6. ADOLESCENTS

6.1 The Adolescent Years

"Within any 24-hour period in the life of a teenager, eating may be a positive or a negative experience. It may involve a quick snack or a grazing process. Eating for teens may be a group decision, an interaction, or an independent endeavor. The experience can vary greatly from teen to teen and for any one teen. Inter- and intravariability may be great. Conversely, eating may be a consistent, uneventful pattern hour-to-hour or day-to-day." Gail C. Frank, 1997 (219)

For this report, the adolescent age group includes children ages 13 to 18 years, although adolescence is often defined as encompassing from 11 through 21 years (251). During adolescence, children undergo profound biological, emotional, social, and cognitive changes to reach adult maturity. They experience the physical transformation into young adulthood and must psychologically adjust to a new body that has changed in shape, size, and physiological capacity. At the same time, adolescents are striving to attain a unique identity and value system separate from parents and other family members as well as personal independence, while still needing financial and emotional support from family members.

Adolescent needs for energy and all nutrients significantly increase to support the rapid rate of growth and development; as much as 50% of adult ideal body weight is gained in adolescence (251). Although appetite and food intake increase, the struggle for independence that characterizes adolescent psychosocial development often leads to the development of high-risk nutritional behaviors such as excessive dieting, meal skipping, use of unconventional nutritional and non-nutritional supplements, adoption of fad diets, and excessive alcohol consumption. The high prevalence of overweight and obesity, eating disorders, adolescent pregnancy, and the lack of consumption of five fruits and vegetables a day are among the challenging nutritional issues facing adolescents in the United States (219;251).

Exhibit 5.1 in Chapter 5 highlights differences in dietary assessment methodological issues between school age children and adolescents. A number of factors contribute to the challenge of collecting valid dietary information from teenagers.

- **Rapidly changing eating habits.** The eating habits of adolescents are not static; they fluctuate throughout adolescence in relation to psychological and cognitive development and to growth and appetite changes.

- **Unstructured eating.** Snacking and meal skipping are routine; "Grazing" is commonplace and teens may have "sneals" and not just snacks and meals (219).

- **Peer influence exceeds parental influence.** Eating away from home becomes prevalent, and fast-food accounts for 31% of food eaten away from home (218); only one-third of middle-class US 14 year olds eat dinner with their family on most days (239).

- **Age related compliance.** An overall trend toward an increase in energy underreporting with increasing age has been documented with DLW studies in adolescents (161).

- **High prevalence of restrained eating.** The well documented high prevalence of dissatisfaction of many normal weight adolescents with their weight has implications for bias in dietary surveys; inclusion of measures of dietary restraint and body image is important in this age group (161).

- **Overweight and obesity may lead to underreporting of intake.** As with obese adults, obese adolescents underreport intake significantly more than their non-obese counterparts; up to 40% of energy intake in obese adolescents may not be reported (195).

- **Dietary assessment probing, coding, and reporting formats designed for adults do not adequately reflect the eating patterns of teens.** Dietary assessment methods should address the eating environments and patterns of teens as well as capabilities and motivation at different stages of adolescence (161;218;219).

- **Research in school settings is difficult.** Increasing time pressures on school curriculum limit time for recruitment and adequate explanation of study forms and procedures; alternative approaches and locations that appeal to young people are needed (218;252).

6.2 Validation of Dietary Assessment Methods in Adolescent Populations

Table 6.1 presents validation studies on adolescent populations, including the studies included in the comprehensive reviews of the literature through 2000 by McPherson and colleagues (1), and by Livingston and colleagues (161) discussed in Chapter 5 (Exhibit 5.3).

Food Record (FR) and Diet History (DH) Methods. Food records, either weighed or estimated, and diet histories have received very limited validation in adolescent populations. Energy intake reported on weighed food records underestimated total energy expenditure (TEE) by 18 to 24 percent in two European studies of adolescents (138;196). Likewise, estimated food records underestimated TEE by more than 20%, with obese teens underreporting energy intake by 42% (195). An intensive diet history interview (2 hours) was found to underestimate energy intake by 10 to 14% compared with TEE measurements by the DLW method in both vegans and omnivore adolescents (253;254). Another study found no significant differences at the group level between energy intake reported in a diet history interview and TEE measurements (138). A reanalysis of a 1990 dataset of concurrent measurements of TEE by the DLW method, 7-day weighed food records (FR), and diet history (DH) by Livingston et al. found only 25% of children who underreported energy intake on weighed food records were identified by blanket cut offs of 1.55 x BMR, based on WHO physical activity levels (199). However, only 6 adolescents were included in the dataset. A 3-day weighed FR correlated significantly with biomarkers of folate intake in a population of older (more than 15 years old) Canadian female adolescents (255).

