Use of Tape-Recorded Food Records in Assessing Children's Dietary Intake

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Abstract

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Background: Dietary assessment among children is particularly problematic when techniques are dependent on memory skills or advanced cognitive development.

Objective: The current study explored the use of self-report by tape recorders to document children's dietary intake immediately upon consumption, and compared this method with the traditional, interviewer-guided recall technique. In addition, the influence of body fatness and sociodemographic characteristics on the accuracy of recall and tape-recorded food records was determined.

Research Methods and Procedures: The sample included 30 black and white children aged 6.5 to 11.6 years ($\bar{x} = 9.5$). Energy intake (EI), measured by six 24-hour food records (three for each method), was compared with total energy expenditure calculated by the doubly labeled water technique. Paired *t* tests, correlation analyses, and multiple regression analyses were performed.

Results: The analyses revealed poor validity of the tape recorder method ($\bar{x}$ misreporting score $= -1.13 \pm 2.62$ MJ/day, *r* for total energy expenditure and EI $= -0.06$, $p = 0.74$). Estimates of EI differed significantly between the tape recorder and recall methods ($p < 0.01$). The traditional recall method was confirmed as a valid estimate of energy intake ($\bar{x}$ misreporting score $= 0.04 \pm 2.38$ MJ/day), although demonstrating a modest correlation with TEE ($r = 0.32$, $p = 0.08$). Although no significant predictors of misreporting using the recall method were identified in the multivariate analyses, older children and children with higher adiposity were more likely to misreport using the tape recorder method.

Discussion: The results suggest that the use of the tape recorder for estimating EI does not result in accurate assessments among children, although this technique may be useful for specific subgroups (i.e., younger and leaner children).

Key words: dietary assessment, dietary recall, doubly labeled water, energy intake, energy expenditure

Introduction

Improvements in the measurement of energy intake and energy expenditure are necessary to accurately assess risk for the development of obesity and subsequent health problems. Patterns of dietary consumption are particularly important to discern among children, as health behaviors formed in childhood are thought to endure into adulthood (1). In addition, several chronic diseases influenced by dietary patterns may originate in childhood (2). Thus, accurate dietary assessment among children is an important goal, because it allows researchers to determine whether dietary recommendations for children are being followed and to explore the immediate and long-term health consequences of dietary patterns.

The measurement of energy intake has received an increasing amount of attention with the recent capability to validate various dietary measurement techniques by utilizing doubly labeled water (see, for example Refs. 3–6). The doubly labeled water technique has been established as an accurate method for measuring total energy expenditure in free living conditions over a limited period of time (7). Based on the principle that energy intake and energy expenditure are equivalent among persons in energy balance, energy expenditure derived from doubly labeled water can serve as a criterion method for energy intake derived from various techniques. Indeed, controlled studies in which energy intake is monitored indicate a strong association between energy intake and energy expenditure measured by the doubly labeled water method (8–10). The use of the

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doubly labeled water technique has been confirmed as an appropriate strategy for assessing the accuracy of dietary measurement in children (11–13) and adults.

Various dietary collection methods have achieved divergent levels of success at accurately estimating energy intake in children. For example, food diaries (4,14,15), food-frequency questionnaires (14,16), and 24-hour recalls (5) have all been validated against the doubly labeled water technique, although no dietary assessment technique has consistently emerged as the best strategy for children (or adults). The accuracy of self-reported food intake is subject to a significant amount of variability. Previous research has shown that estimates of energy intake appear to be more accurate for younger children (4,14,17) and leaner persons. Indeed, several studies have reported that accuracy is around 15% (18) to 20% (17) higher for non-obese than obese persons.

Several new approaches, although not validated against the doubly labeled water method, have been suggested as alternatives to traditional techniques of dietary assessment among children, and may overcome some of the weaknesses of previous approaches. For example, computer-assisted self-interviewing (19), pictorial-recall questionnaires in which children paint pictures of items consumed (20), and food photography (21, 22) have been considered as novel approaches to food intake assessment. However, one of the reasons that an accurate assessment of food intake among children has been particularly problematic is that most self-report techniques rely heavily on memory recall and cognitive development, which are rather limited in childhood (23). Although the strategies used by children to recall their food intake have been qualitatively explored (24), techniques for reducing error in memory-based recalls have not been developed. In particular, the underestimation of actual intake (in terms of both foods consumed and portion sizes) is common when assessment depends on memory (25,26).

