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Parent-Reported Height and Weight as Sources of Bias in Survey Estimates of Childhood Obesity

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Parental reporting of height and weight was evaluated for US children aged 2–13 years. The prevalence of obesity (defined as a body mass index value (calculated as weight (kg)/height (m)^2) in the 95th percentile or higher) and its height and weight components were compared in child supplements of 2 nationally representative surveys: the 1996–2008 Children of the National Longitudinal Survey of Youth 1979 Cohort (NLSY79-Child) and the 1997 Child Development Supplement of the Panel Study of Income Dynamics (PSID-CDS). Sociodemographic differences in parent reporting error were analyzed. Error was largest for children aged 2–5 years. Underreporting of height, not overreporting of weight, generated a strong upward bias in obesity prevalence at those ages. Frequencies of parent-reported heights below the Centers for Disease Control and Prevention's (Atlanta, Georgia) first percentile were implausibly high at 16.5% (95% confidence interval (CI): 14.3, 19.0) in the NLSY79-Child and 20.6% (95% CI: 16.0, 26.3) in the PSID-CDS. They were highest among low-income children at 33.2% (95% CI: 22.4, 46.1) in the PSID-CDS and 26.2% (95% CI: 20.2, 33.2) in the NLSY79-Child. Bias in the reporting of obesity decreased with children's age and reversed direction at ages 12–13 years. Underreporting of weight increased with age, and underreporting of height decreased with age. We recommend caution to researchers who use parent-reported heights, especially for very young children, and offer practical solutions for survey data collection and research on child obesity.

body height; body mass index; body weights and measures; child; data reporting; demographic factors; obesity; socioeconomic factors

Abbreviations: BMI, body mass index; CDC, Centers for Disease Control and Prevention; CI, confidence interval; NLSY79, National Longitudinal Survey of Youth 1979 Cohort; NLSY79-Child, Children of the National Longitudinal Survey of Youth 1979 Cohort; PSID-CDS, Child Development Supplement of the Panel Study of Income Dynamics.

The recommended method for surveillance and routine clinical assessment of child overweight and obesity is to calculate body mass index (BMI) (weight (kg)/height (m)^2) from height and weight measured by trained personnel (1–6). However, for reasons of cost and practicality, survey data with parent-reported or self-reported heights and weights are often used (7–12). Considerable skepticism has been expressed by researchers and health professionals about the accuracy of parent-reported data and the validity of findings drawn from surveys in which children's heights and weights are parent reported (8, 13–18).

Studies evaluating the quality of parent-reported data (7, 8, 13–23) have been inconsistent as to the magnitude and direction of error in parent-reported weight, height, and calculated BMI (5). Differences in error by gender (7, 13, 14, 16–18, 23), race/ethnicity (7, 18, 23), and socioeconomic status (13, 14, 16) have been similarly inconsistent. Most samples are from non-US populations in which metric rather than imperial measurement systems are used (14–17, 19, 20) or are convenience samples of US children (18, 21–23). Because obesity is defined as a BMI value at or above a high threshold point, for example, the 95th percentile according to the Centers for

Disease Control and Prevention (CDC) (Atlanta, Georgia) (1–4), estimates of obesity prevalence are sensitive to error in extreme values of height and weight, especially to very high weight or very low height. This possibility is recognized in the CDC and World Health Organization protocols for identifying "biologically implausible" values of height or weight (24). Parental overreporting of extreme values of height or weight has been attributed to digit preference, rounding, and failing to keep pace with children's rapid growth, especially at the youngest ages (8). Parental underreporting of extreme values has also been observed, with parents of heavy children underreporting weight and parents of light children overreporting weight (13–15, 19, 21, 23). This latter type of reporting error can be interpreted either as simple regression to the mean (25) or as arising from social desirability bias (23, 26–29).

Because increases in weight have driven the obesity epidemic, it is unsurprising that studies have tended to emphasize misreporting of weight rather than height (30, 31). At least equal attention to height misreporting, however, is merited, because height errors are compounded by the squaring of height in the denominator of BMI calculations (7, 8). In this study, we examined error in parental reporting of children's heights and weights as sources of bias in nationally representative survey estimates of childhood obesity in US children aged 2–13 years. Our analyses investigated misreporting of extreme values of height and weight and identified sociodemographic differentials in misreporting.

MATERIALS AND METHODS

Data

The Children of the National Longitudinal Survey of Youth 1979 Cohort (NLSY79-Child) is an ongoing survey with biennial assessments of height and weight for all children born to women followed in the National Longitudinal Survey of Youth 1979 Cohort (NLSY79). The NLSY79 comprises a nationally representative sample of men and women who were aged 14–21 years in 1979 and includes an oversample of non-Hispanic black and non-Hispanic white economically disadvantaged households. NLSY79 subjects were surveyed annually through 1994 with retention rates above 90% and have been surveyed biennially since 1994 with retention rates of 80%–90% (32). Children of women followed in the NLSY79 are eligible for inclusion in the NLSY79-Child if they are younger than 15 years of age, their mothers were assessed in the corresponding NLSY79 wave, they resided at least part-time with their mothers, and their mothers provided informed consent. The proportion of eligible children who were either directly assessed or whose mothers were interviewed each year ranged from a low of 77% in 2000 (a single year when, for budgetary reasons, the NLSY79 oversamples of blacks and Hispanics were not interviewed) to a high of 96% in 1996 (33). There were 6,373 children observed in the 1996–2008 survey waves at ages 2–13 years (20,206 person-years), from which we excluded observations in which children reported their own heights and/or weights (5%) or in which heights and/or weights were not assessed (3%).

A second nationally representative panel survey, the Panel Study of Income Dynamics, included a Child Development Supplement (PSID-Child) in 1997, which included a combination of parent-reported and measured data on children's heights and weights. Since 1968, the Panel Study of Income Dynamics has followed a nationally representative sample of US households, including a low-income oversample. All new households formed by children and other family members descended from the original 1968 households are followed, and an immigrant "refresher" subsample was added in 1997. Wave-to-wave retention rates have ranged from 92% to 98% following the initial 1968 and 1969 response and retention rates of 76% and 81%, respectively (34). The PSID-CDS was administered to primary caregivers of up to 2 randomly selected children aged 0–13 years from the Panel Study of Income Dynamics core and immigrant refresher samples with a response rate of 88% (35). There were 3,113 children aged 2–13 years in the PSID-CDS; from these, we excluded observations for which height and/or weight was not assessed (10%). Both the PSID-CDS and the NLSY79-Child analytical samples were found to be statistically indistinguishable from the total samples without exceptions on the variables used in this study (Web Table 1 available at http://aje.oxfordjournals.org/).

