

# Influence of Body Composition on the Accuracy of Reported Energy Intake in Children

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## Abstract

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**Objective:** Mis-reporting dietary intake is a substantial barrier to understanding the role of dietary behavior in disease. Work with adults indicates that heavier individuals under-report dietary intake and that under-reporting may be macronutrient-specific. Whether weight status and macronutrient intake influence the accuracy of dietary reports among children, however, is less clear. This research evaluated children's dietary reporting accuracy as a function of their relative weight, body composition, and macronutrient intake.

**Research Methods and Procedures:** Participants included 146 4- to 11-year-old children. Reported energy intake was determined by interviewing children in the presence of parents, using three multiple pass, 24-hour recalls. Children were classified as having had an under-reported, accurately reported, or over-reported dietary intake relative to total energy expenditure, as measured by doubly labeled water. Reporting accuracy was examined as a function of children's body weight, body composition (using dual energy x-ray absorptiometry), and macronutrient intake.

**Results:** Average reported intake was, on average, 14% greater than children's estimated expenditure ( $p < 0.01$ ). Reporting accuracy varied as a function of children's relative weight and body composition; under-reporting tended to occur among heavier children, having the highest body fat content ( $p < 0.0001$ ) and relative weight ( $p < 0.0001$ ).

**Discussion:** These findings suggest that weight status influences the accuracy of dietary reports made by children and their parents. More research is needed to address possible psychological and social factors that introduce bias in reporting children's dietary data.

**Key words:** reporting accuracy, under-reporting, over-reporting, dietary intake assessment

## Introduction

Accurately assessing the dietary intake of young children is a fundamental challenge in understanding the role of nutrition in development and disease prevention (1). Estimation of total energy expenditure (TEE) using doubly labeled water provides a noninvasive and accurate criterion to which children's reported dietary intake can be compared (2–4). This approach is based on the assumption that dietary intake equals energy expenditure under conditions of energy balance (5).

Among adults, energy intake tends to be under-reported by individuals who are obese, dieting, less-educated, from lower socioeconomic status classes, female, or are currently smoking (6–15). Under-reporting may not be limited to dietary energy, but may include selective reporting of macronutrient intake as well (6,12,16,17). To date, such characteristics associated with reporting bias in adolescent and younger children's reports of dietary intake are not as well characterized.

Livingstone et al. (18) noted that heavier adolescent girls tended to under-report energy intake, using 7-day weighed food dietary records. These findings were consistent with work by Bandini et al. (19) with adolescent males and females, showing that reporting accuracy in 2 weeks of food records was ~20% lower among obese adolescents than among non-obese adolescents. The relationship between reporting accuracy and weight status in younger children, however, is not as clear.

A recent study by Champagne et al. (20) revealed that obese, 10-year-old children were more likely to under-report intake than their normal weight counterparts, using 2-week food records to measure energy intake and doubly labeled water to estimate energy expenditure. Similarly,

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Maffeis et al. (21), using diet histories and dietary records, noted that obese children under-report energy intake. Two studies, however, did not observe a relationship between children's weight status and under-reporting. Bandini et al. (22) found that under-reporting among 109 preadolescent girls increased with age and total daily energy expenditure, but was not predicted by family income, ethnicity, parental obesity, and children's body fat. Similarly, Johnson et al. (23) recently noted that reporting accuracy among 4- to 5-year-old children using multiple pass, 24-hour recalls (conducted with the parent in conjunction with the child) was not associated with child age, parent adiposity, or child adiposity.

This research was conducted to evaluate dietary reporting accuracy in young children of mixed ethnicity by comparing their reported dietary intakes (obtained in the presence of their parents), measured using multiple-pass, 24-hour recalls, to estimates of TEE, measured using doubly labeled water. The primary objective was to determine whether reporting accuracy varied as a function of body weight, body fatness, macronutrient intake, and demographic characteristics. This study operationalized reporting accuracy as a categorical variable where reported dietary intake was classified as either underestimating, accurately estimating, or overestimating true intake.

