A validation study concerning the effects of interview content, retention interval, and grade on children's recall accuracy for dietary intake and/or physical activity

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Abstract

Background—Practitioners and researchers are interested in assessing children's dietary intake and physical activity together to maximize resources and minimize subject burden.

Objective—To investigate differences in dietary and/or physical-activity recall accuracy by content (diet-only; physical-activity-only; diet-&-physical-activity), retention interval (same-day-recalls-in-the-afternoon; previous-day-recalls-in-the-morning), and grade (third; fifth).

Design—Children (n=144; 66% African American, 13% White, 12% Hispanic, 9% Other; 50% girls) from four schools were randomly selected for interviews about one of three contents. Each content group was equally divided by retention interval, each equally divided by grade, each equally divided by sex. Information concerning diet and physical activity at school was validated with school-provided breakfast and lunch observations, and accelerometry, respectively. Dietary

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accuracy measures were food-item omission and intrusion rates, and kilocalorie correspondence rate and inflation ratio. Physical activity accuracy measures were absolute and arithmetic differences for moderate-to-vigorous-physical-activity minutes.

Statistical analyses performed—For each accuracy measure, linear models determined effects of content, retention interval, grade, and their two-way and three-way interactions; ethnicity and sex were control variables.

Results—Content was significant within four interactions: intrusion rate (content-×-retention-interval-×-grade; p=.0004), correspondence rate (content-×-grade; p=.0004), inflation ratio (content-×-grade; p=.0104), and arithmetic difference (content-×-retention-interval-×-grade; p=.0070). Retention interval was significant for correspondence rate (p=.0004), inflation ratio (p=.0014), and three interactions: omission rate (retention-interval-×-grade; p=.0095), intrusion rate, and arithmetic difference (both already mentioned). Grade was significant for absolute difference (p=.0233) and five interactions mentioned. Content effects depended on other factors. Grade effects were mixed. Dietary accuracy was better with same-day than previous-day retention interval.

Conclusions—Results do not support integrating dietary intake and physical activity in children's recalls, but do support using shorter rather than longer retention intervals to yield more accurate dietary recalls. Further validation studies need to clarify age effects and identify evidence-based practices to improve children's accuracy for recalling dietary intake and/or physical activity.

Keywords

children; recall accuracy; dietary recall; physical activity; school

INTRODUCTION

Parents report children's dietary intake and/or physical activity, but studies[1-4] underscore concerns about such reports. Children eat meals and conduct physical activity at school where parents are not present, so it is unrealistic to expect parents to accurately report children's intake and/or physical activity that occur at school. Although studies rely on children to self-report either dietary intake[5-12] or physical activity,[13] children's reporting accuracy is of concern.

Validation studies of children's dietary recalls have identified omissions (items eaten but unreported) and intrusions (items uneaten but reported);[3,14-24] results show that dietary recall accuracy is improved when the retention interval (elapsed time between to-be-reported meals and the interview) is minimized.[15,25,26] Accelerometers have been increasingly used to study children's physical activity objectively,[27] but self-report instruments are more common, especially for large studies,[28,29] more economical, and provide information about the type and context of physical activity that accelerometers cannot.[30] Considering the childhood obesity epidemic[31] and that schools are common targets for obesity prevention and health promotion,[32-34] there is interest for integrating assessment of children's dietary intake and physical activity to maximize resources and minimize subject burden.[35]

Children have simultaneously reported dietary intake and physical activity in two validation studies. One study[35] evaluated self-administered recall software to simultaneously assess diet and physical activity. Seven-to-15-year-old children (n=121) wore accelerometers; the next day, children completed a self-administered diet-&-physical-activity recall, and then an interviewer-administered diet-only recall. Results showed good dietary agreement between self-administered and interviewer-administered recalls, and good physical activity agreement between the self-administered recall and accelerometry.[35] Limitations included no physical-activity-only recalls to compare to diet-&-physical-activity recalls; relative validity for dietary intake was back-to-back recalls (with self-administered recalls always first) with assessment for food groups only; and using previous-day retention interval only.

Another study, a pilot,[36] observed 32 children (third-grade and fifth-grade) eating school-provided meals, and interviewed each child once (in the afternoon about that day or in the morning about the previous day) to obtain a diet-only or diet-&-physical-activity recall. Dietary accuracy results showed differences by retention interval (better for same-day than previous-day) but not by content or grade. Confidence intervals suggested that larger studies would find no difference by content, but might by grade.[36] Limitations included the small sample and no assessment of physical activity recall accuracy.

This study's objective was to investigate differences in dietary and/or physical activity recall accuracy by content (diet-only; physical-activity-only; diet-&-physical-activity), retention interval (same-day recalls in the afternoon; previous-day recalls in the morning), and grade (third; fifth). Dietary intake and physical activity at school were validated with direct observation of school-provided meals and accelerometry, respectively. Accuracy was hypothesized to be better for the integrated (diet-&-physical-activity) than single (diet-only; physical-activity-only) content, shorter (same-day recalls in the afternoon) than longer (previous-day recalls in the morning) retention interval, and older (fifth-grade) than younger (third-grade) children. Interview length was anticipated to be longer with the integrated than single content.

METHODS

The Institutional Review Board for research involving humans approved the study. Written parental consent and child assent were obtained.

Sample size calculations

Before data collection, past studies' results[15,18-20] were used to estimate omission rates of 28% for same-day recalls in the afternoon and 57% for previous-day recalls in the morning, and intrusion rates of 12% for same-day recalls in the afternoon and 36% for previous-day recalls in the morning. With 144 children overall, within a fixed-effects analysis of variance (ANOVA) including two grades, three contents (although the eventual models considered only two at a time), and two retention intervals, main effects tests had 75% and 89% power to reject equality for omission rates and intrusion rates, respectively, in models with two- and three-way interactions (where s=0.25 for unspecified effects). Power calculations used PASS (2005, Kaysville, UT).

Participants

Data were collected during the 2010-2011 school year. Children from 21 third-grade and 21 fifth-grade classes at four elementary schools in one district were invited to participate. At these schools, eligibility to receive free or reduced-price school-provided meals was 40.3% to 54.0%. Of the 877 children invited to participate, 513 children (58.5%) agreed. Grade, ethnicity, and sex composition of participants was similar to that of children invited.