Assessment of height and weight. In both the NLSY79-Child and the PSID-CDS, height was recorded in feet (1 foot = 30 cm) and inches (1 inch = 2.54 cm), and weight was recorded in pounds (1 pound = 0.45 kg) and ounces (1 ounce = 28 g). At each survey wave of the NLSY79-Child, a trained interviewer or the mother measured each child's height and weight unless the mother did not consent to either measurement or the interview was conducted by telephone, in which case height and/or weight was mother reported. Measurements were taken in the child's own clothes, after removing shoes and coats, by using a portable scale and a tape measure. Survey data "flags" identify whether height and weight were parent reported or measured. Additionally, in the 2006 and 2008 waves of the NLSY79-Child, a subset of children had both mother-reported and measured heights and weights in a given survey wave.

In the PSID-CDS, weight was reported in all cases by the primary caregivers, 92% of whom were the biological mothers. Any primary caregiver who did not know the child's weight was asked to provide an estimate and report when the child was last weighed. Child height was measured by a trained interviewer unless the interview was conducted by telephone, the child was not present, or the primary caregiver did not consent. Unfortunately, no flags are provided with the data to distinguish parent-reported from measured heights or to distinguish whether an interview was conducted in person or by telephone. However, we were able to develop a proxy flag for whether the child was a "nonrespondent" on the in-person child assessment for children aged 3–12 years, thereby identifying children whose primary caregivers were interviewed by telephone or who were otherwise not present for assessment; thus, these children could not have had interviewer-measured heights.

Sociodemographic assessment. In the NLSY79-Child and the PSID-CDS, each child's gender and age and the mother's age at the child's birth were reported or calculated from the month and year of birthdates and interviews. In the NLSY79-Child, race/ethnicity data came from the mother's NLSY79 report of the racial/ethnic origins (chosen from 30 categories) with which she most closely identified. Total family income data in US dollars were constructed by the data producer by using a series of questions in each NLSY79 wave. In the PSID-CDS, children's races/ethnicities were reported by the primary caregivers (as white non-Hispanic, black non-Hispanic, Hispanic, Asian or Pacific Islander, American Indian or Alaskan Native, or "other"). The data producer constructed total family income data from a series of questions and imputed item nonresponse. We harmonized NLSY79-Child and PSID-CDS racial/ethnic origins by using US Census categories (36) and adjusted family income for inflation to year-2000 dollars (37).

Because of sample design differences between the NLSY79-Child (Table 1) and the PSID-CDS (Table 2), and because children in the surveys were not randomly selected into measured versus parent-reported height and weight assessments, we compared the sociodemographic characteristics of the children in each survey overall and by assessment protocol. The PSID-CDS was designed to be representative of US children in 1997, whereas our NLSY79-Child sample was representative of children aged 2–13 years in 1996–2008 who were born to women residing in the United States at ages 14–21 years in 1979. The latter restriction of the NLSY79-Child sample meant that this sample had older mothers and higher family incomes than did our PSID-CDS sample and was less representative of Hispanic children (notably because of the exclusion of children born to mothers who immigrated after 1979). These differences were still more pronounced for our 2006 and 2008 subsample of the NLSY79-Child.

In the NLSY79-Child, the measured and parent-reported subsamples differed significantly on the mean age of the mother at the child's birth and on the distribution of the subsamples by race/ethnicity and family income. Children with measured weights in the NLSY79-Child were more likely than children with parent-reported weights to have older mothers, non-Hispanic black mothers, and mothers with lower family incomes. The latter 2 socioeconomic characteristics are associated with lower rates of obesity (38–40). In the PSID-CDS, there were no statistically significant differences between the entirely parent-reported and measured height subsamples on gender, mother's age, or family income. Subjects in the parent-reported subsample, however, were more likely to be Hispanic and less likely to be non-Hispanic black. Hispanic and black races/ethnicities are associated with higher rates of obesity (30, 41).

Analyses

Children were categorized into percentiles of height-for-age, weight-for-age, and BMI-for-age on the basis of gender and age (in months) by using an SAS program (SAS Institute, Inc., Cary, North Carolina) from the CDC that uses the 2000 CDC growth charts (24, 42). We excluded a small number of observations in the NLSY79-Child ($n = 20$) and the PSID-CDS ($n = 2$) with BMI values outside the range of this program. A BMI-for-age at or above the 95th percentile was classified as "obese" (2). The panel surveys were divided into age groups for which there was sufficient sample size to distinguish between measured and parent-reported heights and weights: ages 2–5, 6–8, 9–11, and 12–13 years in the NLSY79-Child and ages 2–5 and 6–13 years in the PSID-CDS (Table 3). Obesity prevalence was compared between respective survey subsamples, and percentile-by-percentile comparisons of children above or below each of the top or bottom 20 percentiles of weight-for-age and height-for-age were conducted. For the subset of NLSY79-Child observations with both measured and parent-reported heights and weights, mean differences between the measured and parent-reported data for a given assessment of BMI, height, and weight were calculated. Analyses were also conducted by stratifying by gender, race/ethnicity, and family income. For these analyses, observations with item nonresponse on the analyzed characteristic (Tables 1 and 2) were excluded.

All analyses used survey weights and adjusted for clustering of children in families in the NLSY79-Child and the PSID-CDS by using the survey (svy) prefix commands in Stata, version 11, software (StataCorp LP, College Station, Texas). We report 95% confidence intervals for proportions and adjusted Pearson χ^2 statistics for tests of differences in proportions. Analyses were determined to be exempt from human subject review by the RAND Corporation's Human Subjects Protection Committee (Santa Monica, California).

