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Validity of Self-Reported Height, Weight, and Body Mass Index of the Korea Youth Risk Behavior Web-Based Survey Questionnaire

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Objectives: Self-reported anthropometric values, such as height and weight, are used to calculate body mass index (BMI) and assess the prevalence of obesity among adolescents. The aim of this study was to evaluate the validity of self-reported height, weight, and BMI of the Korea Youth Risk Behavior Web-based Survey questionnaire.
Methods: A convenience sample of 137 middle school students and 242 high school students completed a self-administered questionnaire in 2008. Body height and weight were directly measured after self-reported values were obtained from the questionnaire survey. Sensitivity, specificity, and kappa statistics were computed in order to evaluate the validity of the prevalence of obesity (BMI $\geq$ 95th percentile or $\geq$ 25 kg/m^2) based on self-reported data.
Results: Self-reported weight and BMI tended to be underestimated. Self-reported height tended to be overestimated among middle school females and high school males. Obese adolescents tended to underestimate their weight and BMI and overestimate their height more than non-obese adolescents. The prevalence estimate of obesity based on self-reported data (10.6%) was lower than that based on directly measured data (15.3%). The estimated sensitivity of obesity based on self-reported data was 69.0% and the specificity was 100.0%. The value of kappa was 0.79 (95% confidence interval, 0.70-0.88).
Conclusions: This study demonstrated that self-reported height and weight may lead to the underestimation of BMI and consequently the prevalence of obesity. These biases should be taken into account when self-reported data are used for monitoring the prevalence and trends of obesity among adolescents nationwide.

Key words: Adolescent, Body height, Body mass index, Body weight, Reproducibility of results
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INTRODUCTION

Obesity among children and adolescents is a worldwide epidemic; increasing trends in obesity are evident in both developed and developing countries [1]. Obesity in youth is associated with increased risks of cardiovascular disease, type 2 diabetes mellitus, and some types of cancers in later life [2]. An accurate assessment of the prevalence and trends of obesity is essential for public health policies and practices to prevent obesity and related chronic diseases.

Height and weight are important anthropometric values because of their role in calculating body mass index (BMI), a measure of overweight and obesity. Although self-reported height and weight have been used for the assessment of overweight and obesity for reasons of low cost or convenience, previous studies have demonstrated that the prevalence estimates of overweight and obesity derived from self-reported data are likely to be underestimated among both adolescents and adults [3,4].

In a literature review conducted with 11 studies on self-reported height and weight among adolescents in the United States [3], self-reported data underestimated the prevalence of overweight and the bias was affected by weight status and gender. In a systematic review conducted with 64 studies on self-reported height and weight in adult populations [4], overall trends of under-reporting for weight and BMI and over-reporting for height were observed, although the degree of the trends were varied with the characteristics of the population being examined.

The Korea Youth Risk Behavior Web-based Survey (KYRBWS) has been conducted annually since 2005 to assess the prevalence of adolescent health risk behaviors among middle and high school students nationwide. The KYRBWS includes the assessment of obesity by using BMI based on self-reported height and weight [5-7].

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Results from the 2007 KYRBWS demonstrated that the prevalence estimate of obesity (BMI ≥ 95th percentile or ≥ 25 kg/m^2) was 8.1% among middle school students and 11.7% among high school students [7]. In the 2005 National Growth Survey (NGS), the prevalence estimate of obesity for adolescents 13-15 years and 16-18 years of age was 14.8% and 17.5%, respectively [8]. The obesity estimates in the NGS, which were higher than those in the KYRBWS, were computed from direct measurements of height and weight and the definition of obesity was the same as that in the 2007 KYRBWS. Because data from the KYRBWS are used to implement and evaluate obesity prevention and intervention programs, the validity of self-reported height and weight in the survey questionnaire needs to be established.

National surveillance systems for monitoring adolescent health risk behaviors in other countries, such as the Health Behavior in School-aged Children (HBSC) Study and the Youth Risk Behavior Surveillance System (YRBSS) in the United States, include monitoring of the prevalence and trends of obesity by using BMI based on self-reported height and weight [9,10]. The validity of self-reported height and weight in these survey data has been evaluated in previous studies [11-13]. The results from these studies demonstrated that self-reported height and weight may lead to the underestimation of the prevalence of obesity. In this study, we present the first evaluation of the validity of self-reported height and weight of the KYRBWS questionnaire and BMI calculated from these values among Korean adolescents.