24-Hour Recall (24HR) Interviews. Only two studies have examined the validity of 24HR interviews in populations containing adolescents. A comparison between energy intake from

three 24HR interviews over a 2-week period and TEE measurements by the DLW method in a large, diverse group of Alabama youth age 9 to 14 years achieved close agreement at the group level, but wide individual variability (200). In this study, data for adolescents were not analyzed separately and study participants were admitted to a metabolic unit for DLW dosing and the first recall. In Minnesota middle school students, a parent-assisted telephone-administered 24HR interview underestimated energy intake reported on a parent-assisted 3-day FR by 12% (256).

Food Frequency Questionnaires (FFQ). The Youth Adolescent Questionnaire (YAQ), which is an adaptation for adolescents of the Harvard Food Frequency Questionnaire (HFFQ), found close agreement at the group level between energy intake reported on the YAQ and TEE measurements by the DLW method, but not at the individual level (208). Fifty percent of the adolescents misreported intake; misreporting was related to body weight and percent body fat. The YAQ has also been validated with multiple 24HR interviews in mainly white middle-class adolescent populations (188). The 27 fruit and vegetable questions on the questionnaire have been studied in a diverse population (24% black and 15% Hispanic) of high school students; a shorter (6 items) questionnaire had higher correlations with fruit and vegetable intake reported on three 24HR interviews (257).

Small validation studies have assessed a variety of other FFQs in adolescent populations. The differences in the instrument as well as the study designs and adolescent populations limit generalizations of results. In 2002 Van Assema (258) reviewed 26 validation studies of food frequency questionnaires in adults and 8 studies in children/adolescents (167;180;183-185;257;259;260) and concluded available FFQs have only limited capability to make valid assessments of fruit and vegetable intake from children of various socioeconomic status and ethnic groups, although older children and adolescents were generally more accurate than younger children. Larger studies on more diverse groups are needed.

Other Questionnaires. Validation studies on a variety of short questionnaires targeting specific nutrients or food groups are presented in Table 6.1.

6.3 Studies of Adolescent Populations

Table 6.2 presents summary data from epidemiologic surveys with at least 100 subjects collecting food and supplement intake data from adolescent populations. The two most recent US nutrition monitoring surveys, the 1999-2000 National Health and Nutrition Examination Survey (NHANES) and the 1994-96 Continuing Survey of Food Intake of Individuals (CSFII), each included 24HR interviews to assess food and beverage intake. In both surveys, adolescents were interviewed independently without a parent or guardian. The diet-related questions in NHANES, CSFII, and the integrated What We Eat in America-NHANES survey, which is currently in the field, are presented in Table 2.5 in Chapter 2. The rationale for selecting instruments for the

integrated survey as well as the history of past CSFII and NHANES surveys were recently reviewed (9). The integrated What We Eat in America-NHANES includes two 24HR interviews, one in-person and one by telephone, and a propensity questionnaire (100-item NCI DHQ without portion size information) in all children older than age 2 years. For the 24-hr recalls, the probes and portion size estimates aides are the same for both adolescents and adults. Likewise, the propensity questionnaire does not contain any adaptations for adolescent populations. Supplement use is queried in a separate questionnaire on frequency, dosage, and duration of use of specific products.

Food records were used in seven of the surveys in Table 6.2. With adolescents, food records present a challenge in terms of motivation and compliance. A longitudinal study of female adolescents experienced a 28 percent loss in subjects over a 6-year period (261).

In the US, the YAQ has been used in several studies, including studies of diverse populations. The Bogalusa Heart Study FFQ has received more limited use. Various forms of 24HR interviews were adopted by the other surveys listed.

Most of the surveys listed in Table 6.2 did not report methodology for assessing the intake of vitamin and mineral supplements.

