Does self reported BMI really reflect the proportion of overweight and obese children?

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Summary

Background. Monitoring the prevalence of overweight and obesity is crucial to understanding whether adolescents' self reported anthropometric measures can be used to estimate weight problems. This study assesses reliability and validity of self reported height, weight and BMI in a representative sample of Italian adolescents and examines independent predictors of reporting errors.

Methods. The Health Behaviour in School Aged Children questionnaire was used to collect data among 11, 13 and 15 year old pupils in the Piedmont region (Italy). Weight and height were self assessed by students and measured in school by trained personnel. Overweight and obesity were identified using Cole classification. Agreement was assessed by Pearson correlation coefficient and weighted kappa statistic. Validity was evaluated by sensitivity and specificity to determine how accurately students classified themselves into BMI categories. Multivariate logistic regression was performed to study predictors of bias between self rated and measured BMI categories.

Results. Italian students underestimate their weight by an average of 1.2 kg and underreport BMI by 0.6 kg/m^2. Girls tend to underreport their weight more than boys. Self reported data are highly specific in identifying not overweight (94.5%) and obese children (99.3%) but sensitivity is modest. Girls are systematically less sensitive than boys. Body self image may influence self reported data and fat perceiving children are less accurate in reporting their anthropometric measures.

Conclusion. Self reported data may be used to analyse general trends on aggregate data but not to assess correctly overweight and obesity prevalence, especially at the individual level.

KEY WORDS: *adolescents; body mass index; validity of self report; obesity; weight perceptions*

Introduction

Rates of overweight and obesity among children and adolescents have steadily increased in recent years in developed countries and their control is a major public health issue in the 21st century, due to risk for cardiovascular diseases, type 2 diabetes, and some types of cancer in adulthood (1).

Body mass index (BMI), the most commonly used measure to identify obesity, is frequently based on self reports of weight and height in place of measured data for practical and economic reasons. Monitoring the prevalence of overweight and obesity and targeting prevention programmes are crucial to understand whether adolescents' self reported anthropometrics measures can be used as valid tools to estimate weight problems in these age groups.

Agreement and validity studies about self rated weight and height status among adolescents have been conducted mainly in the US (2-10) whereas more limited findings exist for European countries (11-14). These studies suggest that reliability of self reports is generally high, with correlations for BMI ranging from 0.75 in Dutch adolescents (12) to 0.94 in 11 year old US students (7). Commonly, height is over reported and weight is underreported, although it appears to vary by gender, age, and race or ethnicity. In particular, girls underreport their weight more than boys, and older and

Caucasian adolescents over report their height more than younger and African American and Hispanic counterparts. Despite high agreement, self-reports seem not able to correctly estimate weight problems. In fact, even modest misreporting of weight and height leads to an underestimation of the real prevalence of overweight and obese adolescents.

Two recent studies (11,14) suggested that perceived body size and body dissatisfaction can be determinants of adolescents' underestimation of body weight, as well as in adults (15). Elgar et al (11) examined a community sample of 418 11 year old Welsh students showing a relationship between self body perception and biased reported measures. In a larger sample of 15 year old Swedish students, Rasmussen et al (14) found that boys and girls dissatisfied with their physical appearance or size underreported their weight more than satisfied subjects.

The aim of this study was to assess both the reliability and validity of self reported height, weight and BMI in a regional representative sample of Italian adolescents. Moreover we examine some factors that could be independent predictors of reporting errors in BMI, with special attention to body image perception.

Methods

A random cluster sample of 308 school classes stratified on the basis of study level (junior and high schools) and geographical area of residence (province) was drawn from the whole list of schools in the Piedmont Region, obtained from the local educational authority. Consent to the survey was obtained from school officials, and passive parental consent was obtained through an information letter sent to all parents.

About 1536 respondents in each of the three age groups (11, 13 and 15 years old) were selected, in order to obtain estimates of the study variables with a ±3% sampling error (16).

The Health Behaviour in School Aged Children (HBSC) survey questionnaire was used to collect reported data in 2004 among 11, 13 and 15 year old pupils. A detailed study protocol and the list of surveyed items are available online at *www.hbsc.org*. The self administered questionnaire contained questions concerning the sociodemographic status and health risk behaviours of the child. Items related to this study were body image ("*Do you think your body is: much too thin, a bit too thin, about right size, a bit too fat, much too fat?*") and the Family Affluence Scale (FAS), based on the purchasing capacity of the family (low, medium and high) (17).

