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Research Article
Validity of Self-reported Weight, Height and Body Mass Index Among College Students in Indonesia: Consequences for the Assessment of Obesity

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Abstract

Background and Objective: Obesity has often been assessed based on self-reported Body Mass Index (BMI). However, BMI is frequently underestimated when derived from self-reported data, which may lead to an underrated prevalence of obesity. This study aimed to examine the validity of self-reported weight, height and BMI and its accuracy in assessing obesity in a sample of college students in Yogyakarta province, Indonesia. **Materials and Methods:** The weight and height of 209 male and 269 female college students in Yogyakarta province were measured. Before the measurements, the participants were asked to quantify their weight and height. The BMI was calculated. Correlation analysis, kappa statistic and Bland and Altman plots were used to evaluate the agreement between the self-reported and measured values. Multinomial regression analysis was performed to evaluate the factors associated with misreported BMI. **Results:** Self-reported height was underestimated by 1.2 cm in boys and 1.1 cm in girls, whereas weight was underestimated by 1.0 kg in boys and 0.5 kg in girls, consequently, BMI was slightly underestimated (0.67 kg m^{-2} in boys, 0.5 kg m^{-2} in girls), all with $p<0.01$. Nonetheless, there was high correlation, reliability and agreement between self-reported and measured values ($p<0.01$). The use of self-reported BMI to classify obesity indicated moderate to high sensitivity in all BMI categories, except for in underweight boys and overweight girls. Mother's education in girls was the only significant predictor of misreporting BMI. **Conclusion:** Self-reported weight, height and BMI were valid in our sample population. However, this method should be used with caution with underweight boys and overweight girls. Self-reported weight, height and BMI may be useful indicators in large epidemiological studies in Indonesian young adults.

Key words: Self-reported, weight, height, BMI, obesity

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The prevalence of obesity has been increasing globally[1-3] as well as nationally in Indonesia[4]. As a result, concern has risen for the immediate health problems associated with obesity, such as cardiovascular disease, metabolic syndrome, osteoarthritis, respiratory and reproductive system disease and some cancers[5-8]. Attempting to address the obesity epidemic requires an assessment of the prevalence of overweight and obesity, as this information would support the application of interventions to the necessary groups and monitor the efficiency of the interventions. Accordingly, obtaining valid data on weight, height and consequently Body Mass Index (BMI) is critical. Direct measurements of these variables, however, are not always feasible, particularly in large epidemiological studies due to practical or financial limitations. Therefore, the assessment of the prevalence of obesity has often been based on self-reported data, which are cheaper, easier and faster to obtain than directly measured data.

Self-reported weight, height and the resulting BMI have been used for national assessments of overweight and obesity in countries, such as Germany[9], Korea[10], Australia[11], Ireland[12], Spain[13] and the United States[14]. Nonetheless, the validity of self-reported weight, height and BMI is debatable. Some studies have demonstrated high correlations between self-reported weight, height and BMI and a reliable assessment to define obesity in adults[13,15-17] as well as in adolescents[18]. In contrast, other studies have found that self-reported BMI data are unreliable in determining obesity in adults[12,19] or adolescents[9,20-23].

Previous studies have confirmed that self-reported BMI is often underestimated, which is mostly due to an underestimation of self-reported weight and an overestimation of height in adults[16,19,24] and adolescents[9,18,20]. The magnitude of the misreported BMI, however, differ by gender and actual weight. In general, BMI has been overestimated by underweight individuals but underestimated by overweight/obese individuals[9,15,19,24,25]. Individuals at an older age have a tendency to underestimate BMI to a greater extent than younger individuals[15]. As a result of the lower reported values of BMI, the prevalence of obesity could be underestimated. Several studies found that self-reported BMI had low moderate sensitivity but high specificity in identifying obesity[19,20]. Bowring *et al.*[17] demonstrated that self-reported measurements can accurately identify overweight/obesity despite weight underestimation among young people in Australia. Other studies have reported high sensitivity and specificity in self-reported BMI and have thus suggested the use of self-reported BMI in large epidemiological studies[16,18].

