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Accuracy of maternal reports of pre-schoolers' weights and heights as estimates of BMI values

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Background Data is lacking on the reliability of weight and height for young children as reported by parents participating in population-based studies. We analysed the accuracy of parental reports of children's weights and heights as estimates of body mass index, and evaluated the factors associated with the misclassification of overweight and obese children.

Methods Analyses were conducted on a population-based birth cohort of 1549 4-year-old children from the province of Québec (Canada) in 2002. Mothers reported weights and heights for the children as part of the regular annual data collection. Within the following 3 months, children's weights and heights were measured at home as part of a nutrition survey.

Results This study indicates that mothers overestimate their children's weight more than their height, resulting in an overestimation of overweight children of more than 3% in the studied population. Only 58% of the children were reported as overweight/obese with reported values. Maternal misreporting is more important for boys than girls, and for low socioeconomic status children compared with high socioeconomic status children.

Conclusions Research on the prevalence of overweight and obesity has often used self-reported measures of height and weight to estimate BMI. However, the results emphasize the importance of collecting measured data in childhood studies of overweight and obesity at the population level.

Keywords Body mass index, body weight, child, pre-school, socioeconomic factors, weights and measures

Introduction

Obesity is increasing in adults, adolescents, and children in both developed and developing countries.[1–4] Consequently, it is important to ensure that information pertaining to the prevalence of overweight and obesity in populations is accurate in order to effectively assess and prevent the continuation of this trend. A number of studies use reported weight and height to derive body mass index (BMI) values and estimate the prevalence of overweight and obesity at the population level.[5–12] There is an extensive literature comparing the accuracy of self reported weight and height to measured values in adults and adolescence, which demonstrates systematic inaccuracies in self-report.[13–23] Those who are overweight tend to under-report their weight to a greater extent than those who are normal weight, and those who are short tend to over-report their height to a greater extent than taller individuals. This systematic bias has been reported in males, females, older and younger adults, though there is some evidence that in adolescents the extent of misreporting varies by gender, ethnicity and pubertal stage.[15,17,18,20,23–26]

Validation studies of self-reported heights, weights and resultant BMI values have been conducted on self-reports of adults' or adolescents' own weights and heights. Research is lacking on the reliability of parent-reported estimates of children's weights and heights at the population level.

Reported data on weight and height are easier to collect than measured data in large population-based studies. But children's weight and height are less stable than adults' weights and heights, especially during periods of growth such as in pre-school years. In adolescents, the accuracy of reported data varies before and after puberty, which may reflect the complexity of estimating weight and height in periods of body size transformation.[29] It is also important to assess if reported weight and height

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are suitable for the analysis of parental and social factors associated with childhood overweight, as this analysis is at the basis of the identification of at-risk groups and the development of public health programmes at the population level.

This study aims to analyse the accuracy of reported weight and height data used as estimates BMI, as well as factors related to the misclassification of overweight and obese children, in a population-based cohort of 4-year-old children. Maternal reports of children's weights and heights are compared with measured data collected subsequently, to assess the reliability of reported data, and related factors, in studies of overweight in pre-school children.

Methods

Data was collected in 2002 for 1549 of 1550 selected (99.9%) 4-year-old children (51% boys and 49% girls) as part of a population-based birth cohort in the province of Québec (Canada). The cohort, a regional stratified sample of the children born in Québec in 1998 (population 7 million, 70 000 births a year), is representative of the same-aged children living in all sub-areas of the province of Québec in 2002.[28] Reported data was collected through face-to-face interviews at home. One parent or caregiver, generally the mother, reported weight and height for children of the cohort as part of the regular annual data collection. Reported values were collected without mothers knowing that measured data would be collected in subsequent weeks. Mothers were asked to report weights and heights of their children without measuring or weighing them. The interviewers confirmed that mothers did not use scales or rulers during the interview. Within the 3 following months (75% were seen within 1 month and 98% within 2 months), children's weights and heights were measured at home as part of a nutrition survey.

