# Use of accelerometer data in prediction equations for capturing implausible dietary intakes in adolescents[1–3]

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**ABSTRACT**

**Background:** Reporting errors have been quantified in epidemiologic studies by comparing reported intakes with predicted energy requirements (pERs). Several studies lacking measures of physical activity level (PAL) assigned low-active levels to obtain pERs.

**Objective:** We applied objective physical activity measures to current methods to quantify dietary reporting errors and compared associations with anthropometric and dietary variables among plausible and implausible reporters.

**Design:** This study included 2868 adolescents with an average age of 13 y. Three-day dietary records, accelerometers, and dual-energy X-ray absorptiometry were used to assess diet, activity, and body composition, respectively. Three variations of physical activity coefficients were used: *1*) assigning low physical activity coefficients ($PA_{low}$), *2*) calculating PAL values ($PA_{PAL}$), and *3*) applying minutes of moderate-to-vigorous physical activity ($PA_{MVPA}$).

**Results:** Of the total participants, 51.5%, 51.8%, and 37.1% of the $PA_{low}$, $PA_{PAL}$, and $PA_{MVPA}$ groups, respectively, were classified as underreporters, and 40.8%, 37.9%, and 42.4% of the respective groups were classified as plausible reporters. Underreporters had a higher body mass index, body fat, and waist circumference than did plausible reporters ($P < 0.001$ for all). Overreporters had a lower weight and body fat than did plausible reporters ($P < 0.001$ for all). Underreporters reported lower dairy and calcium intakes than did plausible reporters; the results were attenuated with adjustment for total energy.

**Conclusion:** Accounting for objective physical activity measures to quantify reporting errors resulted in different and potentially more reasonable proportions of implausible reporters. *Am J Clin Nutr* 2010;92:1436–45.

## INTRODUCTION

Accurate measurement of the dietary intakes of children is challenging in both epidemiologic and clinical studies given factors known to introduce bias in reports of intakes such as age, weight, and dietary assessment tool (1). Validation studies comparing self-reported dietary intakes from dietary recalls and records with total energy expenditure (TEE) measured by using doubly labeled water (DLW) techniques have found substantial misreporting of intakes in children and adolescents (2–4). Those who are overweight or obese (3–5) or have greater body fatness (6) are especially prone to underreporting. Reported intakes of foods differ based on whether children are classified as underreporters, plausible reporters, or overreporters (7–9). Ventura et al (7) showed that underreporters consumed fewer servings of grains, dairy, fats and sweets compared with plausible or overreporters. Including inaccurate reporters in dietary analyses can lead to distortions in associations with disease, especially in studies of diet and obesity (9, 10).

Inconsistent findings between dairy and calcium intakes and obesity may be due to the inclusion of implausible reporters, introducing measurement errors that distort true associations (8, 11–16). For example, protective associations with dairy intakes (≥3 servings/d) on body weight and fatness in girls aged 11 y disappeared when implausible reporters were excluded from the analyses (8). Therefore, accounting for reporting errors may help clarify relations between diet and obesity (9, 10, 17, 18); further investigation of associations between dairy and calcium intakes and body composition among plausible and implausible reporters is needed.

The use of DLW to measure TEE is not often feasible in large population studies (19). Methods that do not require direct measurement of TEE have been developed on the premise that energy intake equals energy expenditure under weight-stable conditions (9, 19, 20). Huang et al (9) developed age- and sex-specific cutoffs for reported energy intake (rEI) as a percentage of predicted energy requirements (pERs) for children. Several studies have used this technique to capture inaccurate reporters, but have been limited because objective measures of physical activity (PA) were not available for use in prediction equations for estimating energy requirements (7–9, 18). Some studies used similar methods, but included PA from questionnaires or diaries

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to assign or calculate PA levels (PALs) (21–25); others used accelerometer data for estimating TEE and average PAL values for a population (26–28).

The goal of this study was to apply objective measures of PA to the PA coefficients used in TEE prediction equations as part of methods developed by Huang et al (9) to quantify reporting errors in adolescents aged ≈13 y. Specifically, we compared 2 methods that included individual PA estimates in the calculation of dietary misreporting to one that assigned all participants a low-active PA coefficient. To assess whether reporting errors had an effect on particular foods and nutrients, we also analyzed associations with anthropometric measures and dairy and calcium intakes among plausible and implausible reporters for each method.

## SUBJECTS AND METHODS

### Study population

The Avon Longitudinal Study of Parents and Children (ALSPAC) is an ongoing investigation on the health and development of children, as described in detail elsewhere (29) (http://www.alspac.bris.ac.uk). Briefly, 14,541 pregnant women living in the County of Avon, United Kingdom, with an expected delivery date between April 1991 and December 1992 were enrolled; 13,988 children were alive at year 1. Health data were collected through regular questionnaires, and medical and educational records. Anthropometric, PA, and dual-energy X-ray absorptiometry (DXA) measures were obtained during research clinic visits. A total of 6069 participants had DXA measures, 4432 had 3 d of dietary records, and 3800 had accelerometer data. This study included 2868 adolescents with complete dietary, accelerometer, and DXA measures from 13-y research clinic visits (90% were between ages 13 and 14 y). Approval for this study was obtained from the ALSPAC Law and Ethics Committee and the Local Research Ethics Committees and the Institutional Review Board of Boston University Medical Center. Parents provided informed consent on enrollment and additional consent for measures other than questionnaires and research clinic visits, such as accelerometers and DXA measures.

### Anthropometric measures

Anthropometric measures were obtained at 13-y clinic visits. Height was measured by using a Harpenden stadiometer (Holtain Ltd, Crymych, United Kingdom), and weight was assessed by using a weighing scale (Tanita TBF 305; Tanita UK Ltd, Yewsley, United Kingdom). A Lunar Prodigy DXA scanner (GE Medical Systems Lunar, Madison, WI) provided measures of body composition, including fat, lean body mass, and bone mass. Body mass index [BMI; weight (kg)/height squared (m)], BMI percentiles, and BMI $z$ scores were calculated from 2000 Centers for Disease Control and Prevention growth charts (30).