Some major determinants of misreporting BMI have been identified and include age, sex and actual BMI[15], socioeconomic variables[10,11] and race/ethnicity[18,26]. Nevertheless, the results have varied, for example Richmond *et al.*[26] found that white American young adults reported a lower BMI than black males and females, Hispanic females and Native American males, leading to less accurate BMI reporting in young white adults at a higher BMI. In contrast, Perez *et al.*[18] indicated that white American girls overestimated their height less than African-American boys, similarly, white boys underestimated their BMI less than African-American girls. In addition, body image[13,25], physical activity[27] and health behaviors[28] have also been identified as factors associated with bias in self-reporting BMI. The more satisfied individuals feel about their own body image, the less prone they were to under reporting their weight[13]. In contrast, individuals with greater self-reported physical activity were significantly associated with under reporting weight[27].

The validity of self-reported weight, height and BMI has not been investigated in Indonesian young adults to date. The aim of the current study was therefore to first evaluate the validity of self-reported weight, height and the resultant BMI in a sample of college students in Yogyakarta province, Indonesia and to then assess the accuracy of their self-reported BMI compared with measured data on classifying obesity (underweight, normal, overweight and obesity). In addition, it is aimed to identify the potential predictors of the validity of self-reported BMI including socioeconomic factors, physical activity, diet and measured BMI.

MATERIALS AND METHODS

Participants: A total of 478 college students (209 boys and 269 girls) studying at Universitas Gadjah Mada (UGM) and Universitas Teknologi Yogyakarta (UTY) were involved in this study. Male and female students who were apparently healthy and aged 17-25 years were recruited. Those who had physical disabilities or disproportional body segments and pregnant female students were excluded from the study.

Participants were asked to report their body weight (kg) and height (cm) in a questionnaire also addressed gender and basic information (birth and place of date, ethnicity, parent's education, parent's income and engagement in regular

physical activity). Parent's education level (father and mother) was categorized into high school or lower and college graduation. Parent's income level (father and mother) was grouped by less or more than IDR 2.5 million (approximately US $200) monthly. A signed informed consent letter was obtained from each participant. The protocols of this study were approved by the Medical and Health Research Ethics Committee of the Faculty of Medicine UGM.

Measures: Participant's body weight and height were measured using the standard protocol of the International Society for the Advancement of Kinanthropometry (ISAK). Body weight was measured with a Seca weight scale (Seca 803, Seca Deutschland) to the nearest 0.1 kg while participants were wearing light clothing. Height was assessed using an anthropometric set (GPM, Swiss, Ltd.) to the nearest 0.1 cm. The BMI was calculated as kg m^{-2} and was used as the measure of actual weight status. Participants were classified into underweight (<18.5 kg m^{-2}), normal (18.5-24.9 kg m^{-2}), overweight (25.0-26.9 kg m^{-2}) and obese ($\geq$27.00 kg m^{-2}). The classifications were adopted from the World Health Organization and adjusted for Indonesians[14].

Statistical analysis: Self-reported BMI was calculated from the reported weight and height of participants and categorized as underweight, normal, overweight and obese using similar classifications to the measured BMI. Differences were calculated as the reported values minus the measured values for weight, height and BMI. Paired samples t-tests were performed to determine the differences between measured and self-reported weight, height and BMI among boys and girls. Pearson's correlation coefficients and Bland and Altman plots were used to assess the agreement between measured and self-reported weight, height and BMI with 95% limits of agreement. The differences between self-reported and measured values were plotted against the means of the self-reported and measured values with the upper and lower limits of agreement as plus and minus 1.96 times the Standard Deviation (SD), respectively. Linear regression lines were fitted to the plotted values to identify trends in the differences between methods with increasing mean values. In addition, intra-class correlation coefficients (ICCs) with corresponding 95% confident intervals (CIs) were calculated to provide an estimate of the reliability of both methods.

Cohen's kappa statistic was performed to assess the level of agreement between self-reported BMI and measured BMI category (i.e., underweight, normal, overweight and obese). The kappa coefficient (κ) indicating the degree of agreement between self-reported and measured BMI classifications was determined as follows: $\kappa<0$ was none/poor, $0\leq\kappa\geq0.20$ slight, $0.21\leq\kappa\geq0.40$ fair, $0.41\leq\kappa\geq0.60$ moderate, $0.61\leq\kappa\geq0.80$ substantial and $0.81\leq\kappa\geq1.0$ almost perfect. Weight status misclassifications between measured and self-reported BMI were determined using cross-tabulations with BMI classified into underweight, normal, overweight and obese.

