

Longitudinal changes in the accuracy of reported energy intake in girls 10–15 y of age^{1–3}

Linda G Bandini, Aviva Must, Helene Cyr, Sarah E Anderson, Jennifer L Spadano, and William H Dietz

ABSTRACT

Background: Dietary records are often used to estimate individual energy needs and population energy requirements. However, significant underreporting of total energy intake (EI) has been found when EI is compared with total energy expenditure (EE) measured by doubly labeled water.

Objective: This study aimed to determine whether the accuracy of reported EI decreases from middle childhood to adolescence.

Design: In this longitudinal study of 26 healthy girls, EI and EE were measured at ages 10, 12, and 15 y. Accuracy of reported EI (EI/EE × 100%) was calculated at each age. At study entry, girls had a mean (± SD) body mass index (in kg/m²) of 16.8 ± 1.9 and percentage body fat of 24.0 ± 4.6%. Measurements of EI were a 7-d dietary record and those of EE were by doubly labeled water.

Results: As they got older, girls tended to report EI less accurately: the average accuracy was 88 ± 13% at age 10 y, 77 ± 21% at age 12 y, and 68 ± 17% at age 15 y. The declines in reporting accuracy from age 10 y to age 12 y and from age 10 y to age 15 y were statistically significant ($P = 0.03$ and $P = 0.001$, respectively). Reporting accuracy also declined from age 12 to age 15 y but not significantly. When percentage body fat was added to the model, results were essentially unchanged.

Conclusion: Because of the decline in EI reporting accuracy with age, the use of EI data obtained from dietary records in adolescent girls will result in substantial underestimation of energy needs. *Am J Clin Nutr* 2003;78:480–4.

KEY WORDS Energy intake, energy expenditure, adolescents, doubly labeled water

INTRODUCTION

Measurement of energy intake (EI) in persons and populations is often used to estimate individual energy needs and population energy requirements. Dietary records are generally considered more accurate than dietary recall for determining EI because weighing and measuring food reduces the errors associated with estimating portion size and because the participant records intake immediately after eating, which decreases the number of errors associated with recall. However, studies in which EI determined from dietary records was compared with energy expenditure (EE) measured by doubly labeled water have found significant underreporting in adults (1, 2), children, and adolescents (3, 4).

Many studies have been conducted to identify the factors that influence the accuracy of reported EI. Obese persons appear to underreport more than do nonobese persons (1, 4). Cross-sectional

studies in children and adolescents suggest that underreporting increases with age (3). However, no longitudinal studies have examined the effect of age on reported EI during childhood and adolescence. The aim of this study was to ascertain, by using longitudinal data, whether underreporting increases as girls age and whether mean EI expressed as a percentage of EE [EI/EE (× 100)] is influenced by percentage body fat (%BF) or EE during adolescence.

SUBJECTS AND METHODS

Study participants and design

Between September 1990 and June 1993, we enrolled 196 girls in the Massachusetts Institute of Technology (MIT) Growth and Development Study (5). Premenarcheal girls aged 8–12 y were recruited from the Cambridge and Somerville public schools in Massachusetts, the MIT summer day camp, and the friends and siblings of enrolled subjects. The criteria for enrollment were premenarcheal status and a triceps-skinfold thickness < 85th percentile for age and sex (6).

The girls described in this report were part of a subcohort of girls enrolled in the MIT Growth and Development study who entered the present study during the second or third year of enrollment. Twenty-eight girls who were ≈ 10 y old at baseline and had complete measures of EE at study entry were invited, and they agreed to join a subcohort established to examine longitudinal changes in EE. We obtained measures of body composition, resting metabolic rate, EE, and EI from the girls at ages 10, 12 and

¹ From the General Clinical Research Center, Massachusetts Institute of Technology, Cambridge, MA (LGB, AM, HC, JLS, and WHD); the Department of Health Sciences, Boston University (LGB); the Eunice Kennedy Shriver Center at the University of Massachusetts Medical School, Waltham, MA (LGB); the Department of Family Medicine and Community Health, Tufts University School of Medicine, Boston (AM); the Gerald J and Dorothy R Friedman School of Nutrition Science and Policy, Tufts University, Medford, MA (AM, SEA, and JLS); and the Division of Physical Activity and Nutrition, Centers for Disease Control and Prevention, Atlanta (WHD).

