



Accuracy of self-reported weight compared to measured BMI among rural middle school students in Michigan

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Abstract

Aim Measured body mass index (BMI) is recommended for field-based assessments of overweight and obesity in all population groups. However, self-reported perception of body weight is frequently used in surveys targeting overweight and obese individuals. This study's purpose was to examine the accuracy of self-reported weight compared to measured BMI among rural middle school students in Michigan.

Subject and methods A sample of 1995 students aged 11 and 12 were recruited over 5 years from six rural school districts in mid-Michigan. Data were collected using an interviewer-administered questionnaire with questions from the Youth Risk Behavior Survey. Height and weight were measured by research assistants and BMI calculated.

Results Although only 3.5% of the students considered themselves very overweight, 26.4% were in the obese category of BMI. Almost a quarter (23.7%) reported they were slightly overweight, but these were all obese by BMI standards. Conversely, while 18.5% reported they were underweight, only 0.9% were truly underweight by BMI standards. A statistically significant difference ($P < 0.001$) was found in weight perception across BMI categories. Significant gender differences in perception were also found across all perceived weight categories.

Conclusion It is imperative that children accurately perceive their body weight because this is the first step toward lasting behavior changes to achieve the optimal weight for their age and gender. However, when intervention programs use measured BMI rather than self-reports to define weight status among children and adolescents, it is more likely that overweight and obese children will be accurately targeted for intervention.

Keywords Self-reported weight · Body mass index · Middle school children · Rural · Overweight and obesity

Introduction

Childhood obesity is an important public health issue. Its prevalence, along with that of overweight among children,

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has almost tripled over the past 3 decades (Chung et al. 2013). Having attained epidemic proportions, childhood obesity has attracted the attention of public health authorities and received wide media coverage. However, current efforts have focused more on raising awareness of the epidemic itself rather than drawing attention to individuals' perception of their own overweight or obese status (Chung et al. 2013).

Although recognizing childhood obesity as a public health problem is a necessary step toward addressing it, this recognition may not always translate into children and adolescents becoming aware that they are overweight or obese and taking action about it. Several studies show that accurate perception of oneself as overweight or obese is linked to greater motivation to change lifestyle behaviors (Maximova et al. 2008; Sarafrazi et al. 2014; Alwan et al. 2011). It is only when children recognize their own overweight or obese status to be a personal health problem that they can become intentional about changing their lifestyle habits (Chung et al. 2013; Maximova et al. 2008).

One important strategy used to determine and track trends in overweight and obesity is regular assessment of its prevalence (Sherry et al. 2007). Both point and period prevalence rates on overweight and obesity enable us to describe the extent of the problem, show trends over time, target interventions to areas or subgroups with the highest prevalence, and evaluate the effectiveness of intervention programs to prevent and treat overweight and obesity. Body mass index (BMI) is the most commonly used anthropometric screening tool for assessing overweight and obesity in adults and children (Nuttall 2015; Sengupta et al. 2013; Shah and Braverman 2012). However, because the calculation of BMI requires direct measurement of height and weight, the use of trained personnel, and the availability of well-calibrated and well-maintained equipment, obtaining self-reported data from population-based samples is often the easier methodologic approach.

Multiple studies show, however, that inaccuracies and biases are associated with self-reported data. In fact, perceptions of weight status and actual weight are often dissimilar, and such trends seem to be more dominant among overweight and obese individuals (Maximova et al. 2008; Sarafrazi et al. 2014; Alwan et al. 2011; Sherry et al. 2007; Kuchler and Variyam 2003; Paeratakul et al. 2002; Truesdale and Stevens 2008; Viner et al. 2006; Nyholm et al. 2007; Wang et al. 2009). Several studies reported that among adults who were overweight by BMI standards, up to 43% of men and 18% of women perceived themselves to be of “healthy weight or underweight” (Kuchler and Variyam 2003; Paeratakul et al. 2002; Truesdale and Stevens 2008). Among overweight youth, Viner et al. (2006) found that 58% of boys and 34% of girls perceived their weight to be “about right.”