6.4 Research Needs

As with school age children, it is difficult to make conclusions about the validity of available dietary assessment instruments for adolescents because of the differences in instruments, research designs, reference methods, and populations in the validation literature. Many of the research needs identified for adolescents are similar to those identified for school age children:

- Examination of the validity and reliability of each dietary assessment method by age, gender, ethnic subgroup, and socioeconomic status is necessary to understand the best application of each tool (1).
- Development and validation of improved methods for assessing dietary supplement use is needed (9;64).
- Physiologically-based measures, such as doubly labeled water or serum micronutrient concentrations merit further study because these reference measures are not affected by respondent error; (1;161;201) a more extensive database of assessments of TEE by the DLW method is needed.
- Identification and characterization of subgroups most likely to misreport food intakes, together with the reasons for doing so, needs further study, along with the development of improved techniques to identify underreporters and overreporters at the individual level (161;201).
- The issue of whether underreporting of diet applies to the diet as a whole or whether there is selective underreporting of nutrient intake, whether by food types, meals or snack foods needs examination (161).

- The reasons for, effects of, non-participation by children and adolescents should be examined to identify possible sources of bias (non-response bias) and to assess implications for design analysis, and interpretation of results (161;217).

- The effect of body size on reporting of dietary intake requires further study (1;161).

- The effects of a longer time lag between meal recall and environmental factors on the accuracy of recall in adolescents need to be established (202).

- More research is needed on the prompts that can aid memory retrieval at various ages without increasing the risk of eliciting socially-desirable responses. Environmentally specific probes (e.g., school, fast food restaurants, extracurricular activities, media and entertainment, food industry packaging of foods for children) within a food record or food frequency questionnaire also are needed (160;161;206;218).

- Refinement of statistical techniques to account for systematic bias in pediatric populations is needed. Statistical models need to be developed that will estimate the impact of systematic bias on estimates such as relative risk, variance ratios, or proportions on the populations with inadequate intakes (161).

- Emerging technologies should be applied to developing new dietary assessment methods (e.g., Internet-based self-administered methods or dietary assessment methods that incorporate cellular telephones, personal digital assistants, or video recording) (219).

- Methods to improve assessment of alcohol intake are needed (218).

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years)

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD RECORDS (FR) or DIET HISTORY (DH)						
Livingston et al., 2003 (199)	7 yrs = 11 (7 M; 5 F) 9 yrs = 9 (5 M; 4 F) 12 yrs = 10 (5 M; 5 F) 15 yrs = 6 (3 M; 3 F) Total = 36 UK	7d Weighed FR DH	DLW Method for TEE (EE_{DLW}) Heart Rate Monitoring for EE (EE_{HR}) BMR by indirect calorimetry	Retrospective analysis of 1990 dataset (138) to identify underreporters (UR). Students recruited from schools with mixed SES. Parents of children 7-9 yrs completed 7d weighed FR; older children were assisted by parents. Subjects visited at home least 4 times during the weighing period. DH conducted with the child and/or parent either 2-4 wks before or after 7d FR. TEE was measured over 10 days with daily spot urine collection after dosing. HR monitoring for 4 days. BMR measured in early morning in fasting state. School Intake: For weighed FR, pocket notebook carried for recording food and beverages consumed away from home. For DH, school menu obtained and child asked about which foods and amounts eaten.		**Weighed FR vs. TEE** Acceptable reporters (AR) = 83.3% Overreporters (OR) = 5.6% Underreporters (UR) = 11.1% **Diet History vs. TEE** AR = 80.6% OR = 16.7% UR = 2.8% The sensitivity of energy intake measured by heart rate monitoring was 0.50 and specificity was 1.00. Only 25% of children who underreported energy intake on weighed FR were identified by cut offs based on a blanket PAL of 1.55; none of the underreporting by DH was identified.

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD RECORDS (FR) or DIET HISTORY (DH), CONTINUED						
Larsson and Johansson, 2002 and Larsson et al., 2002 (253;254)	16-20 yrs = 60 Mean age 17.5; 30 vegans and 30 omnivores; 50% male in each group; recruited through newspaper ad. Sweden	2 DH 2 separate 1-2 hour interviews 2 wks apart 3-dimensional food models, household measures, standard weights, and food photographs	DLW Method for TEE 4 24h urine collections for urine nitrogen, sodium and potassium. 3 fasting blood samples for serum vitamin B12 and folate.	Each respondent was asked about customary intake during 2 separate DH interviews (2 wks apart). After DH, 3 fasting blood samples 1 wk apart were taken. TEE by DLW method on 32 subjects (16 vegans and 16 matched omnivores) was measured during 14 days. Four 24h urines were collected per subject.		No significant difference in validity of reported intake of energy, nitrogen, and potassium between vegans and omnivores. **DH vs. DLW TEE** 12-14% energy underestimation by vegans and omnivores -1.93 MJ/d (95% CI:-2.89, -0.97) 4-10% underestimation of K intake by vegans and omnivores. Good agreement between methods for nitrogen and sodium
Green et al., 1998 (255)	16-19 yrs = 105 100% female Ontario, Canada	3-d weighed FR	Serum folate, red blood cell (RBC) folate, and serum Vitamin B12	Compared adolescents' report of folate and B12 intake on weighed record against serum micronutrient levels collected 1 week before FR.	**Pearson Correlations** FR Folate and Serum Folate = 0.65 FR Folate and RBC Folate = 0.50 FR B12 and Serum B12 = 0.32	