Thus, although existing techniques for assessing dietary intake are useful methods, poor memory and difficulty complying with detailed instructions may render such techniques problematic among children. Measurement approaches involving documentation at the time of consumption and which are easy to use are likely to improve the accuracy of dietary assessments. Therefore, utilizing a tape recorder to document foods and portion sizes immediately upon consumption may be an ideal technique to explore children's dietary patterns. Initially suggested by Rockett and Colditz (27), the tape recorder method may hold several practical advantages over previous methods for assessing food intake among children, in addition to its primary benefit of not requiring advanced memory recollection. The strengths of the tape recorder method are its convenience and ease of use for children, immediacy, and efficiency (27) in assessing energy intake. It is also likely to be perceived favorably as a technological novelty by children (27), which may increase interest and possibly accuracy in intake estimates.

Therefore, the current study explores the validity of the self-reported tape recorder technique as a method of assessing energy intake among children aged 6.5 to 11.6 years ($\bar{x}$ = 9.5), utilizing energy expenditure assessed by doubly labeled water as a reference criterion. To our knowledge, no other studies have utilized tape recorders to assess free-living dietary intake in children or adults. The validation of this method is likely to make a significant contribution to energy intake assessment. In addition, we determine whether the tape recorder technique contributes to greater accuracy in dietary assessment than the widely used and previously validated (5) 24-hour recall technique. Finally, we explore the influence of sociodemographic background characteristics and body fatness on the accuracy of self-reported energy intake measured by both techniques. We hypothesized that the tape recorder method would be a valid method for energy intake assessment in children, and that accuracy in energy intake estimates will be improved utilizing the tape recorder method rather than the traditional recall method, due to its advantage as an immediate, rather than memory-dependent, technique.

Methods and Procedures

Sample

The data for this study were derived from an ongoing, longitudinal study of childhood obesity in Birmingham, Alabama. Approximately 120 healthy black and white children, recruited through advertisements, flyers, and word of mouth, currently participate in the study. The children represent a wide range of body sizes and activity levels. Each year, the children are admitted to the General Clinical Research Center (GCRC) for an overnight visit. Data are collected on anthropometrics, resting energy expenditure, sociodemographic background, dietary intake, and habitual physical activity. In addition, baseline urine samples are collected and the subjects are orally dosed with doubly labeled water at this time. Two weeks later, the children undergo further testing at the Department of Nutrition Science, at which time data on aerobic fitness and body composition are gathered. Further dietary assessment and the collection of additional urine samples utilized for the measurement of total energy expenditure by the doubly labeled water method are also completed.

The analyses in the current study were cross-sectional, and utilized a subsample of 30 children selected by gender and race to obtain roughly equal numbers of boys (n = 17) and girls (n = 13), and whites (n = 17) and blacks (n = 13). All data were collected during the school year to derive comparable estimates of habitual

dietary intake and energy expenditure, with 12 subjects completing testing from January through May of 1998, and 18 subjects completing testing from September through November of 1998. As described in further detail below, each subject completed three 24-hour dietary recalls and three 24-hour tape-recorded food records within 2 weeks of being dosed with doubly labeled water. Upon completion of the dietary assessment, the children received a $10 cinema voucher for their participation in the substudy. The study protocol was approved by the University of Alabama at Birmingham Institutional Review Board, and written informed consent was obtained from the parents and children before participation.

Energy Intake Measurement

To validate the use of tape-recorded food records to accurately measure energy intake, and to compare the energy intake assessed with the tape recorder method to intake assessed with dietary recalls, the subjects completed a total of six records (three 24-hour records by each technique) within the 2-week time period that total energy expenditure was measured. Both methods of dietary intake included two week days and one weekend day. The children completed their first 24-hour dietary recall during their overnight stay at the GCRC, to become familiar with reporting food intake and using the two-dimensional food models required for both techniques. The second dietary recall was conducted over the telephone on a date randomly selected by the investigators and unknown to the subjects. The final dietary recall was conducted on the last day of the 2-week period, at which time the subjects returned to the Department of Nutrition Sciences for urine collection, treadmill testing, and body composition analysis. All dietary recalls were conducted utilizing the "multiple pass" method, which has been validated and previously described in detail by Johnson et al. (5). This method requires that a trained interviewer gather food consumption information from the subjects in three "passes": a quick list, in which the individual recalls foods consumed within the past 24-hour period uninterrupted by the interviewer; a detailed description, in which the subject is asked to clarify foods mentioned in the first pass and recollect unreported foods; and the review, in which the interviewer reviews all foods and beverages mentioned and probes for additional foods and clarifies serving sizes. Portion sizes were estimated using two-dimensional food models designed for use with the Food Intake Analysis System (FIAS; Health Science Center, University of Texas). These food models portray common household measurements and serving utensils. All dietary recalls were conducted in the presence of one of the child's parents (usually the mother).

