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Validity and Reliability of Dietary Assessment in School-Age Children

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Introduction

This review of 50 studies examines the validity and/or reliability of dietary assessment methods used for school-age children during the last three decades, and discusses the challenges of measuring children's dietary behaviors. This section is an update from previously published work of the referenced authors.[67] Recommendations on the use of available assessment methods are discussed and gaps in our knowledge of dietary assessment in children are outlined, along with suggestions for future research.

Review Methodology

The studies included in this review cover a variety of dietary assessment methods including the 24-hour recall, food record, food frequency questionnaire, diet history, and observation. A total of 41 validity and 9 reliability studies used at least one of these methodologies and met the three review criteria: 1) publication in a peer-reviewed English journal article between January 1970 and August 2000; 2) inclusion of school children age 5 to 18 years living in an industrialized country; and 3) reporting of specific reliability and/or validity tests from a minimum sample of 30 children in either the main study sample or a subsample (denoted by age, gender, or ethnic), after the publishing author's exclusions for analyses. Studies were identified by Medline searches using key words and supplemented by cross-referencing from author reference lists. Studies that did not specifically use the words validity, reliability, reproducibility, or repeatability in the results or discussion may not have been identified. The degree of reliability or validity of the instrument reported was not considered an inclusion factor. Multiple validity or reliability studies that were included in a single article were considered separately and are repeated in the descriptions of results.

TABLE 20.1

Definitions and Explanation of Tables

General

Study entries are listed in ascending order by age.
Multiple validity or reliability studies included in a single journal article are presented as separate entries in the appropriate table.

Definitions

Adults required — Adults provided all of the intake information or were required to supplement and assist the child's report.
Quantitative — Quantity of food consumed was estimated using weights, measures, or food models. Responses were open-ended.
Semi-quantitative — Quantity of food consumed was estimated using a standard portion size, serving, or a predetermined amount, and respondent was asked about the number of portions consumed.
Non-quantitative — Quantity of food consumed was not assessed.
Self-administered — Child completed the dietary assessment without assistance.
Group-administered — Child completed the dietary assessment with help from a proctor, teacher, or caregiver in a group setting.
Interviewer-administered — A trained interviewer elicited the dietary assessment information from the child in a one-on-one setting.

Results Section

Omission of any of the following components indicates it was not provided in the article or was from a sample of less than 30 children. Statistical significance of measures is noted with clarifications as to whether significance testing was shown in the article or only reported via a statement from the publishing authors. The results are ordered as follows:

Correlations for energy, protein, and total fat between methodologies or administrations.
Range of correlations between methodologies or administrations for the nutrients assessed.
For validity studies: the absolute values and percent difference in energy intake between the validation standard and the instrument ([instrument-validation standard]/validation standard × 100).
For reliability studies: the absolute values and percent difference in energy intake between the first and follow-up assessment ([follow-up instrument-first instrument]/follow-up instrument × 100).
Comparison of mean intake of nutrients assessed.
Comparison of foods or food groups consumed.
Comparison of portion size.
Results by age, gender, or ethnicity.

Dietary Assessment Methodologies

The following topics define each dietary method and refer its tables of results of validity and reliability studies, thereby providing a summary of the current state of each field. The format of entries in Tables 20.2 through 20.6, which contain the validity and reliability studies for the various methods, is explained in Table 20.1.

24-Hour Recall (Table 20.2)

The 24-hour recall consists of a structured interview in which a trained nutritionist or other professional asks the child and/or adult caregiver to list everything the child ate or

TABLE 20.2

Recall Validity Studies Among School-Age Children

Reference	Sample	Age/Grade	Instrument	Validation Standard	Design	Results
Basch et al. 1990[16]	18 M[b] 28 F[b] Latino	4-7 y Adults required[c]	Evening meal recall; quantitative	Observation	Compared mothers' recall of what child ate at evening meal on the previous day against observation of the meal. Excerpted evening meal from 24-hour recall.	Energy-adjusted Pearson correlations between recalled evening meal and observed evening meal were 0.71 for energy, 0.50 for protein, and 0.52 for total fat. Range of correlations for 18 nutrients assessed was –0.10 for phosphorus to 0.82 for iron. Recalled energy intake was 9% higher than observed intake (507 vs. 465 kcal/meal). Seven nutrients were significantly overestimated by recalled intake of the meal (significance testing not shown). Range of mothers reporting fewer items consumed as compared to the number of items observed consumed was between 4 and 30%. 15.5% of reported portion sizes were smaller and 33.5% of portions were greater than those observed (significance testing not shown).
Eck et al. 1989[11]	33 M&F	4-9.5 y Adults required	Lunch recall; quantitative	Observation	Compared mother's, father's, or both parents plus child's (consensus) recall of lunch against observation of lunch on the previous day. Excerpted lunch meal from 24-hour recall.	Pearson correlations between consensus recall of lunch and observed lunch were 0.87 for energy, 0.91 for protein as % of kcal and 0.85 for total fat as % of kcal. Range of correlations for 9 nutrients assessed was 0.75 for carbohydrate as % of kcal to 0.91 for protein as % of kcal. Pearson correlations between observed intake and fathers' recall were 0.83 for energy, 0.79 for protein as % of kcal and 0.72 for total fat as % of kcal. Pearson correlations between observed intake and mother's recalled intake were 0.64 for energy, 0.56 for protein as % of kcal and 0.65 for total fat as % of kcal. Recalled energy intake from the consensus, fathers' and mothers' recalls was 2% (558 kcal/meal), 5% (545 kcal/meal) and 4% (550 kcal/meal) lower than observed intake (572 kcal/meal), respectively. Only mothers' recall of energy from dairy foods/beverages and snacks/desserts were significantly different from observed intake. There were no significant differences in mean nutrient intake between any pairs compared. Qualitative comparison of number of items recalled revealed that only fathers' recalls of non-dairy beverages and snacks/desserts differed significantly from observed intake. Consensus approach appeared to reduce the tendency to overreport low intakes and underreport high intakes (flattened slope phenomenon).

TABLE 20.2 *(Continued)*

Recall Validity Studies Among School-Age Children

Reference	Sample	Age/Grade	Instrument	Validation Standard	Design	Results
Lindquist et al. 2000[65]	17 M[b] 13 F[b] 17 White 13 Black	6.5-11.6 y Adults required	Three 24-hour recalls, one phone, two interview	TEE[f] by doubly-labeled water	Compared average of 3 child's parent-assisted recalls against 14-d TEE.	Pearson correlation between average recalled intake and TEE was 0.32 for energy. Recalled energy intake was 0.5% higher than TEE from doubly-labeled water (7.90 vs 7.86 mJ/day). Inaccuracy in energy reporting was not predicted by age, gender, ethnicity, social class, or adiposity.
Reynolds et al. 1990[17]	18 M&F 25 M&F 31 M&F	7-8 y 9-10 y 11-12 y	Daytime recall; non-quantitative	Observation	Compared average of 3 child's recalls of daytime meals against observation of daytime meals. Exchange units of foods that were developed from the recalls for analyses.	Recalled energy intake was 34% lower for 7-8 year olds (1818 vs. 2751 kcal/daytime meals), 21% lower for 9-10 year olds (2291 vs. 2887 kcal/ daytime meals) and 17% lower for 11 year olds (2643 vs. 3185 kcal/daytime meals) than observed intake. Children significantly underestimated their energy, carbohydrate and fat consumption as compared to observers, with younger children having larger differences. Exact agreement for the 9 exchange groups ranged from 94% for lean fat meat to 17% for the fat group. Girls were significantly more accurate in reporting medium fat meat exchange units than boys, 62% versus 50% respectively (significance testing not shown).
Lytle et al. 1993[7]	49 M&F	3rd Grade	24-hour recall assisted by food record; quantitative	Observation	Compared food record-assisted recalls completed by children against observation of school lunch and breakfast by trained personnel and of other meals at home by parents.	Pearson correlations between recalled and observed intakes were 0.59 for energy, 0.62 for protein as % of kcal and 0.64 for total fat as % of kcal. Range of correlations for the 8 nutrients assessed was 0.41 for polyunsaturated fat as % of kcal to 0.79 for saturated fat as % of kcal. Recalled energy intake was 10% higher than observed intake (1823 vs. 1650 kcal/day). There was an overall 77.9% agreement in the types of food items recalled and observed. Food portions were recalled within 10% of observed portions 35% of the time; overestimation occurred 42% and underestimation occurred 23% of the time.