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³ Address reprint requests to LG Bandini, Department of Health Sciences, Boston University, 635 Commonwealth Avenue, Boston, MA 02215. E-mail: lbandini@bu.edu.

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15 y. All participants were healthy, free of disease, and not taking any medications at study entry. The participants self-reported their ethnicity as white, black, Hispanic, Asian, or other. Either a study physician or a female coinvestigator used Tanner's criteria (7) for breast development to determine sexual maturation in the girls before menarche.

Both the Committee on the Use of Humans as Experimental Subjects at MIT and the Human Investigation Review Committee of the New England Medical Center approved the protocol. The girls were compensated monetarily for their participation in the study.

Study protocol

The girls were admitted to the General Clinical Research Center at MIT for an overnight visit. During each girl's initial visit, a physician obtained a medical history and examined the girl to ensure that she was in good health. On the evening of admission, participants consumed no food or beverages after 1800. At 2000, the staff obtained a baseline urine sample and gave each participant 0.25 g H_2^{18}O and 0.1–0.12 g $\text{H}_2^{2}\text{O}/\text{kg}$ estimated total body water (TBW). After administering the isotopes, the study staff collected all urine voided until 0600 the next day to measure the loss of isotope in the urine. Staff collected the second void of the morning at ≈ 0800 to measure ^{18}O and ^2H enrichment above baseline values. This sample was used to determine TBW, and the time at which the sample was taken was the initial time-point of the EE period. When the girls returned to the General Clinical Research Center 2 wk later, the staff collected the second void of the day to end the EE period. On both visits, staff members used a Seca scale that was accurate to 0.1 kg to weigh the girls in a hospital gown after an overnight fast. Height was measured to 0.1 cm with the use of a stadiometer.

Assessment of energy intake

At all 3 time points, a registered dietitian instructed study participants on how to keep a food diary. Food models, measuring cups, and spoons were used to instruct the participants about portion size. The dietitians asked the girls to estimate the size of items that they could not measure. After the training, participants kept a food diary for 7 d during the second week of the EE period. To help maximize compliance, the dietitian telephoned each subject twice during the week of record keeping to review the previous few days of dietary recording. In several instances, the dietitian was able to reach a girl only once. When the participants returned to the research center at the end of the 2-wk EE period, the dietitian reviewed the entire record for each girl. During these telephone calls and interviews, the dietitian obtained information that may not have been recorded by the girls (eg, type of milk or brand names) to obtain a more accurate assessment of intake. In several instances, a girl returned her record without reporting the previous day's intake. When this occurred, the dietitian helped the girl recall the foods eaten the previous day. A food diary was valid if it recorded ≥ 6 d of intake. We used computerized dietary analyses (FOOD PROCESSOR; ESHA Research, Salem, OR)—version 3.06 at age 10 y, version 5.02 at age 12 y, and versions 7.01 and 7.02 at age 15 y—to calculate EI. We used the different versions of FOOD PROCESSOR software to accommodate changes in the food supply over time.

Assessment of body composition and total energy expenditure

Isotopic analyses for assessment of body composition and total EE were conducted at the Jean Mayer US Department of Agriculture

Human Nutrition Research Center at Tufts University, Boston, with the use of a Hydra Gas Isotope Ratio Mass Spectrometer (PDZ Europa LTD, Northwich, United Kingdom). The laboratory modified a technique of Prosser et al (8, 9) to measure isotopic enrichments of deuterium on the Europa instrument. We based the criteria for acceptable values on the SE of replicate measures: 0.35 for oxygen and 1.5 for deuterium.