The tape-recorded food records also represent 24-hour periods and estimate serving sizes from the two-dimensional food models utilized in the recalls. To measure dietary intake using the tape recorder method, each subject was randomly assigned three nonconsecutive days within the 14-day dosing period to tape record all foods and beverages consumed within the 24-hour period. The children were given detailed verbal and written instructions specifying the degree of detail required in the record (e.g., name brands of foods, portion sizes, method of cooking, etc.), along with a two-dimensional food model to use during recording, and a hand-held tape recorder. Each subject was phoned on the evening before his or her scheduled recording date and given a reminder to tape record all foods and beverages consumed the following day. All subjects completed the three food records, although the quality of the records varied across the sample. Because the purpose of the study was to determine the potential use of the tape-recorder technique to produce accurate estimates of energy intake, no records were excluded from the analyses. Eliminating apparently poor or incomplete records would have biased the results toward more compliant subjects, potentially inflating the accuracy of the technique.

All food records were coded and entered into FIAS by a trained interviewer who was blinded to the hypothesis of the study. The FIAS program is based on the USDA Nationwide Food Consumption Survey, Continuing Survey of Food Intakes by Individuals, and allows for comparisons of nutritional intake between a particular sample and nationally representative children. FIAS is also an advantageous system because it allows for the addition of foods not included in the database, the modification of recipes, and the selection of default portion sizes representing commonly consumed portions of specific foods. Because the major research goals of the current study were the validation of the tape recorder method and a comparison of the accuracy of the tape-recorder and recall techniques using the doubly labeled water method to assess energy expenditure, it was necessary to obtain an average estimate of the total energy intake consumed using both methods. Thus, the average MJ/day consumed over 3 days using both methods was used as the measurement of energy intake.

Total Energy Expenditure Measurement

Total energy expenditure was measured over the 14-day period between the children's overnight stay in the GCRC and their return visit to the Department of Nutrition Sciences. Thus, energy expenditure reflects free living conditions. The subjects were orally dosed with doubly labeled water of 0.15 $H_2{}^{18}O$ and 0.12 g ^2H_2O per kilogram of body mass after a baseline urine sample was collected. Two additional urine samples were collected the morning after dosing, and two final urine samples were collected in the morning 14 days later. Isotope ratio mass spectrometry was used to analyze the samples for $H_2{}^{18}O$ and ^2H_2O at the Department of Nutrition Sciences at the University of Alabama at Birmingham. Turnover rates and dilution spaces of

$H_2{}^{18}O$ and ^2H_2O, carbon dioxide production rates, and total energy expenditure were calculated [for a more detailed description, see Goran et al. (28)]. The average daily estimate of energy expenditure, expressed in MJ/day, was used as the comparison value for measures of energy intake.

Independent Variables

To determine whether the accuracy of energy intake estimates using the two methods was influenced by body fatness or other potentially relevant background characteristics, several factors were included as predictor variables in the multivariate analyses. *Body fat* was determined by DXA, using a Lunar DPX-L densitometer and pediatric software, and is expressed as residualized fat mass (the residual of fat mass regressed on fat free mass). Sociodemographic characteristics included *age, gender* (0 = male, 1 = female), *ethnicity* (0 = white, 1 = black), and *social class background*, measured by the Hollingshead 4-factor index of social class (29), which combines the educational attainment and occupational prestige for the number of working parents in the child's family.

Statistics

The data were analyzed using SPSS/PC+ software (Version 8.0, Chicago, IL). First, to compare group estimates of energy intake and energy expenditure, means and standard deviations were calculated for daily energy intake measured by the tape-recorder and recall methods, and energy expenditure assessed by the doubly labeled water method. In addition, mean misreporting scores were calculated by obtaining the difference between energy intake and energy expenditure. Paired *t*-tests were used to determine significant within-subject differences in the estimates of energy intake and expenditure. Next, to determine whether the traditional recall method and the tape recorder method displayed an acceptable linear association with doubly labeled water assessed energy expenditure, the correlations and regression between the two measurements was determined using Pearson product-moment correlation coefficients. The agreement between the two energy intake methods and total energy expenditure was determined according to the method of Bland and Altman (30). Finally, to explore potential determinants of children's inaccuracy in food records, multivariate analyses were conducted using ordinary least squares regression. The extent of inaccuracy in both recall and tape-recorded food records served as the dependent variables, and residualized fat mass, age, gender, ethnicity, and social class were explored as potential predictors.

Results

Descriptive information about the sample is provided in Table 1, with background characteristics presented separately by gender and ethnicity. As indicated in the table, the average age of sample was 9.5 years ($\pm$1.4), with no significant gender or ethnic differences. A highly significant ethnic difference was observed for family social class background ($p < 0.001$). Both components of social class included in the Hollingshead Index, parental educational attainment and occupational prestige, were lower for black children. For example, 80% of white children and 54% of black children had mothers with at least some college education. In addition, while 100% of employed white mothers worked in semiprofessional or professional positions, only 50% of employed black mothers worked in such positions (a similar discrepancy was observed with employed fathers: 82% of white and 29% of black fathers were employed in semiprofessional or professional positions). Several ethnic differences in body composition were evident. Black children were significantly taller and weighed more than white children. In addition, although no ethnic differences in fat mass were evident, black children had higher levels of fat free mass than white children ($p < 0.01$). No significant gender differences in body composition were evident.