METHODS

I. Subjects

A convenience sample of students was selected from four middle and eight high schools, which included the sample schools of the 2008 KYRBWS. In each school, one class at the second grade level was selected in a convenient basis. One hundred forty-three middle school students and 269 high school students in the selected classes were eligible to participate. After excluding students who chose not to participate, 137 (95.8%) middle school students and 242 (90.0%) high school students who agreed to participate completed the survey administration. Signed parental informed consent forms were obtained from all study participants before the survey administration.

II. Data Collection

Data collection began in September 2008 and ended in October 2008. Well-trained data collectors explained the objective of the survey and the entire survey process to the students before the survey administration, including anthropometric measurements. A web-based questionnaire survey was administered in a computer room of each selected school. The students were required to visit the KYRBWS website and logged in with a unique number, which was assigned to each student to assure anonymity. After logging in, the students completed the self-administered questionnaire. The questionnaire included the assessment of demographic factors, perceived body image, weight control, and physical activity, in addition to obtaining self-reported anthropometric values (height in centimeters and weight in kilograms to one decimal place) [7]. In the physical activity questions, vigorous-intensity physical activity was described as activity that caused sweating and rapid breathing and was represented by jogging, fast bicycling, soccer, or similar activities. Moderate-intensity physical activity was described as activity that caused slightly rapid breathing and was represented by table tennis, badminton, slow swimming, or similar activities. Muscle strengthening exercise included weight lifting, dumbbell exercises, or similar activities [14].

After the administration of the questionnaire survey, each student was required to put his or her unique number card into an envelope and to seal the envelope. The sealed envelope, which was labeled with another unique number, was carried by the students when body height and weight were directly measured according to a standard protocol. Body height was measured by a SECA 225 Mobile Measuring Device (SECA Co. Ltd., Hamburg, Germany). Prior to the height measurement, the students were required to remove their shoes and hair accessories. While standing erect and facing forward with the back of head, scapulae, buttocks, and heels in contact with the measuring rod, the students looked straight ahead with their arms hanging loosely at their sides. The data collectors then lowered the horizontal plane, so that it rested flat on the top of the student' s head. The body height in centimeters was read and recorded to the nearest 0.1 centimeter. Body weight was measured by a CAS GL-6000-20 (CAS Co. Ltd., Seoul, Korea), which was zero-balanced before each student was weighed. The students were required to wear light clothing and remove their shoes before stepping on the scale. The body weight in kilograms was read and recorded to the nearest 0.1 kg. After the anthropometric

measurements, the envelope labeled with the unique number was gathered by the data collectors and used to match the questionnaire survey data to the anthropometric data. All data collection procedures were approved by the Institutional Review Board of Daegu Catholic University Medical Center.

III. Statistical Analyses

BMI was calculated as the weight in kilograms divided by the square of the height in meters. Obesity was defined as BMI $\geq$ 25 kg/m^2 or $\geq$ 95th percentile based on the 2007 Korean children and adolescents growth charts [15]. Differences between self-reported and measured means for height, weight, and BMI were assessed by subtracting the measured values from the self-reported values. Paired t-tests were used to compare self-reported means with directly measured means for height, weight, and BMI.

Student's t-tests were used to compare the differences between self-reported and measured means for height, weight, and BMI by selected subgroups. The subgroup analyses were conducted by selected factors as follows: weight status, perceived body image, weight control, and physical activity. With respect to physical activity, vigorous-intensity physical activity was classified into the following two groups: 1) students who participated in the activity for $\geq$ 20 minutes on $\geq$ three of the past seven days, and 2) those who did not. Moderate-intensity physical activity was classified into the following two groups: 1) students who participated in the activity for $\geq$ 30 minutes on $\geq$ five of the past seven days, and 2) those who did not. Muscle strengthening exercise was grouped according to the frequency of the activity as follows: 1) students who participated in the activity on $\geq$ two of the past seven days, and 2) those who did not [14].

Sensitivity, specificity, and kappa statistics were computed in order to evaluate the validity of the prevalence of obesity. To evaluate statistical significance, a two-sided significance level of 0.05 was used. Statistical analyses were conducted using SAS, version 9.1 (SAS Inc., Cary, NC, USA).