Students also reported their height in cm ("*How tall are you without your shoes on*?") and weight in Kg ("*How much do you weigh without your shoes on*?").

In addition to completing the questionnaire, students were weighed and had their height measured in school by trained personnel of the local health authority, just after completing the questionnaire. Height and weight measurements were taken (clothes and shoes *off*) by using a standard height chart and weight scale.

Out of the 308 classes enrolled, 298 (96.8%) returned the questionnaires, without differences by age or geographic location, corresponding to 5578 students. After review for general completeness, a sample of 5227 students (93.7%) was obtained.

Preliminary analyses of the discrepancy between self reported and measured height and weight showed that 617 students had no self rated height and/or weight data and that 119 pupils were not measured. A total of 4513 questionnaires (86.3%) were used for present analyses.

STATA/SE version 9.0 for Windows was used for data management and statistical analyses. BMI (kg/m^2) was calculated on self reported and measured height and weight. Overweight and obesity were identified using age and gender appropriate international BMI cutoff points based on pooled international data and linked to the widely used adult obesity cutoff point of 30 kg/m^2 (18).

The difference between measured and reported values was calculated by subtracting reported data from measured data for each subject. Therefore, negative values reflect underreporting.

Due to statistical significance, all analyses were conducted separately by gender and age class. Paired samples *t* tests were done to compare mean self reported and measured height, weight, and BMI. Agreement was assessed by the Pearson correlation coefficient for continuous variables and by the weighted kappa statistic for data classified into categories (non overweight, overweight and obese).

Sensitivity and specificity were calculated to determine how accurately students were classified into BMI categories when using self reported data.

Stepwise multivariate logistic regression analysis was used to study the influence of age, gender, FAS, and body image perception in discrepancy between participants' self rated and measured BMI categories ac-

cording to Cole classification. Three groups were identified: realistic estimators, under and over estimators; we finally compared realistic vs. under estimators of BMI and vs. over estimators of BMI.
P values below 0.05 were considered to be statistically significant.

Results

The study population consisted of 50.7% (n =2290) girls; the students were evenly distributed in each age group (34.1% in 11 yrs old, 32.1% in 13 yrs old and 33.8% in 15 yrs old). Descriptive statistics on measured and self reported weight, height, and BMI are shown in Table 1. Self reported weight was less than measured weight in both girls and boys and in each age group, with a decreasing trend of difference from younger to older students. There were also differences found in height measures in both genders and data showed a slight underreporting in the younger pupils (-0.3 cm) and an increasing overestimation in 13 (+0.8 cm) and 15 year old (+1.8 cm) children. BMIs based on self reported data were constantly lower than BMIs based on measured data in both boys and girls, with underreporting increasing with age. Overall, girls underreported their weight by 1.3 kg and overestimated their height by 1.3 cm, which resulted in underreporting of BMI by an average of 0.8 kg/m^2. Boys underreported their weight by 1.1 kg, and reported their height almost correctly (0.3 cm), which resulted in underestimation of BMI by an average of 0.4 kg/m^2.
Correlations were generally high, mainly in weight data, and varied between 0.77 in 13 year old girls for height and 0.95 in 15 year old girls for weight. All coefficients are statistically significant ($p<0.001$).
Table 2 shows the adolescents categorized into overweight and obese, according to the self reported and measured data. Based on self reports, prevalence estimates of overweight were 18.5% in boys and 12.5% in girls, but according to measured data were, respectively, 20.3% and 17.3%. In each age class girls underreported their overweight status more than boys; this difference remains stable across age groups. Also the prevalence of obesity was underestimated: 4.0% of boys and 1.9% of girls classified themselves as "obese" compared with, respectively, 5.6% and 3.2% according to the measured data. In younger students both genders misreported approximately in the same proportion; 13-year-old boys underestimated more than girls, while in the older group girls misclassified their obesity status in a larger proportion.
The weighted kappa statistics range from 0.63 for 11 year old girls to 0.70 for 13 year old pupils. Overall, we estimated a reproducibility index of 0.69 for boys and 0.66 for girls, which according to the Landis Kock scale (19) can be considered a good level of agreement.