Table 2 presents estimates of average energy expenditure and energy intake using both the tape recorder and recall methods. In addition, the extent of misreporting, or the difference between energy expenditure and intake, is presented for each method. As noted in the table, daily estimates of energy intake using the recall method were not significantly different from energy expenditure, and the average difference between the two methods was only 0.04 MJ/day. Estimates of energy intake measured by the tape recorder method differed significantly from energy expenditure ($p < 0.05$). The mean difference between the two estimates was -1.13 MJ/day, indicating a significant underestimation of tape recorder-assessed energy intake. Thus, the group estimates of within-subject differences indicate poor validity of the tape recorder method. Although not shown in Table 2, ANOVAs were conducted to determine whether gender or ethnic differences in misreporting using the two methods were evident. The results indicated that misreporting utilizing the tape recorder method was significantly higher among black children ($\bar{x}$ difference score = -2.44 MJ/day) than white children ($\bar{x}$ difference score = -0.23 MJ/day, $p = 0.02$ for ethnic effect). No ethnic differences in misreporting using the recall method were evident, nor were gender differences for either method.

The next series of analyses determined the strength of the linear association between energy intake measured by the two methods and total energy expenditure. The results of the regression analyses and Bland-Altman plots are presented in Figures 1 and 2. Figure 1A indicates relatively good agreement between energy expenditure and energy intake measured by the recall method, although the correlation coefficient was not statistically significant ($p = 0.08$) and the intercept is significantly different from 0 ($\alpha = 5.3$, $p = 0.001$). In addition, as shown in Figure 1B, no systematic

Table 1. Background characteristics of all subjects, by gender and ethnicity

	Total sample ($n = 30$)	Girls ($n = 13$)	Boys ($n = 17$)	Black ($n = 13$)	White ($n = 17$)	Significant effects
Age (yr)	9.5 (± 1.4)	9.7 (± 1.5)	9.3 (± 1.4)	9.7 (± 1.5)	9.3 (± 1.4)	None
Social class	44.3 (± 15.8)	41.0 (± 13.7)	46.7 (± 17.0)	33.2 (± 16.0)	52.7 (± 9.3)	Ethnicity ($p < 0.001$)
Height (cm)	139.8 (± 10.2)	141.3 (± 10.1)	138.7 (± 10.4)	144.3 (± 10.2)	136.4 (± 9.1)	Ethnicity ($p < 0.05$)
Weight (kg)	42.0 (16.6)	42.9 (± 17.0)	41.2 (± 16.6)	49.1 (± 20.1)	36.5 (± 11.1)	Ethnicity ($p < 0.05$)
Body mass index	20.9 (± 5.8)	20.8 (± 5.4)	20.9 (± 6.3)	23.0 (± 7.3)	19.3 (± 3.9)	None
Fat mass (kg)	12.3 (± 10.4)	13.1 (± 10.4)	11.7 (± 10.6)	16.0 (± 12.9)	9.5 (± 7.2)	None
Fat free mass (kg)	27.1 (± 6.4)	27.3 (± 6.9)	26.9 (± 6.2)	30.7 (± 7.2)	24.3 (± 4.1)	Ethnicity ($p < 0.01$)
% body fat	26.3 (± 11.6)	27.9 (± 10.3)	25.1 (± 12.7)	28.8 (± 12.6)	24.4 (± 11.7)	None

error in misreporting was evident across the range of energy intake and expenditure levels. The correlation between energy expenditure and energy intake measured by the tape recorder method was not significant ($r = -0.06$), as indicated in Figure 2A, and the intercept is significantly different from 0 ($\alpha = 8.4$, $p < 0.001$). In addition, the Bland-Altman plot shown in Figure 2B suggests that, at higher levels of energy intake and expenditure, under-reporting of energy intake occurred, although this pattern did not reach statistical significance ($p = 0.08$).

The final series of analyses explored characteristics associated with misreporting using the tape recorder and recall methods. To determine potential predictors of inaccuracy in food records, the absolute values of the misreporting scores based on each method were derived and used as dependent variables in the analysis. This procedure was used because misreporting took the form of both under- and over-reporting. For example, 61% of the subjects under-reported energy intake using the tape recorder method (with 26% over-reporting and 13% accurately reporting, using a range of ±0.42 MJ/day to define accuracy), and 43% of the subjects under-reported energy intake using the recall method (40% over-reported and 17% accurately reported). This pattern indicates that measurements of misreporting commonly used in previous analyses, such as the percentage of total energy intake actually reported by the subject or simply the difference between energy intake and energy expenditure, are inappropriate dependent variables for the current analysis due to their bi-directional nature. For example, a value of 0 indicates perfect accuracy, with both decreasing *and* increasing values indicating greater inaccuracy. Therefore, the absolute values of the misreporting scores, which reflects the magnitude (and not the direction) of inaccuracy were derived and used as dependent variables. The results of the regression analyses, which considered the influence of body fat and sociodemographic background characteristics on the accuracy of energy intake, are presented in Table 3.