From the consented children across all schools and grades, three subsets of children were randomly selected. Subsets One and Three's children were observed eating school-provided breakfast and lunch in the cafeteria on a school day; Subset Three's children also wore accelerometers at school that same day. Subset Two's Children wore accelerometers at school on a school day. Each subset child was interviewed only once about time at school for his/her observation and/or accelerometer day (i.e., from arrival at school until school dismissed) with content as diet-only (Subset One), physical-activity-only (Subset Two), or diet-&-physical-activity (Subset Three). Data collection continued until 144 children were interviewed and, as Figure 1 shows, each subset had 48 children with 24 per retention interval, and within retention interval, 12 per grade with six per sex. School staff and children did not know in advance when observations and/or interviews would occur, when accelerometers would be worn, nor assignment to content and/or retention interval. More children were recruited than needed to ensure random selection, so children could not determine who specifically was being observed, and so more children wore accelerometers than were interviewed. When recruited, children were told that they might each be interviewed zero to two times, so that being interviewed did not indicate that a child would not be interviewed again.

Direct meal observations

School-provided meals were observed by three researchers trained to follow a written protocol using established procedures through practice and assessment of pre-data-collection of interobserver reliability.[15,18-20,25,36] Before and weekly throughout data collection, interobserver reliability was assessed for pairs of observers using established procedures.[15,19,20,25,36,37] During data collection, interobserver reliability was assessed on 23 children (12 girls) for breakfast and 20 children (10 girls) for lunch; mean agreement between observers to within one-fourth serving on amounts eaten was acceptable (98%—breakfast ; 94%—lunch). For non-interobserver reliability observations, each researcher observed one to three children simultaneously during regular meal periods. Children were seated using their school's typical arrangement. Observations covered entire meal periods to account for food trading.[21,38-40] Researchers used paper forms to record items and amounts eaten in servings of standardized school-meal portions.

Accelerometry

ActiGraph accelerometers (Model GT3X, The Actigraph, LLC; Pensacola, FL) were placed on children as they arrived for breakfast in the school cafeteria for the specified day of wear and worn until researchers collected monitors in the afternoon before school dismissed. Children wore monitors on elastic belts on their right hips (anterior to iliac crests). Accelerometers were initialized to save data in one-minute intervals.[35,41,42] Data were

summarized for minutes of moderate to vigorous physical activity (MVPA), calculated using age-specific cut points for a threshold of four metabolic equivalents.[43] Sixty minutes of consecutive zeroes were considered non-wear time. Minutes per day of MVPA was the main outcome variable from accelerometry data.

Interviews

Three researchers conducted individual, face-to-face interviews in private locations at school after lunch on Mondays through Fridays (for same-day recalls in the afternoon), and after breakfast on Tuesdays through Fridays (for previous-day recalls in the morning). Although all three researchers also conducted observations, a child's interviewer had not observed that child's meals. Interviewers were trained using modeling, practice, and assessment of pre-data-collection quality control for interviews. Six written multiple-pass interview protocols were created by crossing three contents with two retention intervals. Interview protocols, described in Figure 2, were modeled on the Nutrition Data System for Research protocol (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN) and adapted for retention interval from past studies.[15,25,36] Researchers incorporated physical activity information into the appropriate interview protocols based on a qualitative study of interviewer-administered physical activity recalls by children.[44] Children reported amounts eaten in servings of standardized school-meal portions using qualitative terms (Figure 2, footnote b) as in past studies.[15,18-20,25,36] Interviewers used paper forms to document beginning and ending times, and to note information children reported. Interviews were audio-recorded and transcribed. Each interviewed child was mailed a $10 check. Quality control for interviews was assessed using established procedures;[15,19,20,25,36,45] a non-interviewing researcher reviewed each interview's audio-recording and typed transcript for protocol adherence. Ten children's interviews failed to abide by the specified protocol. Another five children's interviews had inadequate accelerometer data. These 15 children's interviews were excluded from further analyses, and replaced by another 15 children's interviews.

Outcome measures

Dietary—Accuracy was assessed for only the school-meal parts of recalls because only school meals were observed. As in past studies,[15,18-20,25,36] for reported items to be treated as reports about school meals, children had to identify "school" as the location where items were eaten, refer to breakfast as "school breakfast" or "breakfast", refer to lunch as "school lunch" or "lunch", and report mealtimes to within one hour of observed mealtimes.

For each meal per child, there were two sets of foods; one set contained foods observed eaten, and the other set contained foods reported eaten. According to an established classification system,[14-16,18-20,25,36,46-49] foods in both sets were *matches*, foods only in the reported set were *intrusions*, and foods only in the observed set were *omissions*. As in past studies,[15,18-20,25,36] a meal-component weight was assigned to each food observed eaten and/or reported eaten at a school meal (Table 1, footnote b).

For each child's two school meals, weighted matches, omissions, and intrusions were summed, and the child's *omission rate—*percentage of items observed eaten but unreported

—and *intrusion rate*—percentage of items reported eaten but unobserved—were calculated (Table 1, footnotes a and c). Smaller values for omission and intrusion rates indicate better accuracy.

Amounts observed and/or reported eaten were scored in servings of standardized school-meal portions (Table 1, footnote b) as in past studies.[15,18-20,25,36] Children's accuracy for reporting energy intake (in kilocalories) was assessed as in past studies.[50-55] For each observed and/or reported item, the Nutrition Data System for Research database was used to obtain kilocalories for standard school-meal portions. For each match, (a) the reported amount corresponded exactly to the observed amount, (b) the reported amount corresponded to part of the observed amount and the rest of the observed amount was unreported, or (c) part of the reported amount corresponded to the observed amount and the rest was over-reported. For each omission, the entire observed amount was unreported. For each intrusion, the entire reported amount was over-reported. Each corresponding, unreported, and over-reported amount was multiplied by the per-serving kilocalorie value to obtain corresponding, unreported, and over-reported kilocalories for each item. These amounts were summed for a child's two school meals, and *correspondence rate*—percentage of kilocalories observed eaten and reported correctly—and *inflation ratio*—percentage of kilocalories reported eaten but unobserved—were calculated for each child (Table 1, footnotes d and e). Larger values for correspondence rate, but smaller values for inflation ratio, indicate better accuracy.