## Research Methods and Procedures

### Subjects

Participants were 99 European American, and 50 African American children (76 males, 73 females), with a mean age of  $7.7 \pm 1.7$  years (range = 4.4 to 11.5 years). Children representing a wide range of body size (body mass index [BMI] range = 11.8 to 39.2) were recruited from sites in Burlington, VT ( $N = 60$ ; all European American) and Birmingham, AL ( $N = 89$ ; 39 European American, 50 African American). No differences between locations were observed in terms of child gender, age, and relative weight. Ethnicity was determined by self-report and defined by both sets of grandparents being of the same ethnic group. All children were defined as Tanner stage I, based on breast stage and pubic hair development in girls and genitalia development in boys, as assessed by a physical examination by a pediatrician in Alabama and a nurse practitioner in Vermont. Subjects were recruited by newspaper advertisements, distribution of fliers, and word of mouth, and there were no major inclusion/exclusion criteria other than the absence of major illness since birth. These data were collected between 1995 and 1998 and are reported on in several other studies (24–27). This sample was selected based on having data on TEE, dietary energy intake, and body composition measured by dual energy X-ray absorptiometry (DXA). The studies were approved by the Institutional Review Boards of the University of Vermont and The

University of Alabama at Birmingham. 146 cases were retained for data analysis, with three cases dropped as outliers ( $>4$  SD) on dietary, expenditure, or relative weight measurements.

### Measurement of TEE

TEE was measured over 14 days under free-living conditions with the doubly labeled water technique, using a protocol with a theoretical error of less than 5%, as previously described (24). Samples were analyzed in triplicate for  $H_2^{18}O$  and  $^2H_2O$  by isotope ratio mass spectrometry at the University of Alabama at Birmingham as previously described (26). When all samples for deuterium and oxygen-18 were reanalyzed in seven subjects, values of TEE were in close agreement (coefficient of variation = 4.3%), as previously described (26).  $CO_2$  production rates were determined with a fixed dilution space ratio of 1.0427 using Equation R2 of Speakman et al. (28), and energy expenditure was calculated using Equation 12 of de Weir (29), assuming a mean value for the dietary food quotient obtained by 24-hour recall. The mean food quotient was 0.90 in European American children and 0.87 in African American children.

### Measurement of Dietary Intake

Energy intake was measured with repeated 24-hour recalls using the "multiple-pass" interview approach, which we have previously cross-validated for group accuracy in a smaller sample of children ( $N = 24$ ) relative to TEE via doubly labeled water (23). Interviews were conducted with the child in the presence of the parent, in nearly every case the mother, to improve the completeness of the recall (30). The interviews were directed primarily at the child, with the adult present to provide qualifying or supplemental information. Parents of younger children tended to be more involved in the interview than those parents of older children. Two or three recalls were obtained during the 14-day doubly labeled water study period. All dietary recalls were conducted and coded by cross-trained dietitians. The 24-hour recalls were analyzed with the Food Intake Analysis System (FIAS, version 2.1; Human Nutrition Center, University of Texas Health Science Center). Data from the two to three recalls were averaged to obtain mean daily intake of energy and macronutrients. The intraclass correlation coefficient for 3 days of 24-hour recalls on 233 age-appropriate cases from our laboratory was 0.22.

### Measurement of Body Weight and Composition

Height without shoes was measured, using a stadiometer, and weight in light clothing was measured on an electronic scale, using the procedures of Lohman et al. (31). Weight values were converted to weight-for-age percentile z-scores with the Epi Nut module of Epi Info (Version 6). Body mass index ( $kg/m^2$ ) was determined by dividing weight (kg) by

height (m) squared. Body composition was measured by DXA, using a Lunar DPX-L densitometer that we have previously validated in the pediatric body weight range (32). Subjects were scanned in light clothing while lying flat on their backs with arms by the side. DXA scans were performed and analyzed with pediatric software (version 1.5e) as previously described (32,33). The DPX-L was calibrated on the day of each test, using the procedures provided by the manufacturer. In the current analysis, DXA measures of fat free mass included soft lean tissue and bone mass.