Table 2. Mean estimates of TEE, energy intake, and misreporting for all subjects

	Total sample ($n = 30$)
TEE (MJ/day)	7.86 (± 2.06)
EI (MJ/day)—tape recorder method	6.73 (± 1.47)
EI (MJ/day)—recall method	7.90 (± 2.02)
Misreporting (MJ/day)—tape recorder method	−1.13 (± 2.62)
Misreporting (MJ/day)—recall method	0.04 (± 2.38)
Significant effects	TEE and tape EI ($p < 0.05$) Tape EI and recall EI ($p < 0.01$)

Interestingly, although ethnic differences in misreporting using the tape recorder method were evident at the bivariate level, no ethnic differences in inaccuracy emerged in the multivariate analyses. This suggests that other factors, such as body composition or social class background, may have confounded the bi-variate relationship between ethnicity and misreporting. The only significant predictors of inaccuracy in tape recorder-assessed energy intake were age and residualized fat mass. Older children and children with greater adiposity had higher levels of inaccuracy in their tape-recorded food records. These significant relationships were further examined by calculating misreporting scores for several age groups and fatness levels. Mean misreporting scores increased with age (6 to 8 year olds = 1.4 MJ/day, 9 to 10 year olds = 2.0 MJ/day, 11 to 12 year olds = 2.8 MJ/day). Regarding the influence of residualized fat mass, which was used to categorize the sample into quartiles, the greatest degree of inaccuracy using the tape recorder method appeared to occur among children in the

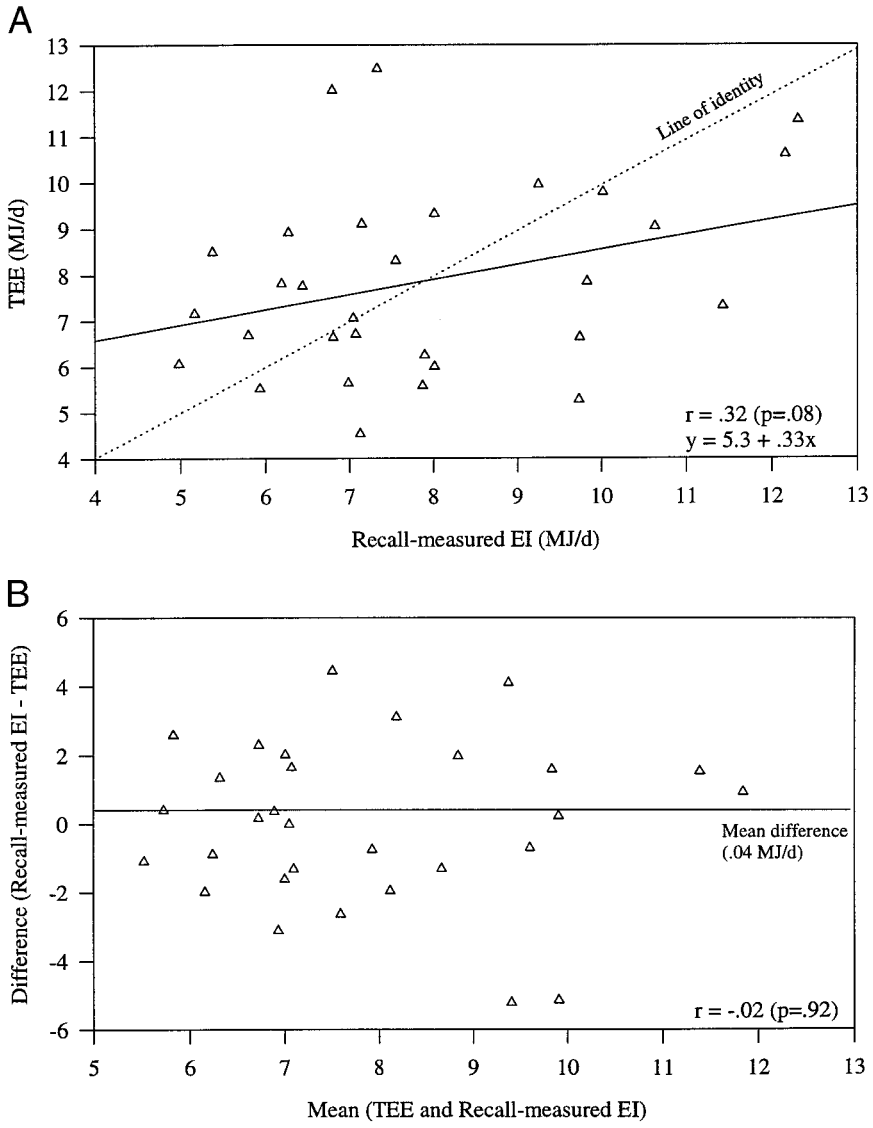

Figure 1. (A) Relationship between total energy expenditure (TEE) and recall-measured energy intake (EI). (B) Agreement between total energy intake (TEE) and recall-measured energy intake (EI).