RESULTS

Obesity prevalence in the exclusively measured sample of the NLSY79-Child was 13.8% (95% confidence interval (CI): 12.1, 15.8) at ages 2–5 years and 15.5% (95% CI: 14.3, 16.8) at ages 6–13 years (Table 3). In contrast, obesity prevalence at ages 2–5 years was 2.5–3 times higher at 32.3% (95% CI: 29.3, 35.6) in the NLSY79-Child and 36.6% (95% CI: 30.9, 42.7) in the PSID-CDS subsamples with parent-reported weights and heights and nearly 2 times higher at 25.3% (95% CI: 17.2, 35.5) in the NLSY79-Child subsample with measured weights and parent-reported heights. At ages 6–13 years, there was a similar pattern of higher obesity prevalence in the subsamples with parent-reported heights. However, additional age breakdowns that were possible for children in the NLSY79-Child with either exclusively measured or exclusively parent-reported data showed that the obesity prevalence in the exclusively parent-reported subsample was significantly higher only at ages 6–8 years; there were no significant differences in prevalence at ages 9–11 years, and prevalence was significantly *lower* at ages 12–13 years in the exclusively parent-reported subsample compared with the exclusively measured subsample.

For children aged 2–5 years, a pattern of parents overreporting weight and/or underreporting height could have produced the higher rates of obesity observed in the reported compared with the measured subsamples. To assess these possibilities, we compared the measured versus the parent-reported proportions in both studies of children who were in the 20 highest percentiles of weight-for-age (Web Figure 1) and the 20 lowest percentiles of height-for-age (Web Figure 2). The percentages of children with height below the first percentile were implausibly high at 16.5% (95% CI: 14.3, 19.0) in the parent-reported subsamples of the NLSY79-Child

Table 1. Demographic and Socioeconomic Characteristics of the Measured and Parent-Reported Components of the Children of the National Longitudinal Survey of Youth 1979 Cohort, United States, 1996–2008[a]

Characteristic	Measured Weight and Height			Measured Weight and Reported Height			Reported Weight and Measured Height			Reported Weight and Height			Subsample, 2006 and 2008[b]			Total		
	Mean	%	95% CI	Mean	%	95% CI	Mean	%	95% CI	Mean	%	95% CI	Mean	%	95% CI	Mean	%	95% CI
Female		48.8	47.1, 50.6		48.7	44.3, 53.2		52.6	49.4, 55.8		47.1	44.9, 49.4		48.9	44.9, 52.8		48.7	47.2, 50.3
Mother's age at child's birth, years	29.7		29.6, 29.9	29.1		28.6, 29.5	30.6		30.3, 30.9	30.0		29.8, 30.2	34.3		34.1, 34.6	29.8		29.7, 30.0
Race/ethnicity of the mother																		
Non-Hispanic white		77.0	75.1, 78.9		79.3	76.2, 82.1		80.6	78.0, 83.1		78.7	76.7, 80.6		80.2	76.7, 83.2		77.9	76.2, 79.4
Hispanic		7.4	6.5, 8.4		7.2	5.8, 9.0		8.1	6.8, 9.7		7.8	6.8, 9.0		5.7	4.3, 7.4		7.6	6.8, 8.4
Non-Hispanic black		14.1	12.7, 15.6		12.6	10.6, 15.0		9.1	7.5, 11.2		11.2	10.0, 12.6		13.2	10.9, 15.9		12.9	11.8, 14.1
Other		1.5	0.9, 2.3		0.8	0.3, 2.0		2.1	1.3, 3.4		2.3	1.5, 3.5					1.7	1.2, 2.4
Family income[c]																		
<$25,000		21.4	19.6, 23.2		23.7	19.8, 28.0		18.9	16.0, 22.1		19.2	17.2, 21.4		14.1	11.3, 17.5		20.8	19.2, 22.4
$25,000–$49,999		25.5	23.6, 27.4		22.3	18.5, 26.7		22.4	19.3, 25.8		22.0	19.9, 24.4		20.7	17.0, 24.9		24.3	22.7, 25.9
$50,000–$74,999		23.2	21.5, 25.0		22.8	18.8, 27.3		25.9	22.7, 29.4		25.0	22.6, 27.6		22.2	18.3, 26.8		23.8	22.3, 25.4
≥$75,000		29.9	27.6, 32.4		31.3	26.4, 36.6		32.9	29.1, 36.8		33.8	30.9, 36.8		43.0	37.7, 48.4		31.2	29.1, 33.3
Total	69,200		65,128, 73,273	72,730		55,040, 90,420	76,214		67,514, 84,914	76,094		69,925, 82,264	90,269		78,789, 101,749	71,604		67,619, 75,590
Year	2000.2		2000.0, 2000.3	2000.2		1999.9, 2000.6	2000.2		1999.9, 2000.5	2000.2		2000.0, 2000.3	2006.7		2006.7, 2006.8	2000.2		2000.1, 2000.3
Observations																		
Weighted % of NLSY79-Child total		62.3	61.0, 63.5		4.6	4.2, 5.0		8.7	8.1, 9.3		24.4	23.4, 25.5					100.0	
Unweighted person-years	11,800			830			1,562			4,443			1,102			18,635		

Abbreviations: CI, confidence interval; NLSY79-Child, Children of the National Longitudinal Survey of Youth 1979 Cohort.
[a] Means and percentages were weighted by using sample weights; confidence interval estimates were adjusted for clustering of children in families.
[b] The subsample comprised children with mother-reported and measured heights and weights in the 2006 and/or 2008 survey waves.
[c] Family income was adjusted to year-2000 US dollars, and analyses excluded observations with item nonresponse on income (2,881 person-years).