### Dietary assessment

Three-day dietary records including 2 weekday and 1 weekend day were obtained from adolescents a few days before the 13-y research clinic visit; parents provided assistance as needed. Participants were instructed to record all foods and beverages consumed by using standard household measures. Records were reviewed during clinic visits to improve completeness. Questionnaires queried for information on vitamin supplements, type of milk or fat spreads consumed, and details of other foods commonly eaten. Diet records were coded and analyzed by using the Diet In Data Out software (MRC Human Nutrition Research, Elsie Widdowson Laboratory, Cambridge, United Kingdom), which generates food codes and weights of each item recorded (31). Average daily nutrient intakes were calculated by using BRIGADE (University of Bristol, Bristol, United Kingdom)—a nutrient analysis program based on a nutrient databank that included the fifth edition of McCance and Widdowson's food tables and supplements (32–40). Nutrients for foods not in the databank were obtained from the National Diet and Nutrition Survey nutrient databases (41) or calculated from the manufacturer's label. Food groups were formed on the basis of nutrient composition and culinary use of foods consumed. Dairy and milk groups were categorized into full-fat, low-fat, and nonfat on the basis of fat content. Total milk intake included full-fat, low-fat and nonfat plain and flavored milk. Total dairy intake included milk, cheese, cream, and yogurt; butter was not included.

### Physical activity

The Actigraph uni-axial accelerometer (Actigraph, Fort Walton Beach, FL) was used to measure PA (42) and has been validated for use in children and adolescents (43, 44). The accelerometer, which is worn around the waist, captures the frequency and intensity of movement in the vertical plane. Adolescents were asked to wear the accelerometer for 7 d during waking hours and to remove the instrument only during showering, bathing, and swimming. PA measured directly from accelerometers (not including time spent swimming or cycling) was used (45). The accelerometers used in this study measured 1-min epochs. Adolescents with $\geq$3 d of accelerometer data were included in the analyses. Variables derived from the Actigraph were counts per minute as an estimate of total activity and minutes of moderate-to-vigorous activity (MVPA). On the basis of the results from a calibration study (46), daily minutes of MVPA were defined by using cutoffs developed for moderate activity (accelerometer output $\geq$3600 and $<$6200 counts/min) and vigorous activity ($\geq$6200 counts/min); time spent performing MVPA were summed to quantify minutes of MVPA.

### Other variables

The age of the adolescents was calculated from the self-reported date of birth. Maternal education was obtained from self-reported questionnaires collected in the third trimester of pregnancy and was grouped according to UK standards as "CSE or less" (schooling to age 16 y but no qualifications), "vocational qualifications," "Ordinary (O) level" (qualifications obtained at age 16 y, school leavers), "Advanced (A) Level" (qualifications obtained at age 18 y), or "degree" (university qualifications). Social class was classified according to the UK 1995 Standard Occupational Classification System (Office of Population Censuses and Surveys. Standard occupational classification. London, United Kingdom: HMSO, 1995) based on occupation as reported in the third trimester of pregnancy. The resulting variable has 6 levels—the lowest indicating higher socioeconomic status. Two questions on weight satisfaction and dieting were used as crude indicators of eating behaviors (47, 48).

### Methods for capturing reporting errors

Methods of Huang et al (10) were used to quantify reporting errors. This method uses equations to predict TEE and error propagation to create age- and sex-specific cutoffs for the ratio of rEI to pER (9, 10). Separate sex-, age-, and weight-specific equations from the US Dietary Reference Intakes (DRIs) (49) were used to calculate pER and included coefficients for age, PA, height, weight, and constants for sex and energy deposition during growth.

To account for actual PA in the estimation of TEE, we created different versions of the Huang et al method, which included modifying the PA coefficient of the pER equation as follows: *1*) $PA_{low}$ [assigned low-active PA coefficients: 1.13 for boys and 1.16 for girls, which is equivalent to walking 3 miles (≈4.8 km)/d] (9), *2*) $PA_{PAL}$ (calculated PAL values from prediction equations), and *3*) $PA_{MVPA}$ (assigned PA coefficients from total minutes of MVPA). For $PA_{PAL}$, PAL values were calculated by dividing TEE estimated from equations developed from accelerometer (counts/min) and anthropometric data (43) by basal metabolic rate (BMR) estimated by using Schofield's equations (50). PAL values were collapsed to PA coefficients (49). For $PA_{MVPA}$, PA coefficients were assigned per the number of minutes spent in MVPA from the accelerometer data. Our decision to use MVPA categories was based on the DRIs from the Institute of Medicine descriptions of PAL and PA coefficient categories, which specifies the amount of time spent in moderate or vigorous activities to move an individual from sedentary to low-active or active PAL (ie, PAL categories) (51). Specifically, the guidelines state that participation in an additional 30 min of moderate activity raises an individual from the sedentary to the low-active PAL category, and ≈60 min of moderate activity raises an individual from the sedentary to the active PAL category (51). Thus, in our study, minutes of MVPA were summed and categorized as follows: *1*) sedentary (<30 min of MVPA), *2*) low-active (30 to <60 min of MVPA), *3*) moderately active (60–120 min of MVPA), and *4*) very active (≥60 min of vigorous and/or >120 min of moderate activity).

For all 3 methods, a 1-SD cutoff was used to account for intraindividual variation in rEI, day-to-day variation in TEE measured by DLW, and errors in predicted energy requirement equations (9). Because the age of the adolescents at the 13-y clinic ranged from 12.5 to 15.2 y, we calculated separate cutoffs by using age-specific (<14 y and ≥14 y) CV values for rEI and pER (9). The CV for rEI ($CV_{rEI}$) was calculated by dividing the SD by the mean energy intake from 3-d dietary records for each adolescent. $CV_{rEI}$ values were 19.8 and 20.7 for girls and 19.0 and 19.4 for boys <14 y and ≥14 y, respectively. The $CV_{pER}$ values were 4.8 and 4.1 for girls and 4.2 and 3.0 for boys <14 y and ≥14 y, respectively, based on DRI data. The $CV_{mTEE}$ was 8.2, as previously reported from DLW studies (19, 52).

### Statistical analysis

The analyses were conducted by using SAS (version 9.1; SAS Institute, Cary, NC), and 2-sided *P* values <0.05 were considered significant. Data were examined for outliers; extreme dairy intakes for one participant were excluded from the analysis. On the basis of 1-SD calculations described above, individual reported energy intakes between 85.7% and 114.3% and between 85.1% and 114.9% were considered plausible reporters for boys and girls aged <14 y, respectively. Boys and girls aged ≥14 y with reported intakes between 85.6% and 114.2% and between 84.9% and 115.1%, respectively, were considered plausible reporters. Percentage agreement between the different methods was assessed by using Bowker's Test of Symmetry and the $\kappa$ coefficient. Chi-square analysis and *t* tests were used to examine differences in frequencies and sample means, respectively. Analysis of covariance was used to examine associations and to calculate adjusted means for body composition and dietary intake (dairy, milk, and calcium) variables across dietary reporting categories. Anthropometric variables were adjusted for age and sex. Dietary intakes were adjusted for age and sex in the first model and age, sex, and total energy intake in the second model. Tukey's honestly significant difference test was used to adjust for multiple comparisons. In secondary analyses, we examined the proportion of underreporters, plausible reporters, and overreporters across reporting methods stratified by sex. We also repeated analyses for sociodemographic, anthropometric, and dietary variables for boys and girls separately to better understand differences seen between reporting methods.

