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ORIGINAL ARTICLE

# Reliability and Validity of Self-reported Height and Weight Among High School Students

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*Purpose:* **To assess the reliability and validity of self-reported height and weight, and variables calculated from these values, in a diverse sample of adolescents.**

*Methods:* **A convenience sample of students (n = 4619) in grades 9 through 12 reported their height and weight on two questionnaires administered approximately 2 weeks apart. Using a standard protocol, a subsample of these students (n = 2032) also were weighed and had their height measured following completion of the first questionnaire.**

*Results:* **Self-reported heights at Time 1 and Time 2 were highly correlated, and the mean difference between height at Time 1 and Time 2 was small. Results were similar for self-reported weight at Time 1 and Time 2 and body mass index (BMI) calculated from these values. Although self-reported values of height, weight, and BMI were highly correlated with their measured values, on average, students overreported their height by 2.7 inches and underreported their weight by 3.5 pounds. Resulting BMI values were an average of 2.6 kg/m$^2$ lower when based on self-reported vs. measured values. The percentages of students classified as "overweight" or "at risk for overweight" were therefore lower when based on self-reported rather than on measured values. White students were more likely than those in other race/ethnic groups to overreport their height, and the tendency to overreport height increased by grade. Female students were more likely than male students to underreport their weight.**

*Conclusions:* **Self-reported height, weight, and BMI calculated from these values were highly reliable but were discrepant from measured height, weight, and BMIs calculated from measured values. BMIs based on self-reported height and weight values therefore underestimate the prevalence of overweight in adolescent populations.**

KEY WORDS:
Adolescence
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Reproducibility of results
Self-assessment
Sensitivity
Specificity

The prevalence of overweight among adolescents aged 12 to 19 years nearly tripled between the late 1970s and 1999, from 5% to 14% [1]. Not only is obesity an immediate health problem for adolescents, but it also is associated with obesity in adulthood as well as with diabetes and other chronic diseases [2].

To assess trends in overweight among nationally representative samples of adolescents, the Centers for Disease Control and Prevention (CDC) added questions on height and weight to its Youth Risk Behavior Surveillance System (YRBSS) in 1999. The YRBSS monitors priority health risk behaviors among young people and includes national, state, territorial, and local surveys of high school students. The CDC uses self-reported height and weight data from these surveys to calculate body mass index

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(BMI), and classifies students as "at risk for overweight" or "overweight" based on percentiles for their age and gender [3,4].

Several studies have examined the validity of self-reported height and weight among adolescents and have found that adolescents' self-reported weight tends to be lower than their measured weight [5–10]. For height, however, results are mixed. Although some studies [5,6,10] have found that adolescents tend to overestimate their height, others have found either no systematic bias [8] or a tendency for adolescents to underestimate their height [9]. Further, the reliability and validity of these measures appear to vary by gender, age, and race or ethnicity. For example, some studies have shown that, although all adolescents tend to underreport their weight, the discrepancy between self-reported and measured weight is greatest among female adolescents [7,9]. Because the YRBSS uses BMI based on self-reported height and weight to determine whether adolescents are at risk for overweight or overweight, the reliability and validity of both of these self-reported measures must be established.

The sample designs of the studies described above vary widely. Although two used large, nationally representative samples of adolescents [7,9], others used smaller samples of students in other countries [6,10]. In the remaining two studies, samples were taken from specific populations: inner-city adolescents [5] and American Indian adolescents [8].

Although studies using nationally representative samples provide useful validity data, no study to date has assessed both the reliability and validity of self-reported height, weight, and BMI calculated from these values. In addition, no study has systematically assessed how the psychometric properties of these variables vary by gender, grade in school, and race or ethnicity. The purpose of this study, therefore, was to assess the reliability and validity of self-reported height and weight, and BMI calculated from these values, in a diverse sample of adolescents in the United States.

## *Methods*

A convenience sample was drawn from 61 schools in 20 states plus the District of Columbia. Because the goal of sampling was to obtain a diverse group of respondents, the 20 states were geographically dispersed. Approximately half (48%) of the schools in the sample were in urban areas, 39% were in suburban areas, and 13% were in rural areas [11]. Selection of 9th- through 12th-grade classes within each participating school varied according to the school's preference. Data were collected between February and May 2000. In each school, local parental consent procedures were followed. This study was approved by the CDC's Institutional Review Board.