Table 1. Means for Self Reported and Measured Height, Weight, and Body Mass Index

	11 years old		13 years old		15 years old	
	Boys N=814	**Girls N=723**	**Boys N=744**	**Girls N=703**	**Boys N=732**	**Girls N=797**
Weight (Kg)						
Self reported	44.1±9.9	43.3±9.3	55.7±11.8	52.0±9.6	64.7±10.6	55.2±8.6
Measured	45.6±10.8	45.1±10.2	56.8±12.3	53.2±10.2	65.3±11.1	56.2±9.1
Mean difference	-1.5±3.6	-1.7±3.7	-1.1±5.0	-1.2±3.4	-0.6±3.9	-0.9±2.9
Correlation	0.94	0.93	0.92	0.94	0.94	0.95
Height (cm)						
Self reported	150.6±9.3	151.8±8.5	165.7±9.4	161.1±7.5	174.4±8.1	164.3±6.1
Measured	151.0±7.8	152.0±7.3	165.3±8.1	159.7±6.0	173.5±6.8	161.7±6.1
Mean difference	-0.4±5.3	-0.2±4.4	0.4±4.7	1.3±4.8	0.9±4.5	2.6±2.9
Correlation	0.82	0.85	0.89	0.77	0.83	0.88
BMI (Kg/m^2)						
Self reported	19.4±3.6	18.7±3.4	20.2±3.5	20.0±3.3	21.3±3.4	20.4±2.8
Measured	19.9±3.6	19.4±3.6	20.7±3.6	20.8±3.5	21.7±3.3	21.5±3.1
Mean difference	-0.5±2.2	-0.6±2.0	-0.5±2.1	-0.8±2.0	-0.4±2.1	-1.0±1.3
Correlation	0.82	0.84	0.83	0.84	0.80	0.92

Table 2. Number of overweight and obese children, based on measured and self reported data, using BMI cutoff points and weighted Kappa statistics.

	Overweight		Obese		
	Self reported	**Measured**	**Self reported**	**Measured**	**Kappa**
11 yrs					
Boys (%)	182 (22.4)	193 (23.7)	44 (5.4)	57 (7.0)	0.67 *
Girls (%)	110 (15.2)	157 (21.7)	21 (2.9)	32 (4.4)	0.63*
13 yrs					
Boys (%)	138 (18.6)	145 (19.5)	29 (3.9)	44 (5.9)	0.70*
Girls (%)	100 (14.2)	127 (18.1)	15 (2.1)	19 (2.7)	0.70*
15 yrs					
Boys (%)	104 (14.2)	127 (17.4)	19 (2.6)	26 (3.6)	0.69*
Girls (%)	67 (8.4)	101 (12.7)	7 (0.9)	22 (2.8)	0.63*
Boys (%)	424 (18.5)	465 (20.3)	92 (4.0)	127 (5.6)	0.69*
Girls (%)	277 (12.5)	385 (17.3)	43 (1.9)	73 (3.2)	0.66*

**p<0.0001*

No evidence of significant differences was found with respect to age and gender.

Table 3 shows how accurately students were classified into BMI categories using self reported data. Among the overweight, sensitivity and specificity were 53.2% (95%CI: 51.2%-55.3%) and 96.1% (95%CI: 95.3%-96.9%) for girls and 63.0% (95%CI: 61.0%-65.0%) and 92.8% for boys (95%CI: 91.8%-93.9%). One hundred out of 385 girls (46.8%), and 172 out of 475 boys (37%), were not detected as overweight according to self reported BMI, resulting as false negative. In all age groups boys showed a higher sensitivity and a lower specificity. In 15-year-old students there was lower sensitivity both in boys (59.8%) and girls (45.5%). In both genders specificity increased with age. Among obese students, sensitivity was 45.2% (95%CI: 43.1%-47.3%) and specificity was 99.5% (95%CI: 99.3%-99.8%) for girls and 56.7% (95%CI: 54.7%-58.7%) and 99.1% for boys (95%CI: 98.7%-99.5%). Forty out of 73 obese girls (54.8%) and 55 out of 127 obese boys (43.3%) were false negative. Fifteen out of 22 older girls (68.2%) did not classify themselves as obese. Specificity was very high in both genders; it ranged from 98.7% for younger boys to 100% in 15 year old girls. Results of multivariate logistic regression to detect predictors of bias in self reporting BMI categories are

Table 3. Sensitivity and specificity of self rated overweight and obesity.