Table 2. Demographic and Socioeconomic Characteristics of the Measured and Parent-Reported Components of the Child Development Supplement of the Panel Study of Income Dynamics, United States, 1997[a]

Characteristic	Reported Weight and Measured Height			Reported Weight and Height			Total		
	Mean	%	95% CI	Mean	%	95% CI	Mean	%	95% CI
Female		49.5	46.4, 52,5		51.0	46.4, 55.5		49.9	47.3, 52.4
Mother's age at child's birth, years[b]	27.3		26.9, 27.7	27.1		26.5, 27.6	27.2		26.9, 27.6
Race/ethnicity of child[c]									
Non-Hispanic white		65.4	61.7, 68.9		66.8	61.9, 71.3		65.8	62.7, 68.7
Hispanic		9.3	7.2, 11.8		14.3	10.7, 19.0		10.7	8.7, 13.0
Non-Hispanic black		17.7	15.2, 20.5		12.9	10.5, 15.6		16.3	14.3, 18.6
Non-Hispanic other		7.7	5.7, 10.3		6.0	4.1, 8.9		7.2	5.7, 9.2
Family income[d]									
<$25,000		26.1	22.9, 29.7		24.3	20.0, 29.0		25.6	22.8, 28.6
$25,000–$49,999		29.8	26.6, 31.2		32.7	28.1, 37.6		30.6	27.9, 33.5
$50,000–$74,999		20.4	17.8, 23.4		20.0	16.1, 24.6		20.3	17.9, 22.9
≥$75,000		23.7	20.8, 26.8		23.1	18.8, 27.9		23.5	21.0, 26.2
Total	57,468		52,671, 62,265	53,332		49,100, 57,563	56,320		52,619, 60,022
Observations									
Weighted % of PSID-CDS total		72.3	69.8, 74.6		27.7	25.4, 30.3		100.0	
Unweighted person-years	2,029			769			2,798		

Abbreviations: CI, confidence interval; PSID-CDS, Child Development Supplement of the Panel Study of Income Dynamics.

[a] Means and percentages were weighted by using sample weights; confidence interval estimates were adjusted for clustering of children in families.

[b] Analyses excluded observations with item nonresponse on mother's age at child's birth (177 children).

[c] Analyses excluded observations with item nonresponse on race/ethnicity (5 children).

[d] Family income was adjusted to year-2000 US dollars; item nonresponse on income was imputed by the data providers.

and 20.6% (95% CI: 16.0, 26.3) in the PSID-CDS compared with the respective measured heights below the first percentile of 3.4% (95% CI: 2.7, 4.3) in the NLSY79-Child and 5.5% (95% CI: 3.6, 8.2) in the PSID-CDS subsamples (Figure 1). In the 1999–2008 National Health and Nutrition Examination Surveys (43), only 0.8% of all children aged 2–5 years fell below the first height percentile (results not shown). Finally, the 20 highest weight proportions were statistically indistinguishable between measured and parent-reported weights in the NLSY79-Child, differing at most by only 1.3% in the 99th percentile (Web Figure 1, Figure 2).

Tabulations of the percentage of children aged 2–5 years with height below the first percentile by sociodemographic characteristics (Table 4) suggest that misreporting was especially high for economically disadvantaged children. In both the NLSY79-Child and the PSID-CDS, there was a statistically significant association between family income and height below the first percentile in the parent-reported subsamples that was not observed in the respective measured subsamples. In the parent-reported subsamples, height below the first percentile among children with family income below $25,000 was nearly 2–3 times more common than for children with family income of at least $75,000. Gender differences in height below the first percentile were mixed across the subsamples and surveys and were never statistically significant. Differences by race/ethnicity were also mixed, with significant racial/ethnic differences in height below the first percentile in both the NLSY79-Child parent-reported and measured samples, but only in the parent-reported sample of the PSID-CDS.

We next addressed the sample of children aged 12–13 years in the NLSY79-Child, in which rates of obesity were *lower* in the exclusively parent-reported subsample than the exclusively measured subsample. Lower rates in the parent-reported compared with the measured subsample could have been produced by parents underreporting weight and/or overreporting height. When considering the 20 highest percentiles of weight (Web Figure 3) and height (Web Figure 4), we found that parents both underreported the heaviest weights and overreported the tallest heights. The percentage of children with parent-reported weight above the 99th percentile was 4.6% (95% CI: 3.5, 5.9), which was significantly lower than the measured percentage of 7.0% (95% CI: 5.8, 8.3) (Figure 3). Similarly, the percentage of children with parent-reported height above the 99th percentile was 4.3% (95% CI: 3.2, 5.7), which was significantly higher than the measured percentage of 2.7% (95% CI: 2.1, 3.5) (Figure 4).

Table 3. Obesity Prevalence by Age Group and Assessment of Weight and Height in the Children of the National Longitudinal Survey of Youth 1979 Cohort, United States, 1996–2008, and the Child Development Supplement of the Panel Study of Income Dynamics, United States, 1997[a]

Age Group by Assessment Type	No. of Observations	Prevalence		
		%	95% CI	χ^2 *P* Value
Aged 2–5 years				
NLSY79-Child, total	4,082	19.9	18.4, 21.5	<0.001
NLSY79-Child, measured weight and height	2,268	13.8	12.1, 15.8	
NLSY79-Child, reported weight and measured height	464	15.7	12.4, 19.8	
NLSY79-Child, measured weight and reported height	101	25.3	17.2, 35.5	
NLSY79-Child, reported weight and height	1,249	32.3	29.2, 35.5	
PSID-CDS, total	1,026	27.2	23.6, 31.2	<0.001
PSID-CDS, reported weight and measured height	620	20.6	16.6, 25.2	
PSID-CDS, reported weight and height	406	36.6	30.9, 42.7	
Aged 6–13 years				
NLSY79-Child, total	14,553	16.1	15.0, 17.2	0.027
NLSY79-Child, measured weight and height	9,532	15.5	14.3, 16.8	
NLSY79-Child, reported weight and measured height	1,098	15.1	12.5, 18.0	
NLSY79-Child, measured weight and reported height	729	20.0	16.9, 23.6	
NLSY79-Child, reported weight and height	3,194	17.1	15.3, 19.0	
PSID-CDS, total	1,772	16.1	13.8, 18.6	0.080
PSID-CDS, reported weight and measured height	1,409	15.0	12.6, 17.8	
PSID-CDS, reported weight and height	363	20.2	15.2, 26.3	
Aged 6–8 years				
NLSY79-Child, total[b]	4,655	15.4	14.0, 16.9	<0.001
NLSY79-Child, measured weight and height	3,274	13.5	12.0, 15.1	
NLSY79-Child, reported weight and height	800	21.9	18.5, 25.7	
Aged 9–11 years				
NLSY79-Child, total[b]	5,817	16.7	15.4, 18.1	0.173
NLSY79-Child, measured weight and height	3,889	16.2	14.7, 17.8	
NLSY79-Child, reported weight and height	1,181	18.2	15.6, 21.1	
Aged 12–13 years				
NLSY79-Child, total[b]	4,081	15.9	14.5, 17.4	0.003
NLSY79-Child, measured weight and height	2,369	17.3	15.4, 19.3	
NLSY79-Child, reported weight and height	1,213	12.8	10.8, 15.2	

Abbreviations: CI, confidence interval; NLSY79-Child, Children of the National Longitudinal Survey of Youth 1979 Cohort; PSID-CDS, Child Development Supplement of the Panel Study of Income Dynamics.