We used TBW to estimate body composition. Oxygen dilution space was calculated according to the method of Halliday and Miller (10), with the assumptions that the ^{18}O dilution space was 1% higher than TBW, the deuterium dilution space was 3% higher than the ^{18}O dilution space (11), and fat-free mass was 73% water (12).

We used a modification of Lifson's equation (13, 14) to calculate the mean daily rate of carbon dioxide production (mol CO_2/d):

$$r\text{CO}_2 = (N/2.078)(1.01k_o - 1.04k_h) - 0.0246r_{\text{Gf}} \quad (1)$$

where N is TBW in mol, k_o is the ^{18}O elimination rate, k_h is the ^2H elimination rate, and r_{Gf} is the estimated rate for isotopically fractionated water loss and equal to $1.05N(1.01k_o - 1.04k_h)$ (13, 14). The elimination rates of the ^2H and ^{18}O isotopes were calculated according to the 2-point method, by comparing the isotopic enrichments at the beginning and end of the EE period with the baseline isotope concentrations and by using the time difference between collection of the initial and final urine samples as follows:

$$k = (\ln\text{APE}_i - \ln\text{APE}_f)/\Delta \text{ time} \quad (2)$$

where APE is atom percent excess, and Δ is change.

We used only the timed urine samples obtained at the General Clinical Research Center to calculate EE by the 2-point method. We used Weir's equation (15) to calculate EE. We determined carbon dioxide production ($r\text{CO}_2$) from the doubly labeled water method and calculated $\dot{V}\text{O}_2$ from $r\text{CO}_2$ and the food quotient calculated from the proportions of dietary fat, carbohydrate, and protein recorded in the 7-d food records (16). In determining food quotients, we assumed that underestimates of portion size would not alter the percentage of macronutrients consumed.

Data analyses

We calculated %BF by subtracting fat-free mass from body weight and dividing the difference by weight expressed as a percentage. Reported EI was calculated as EI from food diaries divided by EE from doubly labeled water (EI/EE).

To determine whether individual girls reported EI more or less accurately at each time point, we calculated for each girl the percentage difference in EI/EE between ages 10 and 12 y and between ages 10 and 15 y. Using a 5% criterion, we classified their paired reports as improving, declining, or unchanged.

Statistical analysis

Using mixed-effects models, as implemented in PROC MIXED software (version 8; SAS Institute Inc, Cary, NC), we assessed the differences in EI/EE at the 3 time points. We did not further adjust for age, because age varied little at each time point. To assess whether changes in reporting over time were influenced by %BF, we included %BF (measured at each of the 3 time points) and reran the model.

In a secondary analysis to assess the influence of any change in weight over the 2-wk EE period, we also calculated an adjusted



TABLE 1
Participant characteristics at ages 10, 12, and 15 y¹

| | Age | | | P ² |
|-------------------------|---------------|---------------|---------------|----------------|
| | 10 y (n = 26) | 12 y (n = 26) | 15 y (n = 21) | |
| Age (y) | 9.9 ± 0.4 | 11.9 ± 0.4 | 14.8 ± 0.4 | <0.0001 |
| Weight (kg) | 33.7 ± 4.7 | 44.9 ± 7.2 | 57.9 ± 6.8 | <0.0001 |
| Height (cm) | 141.4 ± 5.7 | 155.0 ± 6.4 | 164.5 ± 6.5 | <0.0001 |
| BMI | | | | |
| (kg/m ²) | 16.8 ± 1.9 | 18.6 ± 2.5 | 21.5 ± 2.5 | <0.0001 |
| z Score ³ | -0.13 ± 0.89 | 0.06 ± 0.93 | 0.37 ± 0.71 | 0.0004 |
| Fat-free mass (kg) | 25.5 ± 3.0 | 32.4 ± 4.4 | 41.7 ± 4.4 | <0.0001 |
| Percentage body fat (%) | 24.0 ± 4.6 | 27.3 ± 6.1 | 27.7 ± 4.9 | 0.0003 |

¹ $\bar{x} \pm \text{SD}$.²Statistical significance of linear trend in mixed-effects models.³BMI z score from Centers for Disease Control and Prevention growth reference (18).