Physical activity—Physical activity information from interviews was scored to estimate MVPA minutes per day at school as follows: Reported physical activity was considered to be of at least moderate intensity when children reported medium or fast pace. Minutes reported as medium or fast pace were summed to create the interview MVPA variable. This variable excluded physical activity reported as slow pace, for which pace was not reported, for which duration was not reported in minutes, and reported as part of a transition period (e.g., changing classes, going to bathroom or lunch). When ranges of minutes spent in physical activity were reported, the lower end was used because it was anticipated that children would over estimate their MVPA. Analyses included physical activity reported during periods of monitor wear only. During analyses, it was discovered that one accelerometer recorded less than one hour of data; thus, that interview was dropped, which brought Subset Three's final sample analyzed to 47 children.

Children's accuracy for reporting MVPA was evaluated using two variables—absolute and arithmetic differences between interview MVPA and accelerometer MVPA. A child's absolute difference close to zero indicates better accuracy by reflecting the magnitude of error for reporting MVPA minutes, but not whether under- or over-reporting occurred. For arithmetic difference (interview minus accelerometer), negative and positive values indicate average under- and over-reporting, respectively; although values close to zero indicate better accuracy, under- and over-reporting can offset each other, so a small average for a group may disguise large reporting errors balanced over the two directions.

Analyses

Schools provided children's race/ethnicity (reported by parents) to researchers. Researchers re-categorized race/ethnicity from nine categories reported to four[*] due to small numbers for some.

Generalized estimating equation methodology accounted for possible correlation in response values within the same interviewer; an exchangeable correlation structure was assumed. For all models, residual analysis was performed to check assumptions of constant error variance and normality of errors. Simultaneous Wald tests jointly tested for factor effects in each model. The Benjamini-Hochberg procedure[56] adjusted for simultaneous tests on multiple factors and in multiple models, controlling the false discovery rate at .05; thus, adjusted p values are shown. Statistical analyses used SAS/STAT® (Version 9.2, ©2002-2008, SAS Institute Inc., Cary, NC) with a .05 level of significance.

Summary statistics were calculated for interview length. Significance testing was not conducted because this variable does not assess accuracy, although descriptive information is useful from a practical viewpoint (e.g., scheduling research staff time; estimating class time that children will miss for interviews).[35] Each interview's length in minutes was calculated by subtracting beginning from ending time.

Dietary

For Subsets One and Three, various linear models were fit to determine the effects of content (diet-only; diet-&-physical-activity), retention interval (same-day recalls in the afternoon; previous-day recalls in the morning), and grade (third; fifth) on dietary recall accuracy. Models included these three factors of interest and their two-way and three-way interactions with ethnicity and sex as control variables. Separate ANOVA models were fit with omission rate, intrusion rate, correspondence rate, and inflation ratio as dependent variables. Inflation ratio was square-root-transformed to satisfy the normality assumption.

Physical activity

For Subsets Two and Three, two separate linear models were fit to determine the effects of content (physical-activity-only; diet-&-physical-activity), retention interval, grade, and their two-way and three-way interactions (with ethnicity and sex as control variables) on absolute and arithmetic differences as dependent variables. Absolute difference was square-root transformed to satisfy constant-variance and normality assumptions.

RESULTS

Of the 143 children included in analyses, there were 66% African American, 13% White, 12% Hispanic, and 9% Other. There were 71 girls.

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[*]The nine race/ethnicity categories and number of children were (1) African American = 94, (2) African American/American Indian or Alaska Native = 1, (3) African American/Hispanic = 1, (4) African American/White = 5, (5) Hispanic = 17, (6) White = 19, (7) White/African American/Asian = 1, (8) White/Hispanic = 4, and (9) White/Native Hawaiian or Other Pacific Islander = 1. The four race/ethnicity categories used for analyses were (1) African American, (2) White, (3) Hispanic, and (4) Other.

Dietary

Table 1 shows descriptives for dietary recall accuracy measures.

Omission rate—The retention-interval-×-grade interaction (p=.0095) was significant. When the retention interval was same-day recalls in the afternoon, omission rate was better for fifth-grade (19.0%) than third-grade children (33.1%). When the retention interval was previous-day recalls in the morning, omission rate was similar across grades (53.8%; 55.6%).

Intrusion rate—The content-×-retention-interval-×-grade interaction (p=.0004) was significant. For third-grade children, intrusion rate was better for diet-&-physical-activity (25.5%) than diet-only content (51.7%) when the retention interval was previous-day recalls in the morning, but similar by content (17.3%; 19.5%) when the retention interval was same-day recalls in the afternoon. For fifth-grade children, intrusion rate was better for diet-only (22.2%) than diet-&-physical-activity content (51.5%) when the retention interval was previous-day recalls in the morning, but similar by content (16.1%; 19.2%) when the retention interval was same-day recalls in the afternoon.

Correspondence rate—The content-×-grade interaction (p=.0004) and retention interval (p=.0004) were significant. For third-grade children, correspondence rate was better for diet-&-physical-activity (50.9%) than diet-only content (46.6%), but for fifth-grade children, it was better for diet-only (62.1%) than diet-&-physical-activity content (54.7%). Correspondence rate was better when the retention interval was same-day recalls in the afternoon (68.6%) than when it was previous-day recalls in the morning (38.5%).

Inflation ratio—The content-×-grade interaction (p=.0104) and retention interval (p=.0014) were significant. For third-grade children, inflation ratio was better for diet-&-physical-activity (22.9%) than diet-only (31.0%) content, but for fifth-grade children, it was better for diet-only (23.6%) than diet-&-physical-activity (41.2%) content. Inflation ratio was better when retention interval was same-day recalls in the afternoon (25.4%) than when it was previous-day recalls in the morning (34.0%).

Physical activity

Table 2 shows descriptives for total number of accelerometer-determined minutes of MVPA and physical activity recall accuracy measures.

Absolute difference—Grade (p=.0233) was significant. Absolute difference was better for fifth-grade (20.4 minutes) than third-grade (26.8 minutes) children.