Weights and heights were measured following a standardized protocol by trained nutritionists. Calibrated scales were brought to children's homes to measure their weights, and heights were measured using a measuring tape. For each measurement, two values were taken, and in cases where there was more than a 5% discrepancy between values, a third value was taken to obtain a mean value [$<5\%$ ($n=65$) of the children for weight and 0% for height].

For the reported data, when mothers answered in pounds and inches, weights and heights were converted to metric units and were rounded to the nearest half-kilogram (0.5 kg) and nearest centimetre, respectively. Measured weights and heights, already in metric units, were rounded in the same fashion as were reported values.

To study the accuracy of reported data, we developed two types of variables based on the differences between the measurements: the difference between the measured and the reported values, or the absolute difference, and the relative absolute difference between measured and reported values divided by measured values. These variables were calculated for both weight and height and analysed as a continuous variable. They were also grouped into categories by kilograms and metres.

The impact of misreporting weight and height on overweight and obesity was analysed using BMI classifications from Centre for Disease Control (CDC) growth curves. BMI [weight(kg)/height (cm^2)] values, derived from reported and from measured weight and height values, were grouped into 4 categories ($<$10th percentile, 10th−84.9th percentiles, 85th−94.9th percentiles, $\geqslant$95th percentile for sex- and age-specific CDC growth curves).[29] Children 'at risk for overweight' were classified in the 85th−94.9th percentiles, and 'overweight' children were classified at or above the 95th percentile.

According to our literature review, different factors may influence the accuracy of reported weights and heights. From the ones available in the survey, child sex, maternal education, geographical living area, maternal immigrant status, socio-economic-status (in quintiles), maternal BMI and number of overweight/obese parents were included in the analysis.

Before the analysis, data were weighted by a factor based on the inverse of the selection probability, the probability of non-response, and the post-stratification rate, to ensure that data were longitudinally representative of same-aged children in the population.[30] Statistical analyses were based on data for individuals with no missing values for any of the variables studied. Of the 1549 children available, 1464 (95% of the sample) had both reported and measured weight and height values. The impact of missing data was evaluated by conducting with-and-without analyses. Results of analysis including missing values were compared with the ones excluding missing values. Missing data were excluded from the analysis as they had no impact on the results. Analysis was also performed to evaluate the effect of timing of data collection for reported values and measured values. The number of days between the two data collection was added to the analysis. The analysis revealed no time effect and this factor was removed from final analysis.

Statistical analyses were performed with SAS (8.2). Weighted data were used in the analysis, and the significance level was set at 5%. Following descriptive analysis, the Bland–Altman method for assessing agreement between measurements was used to evaluate graphically the magnitude of the differences.[31] The correspondence of BMI in categories derived from reported and from measured values using the CDC growth curves was evaluated by a Kappa agreement factor. Logistic regression analysis was used to estimate odds ratios (OR) and their confidence intervals (CI) for different factors related to reported values and measured values. Analyses were conducted for boys and girls separately, and all together.

Results

Distributions of reported and measured weights differed significantly for boys (*P*-value from Kolmogorov–Smirnov test: $\leqslant$0.0001), but not for girls. A greater proportion of mothers overestimated boys' weights. Table 1 presents differences between reported and measured weights, heights and BMIs by sex, and for all children. Mean reported weight was higher than measured weight for boys and girls. A higher proportion of mothers overestimated weights by 2 kg or more for boys (14.6%) than for girls (9.5%) and a higher proportion misreported weights by 10% or more for boys (25.4%) than for girls (20.7%). We observed no difference between means for reported and measured heights. For BMI values, the greater the difference between measured and reported weights, the greater the difference in BMI.