Though gender differences in weight perception exist, there is a consensus that obesity prevention in young people is critical because childhood obesity often continues into adulthood, leading to higher risks for cardiovascular diseases, type 2 diabetes, some types of cancer, and premature death (Sherry et al. 2007; Nyholm et al. 2007). Importantly, these obesity-related diseases of adulthood tend to be more prevalent in rural areas because of geographic isolation, less educational attainment, limited job opportunities, and lower socioeconomic status. Because actual overweight and obesity become more of a social norm in these areas, accurate self-perception of weight is further hindered (Befort et al. 2012). Therefore, the purpose of this study was to examine the accuracy of self-reported weight compared to measured BMI among rural middle school students.

Methods

Objective

To examine the accuracy of self-reported weight compared to measured BMI among rural middle school students in Michigan.

Background

The study was carried out in a rural, stable community in the geographical center of Michigan’s Lower Peninsula. With an estimated population < 50,000 residents (United States Census Bureau 2016) and about 80% of its arable land being used for farming, the county’s economy is mostly agrarian. Of note, the county’s median household income is about \$10,000 lower than the median household income at the state level (County Health Rankings 2016a), and about 22% of children under the age of 18 live in poverty (County Health Rankings 2016b). During the period 1995 to 1998, the County Health Committee (CHC) examined health indices in the county and found that the crude and age-adjusted rates of ischemic heart disease were significantly higher than the rates in both Michigan and the US. Therefore, the CHC targeted prevention of heart disease as one of its primary goals in the ensuing years. Recognizing that behaviors play a significant role as risk factors for heart disease, the committee included as one of its major health action plans the health education of school-age children to focus on early learned behaviors that could increase the risk for heart disease.

Data collection

The study was carried out as a convenience sample of six rural school districts in the vicinity of the major tertiary academic institution in the county. Elementary schools were selected from three districts, and middle schools were selected from the other three districts. Data were collected during annual heart health fairs for 5th and 6th grade students in each of the selected schools beginning in the year 1999 through 2015. The project received expedited review and was approved through the institutional review board of the tertiary academic institution. After contacting the schools about the heart health fairs and obtaining their permission to carry them out, information letters were sent out to the parents of all the 5th and 6th grade students. Reverse parental consent was obtained for each participant every year. Due to the methodology used in this study, a reverse parental consent implied that if parents did not want their child to participate in the study, they would sign the reverse parental consent form. If parents signed the form, thereby indicating that they did not want their child to participate, we did not collect any data from the child. Overall, only 6% of parents indicated they did not want their child to participate.

The methodology for the heart health fairs consisted of five education and assessment areas, each addressing a risk factor for heart disease: cigarette smoking, obesity/high blood cholesterol, high blood pressure, lack of physical fitness, and lack of physical activity. As each class attended the heart health fair, the students were divided into groups of four to six people and rotated through the areas for a total of 1 hour. Even after

parental consent was received, each child could state whether they wanted to participate in the study or not. No child was coerced or cajoled into participation. For those who assented to participating, they still had a right to choose which of the five areas they did not want to participate in. At each area, health education was given concerning the risk factor being addressed, and the students participated in assessment activities to reinforce the information presented. To maintain confidentiality and privacy of data, all students who participated were given an ID number. These ID numbers were used in the data collection process and data analysis.

For the current study, data from the obesity/high blood cholesterol area of the heart health fair were analyzed via a cross-sectional descriptive study design. Out of 2000 students whose parents consented to have them participate in the study, 4 did not assent to have their height and weight taken, and one student did not complete the questionnaire on weight perception. Therefore, the study sample comprised 1995 students (1012 boys, 983 girls) aged 11 and 12 recruited over a 5-year period (2011–2015)—an overall 99.75% participation rate. Data on weight perception were collected using an interviewer-administered questionnaire based on the Youth Risk Behavior Survey (YRBS). The YRBS was first developed in 1990 by the Centers for Disease Control and Prevention (CDC) as a tool with which to keep track of health risk behaviors that contribute significantly to the causes of social problems, morbidity, and mortality among youth and adults in the US [Centers for Disease Control and Prevention (CDC) (2017a)]. According to Brener et al. (2002), the YRBS has moderate overall reliability ($\kappa = 60.7\%$) and moderate reliability in assessing perception of weight status ($\kappa = 58.6\%$).