Performance of self-reported BMI was assessed with BMI categorized into underweight, normal, overweight and obese: The sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) with 95% CIs were assessed to evaluate the performance of the self-reported method in screening for (1) Underweight and normal individuals, (2) Overweight and normal individuals and (3) Obese, normal individuals, overweight and obese individuals. Kappa statistic with 95% CI was calculated to evaluate the agreement in the distribution between self-reported and measured BMI in the categories observed.

The BMI, parent's education and income and physical activity level were included in a multinomial regression model that was used to detect the factors associated with a misreported weight status classification (overestimation) of BMI in boys and girls. The $p<0.05$ was considered significant. The magnitude of the associations was expressed as an odds ratio with a 95% confidence interval. All statistical analyses were performed using SPSS (version 20.0, SPSS Inc., 2011, Chicago, IL).

RESULTS

Of the 210 boys and 270 girls participating in the study, 7 boys and 8 girls failed to complete the overall study, missing either self-reported data or measured data. Thus, 203 boys and 262 girls were involved in the data analysis. The mean ages were 20.8 ($\pm$1.20) and 20.7 ($\pm$1.16) years for boys and girls, respectively. Participant characteristics by self-reported and measured weight, height and BMI are presented in Table 1. Boys were taller and heavier and had a higher BMI than girls. In contrast to self-reported height, self-reported weight was lower than the measured values in both boys and girls, resulting in a lower self-reported BMI. Nonetheless, the correlation between the self-reported and measured values was very strong to almost perfect ($r = 0.85$-0.95, $p<0.01$). In both genders, weight and BMI showed almost perfect correlations, while height showed a

Table 1: Characteristics of self-reported and measured weight, height and Body Mass Index (BMI) among boys and girls

	Weight (kg)		Height (cm)		Body Mass Index (kg m^{-2})	
Parameters	Mean	SD	Mean	SD	Mean	SD
Boys (n = 203)						
Measured	62.92	14.20	167.45	5.87	22.30	4.39
Reported	61.89	12.94	168.55	5.71	21.63	4.06
Pearson's correlation	0.94**		0.87**		0.92**	0.92**
Mean difference †	-1.0**	4.76	1.22**	2.99	-0.67**	1.77**
95% CI	-1.65, -0.45		0.81, 1.63		-0.43, -0.91	
Intraclass correlation	0.94**		0.87**		0.91**	
95% CI	0.92, 0.95		0.83, 0.90		0.88, 0.93	
Cohen's kappa ‡					0.52**	
95% CI					0.42, 0.61	
Bland and Altman plot §	4.8%		6.4%		5.9%	
Lower-upper LOA |	-10.19, 8.11		-3.66, 5.85		-4.14, 2.80	
Girls (n = 262)						
Measured	51.13	8.52	155.40	5.00	21.16	3.14
Reported	50.63	8.14	156.53	4.99	20.66	3.09
Pearson's correlation	0.95**		0.85**		0.92**	
Mean difference †	-0.50**	2.67	1.13**	2.72	-0.50**	1.25
95% CI	-0.82, 0.18		0.80, 1.46		-0.65, 0.35	
Intraclass correlation	0.95**		0.85**		0.92**	
95% CI	0.93, 0.96		0.81, 0.88		0.90, 0.94	
Cohen's kappa ‡					0.67**	
95% CI					0.58, 0.76	
Bland and Altman plot §	4.6%		4.6%		5.3%	
Lower-upper LOA |	-5.73, 4.75		-4.21, 6.47		-2.99, 1.99	

**p<0.01, †: Self-reported data minus measured data, ‡: Ordinal category, §: Prevalence of individuals with mean differences out of the limits of agreement (Mean±1.96×SD), |: Values for the lower limit of agreement and upper limit of agreement (Mean±1.96×SD)

very strong correlation. The mean differences ranged between -1.0 (±4.76) and 1.22 (±2.99) in boys and between -0.50 (±2.67) and 1.13 (±2.72) in girls. With small values and very strong correlations, the mean differences in weight, height and BMI in both genders were statistically significant (p<0.01). Overall, girls showed smaller mean differences than boys.