Table 1 Comparison of mean values of measured and reported weights, heights and BMIs, and proportion of misclassification, for girls, boys and all children

		Categories	Girls	Boys	All children
Weight (kg)	Measured weight (kg)	Mean (Standard error)	16.7 (0.09)[a]	17.2 (0.10)[a]	16.9 (0.07)
	Reported weight (kg)	Mean (Standard error)	16.8 (0.09)[a]	17.5 (0.10)[a]	17.2 (0.07)
	Difference between measured and reported weight [measured weight – reported weight (kg)]	Mean (Standard error) (kg)	−0.1 (0.05)	−0.2 (0.05)	−0.2 (0.04)
	Overestimation: reported weight is higher than measured weight	% of mothers who overestimated by ⩾2 kg	9.5[a]	14.6[a]	12.1
		% of mothers who overestimated by <2 kg	39.2	35.4	37.2
	Underestimation: reported weight is lower than measured weight	% of mothers with no difference or <0.1 kg	16.8	15.4	16.1
		% of mothers who underestimated by <2 kg	25.9	25.7	25.8
		% of mothers who underestimated by ⩾2 kg	8.6	8.8	8.7
Height (m)					
	Measured height (cm)	Mean (Standard error)	103 (0.2)	104 (0.2)	103 (0.1)
	Reported height (cm)	Mean (Standard error)	103 (0.2)	104 (0.2)	104 (0.1)
	Difference between measured and reported height [measured height – reported height (cm)]	Mean (Standard error) (cm)	−0.3 (0.11)	−0.3 (0.11)	−0.3 (0.07)
	Overestimation: reported height is higher than measured height	% of mothers who overestimated by ⩾3 cm	12.3	13.4	12.8
		% of mothers who overestimated by <3 cm	28.6	30.6	29.7
	Underestimation: reported height is lower than measured height	% of mothers with no difference	26.8[a]	20.9[a]	23.8
		% of mothers who underestimated by <3 cm	25.6	25.7	25.6
		% of mothers who underestimated by ⩾3 cm	6.7	9.5	8.1
BMI					
	Measured BMI	Mean (Standard error)	15.7 (0.1)	16.0 (0.1)	15.7
	Reported BMI	Mean (Standard error)	15.8 (0.1)	15.8 (01)	15.9
	Difference between measured and reported BMI (measured BMI – reported BMI)	Mean (Standard error)	−0.0 (0.1)	−0.1 (0.1)	−0.1 (0.1)
	Overestimation: reported BMI is higher than measured height	% of mothers who overestimated by ⩾2 std[b]	1.9	5.1	3.6
		% of mothers who overestimated by <2 std	11.6	15.5	12.1
	Underestimation: reported BMI is lower than measured height	% of mothers with no difference (mean and 1std)	71.8	68.8	70.3
		% of mothers who underestimated by <2 std	10.9	10.0	10.5
		% of mothers who underestimated by ⩾2 std	3.6	3.6	3.6

[a]Significant difference between boys and girls ($P \leqslant 0.05$).

[b]the cut-off are based on standard deviation (std) from the mean: 1 standard deviation is 1.5 and 2 std is 3.0.