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD RECORDS (FR) or DIET HISTORY (DH), CONTINUED						
Bratteby et al., 1998 (196)	15 yrs = 50 50% male Sweden	7d Weighed FR	TEE by the DLW method	Volunteers recruited by letter and telephone from general population of 15 year olds in two cities. BMR measured on same day as DLW dosing. FR kept for first 7d post dosing. Participants kept log books for food eaten away from home and were debriefed at the end of the recording period.	Significant negative correlations were found both between energy intake as a percentage of TEE and percentage body fat and between energy intake as a percentage of TEE and body mass index.	**Weighed FR vs. TEE (MJ/d)** **Males** 18% underestimation 11.40 ± 2.71 vs. 13.82 ± 1.90 **Females** 22% underestimation 8.28 ± 1.88 vs. 10.70 ± 1.59
Livingston et al., 1992 (138)	15 yrs = 12 50% male 18 yrs = 10 50% male Cambridge, UK	7d Weighed FR Diet History	TEE by the DLW method	Volunteers recruited by letter from schools selected to represent different socioeconomic areas of city. Spot urine samples collected 10 to 14 days post DLW dose. Weighed FR kept for 7 days following DLW dose. DH collected either 2-4 wks prior to DLW test or after Weighed FR. Participants kept log books for food eaten away from home and were visited 4 times during the Weighed FR recording period.		**Weighed FR vs. TEE (MJ/d)** **15 years** 22% underestimation 9.08 ±2.92 vs. 11.71 ± 2.77 **18 years** 24% underestimation 9.28 ± 3.00 vs. 13.50 ± 4.11 **DH vs. TEE (MJ/d)** **15 years** No significant difference 11.62 ± 3.04 vs. 11.71 ± 2.77 **18 years** 2% underestimation 12.83 ± 3.38 vs. 13.50 ± 4.11

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD RECORDS (FR) or DIET HISTORY (DH), CONTINUED						
Bandini, 1990 (195)	12-18 yrs = 55 28 lean; 27 obese Cambridge, UK	14 d Estimated FR	TEE by the DLW method	Daily metabolizable energy intake (ME) and total daily energy expenditure (TEE) were measured in 28 non-obese and 27 obese adolescents over a 2-wk period. Adolescents kept 14d estimated FR starting on the day of DLW dosing.		**Estimated FR vs. TEE (kcal/d)** **Lean** 20% underestimation 2,193 ± 618 vs. ± 600 kcal/d **Obese** 42% underestimation 1,935 ± 722 vs 3,390 ± 612 kcal/d
24-HOUR RECALL (24HR)						
Brady et al., 2000 (200) Longitudinal Study of Childhood Obesity, University of Alabama	7-14 yrs = 110 9.9 yrs. mean age; 20.1 kg/m^2 mean BMI; 43% male; 52% white; 48% black Birmingham, AL	24HR 3x Three pass method; 2 in-person and 1 by telephone; 2 dimensional food models	DLW Method	Children admitted to the metabolic unit overnight for DLW dosing and 24HR 1. Two weeks later, children returned to nutrition center for 24HR 2. Third recall by telephone. Energy-adjusted 24HR intake compared to recommended servings from food guide pyramid. Parents consulted during 24HR interview.	**24HR Energy Intake vs. DLW TEE** 0.32 (p = 0.08) Wide individual variability but nearly identical group mean energy intake measured by 24HR and DLW method.	**24HR Energy Intake vs. DLW TEE** Energy = 0.04MJ/d difference (NS)
Mullenbach et al., 1992 (256) Children and Adolescent Blood Pressure Program (CAPBB)	6th-9th grade = 40 (12-15 yrs) 55% male Minnesota	24HR Telephone-administered; parent-assisted	3d Estimated FR Parent-assisted	Compared 24HR with parent-assisted 3d FR completed 2-4 wks before recalls	**Pearson's Correlation** Energy = 0.42 Protein = 0.33 Total fat = 0.33 Range for 19 nutrients = 0.09 to 0.57	**24HR vs. 3d FR** 12% energy underestimation 1,835 vs. 2,097 kcal/day