## RESULTS

Selected demographic and anthropometric variables for boys and girls are presented in **Table 1**. In general, 96.4% of the study sample was non-Hispanic white. Approximately 40% of boys and girls had a weekly family income between £480 and £800/wk. Compared with girls, boys were more physically active (590 compared with 482 counts/min), participated in more MVPA (28.4 compared with 19.5 min of MVPA), and had a lower percentage of body fat (19.2% compared with 29.3%).

Approximately 41% of adolescents were classified as plausible reporters by using $PA_{low}$ compared with 38% for $PA_{PAL}$ and 42% for $PA_{MVPA}$ (**Table 2**). Differences were observed in the number of overreporters classified between the different methods ($PA_{low}$, 7.7%; $PA_{PAL}$, 10.3%; $PA_{MVPA}$, 20.4%). There was strong agreement in the classification of plausible reporters captured between $PA_{low}$ and $PA_{PAL}$ (78.8%) and between $PA_{low}$ and $PA_{MVPA}$ (63.5%). More than 36% of those classified as plausible reporters captured by using $PA_{MVPA}$ methods were classified as underreporters on the basis of $PA_{low}$. $PA_{PAL}$ and $PA_{MVPA}$ classified 45.8% and 63.0% of adolescents, respectively, as overreporters, who were classified as plausible reporters on the basis of $PA_{low}$.

The mean age of adolescents was 13.8 ± 0.19 y, and 53.6% were girls. Age at menarche was lower for underreporters than for plausible reporters or overreporters (**Table 3**). A greater percentage of girls than boys were classified as plausible reporters (57.6%) and overreporters (73.6%) on the basis of $PA_{PAL}$ and as underreporters (50.6%), plausible reporters (54.7%), and overreporters (56.5%) on the basis of $PA_{MVPA}$. Underreporters were more likely to be always or often dieting and were more likely to be dissatisfied with their weight than were plausible or overreporters ($P < 0.001$). Implausible energy reporting was not associated with mothers' educational attainment, family income, or occupational social class ($P > 0.05$ for all).

**TABLE 1**
Demographic and anthropometric characteristics of 2868 boys and girls with an average age of 13.8 y from the Avon Longitudinal Study of Parents and Children[1]

| Variable | Boys ($n$ = 1332, 46.4%) | Girls ($n$ = 1536, 53.6%) | $P$ value[2] |
|---|---|---|---|
| Age (y) | 13.79 ± 0.005[3] | 13.81 ± 0.005 | 0.03 |
| Weight (kg) | 54.5 ± 0.30 | 54.5 ± 0.26 | 0.96 |
| Height (cm) | 165.0 ± 0.24 | 161.9 ± 0.16 | <0.001 |
| BMI (kg/m$^2$) | 19.9 ± 0.08 | 20.7 ± 0.09 | <0.001 |
| Body fatness (%) | 19.2 ± 0.26 | 29.3 ± 0.21 | <0.001 |
| Total energy intake (kcal) | 2155.2 ± 13.4 | 1784.85 ± 10.2 | <0.001 |
| Physical activity (counts/min) | 590.4 ± 5.2 | 481.6 ± 3.9 | <0.001 |
| MVPA (min) | 28.4 ± 0.49 | 19.5 ± 0.36 | <0.001 |
| Weekly family income (%) | — | — | 0.70 |
| <£120 | 1.2 | 1.7 | — |
| £120 to <£240 | 7.3 | 7.1 | — |
| £240 to <£480 | 33.8 | 35.9 | — |
| £480 to <£800 | 42.0 | 39.8 | — |
| ≥£800 | 15.7 | 15.5 | — |

[1] $n$ = 2868. Sample size differed for body fatness because of missing values for body fat. MVPA, moderate-to-vigorous physical activity.
[2] Differences between means and frequencies were calculated by using $t$ tests and chi-square analyses for continuous and categorical variables, respectively.
[3] Mean ± SE (all such values).

For all 3 methods ($PA_{low}$, $PA_{MVPA}$, and $PA_{PAL}$), underreporters had a higher BMI, BMI percentile, and waist circumference than did plausible reporters and overreporters (**Table 4**). Percentage body fat was also higher for underreporters than for plausible reporters and overreporters ($P < 0.001$ for all methods). For example, percentage body fat was 27.2% for underreporters, 23.3% for plausible reporters, and 20.8% for overreporters for the $PA_{MVPA}$ method ($P < 0.001$); percentage lean body mass was lower for underreporters and higher for overreporters than for plausible reporters ($P < 0.001$).

Average dairy and calcium intakes by reporting category for each method, unadjusted and adjusted for total energy, are presented in **Table 5**. Reported mean intakes of total milk and total dairy were different across all reporting categories for all methods, with underreporters recording lower intakes than plausible reporters (eg, milk intakes of 180 compared with 243 g; $P <$ 0.001) and overreporters recording higher intakes than plausible reporters (eg, milk intakes of 320 compared with 243 g; $P <$ 0.001); differences were attenuated after adjustment for total energy intake (219, 210, and 218 g for underreporters, plausible reporters, and overreporters, respectively; $P > 0.05$). For $PA_{MVPA}$, underreporters had higher intakes of low-fat milk and low-fat dairy than did overreporters, and overreporters had lower intakes of low-fat milk and low-fat dairy than did plausible reporters or underreporters after adjustment for total energy ($P < 0.05$). No differences in recorded intakes of nonfat dairy or nonfat milk were observed across reporting categories for any method ($P >$ 0.05). Underreporters recorded consuming less calcium than did plausible reporters or overreporters ($P < 0.001$); findings were attenuated after adjustment for total energy (except for $PA_{low}$ between plausible and overreporters).