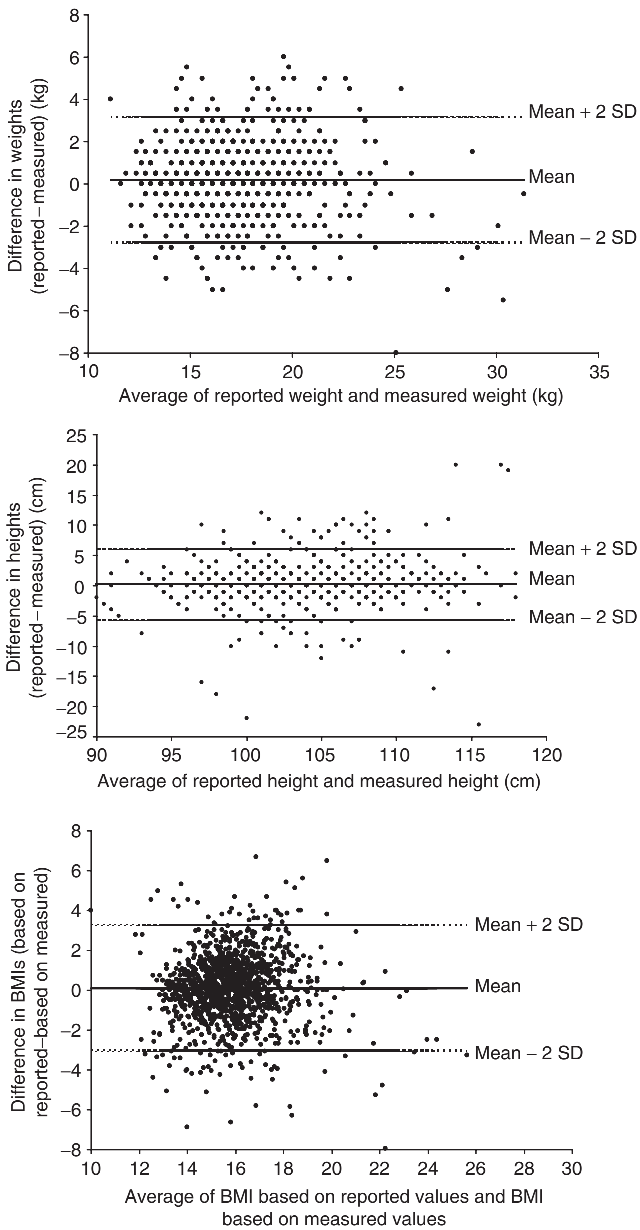

Figure 1 Difference between reported and measured values for weight, height and BMI

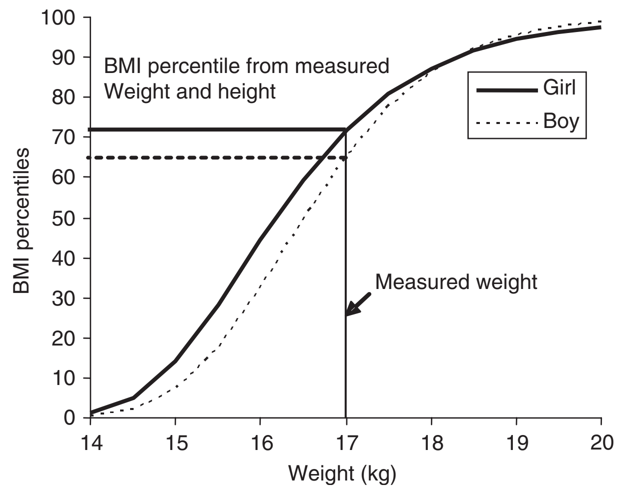

Figure 2 Example of the impact of inaccurate reporting of weight on BMI percentiles from CDC Growth Curves. [a]This figure shows the impact of inaccurately reporting weight on the BMI percentile values from CDC growth curves. In this figure, the measured weight is 17 kg for a 51-month-old child who is 1.03 m tall. The resulting BMI ranks this child at the 71st percentile if the child is a girl and at the 65th percentile if the child is a boy. As an example, if the mother inaccurately reports the weight as being 15 kg (2 kg less than the actual value), the child would be classified as being below the 15th percentile. If she over-reports by 2 kg or more than the actual value (19 kg) the child would be classified as overweight (at or above the 95th percentile).

Figure 1 shows the mean with 2SD space for the difference between reported and measured values by the average of the values, for weight, height and BMI. Since the data follows an approximately normal distribution, 94% of the data should be comprised between the mean ± 2SD. More than 5% lies outside the specified range (7% of data are outside the range for weight, height and BMI), indicating a poor agreement between measured and reported data.