The intra-class correlation analysis revealed that self-reported weight almost perfectly predicted measured weight in both genders, i.e., ICC = 0.94 (95% CI 0.92, 0.95, p<0.01) in boys and ICC = 0.95 (95% CI 0.93, 0.96, p<0.01) in girls. Combined with a very high ICC for self-reported height i.e., ICC = 0.87 (95% CI 0.83, 0.90, p<0.01) in boys and ICC = 0.85 (95% CI 0.81, 0.88, p<0.01) in girls, there was an almost perfect agreement between self-reported BMI and measured BMI (ICC = 0.91 with 95% CI 0.88, 0.93 in boys and 0.92 with 95% CI 0.90, 0.94 in girls, p<0.01) (Table 1). The agreement between self-reported and measured weight, height and BMI using the Bland and Altman plots indicated that approximately 4.8-6.4% of boys and 4.6-5.3% of girls were outside of the 95% CI limits of agreement (LOA) for the mean differences in weight, height and BMI. Additionally, Cohen's kappa coefficient was 0.52 (95% CI 0.42, 0.61, p<0.01) in boys and 0.62 (95% CI 0.58, 0.76, p<0.01) in girls when BMI was categorized into underweight, normal, overweight and obese and compared between the self-reported and measured values (Table 1). These kappa values indicated a moderate agreement between the two values in boys and a substantial agreement in girls.

The prevalence of BMI misclassification by self-reported and measured data was higher in boys (28.8%) than in girls (15.2%) as shown in Table 2. The majority of boys and girls who misclassified BMI were individuals with a normal-weight BMI but who were classified as underweight based on their self-reported BMI (16.9% of boys and 9.5% of girls). This indicated an under reporting of weight status by BMI classification. After assessing the kappa values, girls were considered to have better agreement between their self-reported and measured values of BMI than boys.

Table 3 shows the performance of self-reported BMI regarding its sensitivity, specificity, PPV and NPV. Among boys, self-reported data indicated the poorest ability to determine underweight individuals from normal ones as shown by the low sensitivity (32.7%, 95% CI 19.5 and 45.4) and poor agreement, with a kappa value of 0.37 (p<0.01, 95% CI 0.22 and 0.51). The accuracy of self-reported BMI in

Table 2: Body mass index misclassification by self-reported and measured data among boys and girls

	BMI_m, n (%)				
BMI_s	Underweight	Normal	Overweight	Obese	Total
Boys					
Underweight	17 (8.2)	35 (16.9)*	0 (0)	0 (0)	52 (25.2)
Normal	2 (1.0)*	105 (50.7)	5 (2.4)*	1 (0.5)*	112 (54.6)
Overweight	0 (0)	3 (1.4)*	8 (3.9)	9 (4.3)*	20 (9.7)
Obese	0 (0)	0 (0)	3 (1.5)*	19 (9.2)	22 (10.7)
Total	19 (9.2)	143 (69.1)	16 (7.7)	29 (14.0)	207 (100)
Girls					
Underweight	44 (16.8)	25 (9.5)*	0 (0)	0 (0)	69 (26.3)
Normal	3 (1.1)*	164 (62.6)	5 (1.9)*	3 (1.1)*	175 (66.8)
Overweight	0 (0)	2 (0.8)*	5 (1.9)	2 (0.8)*	9 (3.4)
Obese	0 (0)	0 (0)	0 (0)	9 (3.4)	9 (3.4)
Total	47 (17.9)	191 (72.9)	10 (3.8)	14 (5.3)	262 (100)

BMI_m: Measured BMI, BMI_s: Self-reported BMI, *Indicate misreported classification between self-reported and measured data, percentage in the brackets is within total participants in each gender, prevalence of misreported category was 28.0% of boys (McNemar-Bowker test 33.93, kappa 0.51) and 15.2% of girls (McNemar-Bowker test 23.57, kappa 0.67), p<0.01

Table 3: Performance of self-reported BMI for determining underweight, overweight and obesity in boys and girls