Van Horn et al. 1990[8]	18 M 14 F	8-10 y	24-Hour recall by phone; quantitative	1-Day food record	Compared child's recall of intake against parent's observation recorded as a food record.	Pearson correlations between recalled intake and record of intake were 0.76 for energy, 0.74 for protein as % of kcal and 0.73 for total fat as % of kcal. Range of correlations for the 10 nutrients assessed was 0.64 for saturated fat as % of kcal to 0.93 for iron. Recalled energy intake was 2% lower than recorded intake (1799 vs. 1836 kcal/day). There were no significant differences between child and parent reports of nutrient intake (significance testing not shown).
Todd & Kretsch 1986[a10]	30 M&F Chinese 31 M&F Hispanic	8-11 y	Breakfast and lunch recall; quantitative	Observation	Compared child's recall of intake of school breakfast and lunch against observation of school meals with plate waste subtracted. Excerpted breakfast and lunch meals from 24-hour recall.	Pearson correlations between recalled lunch and observed lunch for Chinese were 0.49 for energy, 0.62 for protein and 0.25 for total fat, and for Hispanics were 0.53 for energy, 0.51 for protein and 0.46 for total fat. Range of correlations for the 15 nutrients assessed for Chinese was –0.10 for sodium to 0.63 for thiamin, and for Hispanics was 0.34 for niacin to 0.81 for vitamin C. Chinese children's recalled energy intake was 10% lower than observed intake (686 vs. 765 kcal/2 meals). Chinese children recalled consistently less food than consumed, which was significantly lower for 4 of the 15 nutrients. Hispanic children's recalled energy intake was 6% higher than observed intake (665 vs. 630 kcal/2 meals). Hispanic children recalled intake versus consumed intake was inconsistent and was significantly higher for 2 nutrients and lower for 1 of the 15 nutrients assessed. For Chinese, food item omissions ranged from 4% for milk to 35% for vegetables. For Hispanics, food item omissions ranged from 0% for juice and milk to 35% for vegetables.
Samuelson 1970[13]	56 M&F 43 M&F	8 y 13 y	Lunch recall; quantitative	Chemical analysis of food	Compared child's recall of lunch against weighed chemical analyses of a double portion of lunch, with plate waste subtracted. Excerpted lunch meal from 24-hour recall.	Spearman correlations between recall of lunch and chemical analyses of lunch for 8- and 13-year olds for energy were 0.68 and 0.71, respectively. Correlations for protein of 8- and 13-year olds were 0.55 and 0.45, respectively. Correlations for total fat of 8- and 13-year olds were 0.61 and 0.69, respectively. Range of correlations for the 4 nutrients assessed for 8-year-olds was 0.55 for protein to 0.68 for energy. Range of correlations for 13-year-olds was 0.45 for protein to 0.71 for energy. Among 8-year-olds, recalled energy intake was 18% higher than chemical analyses (472 vs. 399 kcal/meal). Among 13-year-olds, recalled energy intake was 1% higher than chemical analyses (494 vs. 491 kcal/meal). Median portion size estimated by child compared to weighing was not significantly different for 8-year-olds and was 14% lower among 13-year-olds (significance testing not shown).

TABLE 20.2 *(Continued)*

Recall Validity Studies Among School-Age Children

Reference	Sample	Age/Grade	Instrument	Validation Standard	Design	Results
Lytle et al. 1998[14]	238 M 248 F 253 White 146 Asian 73 Black 14 Other	4th Grade	Lunch recall; quantitative	Observation	Compared child's recall of school lunch against observation of lunch. Excerpted lunch meal from 24-hour recall.	Pearson correlations between recall and observed intake for energy was 0.44. Range of correlations for the 5 nutrients assessed was 0.39 for beta-carotene to 0.61 for vitamin C. Recalled energy intake was 14% higher than observed intake (600 vs. 526 kcal/meal). There were significant differences between recalled and observed nutrient intake for all nutrients except beta-carotene (borderline significant). The highest correlation was for servings of fruit, 0.65, and lowest for servings of vegetables, 0.42. No ethnic specific analyses provided.
Baxter et al. 1997[a15]	120 M 117 F 58 White 179 Black	4th Grade	Lunch recall; quantitative	Observation	Compared child's recall of food items from school lunch either the same day or the following day against observation of that lunch.	Average matched food rates from recall of lunch and observation of lunch were 84% and 68% for same day and next day intervals, respectively. Rates for omitted and added (phantom) foods were significantly lower for the same day (16% vs. 5%) than next day recalls (32% vs. 13%). Children were least likely to omit beverages and main dishes and most likely to omit condiments and miscellaneous foods. There were no significant gender, ethnic, or time interval differences in the accuracy of recalling the amount of food consumed (significance testing not shown).
Mullenbach et al. 1992[9]	22 M 18 F	6-9th Grade Adults required	24-Hour recall by phone; quantitative	3-day food record	Compared adolescents' parent-assisted recall against adolescents' parent-assisted 3-day food records completed 2-4 weeks prior to recalls.	Pearson correlations between recall and food records were 0.42 for energy, 0.42 for protein, and 0.33 for total fat. Range of correlations for the 19 nutrients assessed was 0.09 for cholesterol to 0.57 for riboflavin. Recalled energy intake was 12% lower than recorded energy intake (1835 vs. 2097 kcal/day). There were no significant differences between recalled and recorded average nutrient intake, although the 24-hour recall estimates were all lower than those from the food record.

[a] Results of all subgroups not reported due to samples below the N=30 criterion
[b] Males (M), females (F)
[c] Adult assistance required for instrument administration
[d] N/A — not applicable
[e] FFQ — food frequency questionnaire
[f] TEE — total energy expenditure

drank during a specified time period, typically the previous day.[5] The 24-hour recall is an estimate of actual intake that incorporates a detailed description of the food, including brand names, ingredients of mixed dishes, food preparation methods, and portion sizes consumed. Because of the detail provided, complete nutrient intake can be calculated for the designated day. When conducted with a random sample population, a single 24-hour recall is appropriate for estimating group means, but is not a tool to predict individual-level health outcomes such as serum cholesterol levels. Because of intra-individual variation in intake, multiple recalls are needed to accurately estimate usual nutrient intake. Nelson and colleagues have addressed how to calculate the number of days of recording required to estimate intakes of individual nutrients for children age 2 to 17 years.[6] Collection of 24-hour recall data can occur via paper records or with a computer-assisted program. Prompts for quantification of portion size such as two- or three-dimensional food models are typically employed.

Food Record (Table 20.3)

Food records are written accounts of actual intake of the food and beverages consumed during a specified time period, usually three, five, or seven days.[5] A single food record is a measure of actual intake and, like the 24-hour recall, is appropriate for estimating group means but is not a tool to predict individual-level health outcomes. The work of Nelson and colleagues can be used to calculate the number of days of records necessary to determine nutrient intake with precision.[6] Respondents record detailed information about their dietary intake, such as brand names, ingredients of mixed dishes, food preparation methods, and estimates of amounts consumed. By collecting the information at the time of consumption, error due to memory loss is reduced, and thus food records often serve as a validation standard. Prompts for quantification of food portions, such as two- or three-dimensional food models are frequently used to aid respondents. Audiotaping food records has been explored as an alternative to handwritten records.[8]

Food Frequency Questionnaires (Tables 20.4 and 20.5)

Food frequency questionnaires (FFQs) which measure usual food intake are often used for epidemiological studies, since they are relatively easy to administer, less expensive than other assessment methods, and easily adapted for population studies. These measures of usual intake can be used to rank respondents by intake levels and are useful for predicting health outcomes at both group and individual levels. Respondents are asked to report frequency of consumption and sometimes portion size for a defined list of foods; the questionnaire can be self-administered or conducted with individual or group assistance. Respondents report their usual intake over a defined period of time in the past year, month, or week, although frequency of intake on the previous day has also been assessed. FFQs can be classified as quantitative, semi-quantitative, or non-quantitative. Data from non-quantitative FFQs are generally used to assess frequency of consumption of food; however, these frequencies may also be associated with standard portions to estimate nutrient amounts. The burden of work for the researcher is on the front end, developing the food list for inclusion on the FFQ. The appropriateness of the food list for the FFQ often needs to be population specific to accurately assess usual intake.