Assessment activity: perceived weight status The major question used from the YRBS that assessed perception of weight was: “How do you describe your weight?” There were five response options: very underweight, slightly underweight, about the right weight, slightly overweight, and very overweight. Students were asked to select only one response option based on self-perception of their weight (CDC 2017a).

Assessment activity: measured height and weight status Height and weight of each participant were measured by research assistants. Height was measured using a Child StorrBoard and recorded to the nearest centimeter with shoes and socks off. A BC-534 Tanita InnerScan Body Composition Monitor was used to measure weight with shoes and socks off; it was recorded to the nearest kilogram. The body mass index (BMI) was calculated as the weight of the participant in kilograms divided by the square of the height of the participant in meters (i.e., kg/m^2). Though the chosen cut points for age and gender influence the validity of BMI in detecting children with excess body fatness, Freedman and Bettylou (2009)

report that sensitivity and positive predictive value are within the range of 70–80%, and specificity is about 95% when using measured BMI-for-age to assess body fatness.

In contrast to pre-defined weight categories based on measured BMI in adults, children and adolescents are classified into weight categories based on percentiles of their BMI for age and gender. The CDC (2017b) clinical growth charts depicting the BMI-for-age in boys and girls are used to define the actual weight status for children and adolescents (aged 2 – 20 years). Underweight is defined as a BMI value that falls below the 5th percentile for that age and gender, while normal weight is defined as a BMI value that falls between the 5th and 85th percentile for that age and gender. Overweight refers to a BMI value between the 85th and 95th percentile for that age and gender, while obesity refers to a BMI value greater than the 95th percentile for that age and gender. Table 1 shows the BMI cutoff values used to define the categories of actual weight among 11- and 12-year-old boys and girls.

Statistical analysis

Data were entered into Microsoft Excel and IBM SPSS version 24 for analysis. Measures of central tendency in measured BMI were calculated. To assess the accuracy of self-reported weight in the entire sample of students, the proportions of students in each category of self-reported weight were compared to the proportion of students in the corresponding category of measured BMI. Line graphs showing time trends in mean measured BMI per category of self-reported weight compared to the 5th, 85th, and 95th percentile values of BMI-for-age for that gender were generated. These line graphs gave a visual presentation of the extent to which the students’ perception of their weight compared to their true weight category based on BMI cut points for their age and gender. In addition, chi-square tests of independence were performed to determine whether

Table 1 BMI-for-age percentiles by gender (CDC 2017b)

Age	CDC definition ^a	BMI (kg/m^2)	
		Boys	Girls
11 years	5th percentile	14.5	14.4
	85th percentile	20.2	20.8
	95th percentile	23.2	24.2
12 years	5th percentile	15.0	14.8
	85th percentile	21.0	21.7
	95th percentile	24.2	25.2

^a BMI values that fall below the 5th percentile constitute underweight, values between the 5th and 85th percentile are normal weight, values between the 85th and 95th percentile are overweight, and values greater than the 95th percentile constitute obesity

self-reported weight varied by measured BMI category and whether self-reported weight varied by gender. The null hypotheses were that self-reported weight and BMI category were independent and that self-reported weight and gender were independent. The level of significance (α) was 0.05.

Results

There were 1995 students; 1012 (50.7%) were boys and 983 (49.3%) girls. Almost two-thirds (1276) were 12 year olds (684 boys, 592 girls), while 719 (328 boys, 391 girls) were 11 year olds. Table 2 shows the distribution of weight perception by age and gender. For each age, only a small number of both boys and girls reported that they were very underweight or very overweight, while the majority reported that they were normal weight.

Table 3 shows the proportions of students based on their self-report as underweight (very or slightly), normal weight, and overweight (very or slightly) by gender and age. In general, boys were more likely to self-report as underweight (20.7% compared to 16.3%) or overweight (29.3% compared to 24.9%), while girls were more likely to self-report as normal weight (58.8% compared to 50.0%).

Figure 1 shows the proportions of students in each category of self-reported weight, while Fig. 2 shows the proportions of students in each category of measured BMI. The majority (54.3%) of the students perceived themselves as about the right weight, with about the same proportion (52.7%) in the normal weight category of BMI (difference: +1.6%). Similarly, 23.7% regarded themselves as slightly overweight, with 20.0% in the overweight category of BMI (difference: +3.7%). Although only 3.5% considered themselves very overweight, 26.4% were in the obese category of BMI (difference: -22.9%). In contrast, while 18.5% perceived that they were underweight (2.7% very underweight and 15.8% slightly underweight), only 0.9% were truly underweight by BMI standards (difference: +17.6%).