EI by using the following conservative assumptions: all changes in body weight were due to changes in adipose tissue, adipose tissue is 20% water, each gram of fat stored has an energy equivalent of 39.75 kJ/g (9.5 kcal/g) (17), and the energy equivalent of 1 g adipose tissue is 31.8 kJ/g or 7.6 kcal. We then calculated adjusted EI as follows:

$$\text{Adjusted EI} = \text{EI} - [(\text{weight change}) \times (7600 \text{ kcal/kg}) / (\text{no. of days in the EI reporting period})] \quad (3)$$

RESULTS

Twenty-eight girls were enrolled in the subcohort for examination of the longitudinal changes in EE. Of these girls, 2 did not have valid food diaries at baseline and thus were not included in this aspect of the study. All 26 girls who had valid food diaries at age 10 y also had them at age 12 y. By age 15 y, 2 girls had dropped out of the study, 1 was not available for scheduling the 5-y subcohort visit, and 2 did not complete valid food diaries. One participant's EE at age 12 y was based on only 10 d because she became ill during the last 3 d of the study period (the week when the food diary was kept), and so only the first 4 d of the 7 d of her food diary were used to estimate EI.

Participant characteristics are presented in **Table 1**. At baseline, 17 girls were prepubertal, 9 were pubertal, and all 26 were premenarcheal. According to the girls' self-described race/ethnicity, the sample included 18 whites, 5 African Americans, no Hispanics, 2 Asians, and 1 girl of other race or ethnicity.

More girls had declining reporting accuracy over time than had improved or unchanged reporting accuracy. Of the 21 girls who were observed at ages 10 and 15 y, 19 reported less accurately at age 15 y than at age 10 y; 18 of the 26 girls who participated at

ages 10 and 12 y were less accurate reporters at age 12 y than at age 10 y. Modeled longitudinally, both of the declines in reporting accuracy, from age 10 y to age 12 y and from age 10 y to 15 y, were significant ($P = 0.03$ and $P = 0.001$, respectively). Reporting accuracy from age 12 y to 15 y also tended to decline (12 girls became less accurate reporters), but the difference was not statistically significant ($P = 0.1$) in the mixed model. Daily EE increased from age 10 y to 15 y ($P < 0.001$), but EI from the food diaries did not differ between age 10 y and 15 y (**Table 2**).

In a secondary analysis to adjust for the influence of weight change on reported EI, we repeated the longitudinal analysis with the use of adjusted EI (*see above*) instead of unadjusted EI. The mean (\pm SD) change in body weight per day was 0.02 ± 0.04 kg at baseline, 0.02 ± 0.04 kg at age 12 y, and 0.00 ± 0.05 kg at age 15 y. The trend in reported EI with the use of the adjusted values was statistically significant and similar to that in the unadjusted analysis, but the magnitude of the differences was smaller (**Table 2**). We also examined whether %BF affected EI/EE and found that the results were essentially unchanged with the addition of %BF to the model.