Diet History (Table 20.6)

Diet histories assess the past diet of an individual in the form of usual meal patterns, food intake, and food preparation practices through an extensive interview or questionnaire.[5]

TABLE 20.3

Food Record Validity Studies Among School-Age Children

Reference	Sample	Age/Grade	Instrument	Validation Standard	Design	Results
Lindquist et al. 2000[65]	17 M[b] 13 F[b] 17 White 13 Black	6.5-11.6 y Adults required[c]	3-Day audio-taped food record	TEE[f] by doubly-labeled water	Compared average of 3 child's parent-assisted reports of intake from audiotaped food records against 14-d TEE.	Mean recorded energy intake from 3-day audiotaped records was 14% lower than TEE from doubly-labeled water (6.73 vs. 7.86 mJ/day). Age was significantly related to reporting accuracy with underestimation of energy intake from audiotaped food records increasing with age.
Knuiman et al. 1987[21]	30 M	8-9 y Adults required	3-Day lunch food record; quantitative	Observation	Compared child's parent-assisted record of lunch intake against observation of lunch with weighed duplicate portions. Excerpted lunch meal from 7-day non-consecutive food records collected over 15 days.	Correlations between mean values from recorded and observed lunch intake were 0.71 for energy, 0.66 for protein, and 0.63 for total fat. Range of correlations for 14 nutrients (i.e., both absolute and density values) assessed was 0.62 for saturated fatty acids as % of kcal to 0.92 for polyunsaturated fat as % of kcal. Recorded energy intake was 25% higher than observed intake (456 vs. 365 kcal/meal). Ten nutrients were significantly overestimated by recorded intake of lunch as compared to observation.
Knuiman et al. 1987[21]	68 M	8-9 y Adults required	7-Day dinner food record; quantitative	Chemical analysis of food	Compared mothers' record of dinner intake against chemical analyses of duplicate portions of dinner. Excerpted dinner from 7-day non-consecutive food records collected over 15 days.	Correlations between mean values from recorded dinner intake and chemical analyses of dinner were 0.52 for energy, 0.56 for protein, and 0.58 for total fat. Range of correlations for the 14 nutrients (i.e., both absolute and density values) assessed was 0.45 for polyunsaturated fat as % of kcal to 0.85 for cholesterol. Recorded energy intake was 31% higher than chemical analysis of food (647 vs. 495 kcal/meal). Nine nutrients were significantly overestimated by mother's record of dinner as compared to chemical analysis of dinner.

Van Horn et al. 1990[8]	33 M&F	8-10 y	1-Day food record audio-taped; quantitative	Observation	Compared child's report of intake from taped food record against parent's observation recorded as a food record.	Pearson correlations between child's and parent's records were 0.68 for energy, 0.82 for protein as % of kcal, and 0.82 for total fat as % of kcal. Range of correlations for the 10 nutrients assessed was 0.68 for energy to 0.96 for iron. Child's recorded energy intake was 2% lower than parents' recorded energy intake (1882 vs. 1913 kcal/day). There were no significant differences between child and parent reports of nutrient intake (significance testing not shown).
Bandini et al. 1997[19]	109 F[b] White, Black, Hispanic, other	8-12 y Adults required	7-Day food record; quantitative	TEE by doubly labeled water	Compared child's adult-assisted food record against 14-day TEE.	Mean recorded energy intake was 13% lower than TEE from doubly labeled water (7.00 vs. 8.03 mJ/day). Age was significantly related to reporting accuracy with underestimation of energy intake from food records increasing with age. There were no significant differences by ethnicity.
Champagne et al. 1998 [a20]	60 M[b] 58 F 56 Black 62 White	9-12 y Adults required	8-Day food record; quantitative	TEE by doubly-labeled water	Compared child's parent assisted record of intake against TEE.	Mean recorded energy intake was 24% lower than TEE from doubly labeled water for boys (1953 vs. 2555 kcal/day) and 27% lower for girls (1633 vs. 2232 kcal/day). Mean recorded energy intake was 28% lower than TEE from doubly labeled water for blacks (1678 vs. 2346 kcal/day) and 22% lower for whites (1909 vs. 2441 kcal/day).
Green et al. 1998[18]	14 F 19 F 29 F 43 F	16 y 17 y 18 y 19 y	3-Day food record; quantitative	Serum folate, red blood cell (RBC) folate, and serum vitamin B_{12}.	Compared adolescent's report of folate and vitamin B_{12} intake on weighed record against serum micronutrient levels collected 1 week before food records.	Pearson correlations between recorded folate intake and serum folate were 0.65, between recorded folate intake and RBC folate were 0.50, and between recorded vitamin B_{12} intake and serum B_{12} were 0.32.

[a] Results of all subgroups not reported due to samples below the N=30 criterion
[b] Males (M), females (F)
[c] Adult assistance required for instrument administration
[d] N/A — not applicable
[e] FFQ — food frequency questionnaire
[f] TEE — total energy expenditure

TABLE 20.4

Food Frequency Questionnaire (FFQ) Validity Studies Among School-Age Children

Reference	Sample	Age/Grade	Instrument	Response Categories (Range)	Validation Standard	Design	Results
Blom et al. 1989[a22]	13 M[b] 17 F	2-16 y Adults required[c]	36 Items; (sucrose, protein, fat, fiber, nitrite, vitamin C) self-administered; referent period not specified; non-quantitative	Unknown (<1/ week to ≥4 times/day)	7-Day food record	Compared child's parent-assisted report of intake of foods with high content of sucrose, protein, fat, fiber, nitrite, and vitamin C against child's parent- and other adult-assisted report of intake on 7-day consecutive food record completed 6-8 weeks before the FFQ.	Spearman correlations between FFQ and food records for frequency of food groups with high content of protein and fat were 0.69 and 0.69, respectively. Range of correlations for 6 food groups assessed was 0.52 for sucrose to 0.76 for vitamin C. Compared to the food record, 2 food groups were significantly overestimated and 3 significantly underestimated by the FFQ. Of 34 food items, 5 were significantly overestimated and 8 significantly underestimated by the FFQ.
Taylor et al. 1998[23]	26 M 41 F	3-6 y Adults required	35-Items; (calcium) self-administered; past year; semi-quantitative	Open-ended (never to number of times/month)	4-Day diet record	Compared parent's report of child's intake of calcium against parent's report of child's 4-day diet record.	The FFQ significantly overestimated mean calcium intake by 18% compared to the food record (942 mg vs. 798 mg/day).
Kaskoun et al. 1994[a30]	22 M 23 F white & Native American	4-6 y Adults required	<111-Items; self-administered; past year; semi-quantitative; adult portions	9 (<1/month to ≥6 times/day)	TEE by doubly-labeled water	Compared parent's report of child's energy intake against 14-day TEE completed after or at the same time as the FFQ.	The FFQ significantly overestimated total energy intake by 59% compared to TEE (9.12 vs. 5.74 mJ/day).
Persson et al. 1984[31]	477 M[b]&F[b]	4 & 8 y Adults required	27 Items; interviewer administered; referent period not specified; non-quantitative	8 (None to ≥4 times/day)	7-Day food record	Compared parent's report of child's frequency of intake of foods against parent's report of child's intake on 7-day food records. Foods from the records were translated into food categories of the FFQ.	Of the 27 food items, the frequencies of intake of 15 were significantly overestimated, and 9 were significantly underestimated by the FFQ compared to the food record.

Hammond et al. 1993[24]	150 M&F	5-11 y Adults required	35 Items (fat, energy, fiber); self-administered; past month; non-quantitative	10 (None to 7 days/week)	14-Day food checklists	Compared child's parent-assisted report of frequency of intake of foods against child's parent-assisted report of intake on 14-day food checklists. Food checklists consisted of 2 sets of 7-day consecutive food records 1 and 2 months after the FFQ, respectively, and contained the same food categories as the FFQ.	For the 35 foods, the median difference in days/week consumption between the FFQs and food checklists was: equal to 0 for 17 foods, >0 for 5 foods, and <0 for 13 foods (significance testing not shown). Differences ranged from –1 (cakes, chips) to 1 (green vegetables). Percentage of responders classified by FFQ to within ± 1 day per week of frequencies reported on checklists ranged from 46.8% for low-fiber cereal to 99.3% for lamb, fish, and liver.
Byers et al. 1993[25]	43 M 54 F white & black	6-10 y Adults required	35 Items (15 fruits, 20 vegetables); self-administered; past 3 months; semi-quantitative; adult portions	9 (None or <1 time/month to ≥6 times/day)	Serum carotenoids vitamins A, C, and E	Compared parent's report of child's fruit and vegetable intake against child's serum micronutrient levels.	Spearman correlations between serum and dietary nutrients were 0.16 for carotene, 0.39 for vitamin C, 0.14 for vitamin A, and 0.32 for vitamin E. Correlations between serum levels of carotene, vitamin C, vitamin A, and vitamin E and frequencies of intake of total fruits and vegetables were 0.24, 0.29, 0.14, and 0.17, respectively. There were no differences by gender or ethnicity (significance testing not shown).
Bellu et al. 1996[32]	165 M[b] 158 F[b]	8-10 y Adults required	116 Items; self-administered; past 6 months; semi-quantitative; "average" portions	Unknown	24-Hour recall	Compared parent's report of child's nutrient intake against mother's report of child's intake on 24-hour recall.	Mean energy estimates from the FFQ were 27% higher than the 24-hour recall for girls (2156 vs. 1703 kcal/day) and 25% higher for boys (2281 vs. 1821 kcal/day). Among girls, of the 10 nutrients, the FFQ significantly overestimated 1 nutrient and significantly underestimated 2 nutrients. Among boys, 3 nutrients were significantly overestimated and 1 was significantly underestimated by the FFQ.