Using a chi-square test, a significant difference ($P < 0.001$) was found in weight perception across the BMI categories. As seen in Table 2, self-reported weight category varied by age and gender ($P = 0.011$). When stratified by gender and each self-reported weight category, gender differences were found for underweight (very and slightly) perception ($P = 0.012$), normal weight perception ($P < 0.001$), and overweight (slightly and very) perception ($P = 0.026$).

Figures 3, 4, 5, and 6 show the trends in self-reported weight compared to mean measured BMI for each category of self-reported weight over the 5-year period, stratified by age and gender. In general, all the students who reported they were slightly overweight were obese by mean BMI standards. Those who reported they were very overweight were at higher levels of obesity than those who reported they were slightly overweight. For 11-year-old boys (Fig. 3), the mean BMI of those who self-reported that they were very underweight varied from normal weight to obese. Among 11-year-old girls (Fig. 4), all who self-reported as underweight (very and slightly) were in the normal weight category of mean BMI. In addition, all the 12-year-old boys and girls who self-reported as underweight (very and slightly) were in the normal weight category of mean BMI (Figs. 5 and 6). Though most of those who self-reported as having the right weight were accurate in their estimation, misperceptions occurred in about 60% of 11-year-old boys, 20% of 11-year-old girls, and 20% of 12-year-old girls, all of whom were in the overweight BMI category (Figs. 3, 4, and 6).

Discussion

Our findings show that the greatest level of weight misperception was among obese students, with 86.7% of the students who were obese by BMI standards (representing 22.9% of the entire sample) wrongly perceiving themselves as belonging to other self-reported weight categories. Other studies (Chung et al. 2013; Tang et al. 2010) reported similar findings, with a greater likelihood for youth who are overweight and obese

Table 2 Distribution of self-reported weight perception by age and gender, MI, 2011–2015

Self-reported weight category	11 year olds (<i>n</i> = 719)		12 year olds (<i>n</i> = 1276)		Total	
	Boys	Girls	Boys	Girls	n	%
Very underweight	6	12	17	19	54	2.7
Slightly underweight	67	51	119	78	315	15.8
Normal weight	167	230	339	348	1084	54.3
Slightly overweight	77	84	187	124	472	23.7
Very overweight	11	14	22	23	70	3.5
Total	328	391	684	592	1995	100

* χ^2 (12) = 25.975, $P = 0.011$

Table 3 Proportions of self-reported weight by gender and age, MI, 2011–2015

Self-reported weight category	Boys			Girls		
	11 years (n = 328)	12 years (n = 684)	Overall (n = 1012)	11 years (n = 391)	12 years (n = 592)	Overall (n = 983)
Underweight	22.3%	19.9%	20.7%	16.1%	16.4%	16.3%
Normal weight	50.9%	49.6%	50.0%	58.8%	58.8%	58.8%
Overweight	26.8%	30.5%	29.3%	25.1%	24.8%	24.9%

*Chi-square statistics were calculated using the overall values for each gender, without stratifying by age within each gender. For underweight, $\chi^2(1) = 6.333, P = 0.012$; for normal weight, $\chi^2(1) = 15.562, P < 0.001$; for overweight $\chi^2(1) = 4.932, P = 0.026$

(ranging from 41 to 65%) to misperceive their weight compared to youth who are normal weight or underweight. Our finding of significant difference ($P < 0.001$) in weight perception across the BMI categories agrees with Barrett and Huffman’s (2011) finding of significant differences between perceived weight and actual BMI ($P < 0.01$). Interestingly, we found these differences showed more variation in 11-year-old boys who perceived that they were underweight but had mean measured BMI that ranged from normal weight to obese; these self-perceived weight variations may be explained by the small sample size ($n = 328$) of 11-year-old boys compared to the other groups.