Arithmetic difference—The content-×-retention-interval-×-grade interaction (p=.0070) was significant. For third-grade children, arithmetic difference was best for diet-&-physical-activity–same-day-recalls-in-the-afternoon, diet-&-physical-activity–previous-day-recalls-in-the-morning, and physical-activity-only–same-day-recalls-in-the-afternoon (−4.5 to 5.9 minutes) and worst for physical-activity-only–previous-day-recalls-in-the-morning (10.2 minutes). For fifth-grade children, arithmetic difference was best with same-day-recalls-in-

the-afternoon retention interval regardless of content (3.2 and 4.4 minutes) and worst with previous-day-recalls-in-the-morning retention interval, for which diet-&-physical-activity content (9.7 minutes) was better than physical-activity-only content (15.4 minutes).

Interview length

Table 3 shows descriptives for interview length. Average length for diet-&-physical-activity content (20.5 minutes) was almost twice as long as for diet-only (11.7 minutes) or physical-activity-only (12.4 minutes) content, but similar by retention interval and grade (14 to 15 minutes).

DISCUSSION

Content, retention interval, and grade were three factors of interest for this study. There has been speculation that combining children's dietary and physical activity recall would improve accuracy.[35,57] However, the effects of content differed depending on the levels of other factors, as shown by four significant interactions. First, content interacted with retention interval and grade on intrusion rate, although only for the longer retention interval, with better accuracy for younger children with the integrated than single content, but vice versa for older children. Second, content interacted with grade on correspondence rate and inflation ratio with better accuracy for younger children with the integrated than single content, but vice versa for older children. Third, content interacted with retention interval and grade on arithmetic difference with better accuracy for younger children for the integrated content irrespective of retention interval and for the single content with the shorter retention interval. However, older children were most accurate for the shorter retention interval irrespective of content. With the longer retention interval, accuracy was better for the integrated than single content. These collective results imply that content's effects on children's dietary and/or physical activity recall accuracy are complex rather than straightforward.

Retention interval was significant for correspondence rate and inflation ratio, with better accuracy for shorter than longer retention intervals. Furthermore, in addition to three-way interactions on intrusion rate and arithmetic difference, retention interval interacted significantly with grade on omission rate, such that accuracy was better for older than younger children, but only with the shorter retention interval. Although there is evidence that physical activity accuracy declines as time passes, most physical activity recalls concern the previous day(s).[58] The authors know of no study that has validated children's accuracy for physical activity recalls about the previous versus same day. Only one past study[36] has examined retention interval on dietary recall accuracy with third-grade children.

Grade was significant for absolute difference, with better accuracy for older than younger children, and within three two-way interactions (omission rate, correspondence rate, inflation ratio) and two three-way interactions (intrusion rate, arithmetic difference). Most past cross-sectional studies that examined elementary-school children's dietary recall accuracy and grade found that accuracy improved with increased age,[3,16,49,59] although one study found no age effect.[24] Past cross-sectional studies showed that elementary-school children's physical-activity recall accuracy improved with increased age.[60,61] However, for

this cross-sectional study, the effects of grade usually differed depending on the levels of other factors, as shown by five significant interactions.

The cognitive developmental literature indicates that third-grade children understand causal relationships and can manipulate thoughts and intentions, but their cognitions are tied to reality (personal experiences)[62] and their cognitive ability (viewing process) is still quite linear; this is often referred to as concrete operational thought. Most third-grade children cannot yet consider complex relationships, or proficiently think in abstract terms. By fifth grade, children are more likely to have developed abstract cognitive abilities and to have begun to formulate cognitive beliefs and attributions specific to health behaviors. Some of this study's grade interactions were counterintuitive (i.e., better accuracy for third- than fifth-grade children). For example, content interacted with grade on correspondence rate and inflation ratio; however, the improvements have little practical utility. Specifically, for third-grade children with integrated content, an average correspondence rate of 50.9% meant they correctly reported only half of the kilocalories observed eaten, and an average inflation ratio of 22.9% meant that one fourth of kilocalories reported eaten were unobserved.

This study's third- and fifth-grade children quite accurately reported amounts eaten for matches in qualitative terms. On average, reported amounts for matches differed from observed amounts by only 0.04 servings. However, on average, children had eaten 0.77 serving of items omitted, and reported having eaten 0.73 serving of intrusions. These results are similar to past studies' results with fourth-grade children.[15,18,20,25]

Pairwise correlations between dietary accuracy measures were calculated to determine whether children who committed one type of error also committed another, especially between the single and integrated contents. There was a strong positive association between intrusion rate and inflation ratio (diet-only r=0.80; diet-&-physical-activity r=0.59), and a strong negative association between omission rate and correspondence ratio (diet-only r= −0.88; diet-&-physical-activity r= −0.92). Other pairwise correlations were moderately positive (omission rate/intrusion rate), moderately negative (intrusion rate/correspondence ratio), or weak. Based on a series of z-tests with Bonferroni adjustments, the corresponding pairwise correlations were not significantly different (each adjusted $p>0.30$) between the single and integrated contents.

Considering that all four dietary accuracy measures are important, what constitutes acceptable dietary recall accuracy? Similar to past studies,[18-20] arbitrary criteria was applied which established omission rates, intrusion rates, and inflation ratios of 30% as passing and >30% as failing, and correspondence rates of 70% as passing and <70% as failing. With these criteria, a child's recall had "passing" accuracy even if s/he omitted up to about one third of items and kilocalories eaten, and if up to about one third of items and kilocalories s/he reported were intruded. Of the 95 children analyzed with diet-only or diet-&-physical-activity content, dietary recall accuracy overall was mediocre as 23, 9, 23, 20, and 20 children passed zero, one, two, three, and four measures, respectively. As Table 1's right-hand columns show, the estimated marginal probability of passing all four dietary measures was higher for the single than integrated content, for the shorter than longer retention interval, and for the fifth than third grade. Joint probabilities of passing all four measures

were highest for the single content–shorter retention interval, single content–fifth grade, and shorter retention interval–fifth grade combinations, as well as for the single content–shorter retention interval–fifth grade combination.