TABLE 20.4 *(Continued)*

Food Frequency Questionnaire (FFQ) Validity Studies Among School-Age Children

Reference	Sample	Age/Grade	Instrument	Response Categories (Range)	Validation Standard	Design	Results
Arnold et al. 1995[33]	77 F	7-12 y Adults required	160 Items; self-administered; past year (inferred); semi-quantitative; adult portions	Open-ended (none to number of months/year)	14-Day food record	Compared child's parent-assisted report of nutrient intake from 2 administrations against child's parent-assisted report of intake on 14-day food records. Records, consisting of 2 sets of 7-day consecutive food records were completed 1 month after the first FFQ and 6 months later.	Pearson correlations (log-transformed, energy-adjusted) between the first FFQ and the first food record and the second FFQ and second food record were 0.13 to 0.22 for energy, 0.20 to 0.30 for protein, and 0.28 to 0.46 for fat, respectively. Range of correlations for 16 nutrients assessed was 0.06 for starch to 0.61 for vitamin B_2. For the first FFQ, energy intake was 24% higher than the first food record (2319 vs. 1861 kcal/day). For the second FFQ, energy intake was 16% higher than the second food record (2205 vs. 1902 kcal/day). Both administrations of the FFQ overestimated intake for all 16 nutrients compared to the corresponding food records (significance testing not shown).
Baranowski, Smith et al. 1997[26]	1530-1570 M[b]&F[b] black & white	3rd Grade	7 Items (3 fruit, 4 vegetables); group-administered; past month; semi-quantitative; "serving" portions	10 (None to ≥5 times/day)	7-Day food record	Compared child's report of servings of fruits and vegetables against child's report of intake on 7-day food records. Foods from the records were abstracted into the FFQ categories by a dietitian.	Pearson correlations between FFQ and food records for fruits and vegetables, fruits and juices, and vegetables were 0.20, 0.24, and 0.15, respectively. Total servings of fruits and vegetables/week as measured by the FFQ was 50.9; by food record was 15.9. The FFQ significantly overestimated intake of food items in all 7 food categories, both aggregate and individual items (significance testing not shown).

Bellu et al. 1995[34]	39 M 49 F	9-12 y Adults required	116 Items; self-administered; past 6 months; semi-quantitative; "average" portions	Unknown	14-Day food record	Compared parent's report of child's nutrient intake against parent's report of child's intake on 14-day weighed food records. Records consisted of 2 sets of 7-day consecutive food records at the beginning of the study and 6 months later, respectively, before and after the FFQ.	Pearson correlations between FFQ and food records were 0.46 for energy, 0.34 for protein, and 0.39 for fat. Range of correlations for 18 nutrients assessed was 0.07 for vitamin A to 0.52 for carbohydrates. FFQ energy intake was 40% higher than the diet record (2620 vs. 1865 kcal/day). The FFQ significantly overestimated 6 nutrients and significantly underestimated 5 nutrients compared to the food records.
Rockett et al. 1997[35]	122 M[b] 139 F[b] 96% White	9-18 y	131 Items Youth/Adolescent Questionnaire; self-administered; past year; semi-quantitative; child portions	Dependent on type of food	24-Hour recall	Compared child's report of nutrient intake (mean of 2 administrations 1 year apart) against child's report of intake on three 24-hour recalls. Recalls were collected via telephone by research dietitians in the year between FFQ administrations.	Pearson correlations (unadjusted log-transformed values) between FFQs and recalls were 0.35 for energy, 0.30 for protein, and 0.41 for fat. Range of correlations for 28 nutrients assessed was 0.09 for copper to 0.46 for vitamin C. Deattenuated correlations (adjusted for energy and within-person variation) were 0.43 for protein and 0.57 for total fat. Range of deattenuated correlations for 29 nutrients assessed was 0.24 for sodium to 0.75 for vitamin C. FFQ energy intake was 1% higher than the recalls (2196 vs. 2169 kcal/day). Of 31 nutrients assessed, 16 were overestimated by the FFQ and 8 were underestimated (significance testing not shown). Correlations did not show a consistent pattern by gender or age (significance testing not shown).

TABLE 20.4 *(Continued)*

Food Frequency Questionnaire (FFQ) Validity Studies Among School-Age Children

Reference	Sample	Age/Grade	Instrument	Response Categories (Range)	Validation Standard	Design	Results
Domel et al. 1994[27]	160-165 M&F black & white	4-5th Grade	45 Items (15 fruit, 30 vegetables); group-administered; past month; semi-quantitative; "serving" portions	7 (None or <1/ month to several per day)	22-Day food record	Compared child's report of frequency of fruit and vegetable intake (mean of 2 administrations) against child's report of intake on 22 consecutive days of food records. Records were collected between FFQ administrations; foods from the records were abstracted by a dietitian into servings of fruit and vegetables.	Spearman correlations between month 1 FFQ and food records and month 2 FFQ and food records were 0.12 and 0.17 for total fruit, –0.04 and 0.02 for total vegetables, and –0.05 and 0.01 for total fruit and vegetable. Range of correlations for 8 fruit/vegetable groupings assessed was –0.05 for total fruit and vegetables to 0.32 for fruit and vegetable juice. Mean daily servings of total fruit and vegetables were 409% higher for the month 1 FFQ compared to the corresponding food records (11.7 vs. 2.3), and 135% higher for the month 2 FFQ compared to the food records (5.4 vs. 2.3). Both administrations of the monthly FFQ significantly overestimated mean daily servings for all 8 fruit/vegetable groupings compared to the corresponding food records.
Domel et al. 1994[27]	154-156 M[b]&F[b] black & white	4-5th Grade	45 Items (15 fruit, 30 vegetables); group-administered; past week; semi-quantitative; "serving" portions	5 (None or <1/ week to several per day)	2-Week food record	Compared child's report of frequency of fruit and vegetable intake (mean of 2 administrations) against child's report of intake on 7-day food records. Records were collected between FFQ administrations; foods from the records were abstracted by a dietitian into servings of fruit and vegetables.	Spearman correlations between week 1 FFQ and food records and week 2 FFQ and food records were 0.18 and 0.18 for total fruit, –0.01 and 0.11 for total vegetable, and 0.00 and 0.05 for total fruit and vegetable. Range of correlations for 8 fruit/vegetable groupings assessed was –0.01 for total vegetable to 0.25 for total legumes and fruit. Mean daily servings of total fruits and vegetables were 295% higher for week 1 FFQs compared to the corresponding food record (8.3 vs. 2.1) and 306% higher for week 2 FFQ (7.3 vs. 1.8). Both administrations of the weekly FFQ significantly overestimated mean daily servings for all 8 fruit and vegetable groupings compared to the corresponding food records.