[a] Obesity was categorized by using the Centers for Disease Control and Prevention (Atlanta, Georgia) growth charts. Percentages were weighted by using sample weights for the respective surveys. Confidence interval estimates and χ^2 statistics were adjusted for clustering within families in the NLSY79-Child and the PSID-CDS sample designs.

[b] The NLSY79-Child total for children aged 6–8, 9–11, or 12–13 years included 2 subsamples with insufficient sample sizes to be shown separately: children with reported weight and measured height and children with measured weight and reported height.

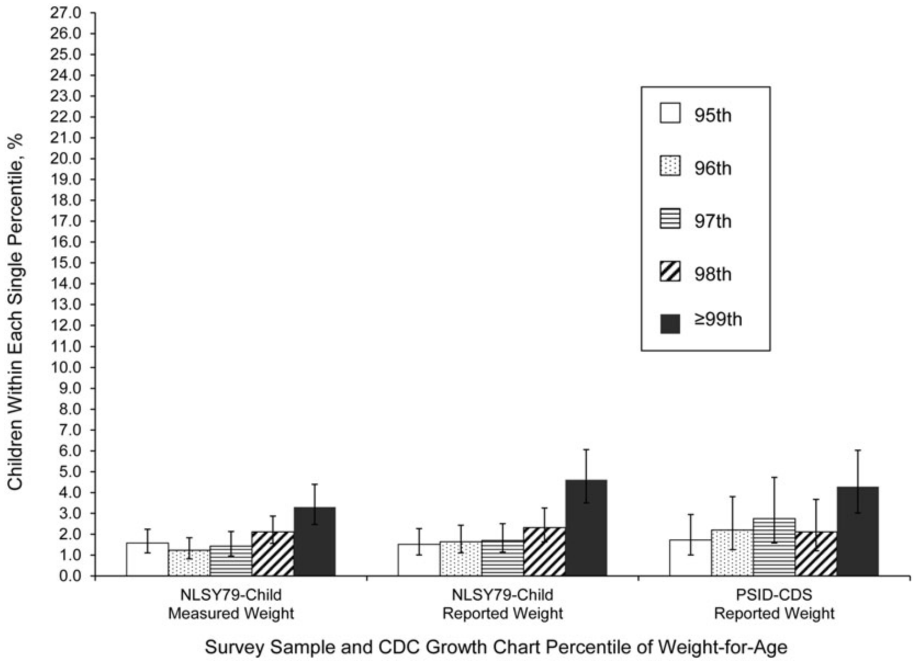

Figure 1. Percentages of US children aged 2–5 years within the 95th, 96th, 97th, 98th, and ≥99th percentiles of weight for age, 1996–2008. Percentages of children within each single percentile are weighted by using respective survey sample weights. Error bars represent 95% confidence intervals. Confidence interval estimates adjust for clustering of children within families. CDC, Centers for Disease Control and Prevention; NLSY79-Child, Children of the National Longitudinal Survey of Youth 1979 Cohort, 1996–2008; PSID-CDS, Child Development Supplement of the Panel Study of Income Dynamics, 1997.

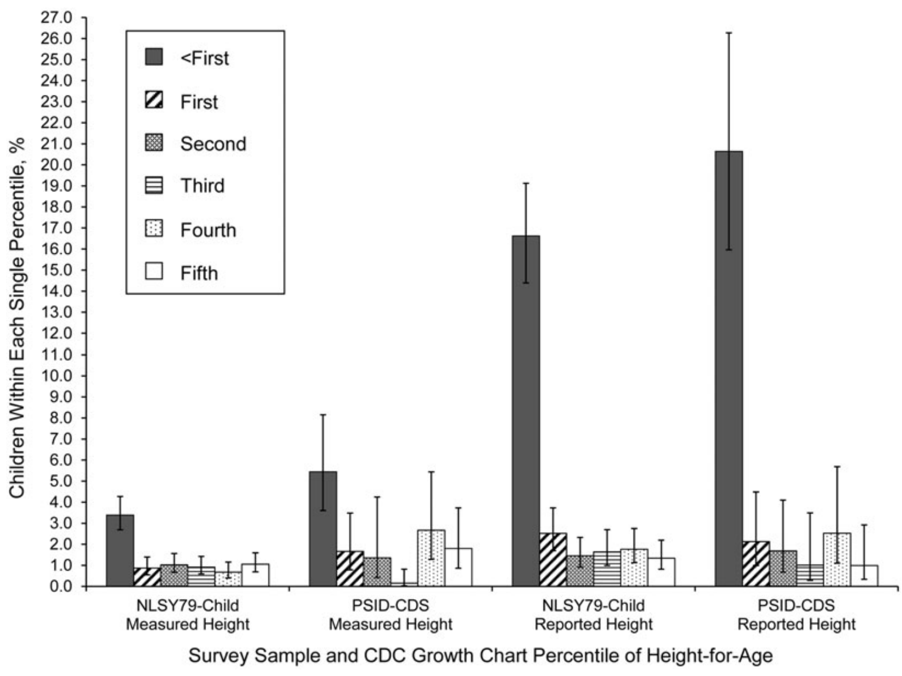

Figure 2. Percentages of US children aged 2–5 years within the <first, first, second, third, fourth, and fifth percentiles of height for age, 1996–2008. Percentages of children within each single percentile are weighted by using respective survey sample weights. Error bars represent 95% confidence intervals. Confidence interval estimates adjust for clustering of children within families. CDC, Centers for Disease Control and Prevention; NLSY79-Child, Children of the National Longitudinal Survey of Youth 1979 Cohort, 1996–2008; PSID-CDS, Child Development Supplement of the Panel Study of Income Dynamics, 1997.