BMI category	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	PPV (%) (95% CI)	NPV (%) (95% CI)	Kappa statistic (%) (95% CI)
Boys					
Underweight†	32.7 (19.9-45.4)	98.1 (95.6-1.00)	89.5 (75.7-1.00)	75.0 (67.8-82.2)	0.37** (0.22-0.51)
Overweight†	61.5 (35.1-88.0)	97.2 (94.1-1.00)	72.7 (46.4-99.0)	95.4 (91.5-99.3)	0.63** (0.39-0.86)
Obese†	94.7 (84.7-1.00)	100.0	100.0	99.1 (97.2-1.00)	0.97** (0.91-1.00)
Obese‡	67.9 (50.5-85.1)	72.7 (46.4-99.4)	86.4 (72.0-1.00)	47.1 (23.3-70.8)	0.35* (0.15-0.63)
Girls					
Underweight†	93.6 (86.6-1.00)	86.8 (81.9-91.6)	63.8 (52.4-75.1)	98.2 (96.2-1.00)	0.68** (0.58-0.78)
Overweight†	50.0 (19.0-81.0)	97.0 (94.5-99.6)	50.0 (19.0-81.0)	97.0 (94.5-99.6)	0.57** (0.28-0.86)
Obese†	75.0 (50.5-99.5)	100.0	100.0	98.2 (96.2-1.00)	0.85** (0.66-1.00)
Obese‡	81.8 (59.0-1.00)	100.0	100.0	71.4 (38.0-1.00)	0.74** (0.41-1.00)

**p<0.01, †: Distinguishing between the written category and normal individuals, ‡: Distinguishing between obese and overweight individuals, PPV: Positive predictive value, NPV: Negative predictive value

predicting overweight from normal individuals and obese from overweight individuals similarly indicated moderate ability with sensitivity levels of 61.7% (95% CI 35.1 and 88.0) and 67.9% (95% CI 50.5 and 85.1), respectively, for overweight-normal and obese-overweight individuals. In contrast, obesity could be well determined from normal, with sensitivity values of 94.7% (95% CI 84.7 and 1.00) and kappa value of 0.97 (p<0.01, 95% CI 0.91 and 1.00). Among girls, the ability of self-reported BMI to identify underweight from normal individuals was the highest, with sensitivity levels of 93.6% (95% CI 86.6 and 1.00) and kappa values of 0.68 (p<0.01, 95% CI 0.58 and 0.78). Distinguishing obesity from normal as well as from overweight was almost similar, with good sensitivity levels (75.0 and 81.8%) and kappa values of 0.85 (p<0.01, 95% CI 0.66 and 1.00) and 0.74 (p<0.01, 95% CI 0.41 and 1.00), respectively. In contrast, the ability to determine overweight from normal individuals was moderate, with half of overweight cases able to be correctly identified using self-reported BMI. Overall, the specificity was very good to almost perfect from 72.7% (95% CI 46.4 and 99.4) to 1.00. Similarly, the PPV and NPV showed good performance in general.

The Bland and Altman plots for BMI in boys and girls are shown in Fig. 1 and 2. The average mean difference was -0.67 and the lower and upper LOA of the 95% CI were -4.14 and 2.80, respectively. In girls, the average mean difference was -0.5, with a lower LOA of -2.99 and upper LOA of 1.99. The fitted regression lines for the Bland and Altman plots in both genders indicated under reporting of BMI when compared to measured values as individual's BMI increased.

Multi variable linear regression models including BMI, father's and mother's education level, income, diet experience and physical activity level were conducted to evaluate the effect of these factors. The results are presented in Table 4 indicate that only mother's education in girls had a significant contribution (p<0.01) to misreported BMI category, with an OR value of 5.76 (95% CI 1.71 and 19.35). However, there were no factors identified as a significant predictor of misreported BMI category in boys.