RESULTS

The demographic and selected behavioral characteristics of the study participants are shown in Table 1. Among 379 study participants, 137 (36.2%) were middle school students and 242 (63.9%) were high school students. Among the 137 middle school students, males accounted for 58.4% and females accounted for 41.6%. Among the 242 high school students, males comprised 57.9% and females comprised 42.1%. The study participants were enrolled from three urban areas: Daegu Metropolitan City (54.6%), Pohang City (7.9%), and Seoul Metropolitan Government (37.5%). Of the fathers, 37.2% had a college or higher level of education. Of the mothers, 27.2% had a college or higher level of education. With respect to body image perception, 37.7% perceived self as overweight or obese. Weight loss was attempted by 39.1% of the study participants during the past 12 months. The percentage of students who participated in moderate-intensity physical activity for $\geq$ 30 minutes on $\geq$ five of the past seven days was 13.5%.

Table 1. Demographic and selected behavioral characteristics of study participants

Characteristic	n	%
Gender		
Male	220	58.1
Female	159	42.0
School grade		
Middle school 2nd grade	137	36.2
High school 2nd grade	242	63.9
Area		
Daegu Metropolitan City	207	54.6
Pohang City	30	7.9
Seoul Metropolitan Government	142	37.5
Paternal education		
$\leq$ Middle school	19	5.0
High school	149	39.3
$\geq$ College	141	37.2
Unknown or non-existent father	70	18.5
Maternal education		
$\leq$ Middle school	29	7.7
High school	185	48.8
$\geq$ College	103	27.2
Unknown or non-existent mother	62	16.4
Perceived self as overweight or obese		
No	236	62.3
Yes	143	37.7
Tried to lose weight during the past 12 months		
No	231	61.0
Yes	148	39.1
Vigorous-intensity physical activity for $\geq$ 20 minutes		
< Three of the past seven days	246	64.9
$\geq$ Three of the past seven days	133	35.1
Moderate-intensity physical activity for $\geq$ 30 minutes		
< Five of the past seven days	328	86.5
$\geq$ Five of the past seven days	51	13.5
Muscle strengthening exercise		
< Two of the past seven days	228	60.2
$\geq$ Two of the past seven days	151	39.8

Table 2 shows the differences between self-reported and directly measured means for height, weight, and BMI. Self-reported weight and BMI tended to be underestimated among middle and high school males

Table 2. Differences between self-reported and directly measured means for height, weight, and body mass index

Variable	Middle school		High school	
	Males	Females	Males	Females
Height (cm)				
SR mean (SD) (1)	165.8 (6.8)	160.2 (5.3)	173.9 (5.5)	161.0 (5.2)
DM mean (SD) (2)	166.1 (6.4)	159.7 (5.4)*	173.4 (5.5)*	160.9 (5.1)
Mean difference (SD) (1)-(2)	-0.3 (1.7)	0.5 (1.4)†	0.5 (1.3)	0.1 (1.3)†
Weight (kg)				
SR mean (SD) (1)	57.3 (10.9)	52.4 (11.8)	65.3 (11.3)	53.9 (8.0)
DM mean (SD) (2)	59.0 (11.7)*	53.5 (12.1)*	66.9 (11.9)*	55.4 (7.8)*
Mean difference (SD) (1)-(2)	-1.7 (3.6)	-1.1 (1.8)	-1.6 (2.3)	-1.5 (2.1)
Body mass index (kg/m^2)				
SR mean (SD) (1)	20.8 (3.3)	20.4 (4.2)	21.5 (3.4)	20.8 (2.7)
DM mean (SD) (2)	21.3 (3.6)*	21.0 (4.4)*	22.2 (3.6)*	21.4 (2.8)*
Mean difference (SD) (1)-(2)	-0.5 (1.3)	-0.6 (0.8)	-0.7 (0.9)	-0.6 (0.9)

SD: standard deviation, SR: self-reported, DM: directly measured.
*$p < 0.05$ estimated by paired t-tests in comparison between SR and DM means.
†$p < 0.05$ estimated by Student' s t-tests in comparison between mean differences by gender.

Table 3. Mean differences* (SD) between self-reported and directly measured means for height, weight, and body mass index stratified by selected factors