This study also showed significant differences in overweight perception between boys and girls. Unlike a meta-analysis of 11 studies that found that females underestimated their weight and BMI more than males (Maximova et al. 2008), boys in this study showed a greater tendency to underestimate their weight. Also, in contrast to other studies that reported that girls were more likely to perceive themselves as

overweight while boys more often perceived their weight status as underweight (Tang et al. 2010; Viner et al. 2006), our findings showed a greater tendency of boys to self-report as underweight or overweight compared to girls (20.7% compared to 16.3% and 29.3% compared to 24.9%, respectively), while girls had a greater tendency to self-report as normal weight compared to boys (58.8% compared to 50.0%). Our findings are supported by one study that reported that 40.2% of overweight boys, compared to 22.6% of overweight girls, misclassified themselves as either normal weight or underweight (Edwards et al. 2010). In addition, Barrett and Huffman (2011) reported that adolescent boys in Jamaica were more likely to perceive themselves as overweight compared to girls, which supports our findings.

The pubertal growth spurt (Neinstein 2017; Rogol et al. 2002), which starts earlier for girls in this age group, could provide a possible explanation for the increased tendency for boys of this age group to self-report as underweight. Because girls aged 11–13 years start to become taller than boys of the

Fig. 1 Proportions of students by self-reported perception of weight, Gratiot Co., MI, 2011–2015

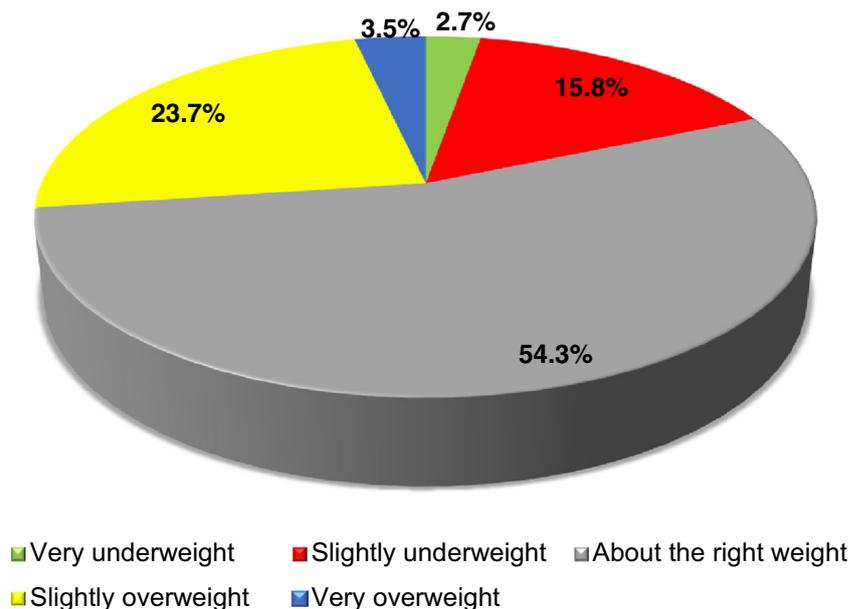
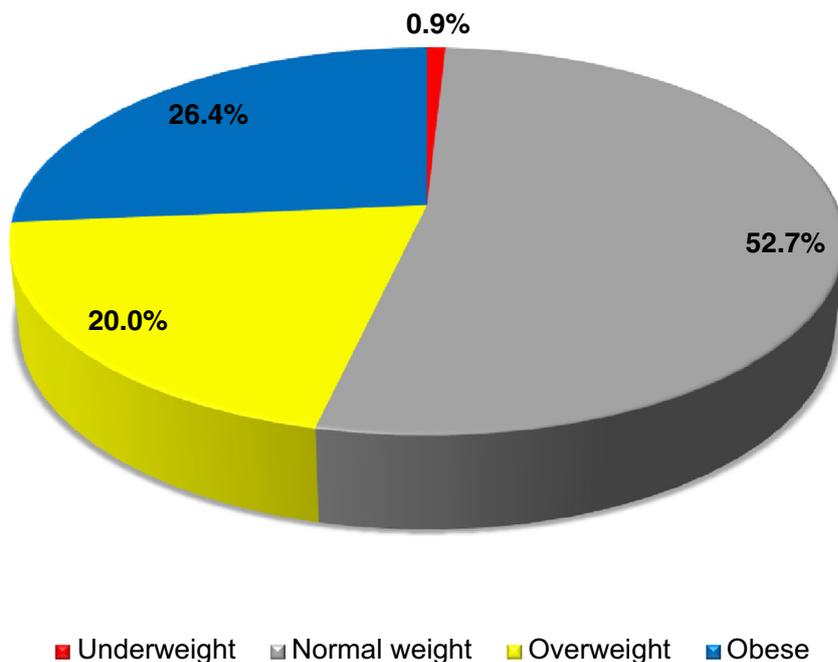