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ)						
Speck et al., 2001 (207)	6th – 8th grade = 24 in validation study; 446 in survey 12.7 yrs mean age; 50% male; 50% black North Carolina	Eating Habits Questionnaire (EHQ) Section 1 = 83-item FFQ on foods eaten for past week. Section 2 = 14 questions on general food habits, food preparation, and eating out. Section 3 = specific foods eaten one day in past week.	24HR = 3x on wk before EHQ	EHQ was adapted from the Health Habits Questionnaire used in the Bogalusa Heart study. EHQ administered to groups of 30-40 students by trained research assistants during health classes. A subset of 24 students were randomly selected to completed 3 24HR administered by a dietitian on week before EHQ. A subset of 31 students repeated EHQ in 48 hours and again 2 wks later.		**EHQ vs. 24HR** **Mean % (SD) Food Categories in Perfect Agreement** 56.0% (20.3%) Factor analysis found 10 factors explained 81.3% of the variance in eating habits (sweet snacks, meats, vegetables, breads/starch, snack foods, fruits, salad dressing, dairy, butter, and miscellaneous.
Perks et al., 2000 (208)	8.6-16.2 yrs = 50 Mean age 12.6 yrs.; 46% male Charlottesville, VA	Youth-Adolescent Food Frequency Questionnaire (YAQ) 131 item; Semi-quantitative; Self-administered	DLW Method for TEE	Subjects completed YAQ within 1 year of TEE measurement by DLW. Subjects also had the following measurements: BMI, BMR, and body composition by 4-compartment model of Lohman.	**YAQ EI vs. DLW TEE** **r = 0.22 (p = 0.13)** The discrepancy in energy intake (YAQ - TEE) was related to body weight (r = -0.25, p = 0.077) and percentage body fat (r = -0.24, p = 0.09) but not to age (r = -0.07, p = 0.63) or the time between measures.	**YAQ EI vs. DLW TEE** 2% overestimation 10.03 $\pm$ 3.12 vs. 9.84 $\pm$ 1.79 (p = 0.91) Limits of agreement = -6.30 and 6.67 MJ 26% of subjects YAQ EI within 10% of TEE 50% of subjects misreported intake Investigator conclusion: YAQ provides an accurate estimation of mean energy intake for a group but not for an individual.

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED						
Yaroch et al., 2000 (262)	11-17 yrs = 22 13.6 yrs mean age; 100% female and black; low income; overweight (BMI range 22.8-49.9) Atlanta, GA	110-item modified picture-sort FFQ 2x in a 2 wk period Modified for food and drink of study population based on previous study. Interviewer-administered	24HR 3 x by telephone in a 2 wk period, between FFQ1 and FFQ2	During a 2 wk period, the FFQ was administered twice. In between the FFQ interviews, 3 telephone 24HR interviews were completed. Data examined for outliers (l<500 or > 5000 kcal); one subject eliminated.	**Pearson correlation FFQ vs. 24HR** Energy-adjusted range of 0.32 for protein to 0.87 for fat with most nutrients above 0.50	**FFQ vs. 24HR Mean kcal (SD)** FFQ1 = 2,377 (1,083) FFQ2 = 1,792 (913) 24HR = 2,323 (850)
Koehler et al., 2000 (187) Pathways to Health	11-13 yrs (5th - 7th grade) = 120 American Indian; non-Hispanic white, Hispanic Southwest US	33-item Yesterday's Food Choices (YFC) Self-administered; past day intake; non-quantitative Categories: yes, not sure, no	24HR	Compared child's reported intake of particular foods against child's 24HR, both completed on same day	**Spearman correlations FFQ vs. 24HR** Low fat foods = 0.71 High fiber foods = 0.35 Fruits & veg. = 0.29 High fat foods = 0.40	**FFQ vs. 24HR** Percentage agreement for all food items = 60%