Of the 6802 students enrolled in the selected classes, 5216 (77%) completed questionnaires during the first survey administration. The remaining 23% were absent on the day of the survey, failed to return a parental consent form, refused to participate, or had not been granted permission by their parents to participate. Of those who completed questionnaires during the first administration, 4628 (89%) also completed questionnaires during the second administration. Nine students did not have matching identification numbers on Time 1 and Time 2 questionnaires; therefore, the final sample for the test-retest portion of the study consisted of 4619 students. Demographic characteristics of this sample are described elsewhere [12].

The self-administered questionnaire contained approximately 100 multiple-choice questions that assessed demographic information and health risk behaviors. Students also reported their height in feet and inches ("How tall are you without your shoes on?") and weight in pounds ("How much do you weigh without your shoes on?"). These questions were identical to those used in the 1999 national Youth Risk Behavior Survey (YRBS). The questionnaire was administered in a regular classroom setting and required approximately 40 minutes to complete. A standard computer-scannable questionnaire booklet contained the questions and was used to record responses.

In addition to completing the questionnaire, 2965 students in 39 of the 61 schools were weighed and had their height measured to assess the validity of the height and weight questions. These schools were selected based on convenience in scheduling data collection and yielded a 57% subsample of those completing at least one questionnaire. Of the students in this subsample, 2142 (77%) had answered the height and weight questions on the questionnaire at Time 1. Fifteen students refused to participate in the measurement portion of the study. The remaining students either did not complete a questionnaire at Time 1, had failed to answer the height and weight questions at Time 1, or had height or weight exceeding plausible limits for age and gender subgroups. Validity analyses were based on Time 1 self-reported height and weight.

**Table 1.** Demographic Characteristics of Validity Sample and Students in Grades 9 Through 12 Nationwide

| Characteristic | Sample Distribution (%) | National Distribution (%)* |
|---|---|---|
| Gender | | |
| Male | 47.1 | 51.0 |
| Female | 52.9 | 49.9 |
| Grade | | |
| 9 | 37.8 | 25.7 |
| 10 | 26.4 | 25.7 |
| 11 | 20.8 | 24.5 |
| 12 | 15.0 | 24.1 |
| Race or ethnicity | | |
| White | 43.2 | 64.8 |
| Black | 40.7 | 12.1 |
| Hispanic | 7.4 | 13.3 |

* Source: U.S. Bureau of the Census [13].

Preliminary analyses of the discrepancy between self-reported and measured height and weight showed that 138 students had a height or weight discrepancy beyond two standard deviations of the mean. Further analyses revealed that 25% of these students came from two of the participating schools. Because those two schools accounted for only 5% of all respondents, a systematic measurement error probably had occurred at these schools. Therefore, data from these two schools were omitted, resulting in a final sample of 2032 students for validity analyses.

The demographic characteristics of this subsample were similar to those of the national distribution of 9th- through 12th-grade students [13]. However, for some groups, the sample percentage differed from the national percentage by more than five percentage points (Table 1). Specifically, 9th-grade students were overrrepresented but 12th-grade students were underrepresented, and white students and Hispanic students were underrepresented, but black students were overrepresented.

### Data Collection Procedures

Before the first survey administration in the 39 schools in which students' height and weight were measured, a unique number was assigned to two scannable questionnaire booklets and a height and weight measurement form. Each student received a packet containing these three identically numbered forms and two blank envelopes. During administration of the first survey, students used one questionnaire booklet and then sealed the height and weight form in one envelope and the second questionnaire booklet in a separate envelope. Each student then wrote his or her name across the seal. At the time of the height and weight measurement, each student received the envelope with his or her name across the seal containing the height and weight form. After the student's height and weight form was completed, the student destroyed the envelope. For the second survey administration, students were given the envelope containing the second questionnaire booklet with their name written across the seal. Students completed the questionnaire booklet and destroyed the envelope. The same survey administration procedures were used in the 22 schools in which height and weight were not measured except that the student packets did not contain height and weight forms. This technique has been used successfully in previous studies, and students perceive that it adequately safeguards their privacy [14].

Trained data collectors from Macro International Inc. (ORC Macro) read aloud scripts that explained the survey procedures and informed students during the first survey administration that, after completing the questionnaire, they "might have their height and weight measured" and they would be asked to complete a "very similar" questionnaire a few weeks later. Other than those variations in the script, the administration procedures used in this study were the same as those used for the standard YRBS.