To study the relationship of the difference between reported and measured values on BMI, BMI percentiles were used to assess overweight in children. Figure 2 shows the impact of inaccurately reporting weight values on BMI percentiles. To illustrate an example, measured weight for a 51-month-old child 1.03 m tall was 17 kg. The resulting BMI ranked this child at the 71st percentile for girls and at the 65th percentile for boys, which falls within the normal BMI range. If the mother inaccurately under-reported the weight by 2 kg (i.e. reported the weight as 15 kg), the child would be classified below the 15th percentile. If the mother inaccurately over-reported her child's weight by 1 kg, the child would be classified as 'at risk for overweight' (85.0 − 94.9th percentile), and if she over-reported it by 2 kg more, the child would be considered as being 'overweight' (⩾95th percentile); a difference as small as 0.5 kg can affect the BMI category. Reporting only height inaccurately has less impact on the estimation of overweight than if weight and height are both reported inaccurately. Thus, overestimating weights is conducive to having more children reported as overweight, based on BMI percentiles, while underestimating weights diminishes the observed proportion of overweight children.

Globally, 12% of the children were classified as being overweight based on the reported data, whereas only 9% were considered overweight using measured data, an overestimation of 3% at the population level (Table 2). For boys, overestimation reached 5%, whereas for girls, values were similar. Only 58% of the children who would be classified as being overweight or obese (at or over 95th percentile) using measured data were identified as such when using reported data. A greater proportion of boys (64%) than girls (49%) were correctly classified as overweight or obese. These proportions were shown to have a fair to moderate agreement between reported values and measured values for girls ($\kappa = 0.337$) and for boys ($\kappa = 0.408$).

Population health analysis estimates the relationship between different individual and social factors and overweight, in order

Table 2 Comparison of estimated BMI values from mother-reported vs actual measured values of children's weights and heights[a]

		Girls-BMI percentiles from CDC growth curves– κ = 0.337 (95% CI: 0.266–0.407)			
		Measured			
		<10th (11.5%)	10–84th (67.5%)	85–94th (13.4%)	⩾95th (7.6%)
Reported	<10th (14.3%)	37.8	14.0	3.8	0.0
	10–84.9th (62.4%)	58.6	68.7	54.5	26.8
	85–94.9th (14.8%)	2.6	12.7	30.7	24.1
	⩾95th (8.5%)	1.0	4.6	11.0	49.1
	Total	100%	100%	100%	100%
		Boys-BMI percentiles from CDC growth curves–κ = 0.408 (95% CI: 0.342–0.474)			
		Measured			
		<10th (16.5%)	10–84th (62.5%)	85–94th (10.1%)	⩾95th (10.9%)
Reported	<10th (15.4%)	43.2	11.5	8.0	2.5
	10–84.9th (58.1%)	49.4	69.4	39.4	23.7
	85–94.9th (10.9%)	4.5	10.1	27.3	10.2
	⩾95th (15.6%)	3.0	9.0	25.3	63.6
	Total	100%	100%	100%	100%
		All children-BMI percentiles from CDC Growth curves–κ = 0.378 (95% CI: 0.329–0.425)			
		Measured			
		<10th (14.1%)	10–84th (64.9%)	85–94th (11.7%)	⩾95th (9.3%)
Reported	<10th (14.8%)	41.0	12.7	5.6	1.5
	10–84.9th (60.2%)	53.0	69.0	47.9	24.9
	85–94.9th (12.8%)	3.7	11.4	29.2	15.8
	⩾95th (12.1%)	2.2	6.8	17.3	57.8
	Total	100%	100%	100%	100%

[a]Using the U.S. CDC growth curves percentiles.

to determine interventions for at-risk groups in the population. Factors relating to estimates of BMI for measured values and for reported values differed, indicating that misreporting generates bias in different population sub-groups (Table 3). For boys, parental BMI was related to reported values but not to measured ones. Differences were more apparent for OR at the 95th percentile. With measured values for boys, there were differences related to immigrant status that did not appear for reported values. For girls, maternal education was related to reported values, but not to measured values. Conversely, no association with parental BMI was observed with reported values, but an association was observed with measured values. Even when associations were seen for BMI both from measured and reported values, the magnitude of the OR was not necessarily the same. For example, for boys, the number of overweight/obese parents increased the odds of being overweight at 4 years by 70% using reported values, and by almost 5 times using measured values.

