± SD.
[b] One-way ANOVA.

model, only students from higher grades were more likely to overestimate their height ($\beta = 0.20$, P = 0.012). In the second linear regression model, girls and students reported poor self-rated health were more likely to underestimate their weight, while in the third linear regression model, girls were more likely to underestimate their BMI.

5. Discussion

The main purpose of the present research was to estimate the validity of measured and personal assessment of height, weight and BMI in Croatian adolescents.

Our results showed that both boys and girls overestimated their height and weight. These findings are consistent to some previous studies (5, 16). Moreover, results from our study did not show significant distinctions between the measured and personal assessment of weight in boys, but only for girls, which is in accordance to some previous findings (8, 17). Previous findings have shown, that girls are more often worried about their body weight and overall image than do boys (18). High difference between the self-reported and measured weight in girls could be explained by the fact, that girls often weigh themselves with clothes off, yet all participants in our study wore light sports clothes (socks, sports dress and T-shirt), which potentially might influence on such differences. Furthermore girls are more often oriented towards weight than height (11), due to their bigger concerns about their body appearance (19). Over reported height values in both boys

and girls could be explained by the fact, that height is not easily self-measured compared to weight. Also, weight is often easily to assess by using a weight scale compared to the height board (20). One previous study reported the same problem (6). Cohen's D showed, that distinctions measured from the personal assessment of BMI were trivial in boys, yet something higher in girls, but statistically significant. These differences can be explained by the higher overestimation of height in boys and higher underestimation of weight in girls, as described by some other previous studies (6, 9, 21).

Next, our results showed, that self-reports led to overestimation in underweight category for girls and underestimation in overweight category in both boys and girls. Weighted Kappa statistics showed good agreement in girls and excellent agreement in boys between the self-reported and measured body-mass index categories, as observed in some previous studies (5, 20). This could be explained by the fact, that both boys and girls overestimated their height by similar values, yet girls underestimated their weight and calculated body-mass index to a greater extent than boys. In that way, the agreement between the measured and self-reported BMI was lower in girls than in boys, respectively. Specifically, overweight adolescents tend to underestimate their weight and overestimate their height, opposed to their normal weight peers (20).

Results from our study showed, that there were significant gender distinction between the self-reported and measured weight and BMI. As explained earlier, girls often underestimate their weight, since they perceive their body appearance in a different way (22) and want to meet the social desirability to be thin and tall (5). Furthermore, significant differences occurred in educational level variable, where adolescents tended to overestimate their height. Again, this potential trend could be explained by the fact, that both boys and girls want to be tall, yet boys perceive the ideal body as muscular and girls as thin (22). Also, grade was positively associated with height difference in some previous studies (21).

Our results showed that students who weigh themselves at home had smaller proportional differences in weight and body-mass index, compared to students who did not weigh themselves at home. In one recent study, only girls who reported not weighting themselves in the past year had bigger underestimation of weight and body-mass index, than girls who reported weighting themselves recently (16). The effect of frequency of weigh to establish better accuracy, when the objective assessment is not possible, should be highlighted. One study concluded, that special testing protocol and guideline should be determined for adolescents, who measure their weight at home prior to completing the study, in order to obtain a more accurate weight result (5). Students who reported poor self-rated health had larger weight and body-mass differences, opposed to student who reported good self-rated health. Previous researches have shown, that overweight and obese adolescents were more likely to have poor self-rated health (23, 24), especially in older age groups. As we highlighted before, overweight children and adolescents tend to underestimate their weight (8, 9), possible because of social acceptance (25).

Finally, our results showed, that gender was the most common contributor, which influenced on the distinction between the measured and self-reported weight and BMI status. Our findings are similar to some other previous studies (5, 16). In general, girls are more sensitive about their body appearance and want to satisfy social acceptable norms and standards in the society (25), which is thin or slim body (19).

Our study has several limitations. First, due to a relatively small sample and urban-type adolescents, it is difficult to generalize our findings to the whole population, particularly for rural-type adolescents. Second, we did not ask more detailed information about types of equipment used for measuring height and weight at home. Third, we did not ask the students not to eat or drink prior the study, since food and water could potentially lead to bias.

Our findings suggest, that despite the high relations between the measured and personal assessment of height, weight and BMI in both boys and girls, self-reported measures led to underestimation of overweight and overestimation of underweight categories. However, it is possible to use self-reported data from height and weight in large epidemiological studies to estimate basic anthropometric characteristics of the participants, but not for clinical or intervention practices. Also, as proposed by one recent study, special measuring guidelines and protocols should be created, in order to improve the accuracy of self-reported measures (5).

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Footnotes

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