Students in the subsample were weighed and measured as soon as possible after the first survey administration. In 20 of the 39 schools, measurements were completed on the same day as the first survey administration. In 15 of the schools, measurements were completed 1 day later, and in four of the schools, measurements were completed 2 days later. The data collectors were trained to use a standard protocol and weighed and measured the students with the assistance of a recorder from each school. Before being measured, students were asked to remove their shoes, hats, and any removable hair accessories. The data collectors measured height to the nearest centimeter using a measuring tape attached to the wall. Students placed their backs against the wall, and the data collectors then placed a measuring triangle on the student's head to form a right angle with the wall. The height measurement was taken from the lower edge of the triangle.

Data collectors measured students' weight to the nearest tenth of a kilogram using Seca brand scales that were zero balanced before each student was weighed. Students removed shoes, outer clothing (such as jackets), and personal items from their pockets before stepping on the scale.

**Table 2.** Pearson r, Mean, and Mean Difference for Self-Reported Height, Weight, and BMI Based on These Values at Time 1 and Time 2

| Characteristic | Pearson r | Mean at Time 1 | Mean at Time 2 | Mean Time 1–Time 2 Difference | 95% Confidence Interval |
|---|---|---|---|---|---|
| Height (m) | 0.93 | 1.69 | 1.70 | −0.03 | −0.11, 0.05 |
| Weight (kg) | 0.93 | 67.0 | 67.2 | −0.08 | −0.13, −0.04 |
| BMI ($kg/m^2$) | 0.87 | 23.3 | 23.3 | −0.49 | −0.91, −0.06 |

BMI = body mass index.

If anything had potentially interfered with an accurate measurement (e.g., nonremovable hair accessories), the data collector could indicate this by marking a box on the form. Forms from 78 students (3%) indicated such measurement problems. All analyses were conducted first with these students' data included and then excluded. Because the differences between these two sets of analyses were negligible, all analyses include all students.

### Data Analysis

Self-reported height and weight were converted to metric units for comparison with the height and weight measurements and calculation of BMI. Self-reported and measured height and weight and BMI based on self-reported and measured height and weight were set to missing if they exceeded plausible limits for age and gender subgroups. Students were then categorized as "at risk for overweight" if their BMI based on self-reported or measured values was $\geq 85^{th}$ percentile but $<95^{th}$ percentile for BMI by age and gender based on reference data from the CDC growth charts [4]. Students with a BMI based on self-reported or measured values $\geq 95^{th}$ percentile for their age and gender were categorized as "overweight."

## *Results*

### Reliability

For those respondents who completed questionnaires at Time 1 and Time 2 (n = 4619), self-reported height at Time 1 and Time 2 were highly correlated, and the mean difference between Time 1 and Time 2 height was small (Table 2). Results were similar for self-reported weight at Time 1 and Time 2 and therefore for BMI calculated from self-reported height and weight.

When respondents were categorized as "at risk for overweight" based on their BMI, this categorization showed substantial reliability (kappa = 0.77, percent agreement = 80.4%), with 14.5% of respondents classified as "at risk for overweight" based on Time 1 BMI and 14.8% so classified at Time 2. The categorization of respondents as "overweight" also showed substantial reliability (kappa = 0.87, percent agreement = 83.3%), with 13.2% of respondents so classified based on Time 1 BMI and 13.0% so classified at Time 2. A three-level classification of respondents as "overweight," "at risk for overweight," or "neither" also was highly reliable (kappa = 0.84, percent agreement = 79.2%).

Analyses by gender, grade, and race or ethnicity did not reveal any significant subgroup differences in any of the reliability measures.

### Validity

The correlation between the self-reported and measured height of respondents who were weighed and measured and had self-reported height and weight at Time 1 was 0.90 (Table 3). The mean self-reported height was 66.4 inches, and the mean measured height was 63.7 inches. The correlation between self-reported and measured weight was 0.93; the mean self-reported weight was 147.8 pounds, and the mean measured weight was 151.3 pounds. Because students, on average, overestimated their height and underestimated their weight, the mean BMI based on self-reported height and weight (23.5 $kg/m^2$) was lower than the mean BMI based on measured height and weight (26.2 $kg/m^2$). The correlation between self-reported and measured BMI was 0.89. Correlations varied slightly by gender, grade, and race or ethnic subgroup (Table 3).