Koehler et al. 2000[66]	66 M 54 F American Indian, non-hispanic-white, Hispanic	5-8th Grade	33 Items Yesterday's Food Choices-YFC; self-administered; past day; non-quanitative	Yes, not sure, and no	24-Hour recall	Compared child's reported intake of particular foods against child's 24-hour recall, both completed on same day.	Spearman correlations between scores on the FFQ and 24-hour recall were 0.71 for low fat foods, 0.35 for high fiber foods, 0.29 for fruits and vegetables, and 0.40 for high fat foods.
Jenner et al. 1989[36]	61 M 57 F	~11-12 y	175 Items; group-administered; past week; non-quantitative	6 (None to every day)	14-Day food record	Compared child's report of nutrient intake against child's report of intake on 14-day diet records. Seven sets of 2 consecutive day records were collected in the 3 months following administration of the FFQ. Nutrient estimates from FFQ completed by parents were also compared to the 14-day diet records.	Pearson correlations (log-transformed) between the children's FFQs and diet records were 0.25 for energy, 0.18 for protein, and 0.19 for total fat. Range of correlations for 13 nutrients assessed was 0.11 for monounsaturated fat to 0.42 for complex carbohydrates. Correlations between the parents' FFQs and diet records were 0.38 for energy, 0.26 for protein and 0.30 for total fat. Range of correlations was 0.26 for protein to 0.47 for complex carbohydrates. Children's FFQ energy intakes were 36% higher than diet records (10.9 vs. 8.0 mJ/day). Parents' FFQ estimates of children's energy intake were 21% higher than the children's diet records (9.7 vs. 8.0 mJ/day). All 13 nutrients were overestimated by both the child and the parent FFQ (significance testing not shown).
Kinlay et al. 1991[28]	57 M[b] 48 F[b]	13-17 y Adults required	12 Items (fat, saturated fat); self-administered; past week; semi-quantitative	Dependent on type of food	FFQ[e]	Compared child's parent-assisted report of fat intake against child's parent assisted report of fat intake on FFQ.	Spearman correlations between the brief FFQ and the FFQ were 0.40 for total fat as % of kcal and 0.54 for saturated fat as % of kcal.
Field et al. 1998[29]	102 M&F 50% M 50% F 35% White 24% Black 15% Hispanic	9-12th Grade	27 Items (12 fruit, 15 vegetables) Youth/Adolescent Questionnaire; self-administered; past year; semi-quantitative	Unknown (<1/month to ≥2 times/day)	Three 24-hour recalls	Compared child's report of fruit and vegetable intake against child's report of intake on 3 nonconsecutive 24-hour recalls completed 2 weeks apart. FFQ was administered 2-4 weeks after the third recall.	Spearman correlations between the brief FFQ and mean of three 24-hour recalls were 0.33 for fruit only, 0.29 for fruit juice, 0.33 for fruit and juice, 0.32 for vegetables, and 0.41 for fruit (including juice) and vegetables.

TABLE 20.4 *(Continued)*

Food Frequency Questionnaire (FFQ) Validity Studies Among School-Age Children

Reference	Sample	Age/Grade	Instrument	Response Categories (Range)	Validation Standard	Design	Results
Field et al. 1998[29]	102 M&F 50% M 50% F 35% White 24% Black 15% Hispanic	9-12th Grade	4 Items (2 fruit, 2 vegetable) Youth Risk Behavior Surveillance System Questionnaire (YRBSS); self-administered; past day; semi-quantitative	Unknown (none to ≥3 times/day)	Three 24-hour recalls	Compared child's report of fruit and vegetable intake against child's reported mean intake of fruits and vegetables calculated with an algorithm using 3 nonconsecutive 24-hour recalls completed 2 weeks apart. YRBSS was administered 2-4 weeks after the third recall.	Spearman correlations between YRBSS items and mean of 24-hour recalls were 0.17 for fruit only, 0.07 for fruit juice, 0.21 for fruit and juice, 0.24 for vegetables, and 0.28 for fruit (including juice) and vegetables.
Field et al. 1998[29]	102 M&F 50% M 50% F 35% White 24% Black 15% Hispanic	9-12th Grade	6 Items (2 fruit, 4 vegetable) Behavioral Risk Factor Surveillance System Questionnaire (BRFSS); self-administered; past day; semi-quantitative	Unknown (none to ≥3 times/day)	Three 24-hour recalls	Compared child's report of fruit and vegetable intake against child's reported mean intake of fruits and vegetables calculated with an algorithm using 2 nonconsecutive 24-hour recalls completed 4 weeks apart. BFRSS was administered halfway between the two recalls.	Spearman correlations between past day BRFSS and mean of 24-hour recalls were 0.33 for fruit only, 0.30 for fruit juice, 0.34 for fruit and juice, 0.14 for vegetables, and 0.30 for fruit (including juice) and vegetables.

Field et al. 1998[29]	100 M&F 50% M 50% F 35% White 24% Black 15% Hispanic	9-12th Grade	6 Items (2 fruit, 4 vegetable) BRFSS; self-administered; past year; semi-quantitative	Unknown (none to ≥5 times/day)	Three 24-hour recalls	Compared child's report of fruit and vegetable intake against child's reported mean intake of fruits and vegetables calculated with an algorithm using 3 nonconsecutive 24-hour recalls completed 4 weeks apart. BFRSS was administered preceding the third recall.	Spearman correlations between past year BRFSS and mean of 24-hour recalls were 0.36 for fruit only, 0.36 for fruit juice, 0.35 for fruit and juice, 0.33 for vegetables, and 0.43 for fruit (including juice) and vegetables.
Green et al. 1998[18]	14 F 19 F 29 F 43 F	16 y 17 y 18 y 19 y	116 Items; self-administered; past year; semi-quantitative	Unknown	Serum folate, red blood cell (RBC) folate, and serum vitamin B_{12}	Compared child's report of folate and vitamin B_{12} intake against serum micronutrient levels.	Pearson correlations were 0.48 between folate intake from the FFQ and serum folate, 0.42 between folate intake from the FFQ and RBC folate, and 0.25 between vitamin B_{12} intake from the FFQ and serum B_{12}.
Andersen et al. 1995[37]	13 M 36 F	11th Grade Adults required	190 Items; group-administered; past year; semi-quantitative	Dependent on type of food	7-Day food record	Compared child's parent assisted report of nutrient intake against child's report of intake on 7-day weighed food records completed 2-3 months after FFQ administration. Records consisted of 4 consecutive days, a 1-week interval, and 3 consecutive days.	Spearman correlations between FFQ and food records were 0.51 for energy, 0.48 for protein, 0.57 for total fat. Range of correlations for 18 nutrients assessed was 0.14 for vitamin D to 0.66 for monounsaturated fat. FFQ energy intake was 24% higher than diet records (10.7 vs. 8.6 mJ/day). The FFQ significantly overestimated 16 of the 18 nutrients. The FFQ significantly overestimated intake of 8 of 13 food items as compared to diet records.

[a] Results of all subgroups not reported due to samples below the N=30 criterion
[b] Males (M), females (F)
[c] Adult assistance required for instrument administration
[d] N/A — not applicable
[e] FFQ — food frequency questionnaire
[f] TEE — total energy expenditure

TABLE 20.5

Food Frequency Questionnaire (FFQ)[e] Reliability Studies Among School-Age Children

Reference	Sample	Age/ Grade	Instrument	Response Categories (Range)	Design	Results
Basch et al. 1994[39]	166 M&F[b] Latino	4-7 y Adults required[c]	~116 Items; interviewer-administered; past 6 months; semi-quantitative; child portions	9 (None or <1/ month to ≥6/ day)	Compared both 3-month and 1-year test-retest reproducibility of nutrient estimates from FFQs completed by the parent.	Pearson correlations (log-transformed) between the 2 FFQs at 3 months were 0.53 for energy, 0.49 for protein, and 0.56 for total fat. Range of correlations for 12 nutrients assessed at 3 months was -0.06 for sucrose to 0.61 for crude fiber. At 1 year, correlations were 0.46 for energy, 0.40 for protein, and 0.47 for total fat. Range of correlations for 12 nutrients assessed at 1 year was 0.06 for sucrose to 0.57 for polyunsaturated fat.
Arnold et al. 1995[33]	77 F	7-12 y Adults required	160 Items; self-administered; past year; semi-quantitative; adult portions	5 (Open-ended, none to number of months/ year)	Compared 6-month test-retest reproducibility of nutrient estimates from FFQs completed by the parent and child.	Pearson correlations (log-transformed, energy adjusted) between the 2 FFQs were 0.60 for energy, 0.51 for protein, and 0.14 for total fat. Range of correlations for 16 nutrients assessed was 0.14 for total fat to 0.71 for fiber. Mean energy intake was 5% higher in the first FFQ compared to the second (2319 vs. 2205 kcal/day). Mean intake of 15 nutrients was higher in the first FFQ compared to the second; 1 nutrient was lower (significance testing not shown).
Domel et al. 1994[27]	146 M&F black & white	4-5th Grade	45 Items (15 fruit, 30 vegetable); group-administered; past week; semi-quantitative; "serving" portions	5 (None or <1/ week to several per day)	Compared 1-week test-retest reproducibility of fruit and vegetable intake from FFQs completed by the child. Order of fruit (15 items) and vegetables (30 items) was reversed between first and second administrations.	Spearman correlations between the 2 FFQs were 0.50 for total fruit, 0.48 for total vegetable, and 0.54 for total fruit and vegetable intake. Range of correlations for 8 fruit and vegetable groupings assessed was 0.39 for fruit and vegetable juice to 0.54 for total fruit and vegetables. Mean daily servings of total fruits and vegetables was 12% higher for Week 1 FFQ compared to Week 2 FFQ (8.3 vs. 7.3). Mean daily servings of 6 fruit and vegetable groupings of 8 assessed were higher for Week 1 FFQ compared to Week 2 FFQ (significance testing not shown).
Domel et al. 1994[27]	156 M&F black & white	4–5th Grade	45 Items (15 fruit, 30 vegetable); group-administered; past month; semi-quantitative; "serving" portions	7 (None or <1/ month to several per day)	Compared 1-month (3.5-week) test-retest reproducibility of fruit and vegetable intake from FFQs completed by the child. Order of fruit (15 items) and vegetables (30 items) was reversed between first and second administrations.	Spearman correlations between the 2 FFQs were 0.43 for total fruit, 0.37 for total vegetable and 0.47 for total fruit and vegetable intake. Range of correlations for 8 fruit and vegetable groupings assessed was 0.28 for fruit and vegetable juice to 0.47 for both legumes and total fruit and vegetable intake. Mean daily servings of total fruits and vegetables was 54% higher for Month 1 FFQ compared to Month 2 FFQ (11.7 vs. 5.4). Mean daily servings of 8 fruit and vegetable groupings were higher for Month 1 FFQ compared to Month 2 FFQ (significance testing not shown).