Variable	n	Mean difference (SD)		
		Height (cm)	Weight (kg)	BMI (kg/m^2)
Obesity† based on DM BMI				
No	321	0.2 (1.4)	-1.3 (2.4)	-0.5 (0.9)
Yes	58	0.7 (1.7)†	-2.8 (2.7)†	-1.2 (1.1)†
Perceived self as overweight or obese				
No	236	0.3 (1.4)	-1.7 (2.2)	-0.6 (0.8)
Yes	143	0.3 (1.6)	-1.8 (3.0)	-0.7 (1.2)
Tried to lose weight during the past 12 months				
No	231	0.2 (1.4)	-1.2 (2.5)	-0.5 (1.0)
Yes	148	0.4 (1.5)	-1.9 (2.5)†	-1.0 (1.0)†
Vigorous-intensity physical activity for ≥ 20 minutes				
< Three of the past seven days	246	0.2 (1.4)	-1.6 (2.6)	-0.6 (1.0)
≥ Three of the past seven days	133	0.3 (1.5)	-1.4 (2.5)	-0.6 (0.9)
Moderate-intensity physical activity for ≥ 30 minutes				
< Five of the past seven days	328	0.3 (1.4)	-1.4 (2.5)	-0.6 (1.0)
≥ Five of the past seven days	51	0.3 (1.9)	-2.2 (2.6)†	-0.9 (1.0)
Muscle strengthening exercise				
< Two of the past seven days	228	0.2 (1.5)	-1.4 (2.6)	-0.6 (1.0)
≥ Two of the past seven days	151	0.4 (1.4)	-1.7 (2.4)	-0.7 (1.0)

SD: standard deviation, DM: directly measured, BMI: body mass index.
* Calculated by subtracting DM values from self-reported values.
† Defined as body mass index ≥ 95th percentile or ≥ 25 kg/m^2.
†$p < 0.05$ estimated by Student's t-tests in comparison between mean differences by selected subgroups.

and females. The magnitude of under-reported weight ranged from -1.1 to -1.7 kg in the subgroup analyses by gender and school grade. The magnitude of under-reported BMI ranged from -0.5 to -0.7 kg/m^2 in the subgroup analyses by gender and school grade. The magnitude of underestimated weight or BMI was not significantly different by gender. Self-reported height tended to be overestimated among middle school females and high school males. There were significant differences in the magnitude of bias in self-reported height between middle school males and females or between high school males and females ($p<0.05$).

The magnitude of bias in self-reported weight and BMI was different by selected behavioral factors related to weight control and physical activity. Students who tried to lose weight during the past 12 months tended to underestimate their weight and BMI more than those who did not. Students who participated in moderate-intensity physical activity for ≥ 30 minutes on ≥ five of the past seven days tended to underestimate their weight more than those who did not (Table 3).

Regardless of body image perception, students who were obese based on directly measured BMI tended to overestimate their height and underestimate their weight

and BMI more than those who were not. The mean difference between self-reported and directly measured heights was 0.7 kg among obese adolescents and 0.2 kg among non-obese adolescents. The mean difference between self-reported and directly measured weights was -2.8 kg among obese adolescents and -1.3 kg among non-obese adolescents. The mean difference between self-reported and directly measured BMIs was -1.2 kg/m^2 among obese adolescents and -0.5 kg/m^2 among non-obese adolescents (Table 3).

The prevalence estimate of obesity based on self-reported data (10.6%) was lower than that based on directly measured data (15.3%). The estimated sensitivity of obesity based on self-reported data was 69.0% and the specificity was 100.0%. The value of kappa was 0.79 (95% CI=0.70-0.88) (Table 4).

Table 4. Classification and prevalence of obesity* based on self-reported and directly measured body mass index

Category	Obesity based on DM BMI		Prevalence of obesity (%)	
	Yes	No	SR BMI	DM BMI
Obesity based on SR BMI (total study participants)†				
Yes	40	0	10.6	15.3
No	18	321		
Obesity based on SR BMI (middle school males)‡				
Yes	10	0	12.5	17.5
No	4	66		
Obesity based on SR BMI (middle school females)§				
Yes	4	0	7.0	12.3
No	3	50		
Obesity based on SR BMI (high school males)‖				
Yes	20	0	14.3	19.3
No	7	113		
Obesity based on SR BMI (high school females)¶				
Yes	6	0	5.9	9.8
No	4	92		

SR: self-reported, DM: directly measured, BMI: body mass index, CI: confidence interval.
*Defined as BMI ≥ 95th percentile or ≥ 25 kg/m^2
†Sensitivity, 69.0%; specificity, 100.0%; kappa, 0.79 (95% CI=0.70-0.88).
‡Sensitivity, 71.4%; specificity, 100.0%; kappa, 0.80 (95% CI=0.62-0.99).
§Sensitivity, 57.1%; specificity, 100.0%; kappa, 0.70 (95% CI=0.39-1.00).
‖Sensitivity, 74.1%; specificity, 100.0%; kappa, 0.82 (95% CI=0.70-0.95).
¶Sensitivity, 60.0%; specificity, 100.0%; kappa, 0.73 (95% CI=0.48-0.98).