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED						
Field et al., 1998 (257)	9th-12th grade = 102 50% male; 35% white; 24% black; 15% Hispanic Boston, MA	4 FFQs all semi-quant., self-admin. 1) Youth /Adolescent Quest.(YAQ) 27 item (12 fruit, 15 veg.) For past year 2) Youth Risk Behavior Surveillance System (YRBSS) 4 items (2 fruits, 2 veg.) For past day 3) Behavioral Risk factor Surveillance System (BRFSS) 6 items (2 fruit, 4 veg.) For past day 4) BRFSS 6 items (2 fruit, 4 veg.) For past year	3 24HR	Compared adolescents' reports of fruit and vegetable intake by 4 different questionnaires with report of intake on 3 nonconsecutive 24HRs completed 2 wks apart. 1) YAQ was administered 2-4 wks after third recall. 2) YRBSS administered 2-4 wks after third recall 3) BRFSS (past day) administered halfway between two 24HRs 4) BRFSS (past year) administered preceding the third recall	**Spearman's Correlations** **1) YAQ (past year) vs. 24HR** Fruit = 0.33 Fruit Juice = 0.29 Fruit & Juice = 0.33 Veg. = 0.32 Fruit & Veg. = 0.41 **2) YRBSS (past day) vs. 24HR** Fruit = 0.17 Fruit Juice = 0.07 Fruit & Juice = 0.21 Veg. = 0.24 Fruit & Veg. = 0.28 **3) BRFSS (past day) vs. 24HR** Fruit = 0.33 Fruit Juice = 0.30 Fruit & Juice = 0.34 Veg. = 0.14 Fruit & Veg. = 0.30 **4) BRFSS (past year) vs. 24HR** Fruit = 0.36 Fruit Juice = 0.36 Fruit & Juice = 0.35 Veg. = 0.33 Fruit & Veg. = 0.43	

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED						
Green et al., 1998 (255)	16-19 yrs = 105 100% female Ontario, Canada	116-item FFQ Semi-quantitative for past year	Serum folate, red blood cell (RBC) folate, and serum Vitamin B12	Compared adolescents' reports of folate and B12 intake on weighed record against serum micronutrient levels collected 1 wk before FR.	**Pearson Correlations** FR Folate and Serum Folate = 0.48 FR Folate and RBC Folate = 0.42 FR B12 and Serum B12 = 0.25	
Anderson et al., 1995 (259)	18 yrs = 49 27% males Norway	190-item FFQ Semi-quantitative; past year; group (child-parent) administered	7 d Weighed FR	Students kept 7d weighed FR with parent's assistance 2 to 3 mo after completing FFQ with parent's assistance. Questionnaire is used in a national survey of Norwegian youth.	**Spearman Correlations FFQ vs. 7d FR** Energy = 0.51 Protein = 0.48 Total fat = 0.57. Range of correlations for 18 nutrients 0.14 for vitamin D to 0.66 for MUFA. Median coefficient = 0.52	**FFQ vs. 7d FR** 24% overestimation of energy intake 10.7 vs. 8.6 MJ/d FFQ significantly overestimated 16 of 18 nutrients and 8 of 13 food items than FRs. On average, 41% of the subjects were classified in the same quartile in the questionnaire and the records and 2% in the opposite quartiles.

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED						
Rockett et al., 1997 (188) Nurses Health Study II Children	9-18 yrs = 261 9-13 yrs = 57%; 14-18 yrs = 43%; 47% male; 96% white; 19% of males obese; 13% of girls obese .	131-item Youth/ Adolescent Quest. (YAQ) Semi-quantitative for past year; self-administered	24HR = 3 Telephone-administered Minnesota Nutrition Data System	The YAQ was administered by mail twice at an approximate 1 year interval (1993-94), and three multiple pass dietary recalls were collected during this period (5 months apart) by telephone. Vitamin-mineral supplement: information collected at end of 24HR.	**Pearson correlations YAQ vs. 24HRs** Unadjusted Energy = 0.35 Protein = 0.30 Fat = 0.41 For 28 nutrients range of 0.09 (copper) to 0.46 (vitamin C) Energy-Adjusted Protein = 0.37 Fat = 0.49 For 29 nutrients range of 0.21 (Na) to 0.58 (folate)	**YAQ vs. 24HR** 1% overestimation of kcal (2196 vs. 2169 kcal) Of 31 nutrients, 16 overestimated by YAQ and 8 were underestimated.
Frank et al., 1992 (260) Bogalusa Heart Study	15-17 yrs = 22 100% female	64 items in 9 food groups of 6 to 12 foods each Semi-quantitative	7 24HRs Group recall method (263)	Female home economics students completed the FFQ and 7 consecutive 24HRs. Recalls were administered by trained nutritionists using group recall protocol. Percentage of agreement for frequency and quantity between methods for 12 foods calculated.		**FFQ vs. 24HRs** In general FFQ underestimated intake. % Perfect Agreement for Frequency/Amount Milk = 78/39 Bread = 26/61 Mayonnaise = 44/35 Gravy = 39/39 Butter = 61/57 Salad Dressing = 78/83 Hard candy/candy bars = 48/39 Snack chips = 61/17 Vegetables with meat = 61/48 Vegetables no meat = 26/30