In secondary analyses, we examined differences between underreporters, plausible reporters, and overreporters for each method separately for girls and boys. A greater percentage of boys than girls were classified as overreporters on the basis of $PA_{low}$ (8.6% compared with 7.0%, respectively). The same percentage of underreporters (50.5%) was observed for boys and girls on the basis of this method, and a greater percentage of boys than girls were classified as underreporters on the basis of $PA_{PAL}$ (50.5% compared with 45.1%) and $PA_{MVPA}$ (39.5%

**TABLE 2**
Percentage agreement between methods for determining the accuracy of energy reporting in 2868 adolescents with an average age of 13.8 y from the Avon Longitudinal Study of Parents and Children[1]

| | $PA_{PAL}$ | | | $PA_{MVPA}$ | | |
|---|---|---|---|---|---|---|
| $PA_{low}$ | Underreporter ($n$ = 1486, 51.8%) | Plausible reporter ($n$ = 1087, 37.9%) | Overreporter ($n$ = 295, 10.3%) | Underreporter ($n$ = 1065, 37.1%) | Plausible reporter ($n$ = 1217, 42.4%) | Overreporter ($n$ = 586, 20.4%) |
| Underreporter ($n$ = 1476, 51.5%) | 88.0 | 15.5 | 0 | 97.4 | 36.1 | 0 |
| Plausible reporter ($n$ = 1170, 40.8%) | 12.0 | 78.8 | 45.8 | 2.6 | 63.5 | 63.0 |
| Overreporter ($n$ = 222, 7.7%) | 0 | 5.7 | 54.2 | 0 | 0.4 | 37.0 |

[1] $PA_{low}$, physical activity coefficients assigned as low-active; $PA_{PAL}$, physical activity coefficients obtained from estimated physical activity levels; $PA_{MVPA}$, physical activity coefficients obtained from minutes of moderate-to-vigorous physical activity. Bowker's Test of Symmetry was significant ($P <$ 0.001), which indicated that there were different proportions of children in the energy-reporting categories between $PA_{low}$ (based on a low-active PA coefficient), $PA_{PAL}$ (based on PAL values), and the $PA_{MVPA}$ (based on accelerometer data). The $\kappa$ coefficient for interrater reliability was 0.66 ("substantial agreement") between $PA_{low}$ and $PA_{PAL}$ and was 0.53 ("moderate agreement") between $PA_{low}$ and $PA_{MVPA}$.

**TABLE 3**

Sociodemographic characteristics across dietary reporting methods among 2868 adolescents with an average age of 13.8 y from the Avon Longitudinal Study of Parents and Children[1]

| | $PA_{low}$ | | | $PA_{PAL}$ | | | $PA_{MVPA}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample characteristics | Underreporter (*n* = 1476) | Plausible reporter (*n* = 1170) | Overreporter (*n* = 222) | Underreporter (*n* = 1486) | Plausible reporter (*n* = 1087) | Overreporter (*n* = 295) | Underreporter (*n* = 1065) | Plausible reporter (*n* = 1217) | Overreporter (*n* = 586) |
| Child characteristics | | | | | | | | | |
| Girls (%) | 53.9 | 54.1 | 48.2 | 46.6 | 57.6 | 73.6[2] | 50.6 | 54.7 | 56.5[3] |
| Physical activity (counts/min) | 522 ± 4.7[a,4] | 539 ± 5.2[b] | 565.1 ± 12.0[c] | 575 ± 4.5[a] | 500 ± 5.2[b] | 434.7 ± 10[c] | 564 ± 5.4[a] | 520 ± 5.1[b] | 499 ± 7.3[c] |
| Age at menarche (y) | 12.4 ± 0.04[a] | 12.8 ± 0.04[b] | 12.9 ± 0.10[c,b] | 12.4 ± 0.04[a] | 12.8 ± 0.04[b] | 12.9 ± 0.07[c,b] | 12.3 ±0.05[a] | 12.7 ± 0.04[b] | 12.9 ± 0.06[c] |
| Frequency of dieting (%) | | | | | | | | | |
| Always/often | 7.8 | 2.0 | 0.5[2] | 7.5 | 1.9 | 2.3[2] | 9.9 | 2.1 | 1.6[2] |
| Several/couple times | 26.2 | 14.6 | 10.4 | 24.8 | 16.3 | 11.9 | 26.1 | 18.5 | 13.2 |
| Never | 66.0 | 83.0 | 89.1 | 67.7 | 81.8 | 85.8 | 64.0 | 79.5 | 85.2 |
| Degree of satisfaction with weight (%) | | | | | | | | | |
| Satisfied | 57.4 | 72.0 | 75.5[2] | 58.9 | 70.0 | 75.1[2] | 55.6 | 69.0 | 72.3[2] |
| Undecided | 9.0 | 6.2 | 5.2 | 8.5 | 6.9 | 4.6 | 9.5 | 6.7 | 5.7 |
| Dissatisfied | 29.0 | 16.3 | 9.4 | 27.9 | 17.3 | 13.0 | 30.6 | 19.0 | 14.3 |
| Not an issue | 4.6 | 5.6 | 9.9 | 4.7 | 5.9 | 7.3 | 4.3 | 5.3 | 7.7 |
| Family characteristics | | | | | | | | | |
| Mother's educational attainment (%) | | | | | | | | | |
| CSE/vocational | 17.3 | 16.4 | 19.6 | 18.2 | 15.5 | 17.9 | 18.9 | 15.0 | 18.5 |
| Ordinary level | 35.3 | 35.9 | 30.8 | 34.8 | 37 | 30.7 | 34.6 | 35.5 | 35.7 |
| Advanced level/degree | 46.5 | 47.3 | 47.7 | 47.0 | 47.5 | 51.4 | 46.6 | 49.5 | 45.8 |
| Maternal overweight/obesity, BMI >25 $kg/m^2$ (%) | 21.9 | 15.5 | 16.7[2] | 20.5 | 18.0 | 13.8[3] | 21.0 | 17.8 | 17.1 |
| Weekly family income (%) | | | | | | | | | |
| <£100 | 4.2 | 2.9 | 3.7 | 4.3 | 2.6 | 4.1 | 4.9 | 2.5 | 3.5[3] |
| £100–£299 | 37.2 | 40.6 | 38.1 | 38.3 | 39.6 | 36.9 | 39.9 | 37.3 | 39.3 |
| ≥£300 | 58.7 | 56.5 | 58.2 | 57.4 | 57.9 | 59.0 | 55.1 | 60.2 | 57.2 |
| Occupational social class (%) | | | | | | | | | |
| I | 8.8 | 8.5 | 5.4 | 8.6 | 8.3 | 7.8 | 8.9 | 8.5 | 7.3 |
| II | 36.1 | 35.8 | 37.0 | 35.8 | 35.7 | 38.7 | 36.4 | 35.6 | 36.4 |
| III (nonmanual) | 40.3 | 43.3 | 39.7 | 40.3 | 43.4 | 40.3 | 39.1 | 42.9 | 42.7 |
| III (manual), IV, and V | 14.8 | 12.5 | 17.9 | 15.4 | 12.7 | 13.2 | 15.7 | 13.0 | 13.6 |

[1] *n* = 2868. Sample size differed between variables because of missing data as follows: age at menarche (*n* = 1260), frequency of dieting (*n* = 2427), degree of satisfaction with weight (*n* = 2422), mother's educational attainment (*n* = 2673), maternal overweight or obesity (*n* = 2507), family income (*n* = 2305), and occupational social class (*n* = 2361). $PA_{low}$, physical activity coefficients assigned as low-active; $PA_{PAL}$, physical activity coefficients obtained from estimated physical activity levels; $PA_{MVPA}$, physical activity coefficients obtained from minutes of moderate-to-vigorous physical activity; CSE, certificate of secondary education. Values within each dietary reporting method with different superscript letters are significantly different, $P < 0.05$ (ANOVA for continuous variables, chi-square analysis for categorical variables).