highest quartile of body fatness (bottom 25% = 1.9 MJ/day, 25th through 50th percentiles = 1.9 MJ/day, 50th through 75th percentiles = 1.0 MJ/day, top 25% = 3.9 MJ/day).

Although the data are not presented, to determine the *direction* of inaccuracy (i.e., over- or under-reporting) in tape-recorded food records, subjects were classified as either under- or over-reporters for energy intake, and logistic regression analysis was employed to determine the significance of predictor variables in influencing under- vs. over-reporting. These analyses revealed a significant relationship with age: older children were more likely to under-report than over-report ($p < 0.05$). The direction of the relationship between body fatness and inaccuracy was not significantly established through logistic regression.

As shown in Table 3, inaccuracy in energy intake measured by the traditional 24-hour recall technique was not significantly predicted by body composition or sociodemographic characteristics. Therefore, further analyses on the direction of misreporting using the recall method were not performed. Half as much variation in inaccuracy using the recall method was explained (16%), compared to the tape recorder method (30%).

Discussion

The analyses conducted to determine the validity of the tape recorder method for use among children revealed poor within-subject agreement and a weak linear association with energy expenditure measured by the doubly labeled water

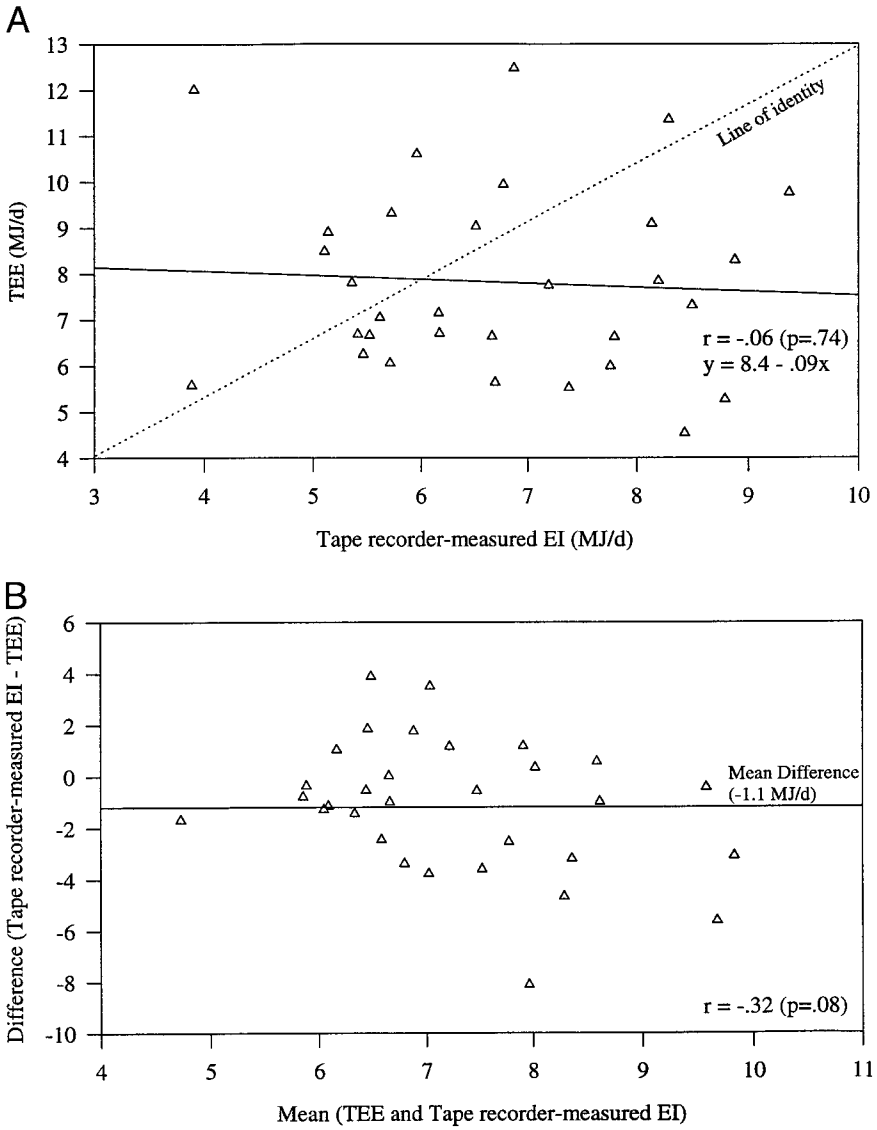

Figure 2. (A) Relationship between total energy expenditure (TEE) and tape recorder-measured energy intake (EI). (B) Agreement between total energy intake (TEE) and tape recorder-measured energy intake (EI).