DISCUSSION

We found that errors in reported EI increased with age for 90% of the girls studied. This study supports the findings of previous cross-sectional studies, which consistently suggested that age influences the accuracy of EI/EE measurements in children. An accurate determination of EI may help determine the contribution of EI to the development of obesity. Several cross-sectional studies in children and adolescents have been conducted to compare EI calculated from food records (either weighed or based on household measures) with

TABLE 2
Measures of energy intake (EI) and energy expenditure (EE) and percentage of EI reported at age 10, 12 and 15 y¹

| | Age | | | P ² |
|--------------------------|---------------|---------------|---------------|----------------|
| | 10 y (n = 26) | 12 y (n = 26) | 15 y (n = 21) | |
| EI (kJ) | 7103 ± 1256 | 7030 ± 1412 | 6823 ± 1540 | 0.6399 |
| EE (kJ) | 8133 ± 1137 | 9339 ± 1328 | 10269 ± 1540 | <0.0001 |
| EI/EE × 100 (%) | 88 ± 13 | 77 ± 21 | 68 ± 17 | <0.0001 |
| Adjusted EI ³ | 82 ± 17 | 71 ± 24 | 66 ± 20 | 0.0250 |

¹ $\bar{x} \pm \text{SD}$.²Statistical significance of linear trend in mixed-effects models.³Adjusted for weight change: EI = EI - [(weight change) × (7600 kcal/kg)/(no. of days in the EI reporting period)].

EE measured by the doubly labeled water method. Davies and Coward (19) found no differences in EE and EI from 4-d weighed records for 1.5–4.5-y-olds, as recorded by the children's caregivers. McGloin et al (20) used food records based on weighed measures to calculate EI in 6-y-old normal-weight children of normal-weight and obese parents. EI was similar to EE in normal-weight children of both normal-weight and obese parents. Although these studies suggest that reporting accuracy may be adequate in young children, other studies suggest that the EI of adolescents is reported less accurately. (4). Champagne et al (21) found significant underreporting (range: 17–33%) in white and African American children aged 8–12 y who kept an 8-d food record, even after nutritionists recorded daily school lunch intake to increase accuracy. Underreporting was greatest in the 12-y-old children, but the differences were not significant. Livingstone et al (3) found no significant differences in reported EI and EE in 7- and 9-y-olds with the use of a 7-d weighed food record, but significant differences between reported EI and EE were observed in the 12-, 15-, and 18-y-old children. These findings are consistent with our cross-sectional study of reporting accuracy in 8–12-y-old normal-weight girls at study baseline, in which we found an inverse correlation between age and EI/EE (24). Bratterby et al (22) also found a significant degree of underreporting in their study of 15-y-old boys and girls ($81.9 \pm 17.9\%$ and $78.3 \pm 16.4\%$, respectively). However, it may be inappropriate to compare data on younger and older children from cross-sectional studies for an assessment of age-related changes in reporting accuracy because the data do not come from the same children over time.

One possible explanation for the findings of our study is related to the fact that, when the girls were 10 y old, it was clear from the handwriting on the diaries that, in some cases, parents had recorded the food eaten by their daughters. Although this could be interpreted as a source of bias, it reflects the reality of the field setting and may explain why accuracy was better at age 10 y. Children who are 10 y old may be more likely than older children to ask a parent for help in either estimating portion size or measuring a food or for specific details about how the food was cooked. As children become older and more independent, they may be less likely to ask for parental assistance in completing their food diaries. Poor recording of food eaten away from home is a potential source of error in any dietary assessment method, because portion sizes may be more difficult to estimate than to measure accurately and the ingredients may not be known. Because adolescents eat a larger percentage of their total diet outside the home (23), they may be less able to measure the food consumed and may need to rely more heavily on estimation, and thus they may be more prone to errors in reporting EI than are younger children.

Cross-sectional studies suggest that %BF may influence EI/EE (4, 20, 22) in children. In the current analysis of this subcohort and in our previously reported cross-sectional analysis of the girls in our cohort when they were aged 8–12 y (24), we did not find an association of EI/EE with %BF. This is in contrast to our earlier study of obese and nonobese adolescents in which the obese adolescents underreported intake to a greater extent than did the nonobese adolescents (4). However, all of the girls enrolled in the present study were of normal weight at age 10 y, and only a few were overweight at 12 and 15 y.