[2,3] Significant differences across reporting categories: $^2P < 0.001$, $^3P < 0.05$.

[4] Mean ± SE (all such values).

**TABLE 4**
Anthropometric measures across dietary reporting methods in 2868 adolescents with an average age of 13.8 y from the Avon Longitudinal Study of Parents and Children[1]

| Anthropometric variables | $PA_{low}$ | | | $PA_{PAL}$ | | | $PA_{MVPA}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Underreporter ($n$ = 1476) | Plausible reporter ($n$ = 1170) | Overreporter ($n$ = 222) | Underreporter ($n$ = 1486) | Plausible reporter ($n$ = 1087) | Overreporter ($n$ = 295) | Underreporter ($n$ = 1065) | Plausible reporter ($n$ = 1217) | Overreporter ($n$ = 586) |
| BMI percentile | 63.4 ± 0.7$^{a}$ | 48.5 ± 0.8$^{b}$ | 38.6 ± 1.7$^{c}$ | 63.0 ± 0.7$^{a}$ | 49.0 ± 0.8$^{b}$ | 39.9 ± 1.5$^{c}$ | 65.6 ± 0.8$^{a}$ | 51.8 ± 0.7$^{b}$ | 44.2 ± 1.1$^{c}$ |
| BMI (kg/m$^2$) | 21.3 ± 0.1$^{a}$ | 19.4 ± 0.1$^{b}$ | 18.5 ± 0.2$^{c}$ | 21.3 ± 0.1$^{a}$ | 19.5 ± 0.1$^{b}$ | 18.5 ± 0.2$^{c}$ | 21.6 ± 0.1$^{a}$ | 19.8 ± 0.1$^{b}$ | 19.0 ± 0.1$^{c}$ |
| Body fatness (%) | 26.9 ± 0.2$^{a}$ | 22.0 ± 0.2$^{b}$ | 19.4 ± 0.6$^{c}$ | 26.6 ± 0.2$^{a}$ | 22.3 ± 0.3$^{b}$ | 19.7 ± 0.5$^{c}$ | 27.2 ± 0.3$^{a}$ | 23.3 ± 0.2$^{b}$ | 20.8 ± 0.3$^{c}$ |
| Lean body mass (%) | 69.3 ± 0.2$^{a}$ | 71.1 ± 0.2$^{b}$ | 76.6 ± 0.5$^{c}$ | 69.5 ± 0.2$^{b}$ | 73.7 ± 0.3$^{c}$ | 76.3 ± 0.5$^{c}$ | 68.9 ± 0.3$^{a}$ | 72.7 ± 0.2$^{b}$ | 75.2 ± 0.3$^{c}$ |
| Weight (kg) | 57.8 ± 0.3$^{a}$ | 51.7 ± 0.3$^{b}$ | 47.5 ± 0.7$^{c}$ | 57.5 ± 0.3$^{a}$ | 52.0 ± 0.3$^{b}$ | 48.5 ± 0.6$^{c}$ | 58.9 ± 0.3$^{a}$ | 53.1 ± 0.3$^{b}$ | 49.6 ± 0.4$^{c}$ |
| Waist circumference (cm) | 74.5 ± 0.2$^{a}$ | 69.9 ± 0.2$^{b}$ | 67.2 ± 0.6$^{c}$ | 74.3 ± 0.2$^{a}$ | 70.0 ± 0.3$^{b}$ | 67.7 ± 0.5$^{c}$ | 75.3 ± 0.3$^{a}$ | 70.7 ± 0.2$^{b}$ | 68.8 ± 0.3$^{c}$ |

[1] All values are means ± SEs by ANOVA adjusted for age and sex. $n$ = 2868. Sample size differed for body fatness ($n$ = 2855), lean body mass ($n$ = 2855), and waist circumference ($n$ = 2861). $PA_{low}$, physical activity coefficients assigned as low-active; $PA_{PAL}$, physical activity coefficients obtained from estimated physical activity levels; $PA_{MVPA}$, physical activity coefficients obtained from minutes of moderate-to-vigorous physical activity. Values within each dietary reporting method with different superscript letters are significantly different, $P < 0.05$ (Tukey's honestly significant difference test).

compared with 35.1%). More girls than boys were classified as overreporters on the basis of both $PA_{PAL}$ (14.1% compared with 8.6%) and $PA_{MVPA}$ (21.6% compared with 19.4%). Underreporters had lower mean counts per minute compared with plausible reporters and overreporters on the basis of $PA_{low}$ for both boys and girls (*see* supplemental Tables 1 and 2 under "Supplemental data" in the online issue). For methods using accelerometer data ($PA_{low}$ and $PA_{MVPA}$), overreporters had higher mean counts per minute than did plausible reporters and underreporters for both boys and girls. For girls, a greater proportion of underreporters than of plausible reporters and overreporters had an overweight or obese mother with all 3 methods; no associations were seen between reporting categories and maternal overweight/obesity for boys. Means for anthropometric variables were in a similar direction when stratified for boys and girls; underreporters had a higher BMI and percentage body fat than did plausible reporters and overreporters (*see* supplemental Tables 3 and 4 under "Supplemental data" in the online issue). Findings for milk and dairy foods were similar for boys and girls with respect to the direction of associations, although boys tended to have higher mean intakes of milk, dairy, and calcium than did girls (*see* supplemental Tables 5 and 6 under "Supplemental data" in the online issue).