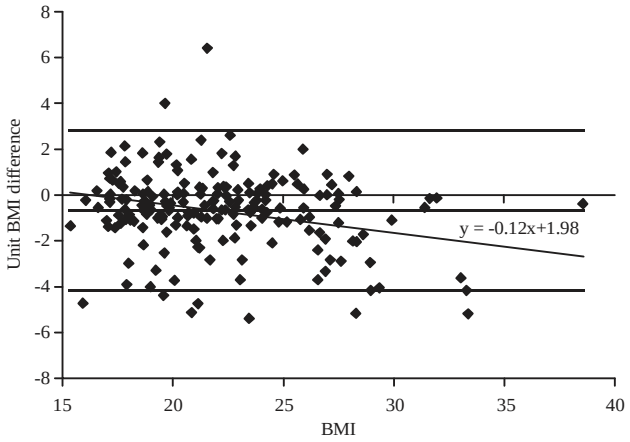

Fig. 1: Bland and Altman plots of the differences between self-reported and measured BMI among boys, the BMI difference (U) was calculated from self-reported data minus measured data, LOA: Limits of agreement, 95% CI was determined by ±1.96×mean difference, the downward slope of the regression line indicates a tendency to underestimate self-reported BMI as measured BMI increased

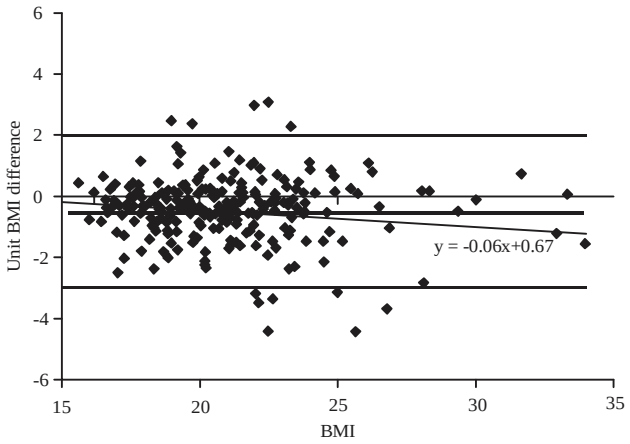

Fig. 2: Bland and Altman plots of the differences between self-reported and measured BMI among girls, the BMI difference (U) was calculated from self-reported data minus measured data, LOA: Limits of agreement, 95% CI was determined by ±1.96×mean difference, the downward slope of the regression line indicates a tendency to underestimate self-reported BMI as measured BMI increased

DISCUSSION

This study was first designed to examine the validity of self-reported weight, height and BMI and its impact on the determination of obesity among a sample of university college students in Indonesia. The findings demonstrated a high correlation and reliability with moderate to substantial agreement between self-reported and measured weight, height and BMI. Nevertheless, significant bias remained between self-reported and measured BMI. The tendency for participants to underestimate weight and overestimate height was consistent with some previous similar studies. A tendency to overestimate BMI among underweight individuals particularly in boys and underestimate BMI among individuals with higher BMI was also observed. Using the reported values to classify individuals into BMI categories led to a fair amount of BMI misclassification, particularly among underweight boys, whose self-reported values showed the lowest sensitivity. In general, girls showed a better performance when self-reported data were used to determine the levels of obesity.

In terms of the degree of inaccuracy in the reported data, girls overall showed less bias than boys in weight, height and the resultant BMI. The difference between self-reported and measured weight in boys (-1.0±4.76 kg) was greater than in girls (-0.50±2.67 kg). The results were similar to those

Table 4: Factors associated with misreported (underreported) BMI category among boys and girls using multinomial regression analysis

	Boys			Girls		
Variables	OR	95% CI	p-value	OR	95% CI	p-value
BMI†	0.93	0.84-1.02	0.131	1.10	0.97-1.24	0.135
Father's education						
≤High school	1.00					
College graduate	1.69	0.65-4.40	0.281	0.73	0.27-1.98	0.535
Mother's education						
≤High school	1.00					
College graduate	0.67	0.25-1.83	0.436	5.76	1.71-19.35	0.005
Father's income						
≤IDR 2.5 million	1.00					
>IDR 2.5 million	1.44	0.63-3.26	0.388	1.77	0.75-4.19	0.193
Mother's income						
≤IDR 2.5 million	1.00					
>IDR 2.5 million	1.17	0.46-3.00	0.746	0.57	0.20-1.61	0.287
Physical activity						
Yes	1.00					
No	0.68	0.28-1.65	0.390	0.40	0.05-3.30	0.398
Diet						
Yes	1.00					
No	2.53	0.68-9.45	0.166	0.79	0.24-2.61	0.704