In our previously published cross-sectional analysis (24) of our larger cohort, we observed a positive relation of EI/EE with EE. In the current analysis, we observed such a relation only when the girls were 15 y old. The discrepancy between these findings at baseline and the previous findings may be due to the fact that

sample size in this analysis was smaller ($n = 26$) than that in the cross-sectional analysis ($n = 109$).

Several limitations of our study should be noted. The EE period was 2 wk, but the EI period coincided with only the second week of the EE period. If participants restricted their intake during the entire measurement period, then their EI would not have reflected their energy needs and they would have lost weight. However, the mean weight change during the 2-wk energy expenditure period was positive (gain), which suggests that participants did not eat less during the measurement period. Moreover, in the secondary analysis in which we adjusted EI for body weight changes (assuming that all weight change represented fat mass), the findings were essentially unchanged. We do not have information on parental assistance with food record keeping, and thus we cannot assess the extent to which the observed decline in reporting accuracy reflected a change in the degree of parental assistance.

Our findings suggest that diet records in adolescents may not accurately reflect EI at the individual level. Only a few studies assessed the accuracy of other dietary assessment methods of calculating EI in adolescents, and all of these studies were cross-sectional. In one of those studies, Perks et al (25) found significant individual underreporting of EI with a FFQ. In another of those studies, Livingstone et al (3) reported good agreement of the diet history with TEE in 15-y-old adolescents, although there was a wide range in individual reporting. The scarcity of data on the accuracy of other dietary methods in adolescence makes it difficult to assess or recommend the use of other methods.

This longitudinal study showed that the accuracy of reported EI in girls declines longitudinally with age. Because even a small energy imbalance maintained over a long period will result in obesity, it is unlikely that any available dietary method of measuring EI will be precise enough to determine how EI contributes to obesity in adolescents.

Despite their limitations, food diaries may be useful to assess patterns of food intake, such as fast food consumption, or the proportion of energy from soft drinks. Given the changes in food patterns among adolescents (26, 27) that are coincident with the rise of the obesity epidemic, food record analysis may yield important insights into the role of diet in the development of obesity in this age group. Food-intake patterns obtained from diaries may be a useful area for research to understand the dietary variables that contribute to obesity. 

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WHD and LGB were the principal investigators on the study. HC provided dietary instructions to the participants and analyzed all the dietary data. JLS performed all the oxygen isotopic analysis. AM provided the statistical guidance and interpretation and assisted SEA with the statistical analyses for the study. None of the authors had any conflict of interest.

REFERENCES

1. Prentice AM, Black AE, Coward WA, et al. High levels of energy expenditure in obese women. *Br Med J* 1986;292:983–7.
2. Livingstone MBE, Prentice AM, Strain JJ, et al. Accuracy of weighed dietary records in studies of diet and health. *Br Med J* 1990;300:708–12.
3. Livingstone MBE, Prentice AM, Coward WA. Validation of estimates of energy intake by weighed dietary record and diet history in children and adolescents. *Am J Clin Nutr* 1992;56:29–35.