## DISCUSSION

Studies using methods of Huang et al (9) to quantify reporting errors in children often lack objective measures of PA for estimating pER (7–9, 18). Our goal was to compare methods for capturing reporting errors when objectively measured PA is considered. We examined this method with low activity assigned to all participants, as done originally (9), and then applied accelerometer data to modify PA coefficients for calculating pER. Although the inclusion of objective PA resulted in different proportions of those classified as implausible reporters, a similar proportion of plausible reporters was captured with all methods. Associations with anthropometric and dietary variables were also similar across methods.

The percentage of underreporters classified from $PA_{MVPA}$ (37%) compared with $PA_{PAL}$ or $PA_{low}$ provided estimates that appeared reasonable, although higher, when compared with findings from 2 studies in children that assessed reporting errors through DLW, which ranged from 20% to 26% (3, 53). The proportion of underreporters captured by using $PA_{MVPA}$ was also comparable with other studies that used equations similar to those in our study (7, 8, 25). A study of 300 African American girls aged 8–10 y found similar estimates of underreporting to $PA_{PAL}$ and $PA_{low}$ ($\approx$50%) using the widely accepted Goldberg method (27). This study and others (26–28) used accelerometer data directly to calculate PAL values in assessing reporting errors using the Goldberg method (20). This method compares rEI with TEE as multiples of BMR and has several limitations in that only extreme inaccurate reporters are identified by using a 2-SD cutoff, and errors that can occur in assigning PAL are unaccounted for (19). Thus, we used methods of Huang et al (9), because they account for errors in rEI, pER, and biological variation from DLW-measured TEE. Furthermore, we calculated $PA_{PAL}$ from TEE prediction equations from a DLW study of 26 children aged 9 y. These equations are the most useful for assessing TEE at the group level because of the large SEE and

**TABLE 5**
Dairy, milk, and calcium intakes across dietary reporting methods in 2867 adolescents with an average age of 13.8 y participating in the Avon Longitudinal Study of Parents and Children[1]

| | $PA_{low}$ | | | $PA_{PAL}$ | | | $PA_{MVPA}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| Dietary intakes | Underreporter (*n* = 1476) | Plausible reporter (*n* = 1170) | Overreporter (*n* = 222) | Underreporter (*n* = 1486) | Plausible reporter (*n* = 1087) | Overreporter (*n* = 295) | Underreporter (*n* = 1065) | Plausible reporter (*n* = 1217) | Overreporter (*n* = 586) |
| Total milk (g) | | | | | | | | | |
| Model 1 | 180.2 ± 4.9$^{a,2}$ | 243.3 ± 5.5$^{b}$ | 319.9 ± 13$^{c}$ | 180.5 ± 4.9$^{a}$ | 242.1 ± 5.7$^{b}$ | 311.6 ± 11$^{c}$ | 171.8 ± 5.8$^{a}$ | 226.2 ± 5.4$^{b}$ | 279.6 ± 7.8$^{c}$ |
| Model 2 | 218.5 ± 5.9$^{a}$ | 210.2 ± 6.2$^{a}$ | 218.2 ± 15.4$^{a}$ | 212.8 ± 5.6$^{a}$ | 213.8 ± 6.2$^{a}$ | 233.3 ± 13$^{a}$ | 219.1 ± 6.9$^{a}$ | 214.5 ± 5.4$^{a}$ | 208.9 ± 9.7$^{a}$ |
| Full-fat milk (g) | | | | | | | | | |
| Model 1 | 30.3 ± 3.3$^{a}$ | 58.0 ± 3.7$^{b}$ | 115.8 ± 8.6$^{c}$ | 31.2 ± 3.3$^{a}$ | 56.7 ± 3.9$^{b}$ | 105.9 ± 7.5$^{c}$ | 24.1 ± 3.9$^{a}$ | 51.4 ± 3.7$^{b}$ | 86.0 ± 5.3$^{c}$ |
| Model 2 | 41.7 ± 4.1$^{a}$ | 48.1 ± 4.3$^{a,b}$ | 85.4 ± 10.7$^{c}$ | 42.5 ± 3.9$^{a}$ | 46.8 ± 4.3$^{a,b}$ | 78.4 ± 9.0$^{c}$ | 38.0 ± 4.8$^{a}$ | 47.9 ± 3.7$^{a,b}$ | 65.1 ± 6.7$^{c}$ |
| Low-fat milk (g) | | | | | | | | | |
| Model 1 | 141.6 ± 4.7$^{a}$ | 177.1 ± 5.3$^{b}$ | 190.1 ± 12$^{b,c}$ | 141.5 ± 4.7$^{a}$ | 176.6 ± 5.5$^{b}$ | 192.9 ± 11$^{b,c}$ | 139.8 ± 5.6$^{a}$ | 167.5 ± 5.2$^{b}$ | 180.6 ± 7.5$^{b}$ |
| Model 2 | 165.3 ± 5.8$^{a}$ | 156.6 ± 6.0$^{a}$ | 127.0 ± 15$^{a}$ | 160.3 ± 5.5$^{a}$ | 160.1 ± 6.0$^{a}$ | 147.4 ± 13$^{a}$ | 170.3 ± 6.8$^{a}$ | 159.9 ± 5.3$^{a,b}$ | 134.9 ± 9.5$^{c}$ |
| Nonfat milk (g) | | | | | | | | | |
| Model 1 | 8.3 ± 1.4$^{a}$ | 8.2 ± 1.5$^{a}$ | 14.1 ± 3.5$^{a}$ | 7.8 ± 1.4$^{a}$ | 8.9 ± 1.6$^{a}$ | 12.9 ± 3.1$^{a}$ | 8.0 ± 1.6$^{a}$ | 7.3 ± 1.5$^{a}$ | 13.0 ± 2.2$^{a}$ |
| Model 2 | 11.4 ± 1.7$^{a}$ | 5.5 ± 1.8$^{a}$ | 5.7 ± 4.4$^{a}$ | 10.0 ± 1.6$^{a}$ | 6.9 ± 1.8$^{a}$ | 7.5 ± 3.7$^{a}$ | 10.7 ± 2.0$^{a}$ | 6.6 ± 1.5$^{a}$ | 8.8 ± 2.8$^{a}$ |
| Total dairy (g) | | | | | | | | | |
| Model 1 | 219.1 ± 5.1$^{a}$ | 296.0 ± 5.8$^{b}$ | 386.7 ± 13$^{c}$ | 220.7 ± 5.1$^{a}$ | 292.6 ± 6.0$^{b}$ | 378.1 ± 12$^{c}$ | 208.7 ± 6.1$^{a}$ | 275.5 ± 5.7$^{b}$ | 339.1 ± 8.2$^{c}$ |
| Model 2 | 266.3 ± 6.2$^{a}$ | 255.2 ± 6.4$^{a}$ | 261.3 ± 16$^{a}$ | 261.1 ± 5.8$^{a}$ | 257.2 ± 6.4$^{a}$ | 280.1 ± 14$^{a}$ | 266.5 ± 7.2$^{a}$ | 261.2 ± 5.6$^{a}$ | 252.4 ± 10$^{a}$ |
| Full-fat dairy (g) | | | | | | | | | |
| Model 1 | 59.0 ± 3.5$^{a}$ | 98.6 ± 3.9$^{b}$ | 170.0 ± 9.0$^{c}$ | 61.0 ± 3.5$^{a}$ | 95.0 ± 4.1$^{b}$ | 160.9 ± 8.0$^{c}$ | 50.7 ± 4.1$^{a}$ | 89.4 ± 3.9$^{b}$ | 133.0 ± 5.6$^{c}$ |
| Model 2 | 78.1 ± 4.3$^{a}$ | 82.2 ± 4.5$^{a,b}$ | 119.5 ± 11$^{c}$ | 79.2 ± 4.1$^{a}$ | 79.1 ± 4.5$^{b}$ | 116.8 ± 9.4$^{b,c}$ | 73.6 ± 5.0$^{a}$ | 83.7 ± 3.9$^{b}$ | 98.7 ± 7.1$^{b,c}$ |
| Low-fat dairy (g) | | | | | | | | | |
| Model 1 | 151.8 ± 4.8$^{a}$ | 189.1 ± 5.4$^{b}$ | 202.7 ± 12$^{b,c}$ | 151.9 ± 4.8$^{a}$ | 188.7 ± 5.6$^{b}$ | 204.4 ± 11$^{b,c}$ | 150.0 ± 5.7$^{a}$ | 178.9 ± 5.3$^{b}$ | 193.1 ± 7.7$^{b,c}$ |
| Model 2 | 176.9 ± 5.9$^{a}$ | 167.5 ± 6.2$^{a}$ | 136.1 ± 15$^{a}$ | 171.9 ± 5.6$^{a}$ | 171.2 ± 6.2$^{a}$ | 155.8 ± 13$^{a}$ | 182.1 ± 6.9$^{a}$ | 170.9 ± 5.4$^{a,b}$ | 144.9 ± 9.7$^{c}$ |
| Nonfat dairy (g) | | | | | | | | | |
| Model 1 | 8.3 ± 1.4$^{a}$ | 8.2 ± 1.5$^{a}$ | 14.1 ± 3.5$^{a}$ | 7.8 ± 1.4$^{a}$ | 8.9 ± 1.6$^{a}$ | 12.9 ± 3.1$^{a}$ | 8.0 ± 1.6$^{a}$ | 7.3 ± 1.5$^{a}$ | 13.0 ± 2.2$^{a}$ |
| Model 2 | 11.4 ± 1.7$^{a}$ | 5.5 ± 1.7$^{a}$ | 5.7 ± 4.4$^{a}$ | 10.0 ± 1.6$^{a}$ | 6.9 ± 1.8$^{a}$ | 7.5 ± 3.7$^{a}$ | 10.7 ± 2.0$^{a}$ | 6.6 ± 1.5$^{a}$ | 8.8 ± 2.8$^{a}$ |
| Total calcium (mg)[3] | | | | | | | | | |
| Model 1 | 665 (653, 677)$^{a}$ | 916 (898, 934)$^{b}$ | 1108 (1064, 1153)$^{c}$ | 665 (653, 677)$^{a}$ | 898 (880, 916)$^{b}$ | 1097 (1054, 114)$^{c}$ | 665 (652, 679)$^{a}$ | 812 (796, 829)$^{b}$ | 992 (973, 1012)$^{c}$ |
| Model 2 | 804 (788, 821)$^{a}$ | 781 (765, 796)$^{a,b}$ | 699 (672, 728)$^{c}$ | 812 (798, 827)$^{a}$ | 812 (796, 829)$^{a}$ | 812 (781, 846)$^{a}$ | 812 (796, 829)$^{a}$ | 812 (798, 827)$^{a,b}$ | 735 (706, 765)$^{a,c}$ |