technique. Error in accuracy was not random, with underreporting tending to occur at higher levels of energy intake and expenditure, although this pattern was not statistically significant. In addition, multivariate analyses revealed that older children and children with higher adiposity were more likely to misreport using the tape recorder method. Thus, the tape recorder method achieved greater accuracy among younger and leaner children and therefore may potentially be of use for these subgroups of the general population.

Consistent with previous research, the traditional 24-hour dietary recall method used in triplicate was confirmed as a valid estimate of the group energy intake of the sample (5). However, the recall technique demonstrated only a modest linear association with total energy expenditure, as the correlation between the two estimates was not statistically significant. No systematic bias in misreporting was evident, and no significant predictors of misreporting utilizing the recall method emerged, with regard to age, gender, ethnicity, social class, and adiposity.

The results of the current study suggest the importance of the interviewer in obtaining accurate dietary estimates among children. The role of the interviewer in traditional recall methods involves a great deal of probing, clarification, and repeated "passes" in eliciting children's recollection of food intake. Indeed, the major advantage of the recall method over many other techniques, including tape-recorded food records, is its dependence on a trained interviewer. The tape recorder method examined in this study was an extremely subject-dependent technique. Although the children were given detailed verbal and written instruc-

Table 3. Regression of misreporting (using tape recorder and recall methods) on body composition and sociodemographic predictors ($n = 30$)

	Misreporting (tape recorder)		Misreporting (recall)	
Independent variable	**Coefficient (MJ/day)**	***p***	**Coefficient (MJ/day)**	***p***
Gender (1 = F)	−0.71	(0.30)	−0.27	(0.63)
Ethnicity (1 = black)	−0.08	(0.92)	0.16	(0.83)
Social class	−0.03	(0.25)	0.00	(0.96)
Age (yr)	0.48*	(0.05)	0.33	(0.10)
Body fat (kg)	0.12*	(0.04)	0.06	(0.18)
Constant	−0.64		−1.20	
R^2	0.30		0.16	

tions, and although they had completed numerous 24-hour recalls throughout their participation in the study, keeping tape-recorded food records was a novel technique and required individual motivation and skill. In contrast, one of the major strengths of the recall method is that the interviewer has a significant amount of control over the quality of the food record. The results presented in this paper suggest that relinquishing this control to subjects, perhaps especially to children, has an adverse effect on the quality of the data. Subject control may be particularly detrimental when participants are not rewarded for the accuracy of their records. Reinforcement for the quality of tape-recorded food records may have yielded more accurate results. This reinforcement was not as essential for the recall technique, which is interviewer-controlled. Interviewer control may result in helpful guidance with the recall as well as moderate pressure on the child to complete an accurate record—both of which are likely to increase the accuracy of energy intake estimates using the recall method. Another explanation for the accuracy of the recall technique compared to the tape recorder method is the children's greater experience and familiarity with the former technique.

However, with children and other populations facing memory limitations, the major disadvantage of the recall method is its dependence on memory. Thus, it was hypothesized that because the tape recorder method did not rely on memory skills, it would produce more accurate estimates of energy intake than the recall method. Yet, the results of the current analyses indicate that any advantage gained from recording food intake immediately upon consumption was outweighed by the numerous sources of error resulting from self-reliant intake techniques. For example, during the reviewing and coding of the tape-recorded food records, it became evident that the participants often overlooked snacks, condiments, and beverages in their records, focusing primarily on major meals consumed. In addition, portion sizes were poorly described and frequently left out entirely. Most notably, it appeared likely that several participants did not record their food intake immediately upon consumption (contrary to the instructions), but waited until the end of the day to provide a cumulative report of the day's energy intake. This pattern indicates that the major advantage of the tape recorder method, its immediacy, may be more theoretical than practical. However, the pattern observed in the current study may be merely anecdotal, as we did not record data on the apparent sources of error associated with the tape-recorded records, and further research is needed to empirically establish the extent of subject compliance with the tape recorder method.

In addition to the poor validity of the tape recorder method in general, it was also found to be particularly problematic for certain subgroups of children. For example, bi-variate analyses indicated that the tape recorder method was less accurate for black children than white children. However, no ethnic differences in misreporting emerged in the multivariate analyses, indicating that the relationship between ethnicity and inaccuracy using the tape recorder method may have been due to potential confounders such as body composition or social class background. Although the later factor was not identified as a predictor of misreporting, adiposity did significantly predict inaccuracy in tape-recorded food records. In addition, inaccuracy (specifically, under-reporting) in energy intake using the tape recorder method was significantly higher among older children.