Limitations

Budgetary constraints precluded observations of physical activity; thus, children's accuracy for reporting specific types of physical activity (e.g., soccer) could not be investigated. Data collection cells could not be stratified by ethnicity. A 2011 paper[63] found that cognitive development influenced fourth-grade children's measures of dietary reporting error. This study's objective was to investigate the effect of content (single versus integrated) on reporting accuracy, and the effects of retention interval and grade. Randomization of children to content and retention interval groups minimized any differences in cognitive ability among groups that would benefit any group in terms of accuracy. Although investigating the joint effect of cognitive ability and content was not this study's objective, it is an area for future research.

Strengths

Dietary recalls and physical activity recalls were validated using direct meal observations and accelerometry, respectively. This avoided problems inherent with relative validity (such as back-to-back recalls by children or other methods that rely on memory [e.g., paper questionnaires]) and recalls by parents (who are not present to witness children's intake or physical activity at school). Rigorous quality control procedures were consistently implemented for observations and interviews.

CONCLUSIONS

This study's findings do not support a recommendation to integrate dietary intake and physical activity in elementary-school children's recalls. However, this study's findings clearly indicate the use of shorter rather than longer retention intervals to yield more accurate dietary recalls from children. Further validation studies are needed to clarify grade (i.e., age) effects and to identify evidence-based practices to improve children's accuracy for recalling dietary intake and/or physical activity.

Acknowledgments

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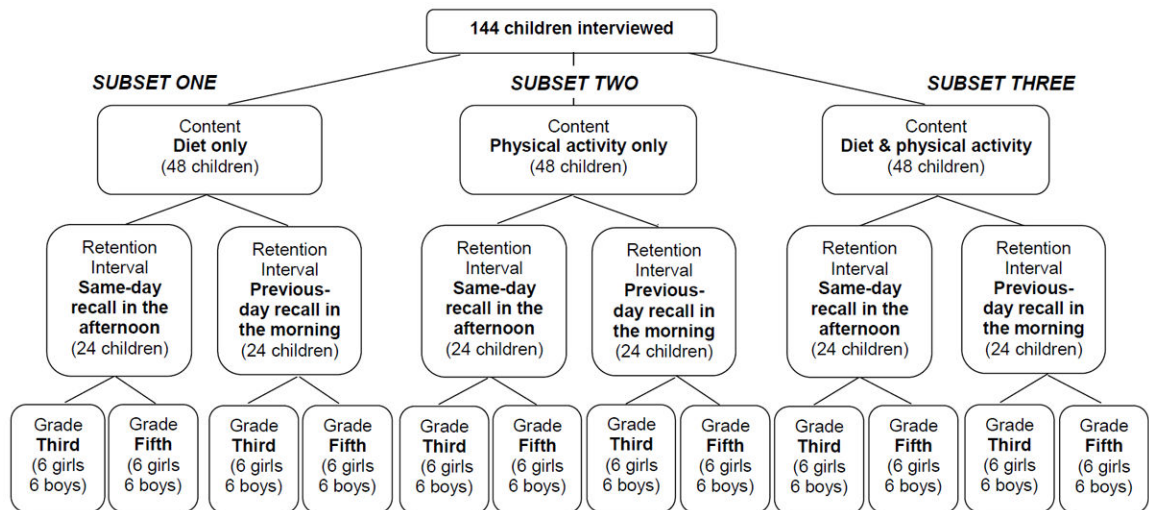
Figure 1.

Design.

Legend: Children in Subset One and Subset Three were observed eating school-provided breakfast and lunch in the cafeteria on a school day to correspond with the day covered in their interview; children in Subset Three also wore accelerometers at school on their observation day. Children in Subset Two wore accelerometers at school on a school day to correspond with the day covered in their interview. Each subset child was interviewed only once about time at school for the observation and/or accelerometer day (i.e., from arrival at school until school dismissed). The final sample consisted of 143 children because one third-grade girl's interview with diet-&-physical-activity content and same-day recall in the afternoon retention interval had to be dropped during analyses when it was discovered that the accelerometer had recorded less than one hour of data.

Diet only content	
Pass	Description [a]
1st	Collect list: *"After you got to school this morning at (time), what was the first time you had something to eat or drink? What time was that? What did you eat or drink at that time? Did you eat or drink anything else at that time? What was the next time at school today that you ..."* Repeat process to cover today at school in chronological order. *"Can you remember any other times at school today that you ate or drank something - either in your classroom, in the cafeteria, or somewhere else at school today?"*
2nd	Obtain details: In chronological order, for each intake time, ask the name of the eating occasion (breakfast, lunch, snack), location of meal (cafeteria, classroom, somewhere else at school), additions to items, details about items, and amounts[b] consumed.
3rd	Review: In chronological order, review and confirm details for each intake time. For each intake time, ask whether anything else was consumed. *"Can you remember any other times at school today that you ate or drank something?"*

Physical activity only content	
Pass	Description [a]
1st	Collect list: *"After you got to school this morning at (time), what was the first time you were physically active, moving around, or exercising? What time was that? What moving around did you do at that time? Did you do any other moving around at that time? What was the next time at school today that you ..."* Repeat process to cover today at school in chronological

order. *"Can you remember any other times at school today that you were physically active, moving around, or exercising - either in your classroom or somewhere else at school today?"*

2nd Obtain details: In chronological order, for each physical activity time, ask how long (in minutes) the activity was done and the pace (fast, medium, slow).

3rd Review: In chronological order, review and confirm details for each physical activity time. For each physical activity time, ask whether any other moving around was done. *"Can you remember any other times at school today that you were physically active, moving around, or exercising?"*

Diet and physical activity content

Pass	Description [a]
1st	Collect list: *"After you got to school this morning at (time), what was the first time you had something to eat or drink, or were physically active, moving around, or exercising? What time was that? Did you eat or drink at that time, or did you move around at that time? What did you eat or drink at that time? Did you eat or drink anything else at that time? What moving around did you do at that time? Did you do any other moving around at that time? What was the next time at school today that you ..."* Repeat process to cover today at school in chronological order. *"Can you remember any other times at school today that you ate or drank something - either in your classroom, in the cafeteria, or somewhere else at school today? Can you remember any other times at school today that you were physically active, moving around, or exercising - either in your classroom or somewhere else at school today?"*
2nd	Obtain details: In chronological order, for each intake time, ask the name of the eating occasion (breakfast, lunch, snack),

location of meal (cafeteria, classroom, somewhere else at school), additions to items, details about items, and amounts[b] consumed. For each physical activity time, ask how long (in minutes) the activity was done and the pace (fast, medium, slow).