Discussion

This article analysed the accuracy of reported weight and height and related BMI to assess the prevalence of overweight preschool children in populations. In studies of adults, weights are generally underestimated and heights overestimated, resulting in an underestimation of BMI values in the population.[13–17] In our study, weight was overestimated and height was reported more accurately. Children's reported data are less reliable than reported data for older age groups; this results in a 3% overestimation of the proportion of overweight children in the population, and 5% overestimation specifically for boys. Only 58% of overweight/obese children were classified as such with reported values. These figures are higher than reports from adolescent studies where proportions of misclassified overweight or obese adolescents ranged from 8% to 34%.[18,19,21] These findings are important for comparisons between countries and to monitoring the trends of overweight in young children at the population level. Reported data should not be mixed to measured data for in- and between-population comparison, or to monitor the situation over time.

One interesting result of this study is that maternal misreporting vary for boys and girls. In older-age-group studies, misreporting has been related to sex and overweight or obesity. Larson reported that misreporting weight was related to social desirability for young non-obese women.[32] Moreover, in adolescents and adults, a higher BMI related to misreporting in the lower values.[13,23,25] In our analysis, we observed sex differences where mothers overestimated values more for boys than for girls. It could be that mothers of young children are also affected by social desirability. However, we found no relationship between misreporting of weight and maternal body

Table 3 Factors related to unadjusted OR (95% CI) for BMI ⩾ 95th percentile for reported and measured values on U.S. CDC Growth curves, for girls, boys and all children

		Unadjusted OR of BMI ⩾ 95th percentile					
		Girls		Boys		All children	
	Category	Reported	Measured	Reported	Measured	Reported	Measured
Maternal education	At least a secondary diploma*	1	1	1	1	1	1
	No secondary diploma	1.9 (1.0–3.7)[a]	1.4 (0.7–2.9)	1.1 (0.6–1.9)	1.3 (0.7–2.5)	1.3 (0.9–2.1)	1.3 (0.8–2.2)
Geographical living area	Urban	1.5 (0.8–2.7)	1.4 (0.8–2.7)	1.3 (0.8–2.0)	1.2 (0.7–1.9)	1.3 (0.9–1.9)	1.3 (0.8–1.9)
	Rural*	1	1	1	1	1	1
Immigrant status	No*	1	1	1	1	1	1
	Yes	0.3 (0.1–1.2)	0.9 (0.4–2.3)	1.4 (0.8–2.4)	2.3 (1.3–4.1)[g]	1.0 (0.6–1.7)	1.7 (1.1–2.8)[r]
Socioeconomic status (in quintiles)	Q4 and Q5 (highest)*	1	1	1	1	1	1
	Q3	1.2 (0.5–2.7)	1.6 (0.7–3.4)	1.8 (1.0–3.2)[c]	1.7 (0.9–3.2)	1.7 (1.0–2.6)[m]	1.7 (1.0–2.7)[s]
	Q1 and Q2 (lowest)	1.8 (1.0–3.2)	1.4 (0.7–2.6)	2.2 (1.3–3.6)[d]	1.9 (1.0–3.2)[h]	2.0 (1.4–2.9)[n]	1.6 (1.0–2.5)[t]
Maternal BMI	<18	NC	0.3 (0.03–2.4)	1.2 (0.6–2.8)	1.1 (0.4–3.2)	0.8 (0.4–1.7)	0.7 (0.3–1.9)
	18–24*	1	1	1	1	1	1
	25–29	1.3 (0.7–2.4)	1.0 (0.5–2.1)	1.2 (0.7–2.2)	2.8 (1.6–5.1)[i]	1.2 (0.8–1.9)	1.8 (1.1–2.8)[u]
	⩾30	1.1 (0.4–2.8)	1.7 (0.7–4.2)	3.4 (2.0–5.9)[e]	4.8 (2.6–8.9)[j]	2.5 (1.6–4.0)[o]	3.3 (2.0–5.4)[v]
Number of parents overweight/obese	0 parent*	1	1	1	1	1	1
	1 parent	1.4 (0.8–2.7)	1.5 (0.7–2.9)	1.6 (1.0–2.6)[f]	2.0 (1.1–3.8)[k]	1.5 (1.0–2.2)[p]	1.8 (1.1–2.8)[w]
	2 parents	2.1 (0.9–4.5)	2.3 (1.0–5.1)[b]	1.7 (0.9–3.1)	4.8 (2.5–9.6)[l]	1.8 (1.1–2.9)[q]	3.5 (2.1–5.9)[x]