Rockett et al. 1995[38]	75 M 101 F 3 N/A[d] multi-ethnic	9-18 y	151 Items Youth/Adolescent Questionnaire; self-administered; past year; semi-quantitative; adult portions	9 (None or <1/month to ≥6/day)	Compared 1-year test-retest reproducibility of nutrient estimates from FFQs completed by the child.	Pearson correlations (log-transformed, energy-adjusted) between the 2 FFQs were 0.49 for energy, 0.26 for protein, and 0.41 for total fat. Range of correlations for 7 nutrients assessed was 0.26 for protein and iron to 0.58 for calcium. Mean energy intake was 10% higher in the first FFQ compared to the second (2477 vs. 2222 kcal/day). Mean intake of 6 nutrients assessed was significantly higher in the first FFQ compared to the second. Range of correlations for 8 food groups assessed was 0.39 for meats to 0.57 for soda. Pearson correlations (log-transformed) for servings/day were 0.49 for fruits, 0.48 for vegetables, and 0.48 for fruits and vegetables. Of 8 food groups, mean serving frequencies of 5 were significantly higher in the first FFQ compared to the second. Reproducibility of nutrient intake was significantly higher for girls than boys (mean correlation for all nutrients was 0.44 and 0.34, respectively). There were no significant differences by age or ethnicity.
Frank et al. 1992[40]	189 M&F black & white	12-17 y	64 Items; group-administered; past week; semi-quantitative; adult portions	6 (None to >3 times/day)	Compared 2-week test-retest reproducibility of food intake from FFQs completed by the child.	Two-thirds of the children reported similar responses for the frequency of consumption of low-fat milk, diet carbonated soft drinks and shellfish. Twelve food groups had percent agreement of 50% or better (significance testing not shown).
Andersen et al. 1995[37]	53 M 50 F	11th Grade Adults required	190 items; group-administered; past year; semi-quantitative	Dependent on type of food	Compared 6-week test-retest reproducibility of nutrient estimates from FFQs completed by the child and parent.	Spearman correlations (energy-adjusted) between the 2 FFQs were 0.87 for energy, 0.86 for protein, and 0.86 for total fat. Range of correlations for 18 nutrients assessed was 0.72 for vitamin C to 0.91 for alcohol. Median energy intake was 11% higher in the first FFQ compared to the second (12.3 vs. 10.9 mJ/day). Median intake of 15 nutrients was significantly higher in the first FFQ compared to the second FFQ. Differences in median correlations for nutrient intake were not significant between girls and boys (0.78 vs. 0.74, respectively).

[a] Results of all subgroups not reported due to samples below the N=30 criterion
[b] Males (M), females (F)
[c] Adult assistance required for instrument administration
[d] N/A — not applicable
[e] FFQ — food frequency questionnaire

The diet history provides a measure of usual intake appropriate for ranking individuals and predicting health outcomes. In contrast to other methods of dietary assessment, a diet history is usually more qualitative than quantitative, allowing detailed information about food preparation, eating habits, and food consumption to be collected by a highly trained interviewer. This method requires children and/or parents to recall dietary intake from the past, understand spatial relationships, be able to apply math skills, and have the stamina to complete the typically one- to two-hour interview. Because of the respondent burden, diet histories are not often used to assess children's diets.

Observation (Table 20.6)

Observation is useful for assessing preliterate children (third grade or younger), either in a lunchroom setting with school meals or in controlled school or group activities. Intensively trained observers unobtrusively watch the children, sometimes many at a time, to ascertain foods, brand names and portion sizes consumed. A single observation provides a measure of actual intake that is appropriate for estimating group means and cannot be used to predict health outcomes. Multiple observations can provide a measure of usual intake. The recordings are interpreted after the collection process and coded to a nutrient database to calculate nutrient intake for each child. Observations are often used as the validation standard for studies among school-age children.

Discussion

Ideally, a comprehensive review of validity and reliability studies such as this one would direct researchers to the best assessment technique for a particular setting. Unfortunately, as this report indicates, dietary assessment techniques for children are difficult to evaluate and generalize because the validation standards against which the instruments have been compared are frequently beset with shortcomings. These validation standards may have inconsistent validity, or use a referent period that differs from that used for the instrument. Heterogeneity of the studies also makes it difficult to draw conclusions; the differences in study administrations and study populations make comparisons uncertain both within a type of assessment method and between methods. Noting these challenges to interpretation, the correlations between the validation standard and the dietary assessment tool were almost always higher for recalls or records than for FFQs.

This review may serve best to facilitate comparison of dietary methods to determine the most effective data collection instruments to use with particular quantitative or qualitative research questions.[43-44] The reader may, for example, scan each table for instruments with higher or lower nutrient correlations with a particular validity standard, instruments that children can complete without adult assistance, those with no portion size estimation, and instruments specific to assessing intake of food groups — all by age or grade. Applications of the dietary assessment methods are summarized in Table 20.7 which provides advantages and disadvantages for using the dietary assessment methodologies, applicable study designs, and brief highlights of their validity from this review. Using this series of tables, the reader can select a dietary assessment tool that is appropriate for specific research questions.

It is evident that many of the validation standards used in the reviewed articles are imperfect, especially for children. Food records or recalls were the most common choices

TABLE 20.6

Diet History and Observation Reliability Studies Among School-Age Children

Reference	Sample	Age/ Grade	Instrument	Design	Results
Rasanen, 1979[41]	47 M&F[b] 50 M&F 37 M&F	5 y 9 y 13 y Adults required[c]	Diet history; past year; interviewer administered; quantitative	Compared 7-month test-retest reproducibility of nutrient intake from a diet history completed by child and parent.	Pearson correlations between the first and second interviews were 0.59 for energy, 0.60 for protein, and 0.57 for total fat. Range of correlations for 11 nutrients assessed was 0.41 for ascorbic acid to 0.60 for protein. Mean daily energy intake was 27% higher in the first diet history interview as compared to the second interview (3256 vs. 2573 kcal/day).
Simons-Morton et al. 1992[42]	45 M&F	3-5th Grade Adults required	Observation; lunch only; quantitative	Compared 2 simultaneously collected adult observers' estimates of nutrient intake and food items from observation of lunch.	Intraclass correlations between paired observers ranged from 0.81-0.90 for energy and from 0.74-0.88 for fat. Of the 6 nutrients assessed, intraclass correlations were lowest for total fat (0.74-0.88) and highest for vitamin A (0.96-0.98). Inter-observer percent differences in mean energy intake ranged from 0.1%-6.8%. Overall agreement on food items between observers was 84%; percent agreement was highest for chips and condiments, and lowest for desserts. Differences in portion size estimates accounted for most of the energy and nutrient differences between observers.