Table 4. Prevalence of Children Aged 2–5 Years With Height Below the First Percentile by Sociodemographics and Assessment of Height in the Children of the National Longitudinal Survey of Youth 1979 Cohort, 1996–2008, and the Child Development Supplement of the Panel Study of Income Dynamics, 1997[a]

	Parent-Reported Height				Measured Height			
	Person-Years	%	95% CI	χ^2 *P* Value	Person-Years	%	95% CI	χ^2 *P* Value
NLSY79-Child								
Total	1,350	16.5	14.3, 19.0		2,732	3.4	2.7, 4.3	
Gender				0.134				0.057
Male	706	14.9	12.1, 18.1		1,344	4.1	3.0, 5.6	
Female	644	18.4	15.0, 22.2		1,388	2.7	1.9, 3.7	
Race/ethnicity[b]				<0.001				<0.001
Non-Hispanic white	743	13.2	10.7, 16.2		1,514	2.5	1.8, 3.5	
Hispanic	298	24.1	18.5, 30.9		524	6.7	4.5, 9.8	
Non-Hispanic black	286	35.0	28.7, 41.9		658	6.4	4.6, 9.0	
Family income[c]				0.014				0.554
<$25,000	276	26.2	20.2, 33.2		599	4.5	2.9, 6.7	
$25,000–$49,999	206	14.2	9.6, 20.5		572	3.0	1.9, 4.9	
$50,000–$74,999	245	16.4	11.8, 22.2		523	3.6	2.1, 6.2	
≥$75,000	368	15.4	11.6, 20.2		656	2.9	1.8, 4.6	
PSID-CDS								
Total	406	20.6	16.0, 26.3		620	5.5	3.6, 8.2	
Gender				0.069				0.432
Male	205	25.3	18.4, 33.9		337	4.7	2.7, 8.0	
Female	201	16.1	10.6, 23.6		283	6.3	3.6, 10.9	
Race/ethnicity[b]				<0.001				0.364
Non-Hispanic white	198	13.1	8.7, 19.3		294	4.6	2.6, 8.2	
Hispanic	35	42.7	25.9, 61.3		31	10.0	2.8, 3.0	
Non-Hispanic black	150	36.9	24.1, 51.9		261	5.4	3.2, 8.9	
Family income[c]				0.018				0.322
<$25,000	130	33.2	22.4, 46.1		212	2.5	1.1, 5.5	
$25,000–$49,999	129	17.7	10.9, 27.4		188	7.6	4.2, 13.6	
$50,000–$74,999	80	17.9	9.7, 30.7		121	6.3	2.6, 14.6	
≥$75,000	67	11.3	5.4, 22.3		99	4.5	3.6, 8.2	

Abbreviations: CI, confidence interval; NLSY79-Child, Children of the National Longitudinal Survey of Youth 1979 Cohort; PSID-CDS, Child Development Supplement of the Panel Study of Income Dynamics.

[a] Height below the first percentile was categorized by using the Centers for Disease Control and Prevention (Atlanta, Georgia) growth charts. Percentages were weighted by using sample weights for the respective surveys. Confidence interval estimates and χ^2 statistics were adjusted for clustering within families in the NLSY79-Child and PSID-CDS sample designs.

[b] Analyses excluded children with non-Hispanic "other" race/ethnicity because of insufficient sample sizes.

[c] Family income was adjusted to year-2000 US dollars. In the NLSY79-Child, analyses excluded observations with item nonresponse on income; in the PSID-CDS, item nonresponse was imputed by the data providers.

The sociodemographic pattern of weight above the 99th percentile was similar in the parent-reported and measured subsamples of children aged 12–13 years, with statistically significant differences by gender, race/ethnicity, and family income irrespective of weight assessment (Web Table 2). For height above the 99th percentile, the sociodemographic patterns were largely similar or not statistically significant in the parent-reported and measured subsamples (Web Table 3).

The subsample of the 2006 and 2008 waves of the NLSY79-Child with both parent-reported and measured weights and heights in the same wave had too few children aged 2–5 years for separate analysis. For children aged 2–8 years, however, parent-reported height was, on average, 2.1 inches lower than measured height at the same assessment and 1.6 inches and 1.1 inches lower for children aged 9–11 and 12–13 years, respectively (Table 5). In contrast, differences between parent-reported and measured weights widened with increasing child age from an average of 35.5 ounces lower at ages 2–8 years to 136.2 ounces lower at ages 12–13 years.

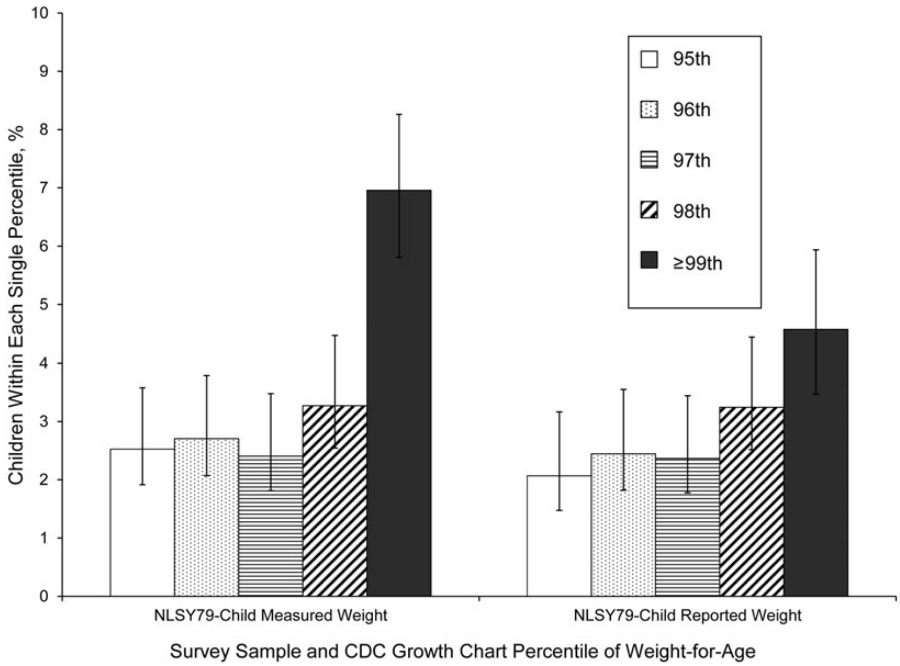

Figure 3. Percentages of US children aged 12–13 years within the 95th, 96th, 97th, 98th, and ≥99th percentiles of weight for age, 1996–2008. Percentages of children within each single percentile are weighted by using respective survey sample weights. Error bars represent 95% confidence intervals. Confidence interval estimates adjust for clustering of children within families. CDC, Centers for Disease Control and Prevention; NLSY79-Child, Children of the National Longitudinal Survey of Youth 1979 Cohort, 1996–2008.