[1] $PA_{low}$, physical activity coefficients assigned as low-active; $PA_{PAL}$, physical activity coefficients obtained from estimated physical activity levels; $PA_{MVPA}$, physical activity coefficients obtained from minutes of moderate-to-vigorous physical activity. Model 1 values were calculated from ANCOVA and adjusted for age and sex. Model 2 was adjusted for age, sex, and total energy intake. Values within each dietary reporting method with different superscript letters are significantly different, $P < 0.05$ (Tukey's honestly significant difference test).

[2] Mean ± SE (all such values).

[3] Values are geometric means; 95% CIs in parentheses. Sample size differed for total calcium intakes (*n* = 2868).

wide limits of agreement observed (43). However, $PA_{PAL}$ may not be the most appropriate method for identifying inaccurate reporters because it calculates PAL for each individual, which possibly introduces additional error in predicting individual energy requirements.

In our study, $PA_{PAL}$ and $PA_{MVPA}$ classified a larger proportion of adolescents as overreporters than did $PA_{low}$. Several studies of children have identified between 15% and 25% of participants as overreporters by using prediction equations (7, 8, 18, 26) or TEE measured from DLW (3, 53), similar to the ≈20% of overreporters obtained on the basis of $PA_{MVPA}$. Fisher et al (3) found that 46% of children (European American and African American with a mean age of 7.7 y) were overreporters and 26% were underreporters on the basis of 24-h recalls, whereas Sjoberg et al (53) found that 17% of Swedish adolescents (mean age: 15.7 y) were overreporters and 26% were underreporters; both studies used DLW to assess TEE. In addition, other studies using methods of Huang et al to identify implausible reporters in children aged 9–11 y have reported proportions of overreporters from 16% to 25.1% and underreporters from 16.4% to 34% on the basis of 24-h recalls (7, 8, 18).