Three difference scores between self-reported and measured height, weight, and BMI based on each set of values were calculated for each respondent. For height, this difference ranged from −13.3 inches to 16.7 inches and averaged 2.7 inches (Table 3). Four percent of respondents underreported their height; 5.3% overreported their height by less than 1 inch, 17.9% overreported their height by 1 to 2 inches,

**Table 3.** Correlations and Mean Difference Between Self-Reported and Measured Height, Weight, and BMI Based on These Two Sets of Values by Gender, Grade, and Race or Ethnicity

| | | Height (m) | | Weight (kg) | | BMI (kg/m$^2$) | |
|---|---|---|---|---|---|---|---|
| Characteristic | n | Mean Difference | Pearson r | Mean Difference | Pearson r | Mean Difference | Pearson r |
| Total | 2032 | 2.7 | 0.90 | −3.5 | 0.93 | −2.6 | 0.89 |
| Gender | | | | | | | |
| Female | 1075 | 2.7 | 0.82 | −4.5 | 0.94 | −3.0 | 0.89 |
| Male | 957 | 2.6 | 0.87 | −2.4 | 0.92 | −2.3 | 0.89 |
| Grade | | | | | | | |
| 9 | 767 | 2.4 | 0.87 | −3.2 | 0.93 | −2.3 | 0.87 |
| 10 | 536 | 2.7 | 0.89 | −4.1 | 0.90 | −2.7 | 0.86 |
| 11 | 423 | 2.9 | 0.94 | −3.1 | 0.96 | −2.8 | 0.94 |
| 12 | 304 | 3.1 | 0.93 | −3.9 | 0.95 | −3.0 | 0.92 |
| Race/ethnicity | | | | | | | |
| Black | 808 | 2.5 | 0.88 | −3.9 | 0.93 | −2.6 | 0.89 |
| Hispanic | 146 | 2.6 | 0.77 | −3.0 | 0.95 | −2.6 | 0.89 |
| Other | 175 | 2.6 | 0.90 | −3.0 | 0.90 | −2.4 | 0.79 |
| White | 858 | 2.9 | 0.93 | −3.5 | 0.93 | −2.7 | 0.90 |

All mean differences are significantly different from 0.
BMI = body mass index.

33.3% overreported their height by 2 to 3 inches, and the remaining 39.5% overreported their height by 3 or more inches. The difference between self-reported and measured weight ranged from −185.6 pounds to 144.2 pounds, and averaged −3.5 pounds. Eighteen percent of students underreported their weight by 10 or more pounds, 13.7% underreported their weight by more than 5 but less than 10 pounds, 28.6% underreported their weight by 5 or fewer pounds, 25.0% overreported their weight by less than 5 pounds, 8.1% overreported their weight by 5 to 10 pounds, and 6.6% overreported their weight by 10 or more pounds. BMI values were an average of 2.6 kg/m$^2$ higher based on measured than on self-reported values. Although only 8.6% of students overreported their BMI, 78.7% underreported it by less than 5 kg/m$^2$, and 12.7% underreported by 5 kg/m$^2$ or more.

Linear regression analyses that examined whether difference scores varied by gender, grade, or race or ethnicity revealed subgroup differences; mean differences for each subgroup are shown in Table 3. After gender and grade were controlled for, white students were significantly more likely than those in the other three race or ethnic groups to overreport their height ($\beta_{race} = 0.09$, $p = .0001$). In addition, grade was positively associated with height difference; after controlling for gender and race or ethnicity, the tendency for students to overreport their height increased by grade ($\beta = 0.22$, $p < .0001$). For weight, after controlling for grade and race or ethnicity, female students were more likely than male students to underreport their weight ($\beta = 2.18$, $p = .001$). The discrepancy between BMI calculated from self-reported vs. measured values also varied by gender after grade and race or ethnicity were controlled for; female students were more likely than male students to have a lower BMI based on self-reported values than based on measured values ($\beta = 0.67$, $p < .0001$). Finally, the tendency for students' BMI based on self-reported values to be lower than their BMI based on measured values increased by grade ($\beta = -0.19$, $p = .002$) after controlling for gender and race or ethnicity.

The prevalence of students at risk for overweight and overweight was higher when BMI was calculated from measured height and weight than when it was calculated from self-reported height and weight. Specifically, 14.8% of students were classified as "at risk for overweight" based on self-reported values, compared with 21.4% of students based on measured values. Similarly, 14.9% of students were classified as "overweight" based on self-reported values, compared with 26.0% based on measured values.

Agreement between self-reported and measured classification of students into three categories ("overweight," "at risk for overweight," and "neither") was moderate (kappa = 0.48); 71.2% of students were classified the same way regardless of whether self-reported or measured data were used. Agreement was higher (kappa = 0.63) for classification of students into two categories (overweight vs. not overweight), with 87.7% of students being classified the same way regardless of method. The sensitivity,

which is the proportion of overweight students correctly identified by self-reported BMI, was 54.9%. The specificity, which is the proportion of students who are not overweight correctly identified by self-reported BMI, was 99.2%. The positive predictive value, which is the proportion of students identified by self-reported BMI as "overweight" that are truly overweight, was 96.0%. When all students in the 85th percentile or above (either at risk for overweight or overweight vs. neither) were examined, agreement between self-reported and measured classification was slightly lower (kappa = 0.60); 80.3% of students were classified the same way regardless of method. The sensitivity of BMI to detect students at risk for overweight or overweight was 60.5%, the specificity was 98.0%, and the positive predictive value was 96.5%.