3rd Review: In chronological order, review and confirm details for each intake time and each physical activity time. For each intake time, ask whether anything else was consumed. For each physical activity time, ask whether any other moving around was done. *"Can you remember any other times at school today that you ate or drank something? Can you remember any other times at school today that you were physically active, moving around, or exercising?"*

[a] **These descriptions are for the "same-day recalls in the afternoon" retention interval.** When the retention interval was "previous-day recalls in the morning," the child was asked about yesterday at school.

[b] Children reported amounts eaten in servings of standardized school-meal portions using qualitative terms: *none, a taste, a little bit, half, most, all,* and *more than 1 serving,* as in past studies.[15,18-20,25,36]

Figure 2.
Overview of multiple-pass interview protocols used to obtain recalls from children

Table 1

Descriptive statistics for four measures of dietary recall accuracy.

Condition	n	Omission Rate[a,b]	Intrusion Rate[b,c]	Correspondence Rate[d]	Inflation Ratio[e]	n dietary measures passed[f]				
		------Least Squares Mean (Standard Error)------				------n of children------				
						0	1	2	3	4
Content										
Diet only	48	40.7 (4.8)	26.8 (3.1)	54.4 (3.3)	26.9 (2.1)	13	3	11	7	14
Diet & Physical Activity	47[g]	40.1 (2.8)	28.9 (1.3)	52.8 (1.6)	32.4 (1.7)	10	6	12	13	6
Retention Interval				***h	***i					
Same-day recall in afternoon	47[g]	26.1 (3.9)	18.0 (1.3)	68.6 (2.5)	25.4 (0.4)	5	1	8	16	17
Previous-day recall in morning	48	54.7 (3.7)	37.7 (4.1)	38.5 (2.2)	34.0 (1.9)	18	8	15	4	3
Grade										
Third	47[g]	43.5 (3.8)	28.5 (2.5)	48.8 (0.7)	27.3 (2.7)	14	6	12	8	7
Fifth	48	37.3 (3.7)	27.3 (2.0)	58.4 (3.9)	32.0 (2.2)	9	3	11	12	13
Content by Retention Interval										
Diet only - Same-day recall in afternoon	24	25.9 (5.6)	16.7 (0.4)	68.8 (2.2)	18.7 (3.0)	2	1	3	6	12
Diet & physical activity - Same-day recall in afternoon	23[g]	26.2 (2.5)	19.4 (2.5)	68.4 (3.0)	32.0 (2.7)	3	0	5	10	5
Diet only - Previous-day recall in morning	24	55.4 (4.3)	37.0 (6.0)	39.9 (4.5)	35.1 (7.0)	11	2	8	1	2
Diet & physical activity - Previous-day recall in morning	24	54.0 (3.1)	38.5 (2.2)	37.2 (1.5)	32.8 (5.0)	7	6	7	3	1
Content by Grade				***j	*k					
Diet only - Third	24	45.5 (6.2)	34.5 (3.4)	46.6 (2.3)	31.0 (3.1)	9	3	4	4	4
Diet & physical activity - Third	23[g]	41.4 (1.7)	22.5 (1.6)	50.9 (1.0)	22.9 (2.4)	5	3	8	4	3
Diet only - Fifth	24	35.8 (3.5)	19.2 (4.2)	62.1 (4.3)	23.6 (2.7)	4	0	7	3	10
Diet & physical activity - Fifth	24	38.9 (3.9)	35.4 (0.9)	54.7 (3.6)	41.2 (1.1)	5	3	4	9	3
Retention Interval by Grade		**l								
Same-day recall in afternoon - Third	23[g]	33.1 (5.1)	18.4 (3.3)	61.9 (2.5)	20.7 (6.4)	5	1	5	6	6
Previous-day recall in morning - Third	24	53.8 (3.5)	38.6 (5.9)	35.7 (1.7)	33.9 (4.1)	9	5	7	2	1
Same-day recall in afternoon - Fifth	24	19.0 (3.4)	17.7 (1.3)	75.4 (3.3)	30.0 (5.7)	0	0	3	10	11
Previous-day recall in morning - Fifth	24	55.6 (4.1)	36.9 (2.9)	41.4 (4.6)	34.0 (1.5)	9	3	8	2	2
Content by Retention Interval by Grade			***m							

Condition	n	Omission Rate[a,b]	Intrusion Rate[b,c]	Correspondence Rate[d]	Inflation Ratio[e]	n dietary measures passed[f]				
		------Least Squares Mean (Standard Error)------				------n of children------				
						0	1	2	3	4
Diet only - Same-day recall in afternoon - Third	12	32.9 (9.4)	17.3 (2.3)	59.4 (3.6)	16.7 (6.9)	2	1	2	4	3
Diet only - Same-day-recall in afternoon - Fifth	12	18.9 (2.9)	16.1 (2.4)	78.3 (2.0)	20.7 (3.9)	0	0	1	2	9
Diet only - Previous-day recall in morning - Third	12	58.1 (4.5)	51.7 (7.5)	33.8 (2.4)	45.3 (6.2)	7	2	2	0	1
Diet only - Previous-day recall in morning - Fifth	12	52.7 (4.4)	22.2 (6.2)	46.0 (7.1)	25.0 (8.2)	4	0	6	1	1
Diet & physical activity - Same-day recall in afternoon - Third	11[g]	33.3 (1.0)	19.5 (4.4)	64.3 (1.4)	24.6 (6.0)	3	0	3	2	3
Diet & physical activity - Same-day recall in afternoon - Fifth	12	19.2 (3.9)	19.2 (1.3)	72.5 (4.7)	39.4 (10.7)	0	0	2	8	2
Diet & physical activity - Previous-day recall in morning - Third	12	49.5 (2.4)	25.5 (4.4)	37.6 (3.3)	22.6 (2.0)	2	3	5	2	0
Diet & physical activity - Previous-day recall in morning - Fifth	12	58.6 (3.9)	51.5 (0.6)	36.8 (2.5)	43.1 (10.9)	5	3	2	1	1

[a] Omission rate = percentage of items observed eaten but unreported calculated as (sum of weighted omissions / [sum of weighted omissions + sum of weighted matches]) × 100%; values range from 0% to 100% with smaller rates reflecting better accuracy.