Fig. 2 Proportions of students in categories of measured BMI, Gratiot Co., MI, 2011–2015



same age, the boys may perceive that their weight is less than ideal and could self-report as underweight. However, this does not explain why boys in this study also were more likely to self-report as overweight compared to the girls.

The prevalence of perceived underweight was consistently overestimated in this cohort of rural school students. Therefore, if perceived underweight alone were used to capture the prevalence of underweight in this cohort, all the students who self-reported they were underweight but truly were not underweight based on measured BMI (17.6% of the students) would be wrongly targeted for intervention. Likewise, the prevalence of obesity was significantly underestimated: if self-report alone were used to capture the prevalence of obese students in this cohort, all those who reported that they were slightly overweight but were truly obese by measured BMI

(23.7% of the students) would be missed. Interventions targeting weight misperceptions may yield significant outcomes for boys in this cohort since they tended to underestimate their weight more than girls. Similarly, obese students will benefit from interventions targeting weight misperceptions since they tended to underestimate their weight more than students of normal weight.

A major strength of this study is its rural setting. While several studies focusing on childhood weight perception in the US involve children and adolescents in urban areas, this is one of few studies that evaluate childhood obesity in a rural, low-income setting. Carrying out this study among 11 and 12 year olds is also relevant because they are beginning to enter the adolescent age group, which is a stage where children become more independent in their decision-making. The socioecologic

Fig. 3 Mean measured BMI and self-reported perception of weight in 11-year-old boys by year, Gratiot Co., MI, 2011–2015

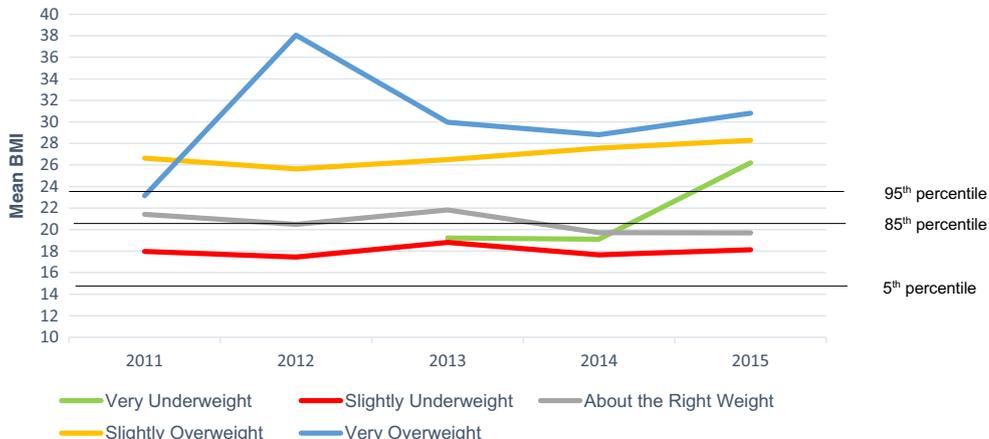
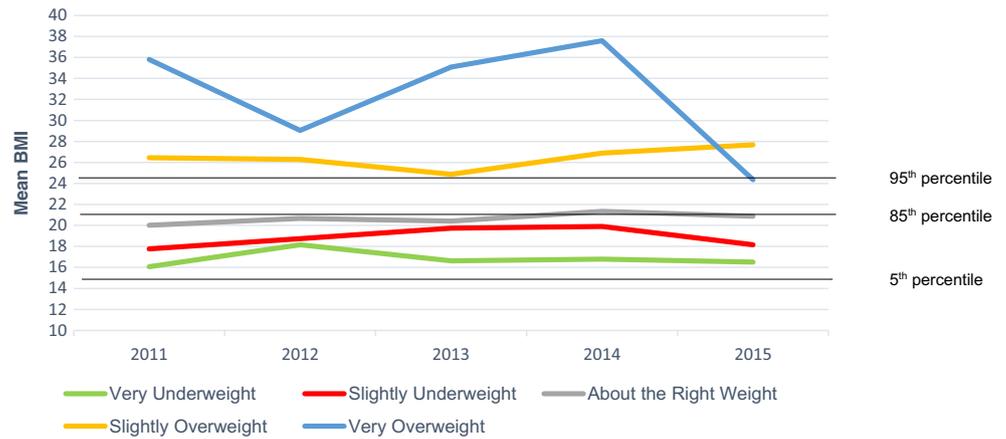