DISCUSSION

This study demonstrated that self-reported data may lead to the underestimation of body weight and BMI, and consequently the prevalence of obesity among Korean adolescents. The prevalence estimate of obesity based on self-reported data was 10.6% and that based on directly measured data was 15.3%. The estimated sensitivity of obesity based on self-reported BMI was 69.0%, while previous studies have reported that the values for sensitivity ranged from 55% to 75% among adolescents [3].

In the current study, the magnitude of under-reported BMI ranged from -0.5 to -0.7 kg/m^2 in the subgroup analyses by gender and school grade. In a literature review among adolescents in the United States [3], the differences between self-reported and directly measured means for BMI were minimal (range, 0 to 0.2 kg/m^2 for males; -0.1 to -0.3 kg/m^2 for females) in the nationally representative studies, whereas the differences were greater (range, -1.2 to -2.3 kg/m^2 for males; -1.0 to -3.0 kg/m^2 for females) in the convenience sample or locally based studies.

The literature review also indicated that the magnitude of underestimated weight was different by weight status and gender. That is, overweight adolescents tended to underestimate their weight more than those who were not overweight. Females tended to underestimate their weight more than males [3]. Our study demonstrated that the differences between self-reported and directly measured means for height, weight, and BMI tended to be greater among obese adolescents than among non-obese adolescents. Specifically, obese adolescents tended to underestimate their weight and BMI and overestimate their height more than non-obese adolescents. As for the gender differences, our study indicated that the magnitude of bias in self-reported height was significantly different by gender. These gender differences may have been partly explained by the differences in growth patterns or in the perception of body image and social desirability between male and female students.

Several previous studies have demonstrated that the bias in self-reported weight may be affected by weight status among both adolescents and adults. In a study of the United States adolescents, Strauss [16] reported that the mean difference between self-reported and directly measured weights was -4.6 kg among obese (BMI > 95th percentile) adolescents and 0.2 kg among non-obese adolescents. In a study of obese women with BMIs between 35 and 40 kg/m^2 [17], the mean

difference between self-reported and directly measured weights was as high as -6.5 kg. Ziebland et al. [18] reported that women with a BMI < 20 kg/m^2 overestimated their weight and women with a BMI > 30 kg/m^2 underestimated their weight. These findings indicate that the social desirability to be of normal weight may have affected the validity of self-reported weight.

The current study also demonstrated that the magnitude of bias in self-reported weight and BMI was different by behavioral factors related to obesity, such as weight control and physical activity. Students who tried to lose weight during the past 12 months tended to underestimate their weight and BMI more than those who did not. Students who participated in moderate-intensity physical activity for ≥ 30 minutes on ≥ five of the past seven days tended to underestimate their weight more than those who did not. However, the magnitude of bias in self-reported data was not different by perceived body image in our study.

There have been several studies addressing the fact that dieting, which can be used as a method to lose weight, may influence the bias in self-reported weight [11,19]. In a study of individuals with dieters and non-dieters conducted in Canada [19], both dieters and non-dieters significantly underestimated their weight. However, dieters underestimated their weight to a greater degree than non-dieters. Differences in the validity of self-reported weight between dieters and non-dieters may reflect the differences in monitoring weight and being motivated to present themselves as thinner.

The effect of physical activity on reporting bias has not been adequately addressed in previous studies among adolescents. Although physically active adolescents may be related to the presumption of weighing less or an intention to lose weight, the underlying cause of the bias is uncertain. Further research is needed to clarify the effect of behavioral factors, including physical activity, on reporting bias and the underlying causes of the bias [3,16].

There were several potential limitations in our study. First, the assessment of the validity of self-reported data was based on a convenience sample, not a nationally representative sample. However, in comparison with the data of the 2008 KYRBWS, our data indicated that the distribution of demographic and selected behavioral characteristics of the study participants was similar to that of the total sample of the 2008 KYRBWS. Second, before obtaining self-reported height and weight, students were told that their height and weight would be measured, which may have led to more accurate reporting than in a typical KYRBWS. Third, light clothing worn during the weight measurement may have caused the measurement error. Finally, the time of day when students were weighed were varied, which may have affected the value of directly measured weight.

In conclusion, this study demonstrated that self-reported height and weight may lead to the underestimation of BMI and consequently the prevalence of obesity. These biases should be taken into account when self-reported data are used for monitoring the prevalence and trends of obesity among adolescents nationwide.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare on this study.

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