CI: Confidence interval, OR: Odds ratio, †: Entered into the model as a continuous variable, OR: Odds of an underreported BMI category associated with 1 U increment in BMI

reported by Chau *et al.*[29], in which boys had a -1.03 kg difference in self-reported weight and a greater difference than in girls (-0.81 kg) but were better than those of Zhou *et al.*[20], who found a difference of -1.23 kg (gender not specified). However, these results did not support the findings of a recent study by Gebremariam *et al.*[25] in adolescents, in which girls showed a greater discrepancy between reported and measured weight at -0.95 kg than boys (-0.71 kg), or the findings of Groβschadl *et al.*[28] in adults, in which these values differed by approximately only -0.25 kg in males, which was smaller than the difference in females at -0.53 kg. Based on the height differences of approximately 1.22 (±2.99 cm) in boys and 1.13 (±2.72 cm) in girls, the results of this study showed greater bias than those of Gebremariam *et al.*[25] and De Vriendt *et al.*[22], who showed differences less than 1.00 cm. However, they are slightly better than those of Zhou *et al.*[20], who found a difference of 1.36 cm. Similarly, the resulting BMIs were approximately -0.67 (±1.77 kg m^{-2}) in boys and -0.50 (±1.25 kg m^{-2}) in girls, these differences were greater than those reported by Zhou *et al.*[20], i.e., -1.23 kg m^{-2} but smaller than those of Gebremariam *et al.*[25], i.e., -0.24 kg m^{-2} in girls and -0.04 kg m^{-2} in boys as well as Elgar *et al.*[23], who showed an approximately -0.29 kg m^{-2} difference in both girls and boys.

The statistical evidence indicated that the correlation coefficients were high to almost perfect in all variables and groups, which supports previous similar studies[16,19,20,27,28]. Similarly, high intraclass correlation coefficients were obtained in all variables in boys and girls, ranging from 0.85-0.95, indicating a high level of association between self-reported and measured values. However, kappa coefficients indicated only a moderate level of agreement (0.52, 95% CI 0.42 and 0.61) in boys and good agreement in girls (0.67, 95% CI 0.58 and 0.76).

Furthermore, the Bland and Altman plots demonstrated good agreement between self-reported and measured data in boys and girls for all three measures with less than 10% (4.6-6.4%) of participants below or above the LOA. As the width of the LOA was less than one standard deviation of the measured data in boys and girls for all measures, except for height in girls, the agreement between the values was considered "Good"[20]. The LOA for height in girls was -4.21-6.47 cm with a SD of measured height of ±5.00 cm, indicating slightly greater than one SD and was thus considered "Fair" agreement. Overall, the LOA for all measures, except height in girls were narrow enough to be considered to indicate "Good" agreement. The agreement between self-reported and measured data of the present study was slightly better than that reported by Zhou *et al.*[20] among Chinese adolescents and among Belgium adolescents[22] and was similar to a study by Brettschneider *et al.*[9] among German adolescents and by Groβschadl *et al.*[28] among Austrian adults. The fitted lines in the Bland and Altman plots for the BMI data in the current study demonstrated a tendency for greater underestimation as BMI increased in boys and girls. This trend has also been documented in other studies[9,14,19,20,23,25,30].

Using self-reported BMI to classify participants into BMI categories led to inaccuracy in the estimations of the obesity prevalence among Indonesian youth, with boys showing greater misclassifications for self-reported values than girls (28.0 vs 15.2%). This conflicts with findings reported by Gil and Mora[13], who found that misreporting BMI was more prevalent among females. The magnitude of bias using kappa statistic indicated moderate and substantial agreement in boys and girls, respectively. It is apparent that a reasonable number of boys (16.9%) overreport their BMI. This may have contributed to the low sensitivity of 32.7% (95% CI 19.9 and 45.4%) of reported BMI in identifying underweight from normal boys. This trend, however, contrasted with the trend among underweight girls, whose self-reports were able to identify 93.6% of underweight individuals based on the measured BMI. In addition, self-reported BMI among boys was only moderately sensitive in distinguishing overweight from normal individuals and overweight from obese individuals but was highly sensitive in identifying obese from normal individuals with a sensitivity value of 94.7% (95% CI 84.7 and 1.00). Overall, girl's reports showed a higher sensitivity in all BMI categories (75.0-93.6%) except for overweight, in which only half of the cases could be correctly determined from normal weight individuals. Specificity levels were very good to almost perfect in most categories regardless of gender. Previous studies demonstrated sensitivity levels of 77% for determining overweight or obesity among Australian youths[17] and 75.8% among German adolescents[9] and these values were comparable to the sensitivity values in girls in this study. Our male samples, however, showed higher sensitivity values, attaining almost excellence (94.7 and 95% CI 84.7 and 1.00).