[b] Meal-component weight assigned to each food item with combination entrée = 2, condiment = .33, and remaining meal components = 1. Children reported amounts eaten in servings of standardized school-meal portions using qualitative terms *none, a taste, a little bit, half, most, all,* and *more than 1 serving.* Amounts observed and/or reported eaten were scored in servings of standardized school-meal portions as none = 0, a taste = .1, a little bit = .25, half = .5, most = .75, all = 1, or actual number of servings if > 1.

[c] Intrusion rate = percentage of items reported eaten but unobserved calculated as (sum of weighted intrusions / [sum of weighted intrusions + sum of weighted matches]) × 100%; defined values range from 0% to 100% with smaller rates reflecting better accuracy.

[d] Correspondence rate = (corresponding amounts in kilocalories from matches / observed amounts in kilocalories) × 100; values may range from 0% (indicating that nothing observed was reported eaten) to 100% (indicating that all observed items and observed amounts were reported correctly); higher rates reflect better accuracy.

[e] Inflation ratio = ([over-reported amounts in kilocalories from matches and intrusions] / observed amounts in kilocalories) × 100; values may range from 0% (indicating no intrusions and no over-reported amounts of matches) to infinity (because there is no limit on what a child can report); lower ratios reflect better accuracy.

[f] Similar to methods used in past studies to define acceptable dietary recall accuracy,[18-20] arbitrary criteria was applied which established omission rates, intrusion rates, and inflation ratios of ≤ 30% as passing and >30% as failing, and correspondence rates of ≥ 70% as passing and <70% as failing. The numbers of children in the right-hand columns show that the estimated marginal probability of passing all four dietary measures was higher for the single than integrated content, for the shorter than longer retention interval, and for the fifth than third grade. Joint probabilities of passing all four measures were highest for the single content–shorter retention interval, single content–fifth grade, and shorter retention interval–fifth grade combinations, as well as for the single content–shorter retention interval–fifth grade combination.

[g] One third-grade girl's interview with diet-&-physical activity content and same-day recall in the afternoon retention interval had to be dropped during analyses when it was discovered that the accelerometer had recorded less than one hour of data.

[h] Correspondence rate was better with same-day recalls in the afternoon (68.6%) than previous-day recalls in the morning (38.5%).

[i] Inflation ratio was better with same-day recalls in the afternoon (25.4%) than previous-day recalls in the morning (34.0%).

[j] Correspondence rate was better for third-grade children for diet-&-physical-activity (50.9%) than diet-only content (46.6%), but for fifth-grade children for diet-only (62.1%) than diet-&-physical-activity content (54.7%).

[k] Inflation ratio was better for third-grade children for diet-&-physical-activity (22.9%) than diet-only (31.0%) content, but for fifth-grade children for diet-only (23.6%) than diet-&-physical-activity (41.2%) content.

[l] Omission rate was better for fifth-grade (19.0%) than third-grade children (33.1%) with same-day recalls in the afternoon, but similar by grade (53.8%; 55.6%) with previous-day recalls in the morning.

[m] Intrusion rate was better for third-grade children for diet-&-physical-activity (25.5%) than diet-only content (51.7%) with previous-day recalls in the morning, but similar by content (17.3%; 19.5%) with same-day recalls in the afternoon. Intrusion rate was better for fifth-grade children for diet-only (22.2%) than diet-&-physical-activity content (51.5%) with previous-day recalls in the morning, but similar by content (16.1%; 19.2%) with same-day recalls in the afternoon.

[*] p < .05,

[**] p < .01,

[***] p < .001

Table 2

Accelerometer-derived minutes of MVPA[a] and descriptive statistics for two measures of physical activity recall accuracy.

Condition	n	Total number of accelerometer MVPA minutes	Absolute difference in MVPA minutes[b]	Arithmetic difference in MVPA minutes[c]
			Least Squares Mean (Standard Error)	
Content				
Physical activity only	48	21.4 (1.9)	23.2 (1.6)	9.0 (0.8)
Diet & physical activity	47[d]	25.6 (1.8)	24.0 (1.3)	3.3 (2.8)
Retention Interval				
Same-day recall in afternoon	47[d]	24.5 (2.0)	23.4 (0.4)	2.3 (0.5)
Previous-day recall in morning	48	22.4 (1.7)	23.8 (0.8)	10.0 (3.1)
Grade			*e	
Third	47[d]	27.3 (1.7)	26.8 (0.9)	4.1 (3.0)
Fifth	48	19.7 (1.8)	20.4 (0.6)	8.2 (0.5)
Content by Retention Interval				
Physical activity only - Same-day recall in afternoon	24	22.3 (2.9)	24.3 (3.1)	5.2 (0.7)
Diet & physical activity - Same-day recall in afternoon	23[d]	26.8 (2.7)	22.5 (3.4)	−0.6 (1.2)
Physical activity only - Previous-day recall in morning	24	20.5 (2.5)	22.1 (0.6)	12.8 (1.8)
Diet & physical activity - Previous-day recall in morning	24	24.3 (2.3)	25.6 (1.2)	7.1 (4.5)
Content by Grade				
Physical activity only - Third	24	23.0 (2.3)	27.2 (3.4)	8.1 (3.5)
Diet & physical activity - Third	23[d]	31.8 (2.2)	26.4 (1.6)	0.1 (2.6)
Physical activity only - Fifth	24	19.8 (3.0)	19.2 (0.2)	9.9 (2.0)
Diet & physical activity - Fifth	24	19.6 (2.2)	21.7 (1.0)	6.5 (3.0)
Retention Interval by Grade				
Same-day recall in afternoon - Third	23[d]	29.1 (2.6)	28.8 (2.5)	0.7 (1.6)
Previous-day recall in morning - Third	24	25.6 (2.2)	24.7 (0.8)	7.4 (7.6)
Same-day recall in afternoon - Fifth	24	20.1 (2.8)	17.9 (2.9)	3.8 (2.4)
Previous-day recall in morning - Fifth	24	19.3 (2.4)	23.0 (1.9)	12.5 (1.4)
Content by Retention Interval by Grade				**f
Physical activity only - Same-day recall in afternoon - Third	12	26.7 (3.9)	33.1 (8.9)	5.9 (1.5)