### Definition of Dietary Reporting Accuracy

Dietary reporting accuracy was defined as children's reported dietary intake in the presence of the parent expressed as a percentage of estimated TEE. Basiotis et al. (34) defined a "precise" estimate of intake as being within 10% of the true intake for a group 95% of the time. This definition of accuracy is consistent with estimates of daily variation in energy intakes among young children. Birch et al. (35) observed that the median coefficient of variation (mean/SD) for a 2- to 5-year-old child's daily intake was 10.9%. Additionally, the energy requirements needed to support growth are probably 25 kcal/day beyond energy balance for children of this age (36). In this sample, this increase translates into an increase of ~ 1% to 2% in average energy intake per day, a value that falls well within the  $\pm 10\%$  error allowed in the accurate reporting group in this study. Therefore, accurate reporters were defined as those children within 10% of perfect reporting, with reporting accuracy scores between 90% and 110% of TEE. Under-reporters were defined as those children with reporting accuracy scores below 90% of TEE and over-reporters with scores above 110% of TEE.

### Statistical Analysis

Descriptive statistics were generated for all variables. A log transformation was used on fat mass variables to better approximate a normal distribution. Children's reported energy intakes were compared with age- and gender-specific recommendations (37). Chi-square was used to evaluate reporting accuracy scores by gender and ethnicity. Analysis of covariance (ANCOVA) was used to evaluate the association between adiposity measures and reporting accuracy with energy intake as a covariate to adjust for possible collinearity between adiposity and energy intake. ANOVA was used to evaluate mean differences across reporting accuracy groups in 1) age and 2) energy and macronutrient intake. Tukey's tests were used to identify post-hoc differences between groups. Statistical significance was set at  $p < 0.05$ .

## Results

Descriptive statistics on energy intake, energy expenditure, adiposity, and dietary reporting accuracy are presented

in Table 1. Reported dietary energy intakes (mean =  $1881 \pm 470$  kcal/d; range = 825 to 3384 kcal/d) were not different from children's age- and gender-determined Recommended Dietary Allowances for energy ( $t = 1.52, p = 0.13$ ) (38). On average, reported energy intake was 175 kcal/d higher than TEE ( $1704 \pm 318$  kcal/d), resulting in mean reported intake that was  $110 \pm 31\%$  of estimated energy expenditure ( $p < 0.01$ ) (Figure 1). The correlation between reported energy intake and TEE indicated weak positive agreement ( $r = 0.27, p < 0.01$ ). Approximately 34% of the sample reported dietary intakes that were within 10% of their estimated TEE (accurate reporters, reporting  $102 \pm 7\%$  of estimated expenditure), 20% reported intakes that were below 90% of TEE (under-reporters, reporting  $75 \pm 12\%$  of estimated expenditure), and 46% reported intakes that were above 110% of their estimated TEE (over-reporters, reporting  $140 \pm 22\%$  of estimated expenditure). No associations between reporting accuracy and age, gender, or ethnicity were observed (Table 2).

As shown in Table 3, under-reporters had higher relative weight and higher adiposity measurements than over-reporters, indicating that under-reporting was more pronounced among heavier children. These results were obtained when controlling for children's level of energy intake. No differences in macronutrient composition (percentage of fat, percentage of carbohydrate, and percentage of protein) of reported dietary intake were found across reporting accuracy groups (Table 4).

## Discussion

The primary goal of this research was to evaluate reporting accuracy in a relatively large sample of children of mixed ethnicity. This study evaluated over-reporting, under-reporting, and accurate reporting of dietary intake, because

**Table 1.** Descriptive statistics for estimated TEE, reported energy intake, and relative weight scores ( $N = 146$ )

	Mean $\pm$ SD	Range
TEE (kcal/d)	$1704 \pm 318^*$	938–2793
Intake (kcal/d)	$1881 \pm 470$	825–3384
% Fat	$32.8 \pm 6.2$	14.8–45.8
% CHO	$54.3 \pm 8.0$	36.4–72.8
% Protein	$14.2 \pm 4.2$	7.6–37.3
Weight-for-age (%) <sup>†</sup>	$72 \pm 28$	1–99

\* TEE was lower than energy intake,  $p < 0.01$ .

<sup>†</sup> National Center for Health Statistics (NCHS) reference data (37);  $N = 145$ .