	Overweight		Obese	
	Sensitivity	Specificity	Sensitivity	Specificity
11 yrs				
Boys	62.7	90.2	59.7	98.7
Girls	51.6	94.9	46.9	99.1
13 yrs				
Boys	66.2	93.0	52.3	99.1
Girls	61.4	96.2	57.9	99.4
15 yrs				
Boys	59.8	95.4	57.7	99.4
Girls	45.5	97.0	31.8	100.0
Boys	63.0	92.8	56.7	99.1
Girls	53.2	96.1	45.2	99.5

Table 4. Bias in self reported BMI-categories (not overweight, overweight, obese): students in a lower/higher than measured self reported BMI-category (under/over reporting) vs students assessing correctly their BMI category (concordant).

	Underreporting BMI category Underestimating/concordant[1]		**Over reporting BMI category Overestimating/concordant[1]**	
	OR[2] (CI 95%)	N=432/3940	OR[2] (CI 95%)	N= 141/3940
Gender				
Boys	1.0	218/1974	1.0	98/1974
Girls	0.79 (0.64-0.98)	214/1966	0.42 (0.29-0.62)	43/1966
Age class				
11 yrs	1.0	178/1291	1.0	68/1291
13 yrs	0.69 (0.54-0.89)	124/1277	0.68 (0.46-1.01)	46/1277
15 yrs	0.67 (0.52-0.86)	130/1372	0.39 (0.24-0.62)	27/1372
FAS[3]				
Low	1.0	71/619	1.0	32/619
Medium	1.07 (0.80-1.44)	211/1888	0.60 (0.38-0.94)	57/1888
High	1.02 (0.74-1.39)	142/1383	0.68 (0.43-1.09)	46/1383
Body Image				
Right size	1.0	182/2425	1.0	84/2425
Thin	0.09 (0.03-0.25)	4/559	0.50 (0.26-0.95)	13/559
Fat	3.58 (2.90-4.43)	243/935	1.42 (0.97-2.09)	44/935

[1] Concordant: student who assesses correctly his BMI category (normal/overweight/obese) Under/over reporting: student who underestimates/ overestimates his BMI category (normal/ overweight/ obese)
[2] Odds Ratio (OR) controlled for gender, age class, FAS and body image
[3] Family Affluence Scale (FAS)

shown in Table 4. Overall, 573 (12.7%) out of 4513 students did not assess their BMI status correctly. Four hundred and thirty two respondents classified themselves as thinner than they were. Young males believing to be fat (OR:3.58, 95%CI: 2.90-4.43) were more likely to underestimate their status, whereas socioeconomic position was not associated with reporting errors. One hundred and forty one students (3.1%) overestimated their status: female (OR: 0.42, 95%CI: 0.29-0.62) and older students (13 years old: OR: 0.68, 95%CI: 0.46-1.01; 15 years old: OR: 0.39, 95%CI: 0.24-0.62) did not classify themselves as fatter than they actually were.
Logistic regression was also carried out after stratifying by body image perception, among the underestimating group (Table 5), to account for differences in age and gender. Due to the very small sample (4 males), data on the group perceiving themselves as thin were not analysed. Among those perceiving themselves to be the right size, girls underreported less than boys (OR:0.62, 95%CI: 0.45-0.84) and accuracy tended to increase by age. For the fat perceiving group, our results showed no significant difference by age and gender: boys and girls in each age tended to underreport their BMI status.

Discussion

Findings from this study indicate that, overall, students provide valid estimates of their height but underestimate their weight by an average of 1.2 kg, resulting in a mean underreported BMI of 0.6 kg/m^2. Significant differences were found by age and gender: girls tend to overestimate their height and underreport their weight more than boys, with an increasing difference from younger to older students for height, and a decreasing difference for weight.
The direction and degree of biases are substantially in accordance with recent studies. In the US, Brener et al. (7) showed that girls underreported their weight more than boys (2.0 kg vs 1.1 kg), and also Himes et al. (8) reported a considerably larger degree of underreporting of weight among females (3.5 kg) with respect to males (1.6 kg); girls were, on the contrary, likely to over report their height (2.4 cm) more than boys (1.2 cm). In European countries, Rasmussen et al. (14) reported that Swedish female adolescents underreported their weight by an average of 1.3 kg, while males only by 0.3 kg; height overestimation was smaller (0.2 cm in

Table 5. Bias in self reported BMI categories according to Body Image classification (Right Size and Fat) in the underreporting group.