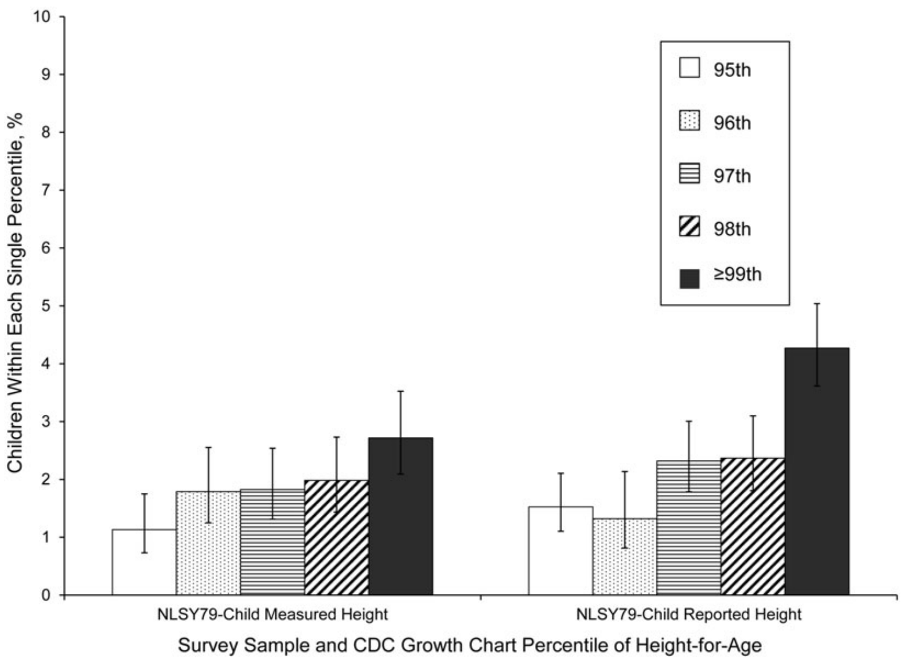

Figure 4. Percentages of US children aged 12–13 years within the 95th, 96th, 97th, 98th, and ≥99th percentiles of height for age, 1996–2008. Percentages of children within each single percentile are weighted by using respective survey sample weights. Error bars represent 95% confidence intervals. Confidence interval estimates adjust for clustering of children within families. CDC, Centers for Disease Control and Prevention; NLSY79-Child, Children of the National Longitudinal Survey of Youth 1979 Cohort, 1996–2008.

Table 5. Differences Between Mother-Reported and Measured Heights, Weights, and Calculated BMI[a] Values by Age Group in the 2006 and 2008 Subsample of the Children of the National Longitudinal Survey of Youth 1979 Cohort, United States[b]

Age, years	No. of Observations	BMI[a]		Weight		Height	
		Mean Difference	95% CI	Mean Difference, ounces[c]	95% CI	Mean Difference, inches[d]	95% CI
2–8	337	1.5	0.8, 2.2	−35.5	−54.2, −16.7	−2.1	−2.8, −1.3
9–11	415	0.1	−0.4, 0.5	−98.9	−127.4, −70.4	−1.6	−2.1, −1.2
12–13	350	−0.6	−1.1, −0.2	−136.2	−166.4, −106.0	−1.1	−1.5, −0.7

Abbreviations: BMI, body mass index; CI, confidence interval.

[a] BMI is calculated as weight (kg)/height (m)^2.

[b] Differences between mother-reported and measured values were calculated by subtracting the measured observations from the mother-reported observations for each survey wave during which the child was assessed with both mother-reported and measured weights and heights. Data were weighted by using survey sample weights, and confidence interval estimates were adjusted for clustering of children in families.

[c] One ounce = 28 g.

[d] One inch = 2.54 cm.

The differences between parent-reported and measured heights and weights in the 2006 and 2008 waves of the NLSY79-Child (with both parent-reported and measured weights and heights in the same wave) reinforced both the direction and age pattern of the results previously described. Results for extreme height and weight values among the youngest children in this subsample were comparable to those for the full NLSY79-Child sample with misreporting on extremely low heights predominating, especially among the lowest-income children. In the 2006 and 2008 waves of the NLSY79-Child (with both parent-reported and measured weights and heights in the same wave), 28.1% (95% CI: 22.5, 34.5) of children aged 2–8 years had mother-reported heights below the fifth percentile compared with only 5.4% (95% CI: 3.2, 9.1) when using the measured heights (Table 6). In comparison, the prevalence of extremely high weight was 11.6% (95% CI: 8.1, 16.4) when weights were mother reported and 12.2% (95% CI: 8.5, 17.2) when weights were measured (data not shown). Also, as observed in the full NLSY79-Child sample, the prevalence of extremely low heights was significantly associated with family income when using mother-reported heights but not when using measured heights (Table 6). When using mother-reported heights, we found that 57.1% (95% CI: 38.4, 74.0) of the children with family incomes below $25,000 had heights below the fifth percentile.

Consistent with the results from the full NLSY79-Child sample, the subsample of the 2006 and 2008 waves (with both parent-reported and measured weights and heights in the same wave) showed fewer extremely high mother-reported weights than measured weights for children aged 12–13 years. For this age group, the prevalence of mother-reported weight above the 95th percentile was 11.8% (95% CI: 8.5, 16.2), whereas the respective measured prevalence was 15.9% (95% CI: 12.0, 20.7) (data not shown). In contrast to the full NLSY79-Child sample, however, the prevalence of extremely high heights in the subsample was 12.8% (95% CI: 9.1, 17.9) when heights were mother reported and 13.4% when weights were measured (95% CI: 9.8, 18.1) (results not shown). For both weight and height, the patterns of sociodemographic differences in extreme values were similar, irrespective of whether the mother-reported or measured data were used (results not shown).