Condition	n	Total number of accelerometer MVPA minutes	Absolute difference in MVPA minutes[b]	Arithmetic difference in MVPA minutes[c]
			Least Squares Mean (Standard Error)	
Physical activity only - Same-day recall in afternoon - Fifth	12	18.0 (4.1)	15.5 (3.0)	4.4 (0.6)
Physical activity only - Previous-day recall in morning - Third	12	19.4 (2.1)	21.3 (2.1)	10.2 (8.0)
Physical activity only - Previous-day recall in morning - Fifth	12	21.7 (4.5)	22.9 (2.5)	15.4 (4.5)
Diet & physical activity - Same-day recall in afternoon - Third	11[d]	31.8 (3.4)	24.6 (3.9)	−4.5 (2.0)
Diet & physical activity - Same-day recall in afternoon - Fifth	12	22.3 (3.9)	20.3 (3.0)	3.2 (4.2)
Diet & physical activity - Previous-day recall in morning - Third	12	31.8 (3.1)	28.2 (1.0)	4.6 (7.2)
Diet & physical activity - Previous-day recall in morning - Fifth	12	16.9 (1.8)	23.0 (1.4)	9.7 (1.7)

[a] MVPA = moderate to vigorous physical activity

[b] Absolute difference between interview-MVPA and accelerometer-MVPA = absolute difference between minutes of MVPA reported during the interview compared to minutes of MVPA from the accelerometer. Values close to zero indicate better accuracy, but not whether under- or over-reporting occurred.

[c] Arithmetic difference between interview-MVPA and accelerometer-MVPA = arithmetic difference between minutes of MVPA reported during the interview minus minutes of MVPA from the accelerometer. Values close to zero indicate better accuracy; negative and positive values indicate average under- and over-reporting, respectively. Under-reporting and over-reporting can offset each other, so a small average for a group may disguise large reporting errors balanced over the two directions.

[d] One third-grade girl's interview with diet-&-physical-activity content and same-day recall in the afternoon retention interval had to be dropped during analyses when it was discovered that the accelerometer had recorded less than one hour of data.

[e] Absolute difference was better for fifth-grade (20.4 minutes) than third-grade (26.8 minutes) children.

[f] Arithmetic difference was best for third-grade children for diet-&-physical-activity–same-day-recalls-in-the-afternoon, diet-&-physical-activity–previous-day-recalls-in-the-morning, and physical-activity-only–same-day-recalls-in-the-afternoon (−4.5 to 5.9 minutes) and worst for physical-activity-only–previous-day-recalls-in-the-morning (10.2 minutes). For fifth-grade children, arithmetic difference was best with same-day-recalls-in-the-afternoon regardless of content (3.2 and 4.4 minutes) and worst with previous-day-recalls-in-the-morning, for which diet-&-physical-activity content (9.7 minutes) was better than physical-activity-only content (15.4 minutes).

*
  p < .05,

**
  p < .01

Table 3

Means (and standard errors) for interview length in minutes.

		n[a]	Interview length
Content	Diet only	48	11.7 (0.4)
	Physical activity only	48	12.4 (0.2)
	Diet & physical activity	47	20.5 (0.8)
Retention Interval	Same-day recall in the afternoon	71	15.3 (0.3)
	Previous-day recall in the morning	72	14.5 (0.4)
Grade	Third	71	15.5 (0.6)
	Fifth	72	14.3 (0.1)
Content by Retention Interval	Diet only - Same-day recall in the afternoon	24	11.9 (0.1)
	Physical activity only - Same-day recall in the afternoon	24	13.1 (0.1)
	Diet & physical activity - Same-day recall in the afternoon	23	21.0 (0.8)
	Diet only - Previous-day recall in the morning	24	11.6 (0.8)
	Physical activity only - Previous-day recall in the morning	24	11.8 (0.4)
	Diet & physical activity - Previous-day recall in the morning	24	20.2 (0.7)
Content by Grade	Diet only - Third	24	11.9 (0.4)
	Physical activity only - Third	24	12.4 (0.5)
	Diet & physical activity - Third	23	22.3 (1.2)
	Diet only - Fifth	24	11.6 (0.5)
	Physical activity only - Fifth	24	12.5 (0.9)
	Diet & physical activity - Fifth	24	18.8 (0.4)
Retention Interval by Grade	Same-day recall in the afternoon - Third	35	15.4 (0.5)
	Previous-day recall in the morning - Third	36	15.7 (0.9)
	Same-day recall in the afternoon -Fifth	36	15.2 (0.3)
	Previous-day recall in the morning -Fifth	36	13.4 (0.1)
Content by Retention Interval by Grade	Diet only - Same-day recall in the afternoon - Third	12	10.5 (0.2)
	Diet only - Same-day recall in the afternoon - Fifth	12	13.2 (0.1)
	Diet only - Previous-day recall in the morning - Third	12	13.3 (0.6)
	Diet only - Previous-day recall in the morning - Fifth	12	9.9 (1.0)
	Physical activity only - Same-day recall in the afternoon - Third	12	12.9 (0.8)
	Physical activityonly - Same-day recall in the afternoon - Fifth	12	13.3 (0.9)
	Physical activity only - Previous-day recall in the morning - Third	12	11.9 (0.5)
	Physical activity only - Previous-day recall in the morning - Fifth	12	11.7 (1.3)
	Diet & physical activity - Same-day recall in the afternoon - Third	11	22.8 (0.8)
	Diet & physical activity - Same-day recall in the afternoon - Fifth	12	19.2 (0.8)
	Diet & physical activity - Previous-day recall in the morning - Third	12	21.9 (1.6)
	Diet & physical activity - Previous-day recall in the morning - Fifth	12	18.4 (0.2)

[a]The final sample consisted of 143 children because one third-grade girl's interview with diet-&-physical-activity content and same-day recall in the afternoon retention interval had to be dropped during analyses when it was discovered that the accelerometer had recorded less than one hour of data.