[a] Results of subgroups not reported due to samples below the N=30 criterion
[b] males (M), females (F)
[c] adult assistance required for instrument administration
[d] N/A — Not applicable
[e] FFQ — Food frequency questionnaire

TABLE 20.7

Summary of Reviewed Dietary Assessment Methods for School-Age Children

Method and Number of Studies Reviewed	Ages Evaluated	Energy & Macro-Nutrient Validity[a]	Energy Intake Compared with Standard[b]	Type of Diet Measure	Study Design Applications	Advantages	Disadvantages
FOOD RECALL Validity — 12 Reliability — 0	4-14 y Adult assistance needed for <9 y	Energy 0.23-0.87 Protein 0.05-0.82 Total fat 0.25-0.46	–34 to 18%	One recall measures group intake Multiple recalls measure individual or group intake	• Cross-sectional • Intervention • Monitoring • Clinical • Epidemiologic	• Short administration time • Defined recall time • Intake can be quantified • Procedure does not alter habitual dietary patterns • Low respondent burden • Can be telephone administered • Procedure can be automated	• Recall depends on memory • Portion size difficult to estimate • Trained interviewer required • Expensive to collect and code
FOOD RECORD Validity — 7 Reliability — 0	8-19 y Adult assistance needed for <9 y	Energy 0.52-0.71 Protein 0.56-0.66 Total fat 0.58-0.63	–28 to 31%	One record measures group intake Multiple records measure individual or group intake	• Cross-sectional • Intervention • Monitoring • Clinical • Epidemiologic	• Record does not rely on memory • Defined record time • Intake can be quantified • Training can be group administered • Procedure can be automated	• Recorder must be literate • High respondent burden • Food eaten away from home less accurately recalled • Procedure alters habitual dietary patterns • Validity may decrease as recording days increase • Expensive to collect and code
FOOD FREQUENCY Validity — 22 Reliability — 7	2-19 y Adult assistance needed for <9 y	Energy 0.13-0.51 Protein 0.18-0.34 Total fat 0.19-0.39	1 to 59%	One FFQ measures usual intake	• Cross-sectional • Intervention • Monitoring • Epidemiologic	• Trained interviewers not needed • Interviewer or self-administered • Relatively inexpensive to collect • Procedure does not alter habitual dietary habits • Low respondent burden • Total diet or selected foods or nutrients can be assessed • Can be used to rank according to nutrient intake • Procedure can be automated	• Recall depends on memory • Period of recall imprecise • Quantification of intake imprecise because of poor recall or use of standard portion sizes • Specific food descriptions not obtained

DIET HISTORY Validity — 0 Reliability — 1	5-13 y Adult assistance needed for all ages	N/A	N/A	One history measures usual intake	• Monitoring • Clinical • Epidemiologic	• Literacy not required • Procedure does not alter habitual dietary habits • Can obtain highly detailed descriptions of foods and preparation methods	• Recall depends on memory • Highly trained interviewers required • Period of recall imprecise • Very high respondent burden • Requires long interview time • Quantification of intake imprecise because of poor recall or use of standard portion sizes • Expensive to administer
OBSERVATION Validity — 0 Reliability — 1	8-10 y	N/A	N/A	One observation measures group intake Multiple observations measure individual or group intake	• Intervention • Monitoring • Epidemiologic	• Literacy not required • Procedure does not alter habitual dietary habits • Procedure does not rely on memory • Defined observation time • Intake can be quantified • Multiple days give measure of individual or group intake	• Highly trained observers required • Requires long observation period • Expensive to administer

[a] Pearson correlation
[b] Calculation of percentage = ([instrument-validation standard]/validation standard)

for validation standards here, and information on the validity of these methods in children is mixed. Recalls both over- and underestimated energy, and food records underestimated energy intake. Most recall validity studies used observation of the child as the standard, but the majority of the studies only considered individual meals or daytime intakes to determine validity of the 24-hour recall. Accurate completion of food records is greatly dependent on the ability of the child to read and write. Because young children have not been shown to accurately complete food records independently, caution is suggested when interpreting studies that use records as the validation standard. The validity of food records or recalls for measuring long term or usual food intake improves with more days of recording,[5] indicating that multiple records may be needed. Multiple food records/recalls can introduce compliance issues for children because of the high respondent burden. Since a high degree of cooperation is required from children for food records and recalls, it is essential for both methods that children be motivated to participate, and in particular be cognitively able to complete the records.

In evaluating validation studies, the effect of correlated errors between the method evaluated and the validation standard should be considered. All dietary assessment methods have inherent errors; for validation studies, it is important that these errors be as independent as possible.[45] For example, if errors between the methods are similar (e.g., both methods rely on dietary information from a respondent such as FFQ and recalls), correlations between the two methods will be artificially inflated. In contrast, errors inherent in physiologic measures (e.g., doubly labeled water measurements or serum micronutrients) or observational data do not rely on information provided by respondents, and would be a more independent comparison to a respondent-based measure.[46] Comparisons of physiologic endpoints, such as blood nutrient levels, to dietary assessment methods have not been widely used with school-age children and offer other problems, since food intake may not be directly correlated with physiologic endpoints.

Selecting a validation standard can be a difficult task, because there is often no dietary assessment tool available with the same referent period as the assessment tool. Thus, a compromise may be needed in the study design. For example, an FFQ measures usual food consumption over a period of six months to a year, while a food record generally is used to measure food consumption on a day-to-day basis. In order to validate an FFQ, it would be necessary to complete several sets of food records over the referent period for the FFQ. Clearly, validation studies that use a week of continuous consecutive food records may not capture seasonal variation in diet. Similarly, a food recall, which is generally used to measure one complete day of consumption, should be validated by a method that assesses an entire day, not just a portion of the day.

The problem of referent periods also influences the experimental design for reliability studies. Because there is much day-to-day variation in diet, re-administration should be close enough in time to reflect the same referent period. Since some methods reflect diet over a short span of time (e.g., 1-day records and 24-hour recalls), theoretically the reliability testing should be completed on the same day as the assessment tool, which may allow memory effects from the first assessment to bias the re-administration. Studies that examine reliability should alternate administrations in order to eliminate bias as much as possible. Because FFQs usually include a longer referent period, it is easier to develop reproducibility studies for this method.

In all the studies reviewed, adult dietary assessment methods were adapted for administration to a pediatric population. Specific adaptations included incorporating parental or adult assistance, adjusting portion size information, using shorter referent times, and administering the instrument in the school setting. Children younger than nine years of age need adult assistance to provide accurate dietary information because they usually have limited reading skills and adults control most of the food offered, as well as the timing and frequency of eating occasions.[47-48] This review found that almost all of the validity and reliability studies among children less then nine years of age, with the exception of a few of the recall and FFQ studies, included adult participation. This participation varied from completion of the form entirely to obtaining only supplemental information from parents or surrogates, such as childcare providers, or secondary sources such as school food service observations.

Children generally have difficulty in estimating portion sizes.[30,49,50] A recent review of portion size aids was unable to make guidelines for portion size estimation for children or adults.[51] Both two- and three-dimensional models have been used to enhance children's portion size estimation.[7-9,11,16,21,39,41-42,52-54] Pictures of food and portions have been incorporated in assessments to enhance children's understanding; however, the addition of pictures did not increase accuracy among third-graders.[55] Among the newer tools for dietary assessment are reference books with life-size photographs of portion sizes, which have been credited as being both easy and accurate.[56-59] Training to improve portion size estimation among children has been attempted with significant improvements in estimation; however, even with training, some errors were reported as high as 100%.[60]

Semi-quantitative FFQs have not generally used portion sizes adjusted for children's level of intake. This may have enhanced the lack of agreement between the FFQ and validation standard, if the validation standard allowed for collection of specific portions consumed by the child. These FFQs may have systematically overestimated intake due to portion size miscalculations.

Because the school provides a natural means of regularly accessing school-age children, several researchers continue to explore ways of using this setting to collect dietary intake data. Methods such as using a group workbook to collect 24-hour recall information[61] have been developed to expand the number of eating occasions that can be evaluated, while trying to minimize the respondent burden for multiple records or recalls.

Recommendations

Despite the extensive dietary intake data available to nutritionists, epidemiologists, and pediatricians, this review identifies methodological concerns associated with the assessment tools currently used to determine dietary intake of school-age children. Generally, comparisons across studies were limited by differences in instruments, research design, validation standards, and populations. The paucity of data in many areas also made it difficult to draw generalized conclusions.

In the last three decades the most extensive body of validation work among children has occurred with FFQs, with only a limited number of validation studies and even fewer reliability studies of the other methods among school-age children. In the future, evaluations of dietary assessment techniques for children need to be conducted that give particular attention to experimental design, careful use of validation standards, and inclusion of different age, gender, and ethnic subgroups. As with adults, there is no perfect method of assessing dietary intake in children. Special consideration must be given to the age and cognitive ability of the child as well as methodological issues associated with nutrient analyses, food coding, and portion sizes. Both age and cognitive ability relate to the child's understanding of the method used and the thought processes that contribute to self-reporting of food choices.