DISCUSSION

Previous studies that used nationally representative samples of US children with parent-reported weights and heights found that obesity prevalence for children aged 2–3 years was overestimated by a factor of 5–10 (7, 8) and that this bias diminished rapidly with increasing age, reversing to underestimating obesity prevalence after ages 12–13 years (7). Our findings provide new empirical evidence supporting both of these findings. On the basis of larger observed differences in mean height than in mean weight between the parent-reported versus the measured samples, both of these earlier studies speculated that height underreporting rather than weight overreporting accounted for the overestimation of obesity at young ages (7, 8). Our study provides strong evidence supporting this speculation. We found that implausibly large proportions of the parents of young children reported extremely low heights but not extremely high weights. Not only is recall error regarding height compounded by its being squared in the calculation of BMI, but our study and others (7, 8, 13, 14) found that parents are more likely to track children's weight than height accurately at these ages. In addition, our findings indicated that underestimation of obesity prevalence from parental reporting on older children arose from their underreporting very high weights. As in several of the preceding studies (7, 8, 13, 17, 18), in our study we observed that the underreporting of height decreases with age, whereas the underreporting of weight increases with age. The greater underreporting of weight that we observed among parents of the heaviest older children has previously been attributed both to social desirability bias and to actual misperceptions (23, 27–29).

As in the only previous nationally representative US study considering parental reporting bias and child gender (7), in

Table 6. Prevalence of Height Below the Fifth Percentile Among Children Aged 2–8 Years by Sociodemographic Characteristics Using the Mother-Reported and Measured Heights in the 2006 and 2008 Subsample of the Children of the National Longitudinal Survey of Youth 1979 Cohort, United States[a]

Characteristic	Mother-Reported Height				Measured Height			
	Person-Years	%	95% CI	χ^2 *P* Value	Person-Years	%	95% CI	χ^2 *P* Value
Total	337	28.1	22.5, 34.5		337	5.4	3.2, 9.1	
Gender				0.627				0.851
Male	166	26.8	19.2, 36.0		166	5.7	2.9, 11.0	
Female	171	29.6	22.1, 38.3		171	5.1	2.2, 11.6	
Race/ethnicity[b]				0.251				0.403
Non-Hispanic white	189	27.2	20.7, 34.9		189	4.9	2.5, 9.3	
Hispanic	66	41.4	27.4, 57.0		66	10.4	3.5, 27.1	
Non-Hispanic black	78	27.8	17.7, 40.9		78	4.2	1.3, 12.6	
Family income[c]				0.002				0.742
<$25,000	62	57.1	38.4, 74.0		62	9.4	2.9, 26.3	
$25,000–$49,999	62	20.6	10.8, 35.5		62	5.3	1.5, 17.1	
$50,000–$74,999	66	32.3	21.3, 45.7		66	6.5	2.1, 18.5	
≥$75,000	117	22.7	14.8, 33.1		117	4.3	1.5, 11.4	

Abbreviation: CI, confidence interval.

[a] Mother-reported height below the fifth percentile and measured height below the fifth percentile were calculated for each survey wave during which the child was assessed with both mother-reported and measured weights and heights. Data were weighted by using survey sample weights, and confidence interval estimates and χ^2 statistics were adjusted for clustering of children in families.

[b] Analyses excluded children with non-Hispanic “other” race/ethnicity because of insufficient sample sizes.

[c] Family income was adjusted to year-2000 US dollars, and analyses excluded observations with item nonresponse on income.

our study we observed no gender differences in height or weight misreporting for young children. Our null findings neither refuted nor supported previous findings that parents were more likely to underreport girls’ weights at older ages (7, 17, 18). We observed null and mixed findings on race/ethnicity, as have other authors (7, 18). However, ours is the first study to provide evidence on parental reporting bias by family income for the full US child population from a nationally representative sample. We found that the lowest-income parents of young children were consistently the most likely to report extremely low child heights, whereas no consistent pattern by income emerged across our 2 surveys when children’s heights were measured by survey staff. Our findings on income extend those for Mexican-American children in the Hispanic Health and Nutrition Examination Survey, in which underreporting of height was greater among economically disadvantaged mothers than among advantaged mothers of young children (13). We speculate that for low-income parents, reduced access to and utilization of health care (44–46), including child well-visits, in which height and weight are routinely assessed (46), may exacerbate parents’ difficulties keeping up with children’s height gains.

We are less confident of the generalizability of our findings beyond the United States. Most previous studies on parental reporting of child height and weight were conducted in Canada or Western Europe (14–17, 19). A number of these studies found greater misreporting of weight than height (15, 16). Moreover, error in reporting of height was nearly evenly balanced among accurate reporting (15, 16), overreporting (14), and underreporting (17, 19). We speculate that the use of the metric system in those countries may lead to different types of recall error.

Several limitations of our study warrant discussion. Our data come from child supplements of 2 nationally representative surveys of adults. However, only the PSID-CDS conducted supplementary sampling of more recently arrived immigrant families. This, and the overall older age of mothers in the NLSY79-Child, may explain why we saw racial/ethnic differences in the underreporting of young children’s heights in the PSID-CDS but not in the NLSY79-Child. On the other hand, in the PSID-CDS and in the majority of the NLSY79-Child sample, children were not randomly selected by having parent-reported data or measured data. The consistency of our key findings when using the PSID-CDS, the NLSY79-Child, and the subsample of the 2006 and 2008 waves of the NLSY79-Child (with both parent-reported and measured data in the same wave) strengthens our confidence about the conclusions of this study.

Our results lead us to caution researchers especially against using parent-reported data on height for very young children and to note that by approximately ages 9–11 years, parent-reported data become reasonably accurate. One practical solution for child obesity researchers who have only parent-reported data available on young children is to consider analyzing weight-for-age, which is generally accurately reported. To survey data producers, we suggest that in cases in which child measurement is practically or financially impossible, survey collection efforts should focus on improving the quality of height assessments more than that of weight assessments. For example, 1 recent study (20) reported that the authors were able to substantially improve the accuracy of parent-reported data by simply asking them to measure their children before scheduled telephone interviews.

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