The proportion of underreporters and overreporters captured with the $PA_{MVPA}$ method in our study was comparable with the above estimates, and inconsistencies may have been due to differences in the nature of dietary reporting errors, the age of the study participants, and/or the methods used to assess dietary intake and PA. Nonetheless, our finding of 20% overreporters was surprising. In theory, the use of objectively measured PA at the individual level should lead to higher pER values for physically active children than the default method ($PA_{low}$), which assigns all individuals a low-active value. However, for children who participate primarily in light PA [eg, slow walking (4.4 km/h) or housework, such as washing dishes or cooking], pER may be underestimated with the $PA_{MVPA}$ method. Specifically, this method would classify such children as "sedentary," because it only includes minutes of MVPA to estimate the PA coefficients. Holding total energy intake constant, this underestimation of true PA could shift individuals from plausible reporters to overreporters, which may have spuriously inflated our estimate of overreporters. This misclassification may be especially true for girls, who generally participate in less MVPA than boys (54) but still participate in light-intensity activity that likely affects TEE. Indeed, we observed in a stratified analysis that a higher percentage of girls (22%) than of boys (19%) were classified as overreporters, although both boys and girls classified as overreporters had lower mean counts per minute than did plausible reporters and overreporters on the basis of $PA_{MVPA}$. This suggests that total PA (hence TEE) is likely underestimated for some individuals with this method. Light-intensity PA contributes about one-third to TEE in 14-y-old ALSPAC participants (unpublished observations, JA Mitchell, SN Blair, C Mattocks, et al, 2010). Currently, the health benefits of light-intensity activity are unclear. Recently, Healy et al (55) showed that breaks in sedentary activity that were mainly of light-intensity activity, as measured by accelerometers, were associated with lower waist circumference, BMI, triglycerides, and plasma glucose in adults. We are unaware of similar reports in children.

For all methods, underreporters had higher and overreporters had lower body weight, BMI percentiles, percentage body fat, and waist circumference measures than did plausible reporters; these findings are similar to other studies (3, 7, 18). A greater percentage of underreporters was dissatisfied with their weight and were always or often dieting (true for both boys and girls). As anticipated, underreporters also recorded consuming less dairy and calcium, whereas overreporters recorded consuming more than did plausible reporters (except for low-fat dairy). Boys tended to have higher average intakes of total, full-fat, and low-fat dairy and milk than did girls. As expected, for most results, differences in dietary intakes were attenuated after adjustment for total energy intake. For $PA_{MVPA}$, additional adjustment for total energy intake changed the direction of the associations with low-fat milk and dairy intakes such that overreporters had lower intakes of low-fat milk and dairy than did plausible reporters and overreporters, and underreporters had higher intakes than did overreporters. These findings suggest that foods other than low-fat milk and dairy are being reported less by underreporters, which may be due to the fact that low-fat versions of dairy and milk are considered healthier than other foods. On the other hand, overreporters had lower energy-adjusted intakes of low-fat milk and dairy, which suggested that other foods were being overreported by this group. Differential reporting of dietary intakes, particularly of low-energy-density foods, has been noted between plausible and implausible reporters, underscoring the importance of differences in diet quality and composition rather than in just quantity (7). Existing evidence indicates that accurate measures of dietary intakes are needed to better understand the role of diet in the development of obesity (8, 9). In a study of girls aged 11 y, Fiorito et al (8) found that girls consuming ≥3 servings/d of dairy had lower BMI percentiles, BMI *z* scores, and body fat than did those consuming <3 servings/d in an analysis that included both plausible and implausible reporters; however, no associations were observed between dairy intake, weight, or body fatness when only plausible reporters were examined. Our future work will examine relations between dairy and calcium intakes and body weight and fatness while considering the influence of implausible reporting on these associations in the ALSPAC study.

Research is needed to develop methods using the full spectrum of data available from accelerometers to estimate habitual and lifestyle PA as PAL values for individuals. This would ideally provide more precise estimates of TEE. Precise measures of habitual and lifestyle PA are required to best estimate TEE from DRI equations, a critical component of the reporting error equations developed by Huang et al (9). Including measured PA when quantifying reporting errors may have provided more realistic proportions of plausible and implausible reporters than assuming a low-active level for all children. To identify the most accurate method for capturing reporting errors, an adequately powered study with DLW and high-quality measures of dietary intake and PA is needed.

This study had several limitations. Most important, we did not have the gold standard measure of energy expenditure, DLW, to apply to our equations. Thus, errors may have been introduced in the estimation of TEE and BMR. In particular, it is possible that some subjects were misclassified when $PA_{MVPA}$ was used, because this method does not account for "light" activity, as mentioned previously, because all PA categories were defined on the basis of minutes of MVPA. Whereas accelerometers are one of the most accurate methods available for assessing PA, they do have limitations. The Actigraph cannot be used during water sports, and accelerometers generally do not reflect the exercise intensity of cycling or moving up and down inclines or stairs, which contribute to TEE. There is also inconsistency in the literature in approaches to processing the raw data. For example, issues such as how to distinguish between periods of nonwear time and bouts of sedentary behavior have yet to be resolved (56), and calibration studies have produced a variety of different cutoffs to estimate MVPA (46, 57, 58). The use of 1-min epochs may lead to underestimation of vigorous PA, as noted by others (59), although the memory size of accelerometers during the time of data collection limited us to 1-min epochs. Such unresolved issues may lead to an underestimation of total activity, and hence TEE. Whereas we believe that this study furthers our understanding of reporting errors in children by applying accelerometer data, these limitations underscore the need for future work that uses gold-standard measures of energy expenditure. In addition, our study sample was relatively homogeneous in that most participants were non-Hispanic whites; additional work should examine differences in reporting errors in a more representative population, because adolescents of different race-ethnicities may differently report dietary intakes (60). Finally, because this was a large epidemiologic study, dietary data were based on self-report. Important strengths of this study included objective measures of PA, high-quality dietary measures collected by using 3-d diet records, precise measures of body composition, a large sample size, and a wide range of covariates.

In summary, our study contributes to the literature on quantifying dietary reporting errors by incorporating accelerometer data into the calculations for underreporting and overreporting. Whereas our methods seemed to provide more reasonable estimates of plausible and implausible reporters than assuming that all participants are low-active, we were only able to include minutes of MVPA and not light activity in the assessment of PAL. Future research should focus on the use of the full range of accelerometer data to assess habitual and lifestyle PA, which would further refine methods for capturing and understanding reporting errors in dietary studies. Importantly, better measurement and adjustment of dietary reporting errors will, in turn, improve the precision and accuracy of results in studies of diet and disease.

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The authors' responsibilities were as follows—SEN: was responsible for the analyses and interpretation of data and preparation of the manuscript; CM: contributed to the analyses and interpretation of the data and to the preparation of the manuscript; PE: was responsible for the acquisition and preparation of the dietary data; CJR and ARN: were responsible for the acquisition and preparation of the PA data, helped in the preparation of the manuscript, and helped with the analyses of this manuscript; and PKN: was instrumental in the design of the study, the analysis and interpretation of the data, and the preparation of the manuscript. All of the authors critically reviewed and approved this manuscript for publication. The authors had no conflicts of interest.

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