Fig. 4 Mean measured BMI and self-reported perception of weight in 11-year-old girls by year, Gratiot Co., MI, 2011–2015



model of health behavior (DiClemente et al. 2013) may explain some of the patterns seen in a rural setting such as this. The child’s exosystem, which includes the low socioeconomic status of the community, may contribute to difficulty in obtaining healthy foods and difficulty in accessing facilities for regular physical activity, thus serving as a distal contributing factor to childhood obesity. The microsystem of children in rural areas—including their family members, peers, and neighborhood—is a more proximal determinant of the tendency of children to become overweight or obese.

Studies show that adults in rural/nonmetropolitan areas are more likely to be overweight or obese compared to their urban/metropolitan counterparts (Abadio-Finco et al. 2017; Befort et al. 2012; Lundeen et al. 2018; Meit et al. 2014). Since parents’ sedentary lifestyle has been associated with a greater likelihood for their children to be engaged in sedentary activity (Jago et al. 2010) and engagement in physical activity is lower in rural areas (Cleland et al. 2017; Ding et al. 2011), children in rural areas who have overweight or obese parents are more prone to becoming overweight or obese compared to children in urban areas. Furthermore, considering that majority of the children in rural, low-income areas are exposed to similar environments at home, in school, and in their

neighborhood, many of those who are overweight or obese may develop a distorted sense of body image and ideal body weight such that they perceive overweight or obesity as normal because they see that their peers and family members have similar weight.

One limitation of our study is that we could not determine causality because we used a cross-sectional design. Though we assessed the distribution of self-reported weight in this group of students, we could not assess for the determinants of their weight perceptions. Also, our study design does not allow us to follow up students who were categorized as overweight or obese by BMI standards into adulthood to observe what health outcomes they will have. The format of the YRBS questionnaire could also serve as a limitation of our study. The questionnaire does not provide any visual aids to help students more accurately classify their weight into specific categories. Furthermore, the lower sensitivity values of BMI in assessing levels of adiposity compared to other newer, direct methods, including dual-energy x-ray absorptiometry (Daniels et al. 2000; Shah and Braverman 2012) and the fat mass index (Samadi et al. 2013), suggests that a substantial proportion of false negatives could have been prevented if one of these other methods had been used for this study.

Fig. 5 Mean measured BMI and self-reported perception of weight in 12-year-old boys by year, Gratiot Co., MI, 2011–2015