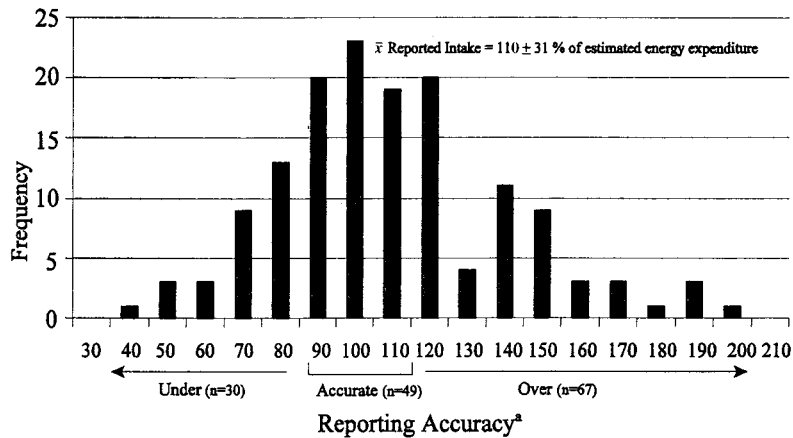


Figure 1. Frequency distribution of reporting accuracy scores into under-reporting, accurate reporting, and over-reporting groups (N = 146).

the ratio of energy intake to expenditure is not unidirectional; reported energy intakes may be much lower or much higher than estimated expenditure. Consistent with previous work in adults (4–7,12–15,39) and children (18–21) there was a trend for under-reporting to occur among the heaviest children. More notable, however, was the fact that over-reporters were lighter and had less body fat than under- and accurate reporters. These results were observed despite our using a relatively conservative estimate of accurate reporting, within 10% of estimated energy expenditure. The association between children’s weight status and reporting accuracy was observed when taking into account colinearity between adiposity and children’s energy intake.

Selective mis-reporting of certain types of foods affects reporting accuracy (40) and may be particularly detrimental to understanding the role of nutrition in health to the extent that such bias affects the macronutrient composition of the reported diet (6,8). Although we did not assess children’s intake of selected foods or food groups, we did not observe any differences in the macronutrient composition of children’s diets among reporting accuracy groups (Table 4). These findings are inconsistent with work in adults that demonstrates that under-reporting can be macronutrient-specific (6,12,16,17). For instance, one study found that adults who under-reported energy intake also report eating less sugar and carbohydrate, particularly from biscuits/pastries/puddings and sugar/confections (6). Although more research is needed to examine whether mis-reporting among children and their parents is food group- or macronutrient-specific, the findings of this research do not provide support for this hypothesis.

Approximately 20% of children in this sample reported dietary intakes that were more than 10% below their estimated energy expenditure. This finding is consistent with the range reported in adult men and women from the third National Health and Nutrition Examination Survey (8) and other reports (7,41). More notable, however, is the result

that ~46% of child- and parent-reported intakes were at least 10% greater than their estimated energy expenditure. Myers et al. (42) reported that approximately half of 40 female college-age students over-reported their dietary energy intake of a meal by greater than 10%, using recalls. However, other studies that assessed dietary over-reporting among adults across longer time frames and in larger samples observed only 6% to 8% over-reporting for dietary energy intake (16,41). Although over-reporting energy intake may not represent a large source of error in adults’ dietary reports, these findings indicate that over-reporting may constitute a major form of children’s and parents’ inaccurate dietary reporting, particularly for those children of normal weight. Given the increasing prevalence of overweight among children, an alternative interpretation of this finding is that “over-reporting” reflected actual child energy

Table 2. Age, gender, and ethnicity among under-reporters, accurate reporters, and over-reporters (N = 146)

	Under (N = 30)	Accurate (N = 49)	Over (N = 67)
Age	7.7 ± 1.3	7.9 ± 1.9	7.5 ± 1.7
Gender*			
Male	13 (18%)	26 (35%)	35 (47%)
Female	17 (24%)	23 (32%)	32 (44%)
Ethnicity†			
European	21 (22%)	31 (32%)	45 (46%)
American			
African American	9 (18%)	18 (37%)	22 (45%)

\* Chi-square = 0.82, df = 2, p = 0.66.