## *Discussion*

This study adds to a growing literature on the validity of self-reported height and weight among adolescents and is among the first to demonstrate that self-reported height and weight, and BMI calculated from these values, are highly reliable. In terms of validity, however, this study found that self-reported height and weight were discrepant from measured height and weight. As in past research, this study found that adolescents tend to underreport their weight [5–10]. The tendency for adolescents to overreport their height found in this study is consistent with some [5,6,10] but not all previous research on adolescents [8,9]. This tendency to underreport weight and overreport height also has been found in several population-based studies of adults [15–17].

Given that body weight tends to fluctuate slightly from day to day and varies according to clothing worn, the finding that adolescents do not always estimate their weight correctly is not surprising. However, the finding that adolescents also overestimate their height is less expected. Perhaps these findings can be explained by the fact that most adolescents have access to a household scale to measure their weight but have few opportunities to measure their height and therefore have less information about their height than their weight. Another possibility is that adolescents believe they are continuing to grow at a rate similar to when they were children and therefore overcompensate for growth when reporting their current height. This is consistent with the finding that the discrepancy between self-reported and measured height increased steadily between grades 9 and 12. Finally, students' tendency to overreport height may be a function of social desirability.

This study also found that, similar to the findings of past research [6,7,9], female adolescents tend to underreport their weight, which consequently leads to a BMI that is less than it would be based on measured values, to a greater degree than male adolescents. Perhaps this is related to social desirability, a reflection of the greater emphasis on thinness for women in our society [18].

This study found that white adolescents were significantly more likely than those in all other racial or ethnic groups to overreport their height. Previous studies have not systematically examined racial or ethnic differences in the validity of self-reported height and weight; further research is needed to replicate this effect before speculating on its cause.

The classification of adolescents into those who are "at risk for overweight" and those who are "overweight" was reliable in this study. The validity of these classifications, however, was less certain. The percentage of students who were classified as "at risk for overweight" or "overweight" was substantially lower when self-reported height and weight were used than when measured values were used, a finding similar to those of studies of adults [15,19]. Classifying adolescents as "overweight," "at risk for overweight," or "neither" yielded moderate agreement; combining the "at risk for overweight" and "overweight" categories provided better agreement. The most accurate classification of adolescent weight status was found when overweight students were compared with those who were not overweight.

This study has several limitations. First, before students self-reported their height and weight, they were told that their height and weight "might" be measured, which could have led to more accurate reporting than in a typical YRBS administration. Second, the data were based on a convenience sample in which black students were overrepresented and white and Hispanic students were underrepresented. Given that this study was not intended to calibrate self-reported height and weight, the use of a convenience sample is appropriate; however, the percentage of overweight students in this sample based on measured height and weight (26%) is substantially higher than the national average of 14%, for reasons that cannot be determined [1]. This may have led to greater discrepancies between self-reported and measured height and weight than

might have been found in a representative sample because adolescents with the highest measured weight have been shown to underreport their weight significantly more than adolescents with lower measured weight [5,8,9]. Third, additional measurement error might have been introduced by converting inches and pounds into metric units. Fourth, missing data from students' absence or refusal to participate might have biased the results. Without additional data, the direction of this bias cannot be predicted. Finally, the time of day when students were weighed varied among schools. Students who were weighed after lunch might be expected to have greater weight and, consequently, BMI discrepancies.

Despite these limitations, the high correlations between self-reported and measured height, weight, and BMI suggest that self-reported height and weight are valid proxy measures for measured values, especially in analyses that use these values as continuous variables. When BMI values are used to classify adolescents as "at risk for overweight" or "overweight," however, basing BMI on self-reported height and weight clearly leads to underestimates of the prevalence of obesity in this population. Perhaps, as has been suggested [6], prevalence estimates should be corrected using a conversion factor that takes this misreporting into account. If such a method is used, results from this study indicate that separate conversion factors should be calculated for each demographic subgroup. Even without such conversion factors, surveillance systems, such as the YRBSS, can still yield valuable results by using self-reported height and weight to assess trends in the prevalence of obesity.

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