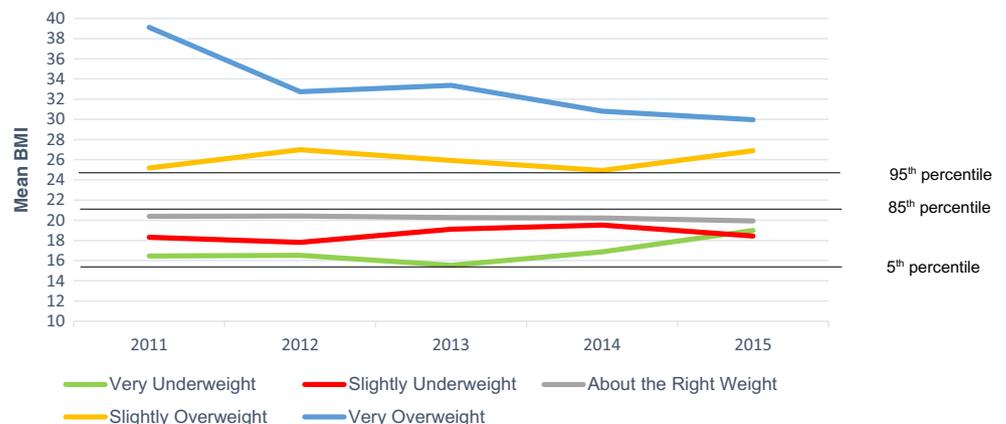
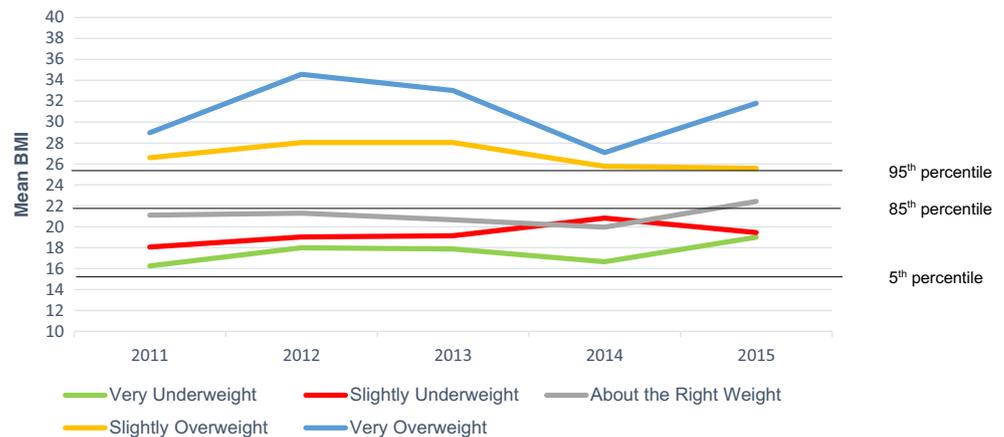


Fig. 6 Mean measured BMI and self-reported perception of weight in 12-year-old girls by Year, Gratiot Co., MI, 2011–2015



Conclusion

Although direct measurement of height and weight may be more time-consuming and more expensive, it has been shown to yield more accurate results than self-reported data (Sherry et al. 2007). Therefore, obesity prevention and intervention programs and state and local surveillance programs are encouraged to use measured BMI as much as possible. The use of self-reported data should be limited to situations where no better alternative is possible.

Our findings indicate that there often is a discrepancy between measured weight status and weight self-perception, which is supported by findings from several other studies (Chung et al. 2013; Maximova et al. 2008; Sherry et al. 2007; Viner et al. 2006). For individuals to take appropriate steps toward modifying their lifestyle habits, it is crucial that they accurately perceive their overweight or obese status. Failing to effectively address body misperceptions may be one of the reasons why obesity intervention programs have had such limited success. Such programs should seek to incorporate awareness of misperceptions as a component of their programs (Maximova et al. 2008).

Parents' recognition that their children are overweight or obese has been associated with a higher parental motivation and readiness to encourage lifestyle modifications in their children (Sherry et al. 2007). As illustrated by the socioecologic model of health behavior, parents influence many lifestyle choices in their children, such as the consumption of fruits and vegetables, the types of meals prepared and consumed, or whether their children join exercise classes or sports teams. There is ample evidence that parents who are physically active influence their children to become physically active, and group physical activity involving family members is highly sustainable (Brown et al. 2015; Moore et al. 1991; Wang et al. 2015). Therefore, childhood obesity interventions that address the more distal causes of childhood obesity in rural settings, involve parents, and incorporate mechanisms that ensure accurate perception of weight are likely to be effective in reducing

childhood obesity. Further research might consider examining the extent to which having overweight or obese family members alters children's perception of their own weight.

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Compliance with ethical standards

All the authors have made substantial contributions to the following: the conception and design of the study, or acquisition of data, or analysis and interpretation of data; drafting the article or revising it critically for important intellectual content; and final approval of the version to be submitted. Having been actively involved, both personally and jointly, in substantive work that led to the report in the manuscript, the authors will hold themselves responsible for its content. No grant funding was received for this study, and the authors have no conflicts of interest to declare.

All relevant ethical safeguards have been met in relation to protection of participants. An application for ethical approval of this study was submitted to the Institutional Review Board (IRB) of Alma College, Alma, Michigan. The project received expedited review and was approved by the IRB. In addition, permission letters were obtained from each school, and reverse parental informed consent and child assent were received for each participant in the study.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Conflicts of interest The authors declare that they have no conflict of interest.

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