† Chi-square = 0.41, df = 2, p = 0.82.

**Table 3.** Adiposity measures among under-reporters, accurate reporters, and over-reporters ( $N = 146$ )\*

	Mean $\pm$ SD		
	Under ( $N$ )	Accurate ( $N$ )	Over ( $N$ )
Weight-for-age (%)†	79 $\pm$ 28 <sup>a§</sup> (29)	75 $\pm$ 28 <sup>a</sup> (49)	66 $\pm$ 27 <sup>b</sup> (67)
Fat mass (kg)‡	12.8 $\pm$ 8.6 <sup>a</sup> (30)	9.6 $\pm$ 6.9 <sup>a,b</sup> (49)	6.13 $\pm$ 3.8 <sup>b</sup> (67)
% Body fat‡	31.3 $\pm$ 12.4 <sup>a</sup> (30)	27.1 $\pm$ 10.9 <sup>a</sup> (49)	22.0 $\pm$ 7.9 <sup>b</sup> (67)

\* Unadjusted means, controlling for children's level of energy intake.

† NCHS reference data (37).

‡ Measured using DXA.

§ Means with different superscript letters are different from one another,  $p < 0.0001$ .

intakes that were greater than their estimated energy expenditure. Use of doubly labeled water, in conjunction with biomarkers for specific nutrients, might have particular utility in beginning to disentangle the influences of over- and under-eating from what constitutes the boundaries of accurate reporting.

The finding that roughly two of three participants in this sample did not report dietary intakes within 10% of their estimated energy expenditure speaks to the sensitivity of these methods for children of this age. In this study, children's average reported energy intake from 2 to 3 days of dietary recall was significantly higher than their average estimated energy expenditure. Additionally, reported intakes were only modestly related to estimated energy expenditure ( $r = 0.27$ ,  $p < 0.01$ ), indicating relatively poor precision to accurately rank individuals. The extent to which the discrepancy between reported intake and energy expenditure reflects instability in the measurement of children's intake (day-to-day variability), true deviations from

energy balance (under- and over-eating), error specific to the 24-hour recall method, or inaccurate reporting is unclear. These sources of bias, however, likely attenuated the relationship between reported energy intake and expenditure. Johnson et al. (23) reported that 3 days of 24-hour recalls provided valid estimates of group intake; children's average reported intake was not different from their estimated energy expenditure. The underlying cause of the discrepancy between these studies is not clear but may be partially attributable to the larger sample size evaluated in this study as well as to the ethnic differences between the two samples.

In conclusion, this research provides evidence that misreporting children's dietary energy intake is linked to weight status among both European American and African American children. These findings imply that children's ability to provide accurate reports of their dietary intake may be compromised by the extent to which the child or parent perceives that such information is a reflection of the child's weight. More work is needed to understand factors that might contribute to over-reporting children's dietary intake, such as over-estimating the amount of food consumed, perceived social approval in reporting (43), providing dietary information directly to staff interviewers (44), and perhaps the use of overly large default portion sizes to estimate intake in cases where the amount consumed is unknown. Psychological measures related to weight and eating, such as children's body satisfaction, and weight concerns might shed light on children's susceptibility to report dietary intakes in a socially desirable manner.

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**Table 4.** Reported dietary intake among under-reporters, accurate reporters, and over-reporters ( $N = 146$ )

	Mean $\pm$ SD		
	Under ( $N = 30$ )	Accurate ( $N = 49$ )	Over ( $N = 67$ )
Energy (kcal/day)	1487 $\pm$ 375 <sup>a*</sup>	1798 $\pm$ 331 <sup>b</sup>	2117 $\pm$ 459 <sup>c</sup>
% Fat	32.8 $\pm$ 7.0	33.1 $\pm$ 5.6	32.6 $\pm$ 6.3
% CHO	53.4 $\pm$ 8.3	53.5 $\pm$ 7.5	55.3 $\pm$ 8.3
% Protein	14.9 $\pm$ 5.1	14.5 $\pm$ 4.8	13.6 $\pm$ 3.3

\* Means with different superscript letters are different from one another,  $p < 0.01$ .

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