4. Bandini LG, Schoeller DA, Cyr H, Dietz WH. Comparison of energy intake and energy expenditure in obese and nonobese adolescents. *Am J Clin Nutr* 1990;52:421-5.
5. Bandini LG, Must A, Spadano JL, Dietz WH. Relation of body composition, parental overweight, pubertal stage, and race-ethnicity to energy expenditure among premenarcheal girls. *Am J Clin Nutr* 2002;76:1040-7.
6. Must AM, Dallal GE, Dietz WH. Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht²) and triceps skinfold thickness. *Am J Clin Nutr* 1991;53:839-46.
7. Tanner JM. Growth at adolescence. Oxford, United Kingdom: Blackwell Scientific, 1962.
8. Scrimgeour CM, Rollo MM, Mudambo SM, Handley LL, Prosser SJ. A simplified method for deuterium hydrogen isotope ratio measurements on water samples of biological origin. *Biol Mass Spectrom* 1993;22:383-7.
9. Prosser SJ, Scrimgeour CM. High precision determination of ²H/¹H in ²H and H₂O by continuous-flow isotope ratio mass-spectrometry. *Ann Chem* 1995;67:1992-7.
10. Halliday D, Miller AG. Precise measurement of total body water using trace quantities of deuterium oxide. *Biomed Mass Spectrom* 1977;4:82-7.
11. Schoeller DA, van Santen DW, Peterson DW, Dietz WH, Jaspan J, Klein PD. Total body water measurement in humans with ¹⁸O and ²H labeled water. *Am J Clin Nutr* 1980;33:2686-93.
12. Pace N, Rathbun EN. Studies of body composition III. The body water and chemically combined nitrogen content in relation to fat content. *J Biol Chem* 1949;158:685-91.
13. Lifson N, McClintock R. Theory of turnover rate of body water for measuring energy and material balance. *J Theor Biol* 1966;12:46-74.
14. Schoeller DA, Ravussin E, Schutz Y, Acheson KJ, Baertschi P, Jequier E. Energy expenditure by doubly labeled water: validation in humans and proposed calculation. *Am J Physiol* 1986;250:R823-30.
15. Weir JB. New method of calculating metabolic rate with special reference to protein metabolism. *J Physiol* 1949;109:1-9.
16. Black AE, Prentice AM, Coward WA. Use of food quotients to predict respiratory quotients for the doubly-labeled water method of measuring energy expenditure. *Hum Nutr Clin Nutr* 1986;40C:381-91.
17. Brouwer E. Report of sub-committee on constants and factors. In: Blaxter K, editor. *Energy metabolism*. London: Academic Press, 1965:441-3.
18. Ogden CL, Kuczmarski RL, Flegal KM, et al. Centers for Disease Control and Prevention 2000 growth charts for the United States: improvements to the 1977 National Center for Health Statistics version. *Pediatrics* 2002;109:45-60.
19. Davies PSW, Coward WA. Total energy expenditure and energy intake in the pre-school child: a comparison. *Br J Nutr* 1994;72:13-20.
20. McGloin AF, Livingstone MBE, Greene LC, et al. Energy and fat intake in obese and lean children at varying risk of obesity. *Int J Obes Relat Metab Disord* 2002;26:200-7.
21. Champagne CM, Baker NB, Delany JP, Harsha DW, Bray GA. Assessment of energy intake underreporting by doubly labeled water and observations on reported nutrient intakes in children. *J Am Dietetic Assoc* 1998;98:426-30.
22. Bratterby LE, Sandhagen B, Fan H, Enghardt H, Samuelson G. Total energy expenditure and physical activity as assessed by the doubly labeled water method in Swedish adolescents in whom energy intake was underestimated by 7-d diet records. *Am J Clin Nutr* 1998;67:905-11.
23. Lin B-H, Guthrie J, Blaylock JR. The diets of American children: influences of dining out, household characteristics, and nutrition knowledge. Agricultural Economic Report no. 746. Washington, DC: US Department of Agriculture, 1996.
24. Bandini LG, Cyr H, Must A, Dietz WH. Validity of reported energy intake in preadolescent girls. *Am J Clin Nutr* 1997;65(suppl):1138S-41S.
25. Perks SM, Roemmich JN, Sadow-Pajewski M, et al. Alterations in growth and body composition during puberty. IV. Energy intake estimated by the Youth-Adolescent Food-Frequency Questionnaire: validation by the doubly labeled water method. *Am J Clin Nutr* 2000;72:1455-60.
26. Ludwig DS, Peterson KE, Gortmaker SL. Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. *Lancet* 2001;357:505-8.
27. Jahns L, Siega-Riz M, Popkin BM. The increasing prevalence of snacking among US children from 1977 to 1996. *J Pediatr* 2001;138:493-8.