In the present study, we found that mother's education level was the only significant predictor of misreported BMI category, whereas mother's income level, father's education and income level, dieting and physical activity level did not significantly predict misreported BMI categories. This study partly agreed with a previous study of Zhou *et al.*[20] in that household economic status was associated with a bias in self-reported BMI. Vartanian and Germeroth[30] revealed that dietary restraint and BMI did not influence the degree of inaccuracy of self-reported weight but they did reflect deliberate misreporting rather than cognitive or perceptual bias. Similarly, Elgar *et al.*[23] indicated that dieting did not predict bias in self-reported weight but did predict bais self-perception of body size. This finding is not in line with a study of Larsen *et al.*[19], in which dietary restraint did not significantly predict weight underestimation, but higher BMI was an important predictor. With regard to physical activity, this study did not support the findings of Gunnare *et al.*[27], who found that BMI and physical activity level were significantly associated with underreporting weight in US young adults.

The limitations of this study were that the sample was limited to college students with a small age range between 21 and 24 years, as age was significantly associated with misreporting BMI[28]. The sample was also not ethnically diverse, considering the complexity of Indonesian ethnicities. Previous studies have demonstrated that race/ethnicity contribute to bias in self-reported BMI[18,26]. Nevertheless, the samples were mostly of Javanese ethnicity, which represents the largest ethnicity in Indonesia. The quota sampling design and restriction of sampling to only two universities may also have influenced participant's characteristics, which failed to replicate the lower prevalence of national obesity among males than among females (19.7 and 32.9% for males and females, respectively)[4] as well as the prevalence in a previous study in a similar area in which obesity was consistently more common in females than males[31]. Therefore, we suggest that future studies should include larger sample sizes with a wider age range and with various ethnicities to represent the national statistics. The strengths of this study included the small elapsed time between the questionnaire administration and the measurement of anthropometry. Long periods of time between surveys and measurements can cause bias in self-reporting data, as individual's weight may change during long waiting times. In future studies, some other factors, such as sociodemographic characteristics, body image and health behavior may be useful to include in modelling the determinants of misreporting. Lastly, to improve the validity of self-reported data, future health surveys can be obtained by including necessary adjustments and developing correction equations derived from a small sample of overweight and obese. The usefulness of these methods has been reported in some previous investigations among Australians[11], Canadians[32] and US adults[14].

Finally, although these findings should be interpreted with care because of the sample limitations, this study provided evidence that indicated self-reported weight, height and BMI were reasonably valid for use in this study population. As observed in many other studies, heavier participants underestimated their BMI to a greater extent than slimmer participants[19,25,30]. Using BMI derived from self-reported data to determine the prevalence of underweight, overweight and obesity in populations may produce overestimations particularly among underweight boys or underestimations of overweight/obesity among boys and girls.

CONCLUSION

Although self-reported BMI produced lower values than the objective measurements, self-reported weight, height and BMI were shown to be acceptable in the sample population and could therefore be used in clinical and public health settings when resources are limited. Nevertheless, caution should be used when adopting self-reported weight, height and BMI data, especially among groups that have potential bias in reporting data, such as underweight and overweight males and females. Overall, these findings provide useful insight into the use of self-reported weight, height and BMI among a young Indonesian population.

SIGNIFICANCE STATEMENTS

- There was high correlation, reliability and agreement between the self-reported and measured data
- Self-reported weight, height and BMI were valid in this young Indonesian population
- The results may help researchers collect large amounts of epidemiological data with restricted time, budget and human resources

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