Although the pattern of greater inaccuracy with age seems counter-intuitive, because older children would be expected to understand and comply with instructions better than younger children, it has been identified in several previous studies. For example, Livingstone et al. (14) found that estimates of energy intake among 7- and 9-year-old children were more accurate than those of 12 and 15 years old. Similarly, Bandini et al. (17) reported that among 8- through 12-year-old girls, under-reporting increased with age. Some of the inaccuracy associated with age may be attributed to increasing pressure to provide socially desirable responses. For example, older children may be more aware of value judgments accompanying the quality and quantity of foods they report. Similarly, children with higher levels of body fat may be more conscious of the social stigma associated with certain food consumption patterns, and therefore may provide less realistic estimates of food intake. The social desirability interpretation may also explain why under-reporting energy intake was more likely at higher levels of energy expenditure and intake (Figure 2B). In short, greater awareness of social pressure to consume fewer calories (and, although not explored in the

current study, less dietary fat) may be responsible for the significance of age and body fat as predictors of inaccuracy in energy intake.

However, the relationship between age, body fat, and inaccuracy in energy intake only occurred with tape-recorded food records. This pattern is perplexing because one would expect *less* of a social desirability bias to occur with the tape recorder method than with the recall method, as a greater amount of anonymity is provided with the former technique. Indeed, anonymity can be considered one of the advantages that the tape recorder method holds over interviewer-based techniques. The social desirability interpretation suggests that estimates of energy intake provided in the presence of an interviewer would be expected to be more inaccurate than self-recorded estimates, due to the influence of social pressures toward healthful dietary patterns. In addition, interviewer-guided estimates of energy intake would be expected to be more inaccurate for older and more overweight children, who may experience greater social pressure. Yet, neither age nor adiposity were associated with inaccuracy using the recall method, suggesting that additional interpretations are necessary. One interpretation, which stems from further consideration of the social desirability response (31), suggests that the two dietary techniques may promote two distinct types of misreporting. The recall method, which is conducted in the presence of the interviewer, may be subject to attempts to appear favorable in front of others. Known as "other-deception," or impression management (31), such strategies are distinct from attempts to appear favorable in front of oneself. The tape recorder method, in providing anonymity, may be conducive to measurement error based on self-deception, or attempts to deceive oneself by denying threatening thoughts (31). It is possible that in preserving their self-esteem, older and more overweight children may be particularly vulnerable to the "unconscious defensiveness that underlies self-deceptive responding" (31), because they do not want to admit to themselves how much they eat.

Other possibilities for age differences in the accuracy of tape-recorded estimates, initially suggested by Bandini et al. (4) include the effects of greater independence experienced by older children, which is likely to be accompanied by less parental involvement in children's food choices and dietary records. In short, although no data from the current study are available, inaccuracy in tape-recorded food records may have been greater for older children simply because they received less assistance from their parents than the younger participants in the study.

Conclusions

Although the results of the current study do not support the use of the tape recorder method for dietary assessment among children, this technique may be useful for subgroups, such as younger and leaner children. Future research is needed to address several issues relating to this novel technique. Specifically, details related to subject compliance would be useful, such as the time difference between consumption and recording, the types of foods that were omitted (or added), and the extent of assistance from parents or others. In addition, the validity of tape-recorded food records should be determined among samples containing wider age ranges. The current study included a relatively limited age range (6.5 through 11.6 years), which precludes significant generalization. It is possible that the tape recorder method would result in greater validity among younger children, due to greater parental involvement, or adults, due to stronger motivation and higher compliance. Regardless of the age range under study, future studies utilizing larger samples are needed to accurately determine predictors of the direction of misreporting. The current study relied on a small sub-set of participants, which limited the ability to identify characteristics associated with over- or under-reporting.

In conclusion, the results of the current study illustrate the advantage of the traditional recall method over tape-recorded estimates of food intake among children. The strengths of the recall method, mainly the control of the interviewer over the quality of the data, appear more influential than the potential advantages of the tape recorder method, such as immediacy and anonymity. Validated against the doubly labeled water technique to assess total energy expenditure, the recall method can clearly provide accurate estimates of group energy intake among children. Recall-based estimates of energy intake have extensive public health applications, such as the exploration of determinants of energy intake, the examination of potential health consequences of dietary patterns, and the identification of population subgroups in need of dietary interventions or nutrition education. However, both the recall and the tape recorder techniques can be strengthened by ensuring that subjects receive proper training and experience and providing appropriate incentives for the accuracy of completed records.

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