What needs to be done? Ideally, studies need to examine the validity and reliability of each dietary assessment method by age, gender, and ethnic subgroup to understand the best application of each tool. Selection of the measure of truth for validation studies will be challenging, since there is not always a good choice when the referent periods differ so markedly between instruments, and the potential effect of correlated errors is considered. Physiologically based measures, such as doubly labeled water or serum micronutrient concentrations, represent a type of standard with considerable appeal and merit further study, since these measures are not affected by respondent error. In addition, studies that compare multiple validation standards for a particular assessment method would allow comparisons of the validation standards best suited for particular situations. Future studies need to address the timing of the referent period that best suits the assessment instrument in the design phase.

New approaches and modifications to existing approaches for dietary assessment among school-age children are needed. The dietary habits of children, especially young children who are preliterate, are inherently difficult to study. Unfortunately, assessment techniques that work reasonably well among adult men and women may not be useful for children, especially those less than nine years of age, who may need assistance from a proxy or special prompting techniques to estimate portion size. Creative measures must be developed to better estimate children's portion sizes and enhance researchers' ability to capture details of their dietary intake. Systematic evaluations of children's ability to estimate portion size utilizing various approaches by age are needed.

Researchers are urged to investigate how variables such as age, gender, ethnicity, socioeconomic status, and obesity affect the validity of dietary assessment methods. This review found little research on the effects of age, gender, or ethnicity. Given the multiplicity of minority groups in the U.S., there is a need for research to determine whether group-specific dietary assessment tools are necessary. Other areas, such as the effect of body size on reporting of dietary intake, require further study. For example, a recent study suggested that children with central fat distribution had higher rates of underreporting energy intake than lean or obese children, or those with peripheral fat distribution.[20] Another study reported that energy intake was significantly lower in obese children than non-obese children when compared to doubly labeled water as a percentage of energy expenditure.[62] Underreporting of dietary intake by obese adolescents is consistent with recent findings that obese adults tend to underreport their dietary intake.[62] With the increasing prevalence of obesity among children and adolescents, it is essential to determine whether body size differences significantly affect completion of dietary assessment instruments.[64]

In summary, much remains to be learned about the dietary intake of American youth. This review serves as a guide to the state of dietary assessment among school-age children. Recalls and records generally agreed more with the validation standards than did FFQs. Administration protocols differed greatly, the recalls and records often represented only meals or portions of the day, and the FFQ food lists varied from a few items to the total diet. This review can also serve as a foundation for initiating new studies and as a resource for developing research questions from the gaps identified in the current methodologies. The key to advancing the field is to build on our current base of methods, refine techniques that are useful, and develop new approaches to overcome obstacles that have been identified in study designs and data collection procedures. In the new millenium we must be able to accurately assess the dietary intake of our school-age children so that we can monitor dietary intake trends, make accurate research and policy decisions, and develop and effectively evaluate nutrition interventions.

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References

1. McPherson RS, Montgomery DH, Nichaman MZ. *J Nutr Ed* 27: 225; 1995.
2. Kennedy E, Goldberg J. *Nutr Rev* 53: 111; 1995.
3. US Department of Health and Human Services. Healthy people 2000: national health promotion and disease prevention objectives. DHHS Publication No. (PHS) 91-50212, US Gov. Printing Office, Washington, DC, 1990.
4. Ferro-Luzzi A, Martino L. In *Implementing Dietary Guidelines for Healthy Eating*, (Wheelock V, Ed), Blackie A&P, London, 1997, pg 3.
5. Thompson FE, Byers T. *J Nutr*, 124: 2245S, 1994.
6. Nelson M, et al. *Am J Clin Nutr* 50: 155; 1989.
7. Lytle LA, et al. *JADA* 93:1431; 1993.
8. Van Horn LV, et al. *JADA* 90: 412; 1990.
9. Mullenbach V, et al. *JADA* 92: 743; 1992.
10. Todd KS, Kretsch MJ. *Nutr Res* 6: 1031; 1989.
11. Eck LH, Klesges RC, Hanson CL. *JADA* 89: 784; 1989.
12. Emmons L, Hayes M. *JADA* 62: 409; 1973.
13. Samuelson G. *Nutr Metabol* 12: 321; 1970.
14. Lytle LA, et al. *JADA*, 98: 570; 1998.
15. Baxter SD, et al. *JADA* 97: 1293; 1997.
16. Basch CE, et al. *Am J Pub Health* 81: 1314; 1990.
17. Reynolds LA, Johnson SB, Silverstein J. *J Ped Psych* 15: 493; 1990.
18. Green TJ, Allen OB, O'Connor DL. *J Nutr* 128, 1665, 1998.
19. Bandini LG, et al. *Am J Clin Nutr* 65: 1138S; 1997.
20. Champagne CM, et al. *JADA* 98: 426; 1998.
21. Knuiman JT, et al. *JADA* 87: 303; 1987.
22. Blom L, et al. *Acta Pediatr Scand* 78: 858; 1989.
23. Taylor RW, Goulding A. *Eur J Clin Nutr* 52: 404; 1998.
24. Hammond J, et al. *Eur J Clin Nutr* 47: 242; 1993.
25. Byers T, et al. *Epidemiology* 4: 350; 1993.
26. Baranowski T, et al. *JADA* 97: 66; 1997.
27. Domel SB, et al. *J Am Col Nutr* 13: 33; 1994.
28. Kinlay S, Heller RF, Halliday JA. *Prev Med* 20: 378; 1991.
29. Field AE, et al. *Am J Pub Health* 88: 1216; 1998.
30. Kaskoun MC, Johnson RK, Goran MI. *Am J Clin Nutr* 60: 43; 1994.
31. Persson LA, Carlgren G. *Int J Epidemiol* 13: 506; 1984.
32. Bellu R, et al. *Nutr Res* 16: 197; 1996.
33. Arnold JE, et al. *Ann Epidemiol* 5: 369; 1995.
34. Bellu R, et al. *Nutr Res* 15: 1121; 1995.
35. Rockett HRH, et al. *Prev Med* 26: 808; 1997.
36. Jenner DA, et al. *Eur J Clin Nutr* 43: 663; 1989.
37. Andersen LF, et al. *Eur J Clin Nutr* 49: 543; 1995.
38. Rockett HRH, Wolf AM, Colditz GA. *JADA* 95: 336; 1995.
39. Basch CE, Shea S, Zybert P. *Am J Pub Health* 84: 861; 1994.
40. Frank GC, et al. *JADA* 92: 313; 1992.
41. Rasanen L. *Am J Clin Nutr* 32: 2560; 1979.
42. Simons-Morton BG, et al. *JADA* 92: 219; 1992.
43. Cullen KW, et al. *JADA* 99: 849; 1999.
44. Eldridge AL, et al. *JADA* 98: 777; 1998.

45. Willett W. *Nutritional Epidemiology*, 2nd ed, Oxford University Press, New York, 1998.
46. Bingham SA. *Am J Clin Nutr* 59: 227S; 1994.
47. Frank GC. *Am J Clin Nutr* 59: 207S; 1994.
48. Baranowski T. In *Handbook of Health Behavior Research I: Personal and Social Determinants*, (Grochman DS, Ed), Plenum Press, New York, 1997, pg 179.
49. Buzzard IM, Siever YA. *Am J Clin Nutr* 59: 275S; 1994.
50. Contento I, et al. *J Nutr Educ* 27: 284; 1995.
51. Cypel YS, Guenther PM, Petot GJ. *JADA* 97: 289; 1997.
52. Crawford PB, et al. *JADA* 94: 626; 1994.
53. Frank GC, et al. *JADA* 71: 26; 1977.
54. McPherson RS, et al. *Pediatrics* 86: 520; 1990.
55. Baranowski T, et al. *JADA* 86: 1381; 1986.
56. Nelson M, Atkinson M, Darbyshire S. *Br J Nutr* 72: 649; 1994.
57. Nelson M, Atkinson M, Darbyshire S. *Br J Nutr* 76: 31; 1996.
58. Faggiano F, et al. *Epidemiology* 3: 379; 1992.
59. Hess MA, Ed. *Portion Photos of Popular Foods.* The American Dietetic Association & Center for Nutrition Education, University of Wisconsin-Stout, 1997.
60. Weber JL, et al. *Am J Clin Nutr* 69: 782S; 1999.
61. Farris RP, et al. *JADA* 85: 1315; 1985.
62. Bandini LG, et al. *Am J Clin Nutr* 52: 421; 1990.
63. Schoeller DA. *Metabolism* 44: 18S; 1995.
64. Goran MI. *Pediatrics* 101: 505S; 1998.
65. Lindquist CH, et al. *Obesity Res* 8: 2; 2000.
66. Koehler KM, et al. *JADA* 100: 205, 2000.
67. McPherson RS, et al. *Prev Medicine* 31: 11S; 2000.