*Reference category.

P-values (from logistic regression): [a]$P=0.0266$; [b]$P=0.0455$; [c]$P=0.0464$; [d]$P=0.0066$; [e]$P<0.0001$; [f]$P=0.0347$; [g]$P=0.0142$; [h]$P=0.0475$; [i]$P=0.0488$; [j]$P=0.0004$; [k]$P=0.0434$; [l]$P<0.0001$; [m]$P=0.0445$; [n]$P=0.0027$; [o]$P<0.0001$; [p]$P=0.0479$; [q]$P=0.0402$; [r]$P=0.0184$; [s]$P=0.0353$; [t]$P=0.0224$; [u]$P=0.0466$; [v]$P=0.0001$; [w]$P=0.0434$; [x]$P=0.0010$.

weight, indicating that mothers may not use the same bias for their children as they use for themselves. Also, in adolescents, females are more likely than males to underestimate their weight.[27] In our study, misreporting varied by children's sex but rather, weight values for both boys and girls were overestimated while height was reported more accurately. It seems that parents have a different evaluation process when it comes to their children.

Socioeconomic status also influences misreporting. This element is important as children of low socioeconomic status are more likely to be overweight, and their mothers are more likely to misreport it. The analysis of factors associated with misclassification indicates that a greater proportion of mothers of low socioeconomic-status misreport their children's weight, with greater disparities among socioeconomic-status categories seen for boys. This result is contrary to what has been observed in adults.[13] A study of children and adolescents (9–21 years) also found that weight underestimation was higher among girls aged 16–21 years from high-socioeconomic-status families and with more educated mothers.[22] Mothers tended not to reproduce the same bias in reporting their own weights and heights as they did for the weights and heights of their children. Also, contrary to Bostrom and Diderichsen[17] findings in an adult population, socioeconomic differences (as measured by maternal education and socioeconomic-status) among overweight children were overestimated using reported values when compared with measured values. This socioeconomic-status bias is important to take into consideration in population studies because the prevalence of overweight is higher in lower-socioeconomic-status families, as is over-reporting. Thus, reported values create distortions and affect the mean values for the population under study.

A study of adults indicated that the pattern of adults misreporting weights of other adults was not similar to the pattern observed for self-reports of weights, indicating that motivated distortions are more likely to be at cause than perceptual biases.[33] Given that maternal misreporting of children's weights does not follow the same pattern as personal misreporting, it would be interesting to perform qualitative studies to gain a better understanding of the social representations behind these differences, particularly in terms of the image parents have of weights for boys and girls. It would also be interesting to evaluate whether this misevaluation interferes with children's diets and with the development of good eating habits. Additionally, it could be important to follow these representations over time to understand at what age over-reported values become under-reported values. These results suggest a distinct need for developing a conversion factor, as suggested by Giacchi *et al.*,[21] using data from different countries. The results of this research reinforce the collection of measured data in childhood studies designed to explore the roots of the obesity epidemic and related social inequalities at the population level.

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