	Body Image classification			
	Right size Underestimating/concordant[1]		Fat Underestimating/concordant[1]	
	OR[2] (CI 95%)	N=182/2425	OR[2] (CI 95%)	N=343/935
Boys	1.0	114/1230	1.0	98/361
Girls	0.62 (0.45-0.84)	68/1195	0.96 (0.71-1.29)	145/574
11 yrs	1.0	84/775	1.0	90/294
13 yrs	0.62 (0.44-0.89)	54/796	0.76 (0.53-1.08)	68/295
15 yrs	0.48 (0.33-0.70)	44/854	0.81 (0.58-1.14)	85/346

[1] Concordant: student who assesses correctly his BMI category (normal/overweight/obese)
Under/over reporting: student who underestimates/ overestimates his BMI category (normal/overweight/obese)
[2] Odds Ratio (OR) controlled for gender, age class and FAS

girls and correctly reported by boys). Also Welsh adolescents (11) underreported their weight, but no differences were found between self reported and measured weight, height and BMI in boys or in girls. Finally, 12 and 13 year old Dutch adolescents (12) considerably underreported their weight (6.1 kg) and height (1.5 cm) resulting in a underestimation of BMI of 1.5 kg/m^2.

Correlations between measured and self reported height, weight and BMI, generally lower in adolescents than in adults, are high in both genders and across all age classes. Similar results have been previously described in other studies (4,7,12,14), with correlations for BMI ranging from 0.75 in Dutch adolescents (12) to 0.94 in 11 year old US students (7).

Notwithstanding the highly correlated actual and self reported measures, the resulting BMI status of overweight and obese children appears more misreported than expected. This is a consequence of the systematic overestimation of height and underestimation of weight, which leads to a self perceived BMI failing to detect a substantial proportion of overweight and obese cases. Therefore, self reported data are highly specific in identifying not overweight (94.5%) and obese children (99.3%) but sensitivity, which is the proportion of overweight and obese pupils correctly identified by self reported BMI, is modest (respectively, 58.6% and 52.5%). Girls are systematically less sensitive than boys, while there appears to be no significant difference across age groups.

The high specificity and low sensitivity detected in our study are similar to those reported from other countries: in the UK, Elgard et al (11) showed that self reported data are highly specific in identifying cases of overweight (94.7%) and obesity (99.6%) but only moderately sensitive (52.2% and 55.6%), with no gender differences. In Sweden, Rasmussen et al (14) reported that, among obese children, sensitivity and specificity were 0.65 and 1.00 among girls, and 0.52 and 1.00 for boys, while, among overweight children, sensitivity was 0.70 for girls and 0.74 for boys. In the US, similar results were found by Brener et al (7) but not by Strauss et al (4); in fact they reported a correct classification of obesity status in 94% of children, similar in both genders.

Our study also shows that being a male in the younger age class is associated with a higher bias in self reported BMI, even after controlling for body perception. Girls are more likely than boys to assess their weight status accurately, particularly in the older age class. This finding is closer to what is observed in adults (20) rather than among adolescents. As for age and gender, Elgar et al (11) found that these do not predict bias in self reported weight and also Rasmussen et al (14) showed that, overall, girls underreport their weight to a larger extent than boys and underreport their weight, regardless of body size, degree of body dissatisfaction and perception of physical appearance. Among overweight and obese girls we observed, as might be expected, that weight underreporting is greater with respect to their non overweight counterparts. Our results may suggest that Italian girls are more aware of their bodies than other European females. However, the stratified analysis carried out according to body perception, shows that gender differences disappear in the group of fat perceiving chil-

dren, while they remain in the children perceiving correct body weight. This finding suggests that body self image may influence self reported height, weight and BMI and that, overall, fat perceiving children are less accurate in reporting their anthropometric measures and that they underestimate their BMI status regardless of age and gender.

Finally, we found no socioeconomic differences in our Italian sample concerning bias in BMI categories resulting from the self reported height and weight, which is in agreement with a study from Sweden (14), but not with the American study by Himes et al (8). In conclusion we could state that self reported data on height and weight may be used to analyse general trends on aggregate data but not to correctly assess overweight and obesity prevalence, especially at the individual level.

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