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
OTHER QUESTIONNAIRES						
Frobisher et al., 2003 (211)	6-16 yrs = 37 17-82 yrs = 42 Mean age 12 yrs for children and 42 yrs for adults; university academic and administrative personnel or their children; 25 of adults and 8 of children overweight UK	Portion size estimation	Weighed portion sizes	Subjects served themselves usual portion of food. Food was immediately removed and weighed. Subjects described the portions size (S,M,L) and choose a photograph. Three to four days later the subjects described the portion size again (S,M,L) and choose a photograph. 9 foods studied: baked beans, cheese, chips, corn flakes, margarine on a slice of bread, mashed potato, rice, spaghetti and sausage roll.		Using descriptions (S,M,L) the percentage of children within $\pm$ 10% and $\pm$ 50% of the actual weights ranged from 3 to 31% and 19 to 84% respectively, compared with 9 to 64% and 60-91% for adults. For both children and adults the food photographs produced higher estimated weights than the descriptions.
Hoelscher et al., 2003 (264)	13-15 yrs = 209 Male and female; 38% white 41% Hispanic 17% African American	School Based Nutrition Monitoring (SBNN) secondary level student questionnaire 63 items including food and meal choice "yesterday" and "usually" for certain foods	24HR Multiple pass method	December 1995 through May 1996, instruments administered during school hours Tuesdays, Wednesdays, and Thursdays. In half the students, SBNN administered first followed by 24HR 2 hours later. In other students, the order of administration of instrument was reversed.	**Spearman Correlation** Correlation coefficients ranged from 0.32 for bread, buns, bagels, and others to 0.68 for milk and beans. Correlations > 0.5 for 12 of 17 food groups	**SBNN vs. 24H** Percent agreement ranged from 38% for breads to 89% for gravy.

Table 6.1. Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
OTHER QUESTIONNAIRES, CONTINUED						
Van Assema et al., 2002 (258)	12-18 yrs = 51 37% male Netherlands	F/V List (short FFQ to assess fruit and vegetable intake; 6 questions on fruit and 4 on vegetables)	7d Estimated FR	Subjects recruited from random sample of medium size town (76% response rate for adolescents). FFQ mailed to subjects. 1 wk after completed F/V list returned, dietitian visited the home twice to instruct on 7d FR completion and then to review completed record.	Pearson Correlation F/V and 7d FR Total = 0.56 Fruit = 0.64 Vegetables = 0.22	FFQ vs. 7d FR Boys: 50% fruit and 29% vegetable overestimation Girls: 101% fruits and 56% vegetable overestimation 35% misclassification into tertiles for total fruit; 27.4% for total vegetables.
Van Assema et al., 2001 (258a)	12-18 yrs = 50 37% male Netherlands	Fat List (short FFQ to assess fat intake; 35 questions on 19 categories of food items)	7d Estimated FR	Subjects recruited from random sample of medium size town (75% response rate for adolescents). Fat list mailed to subjects. 1 wk after completed Fat List returned, dietitian visited the home twice to instruct on 7d FR completion and then to review completed record.	**Pearson Correlation Fat List and 7dFR** Total fat = 0.61 Saturated fat = 0.56 %kcal fat = 0.2 Correlations lower for girls.	Gross misclassification, defined as disagreement between the two fat consumption assessments beyond an adjacent tertile, was less than 6% for boys and 15.7% for girls for total fat intake. Relative validity for female adolescents not acceptable.
Prochaska et al., 2001 (188;265)	13-14 yrs = 59 13.9 yrs mean age; 37% male; 37% white; 25% Asian/Pacific Islander; 12% Hispanic; 3% black San Diego, CA	21-item Dietary Fat Screening Measure 4-item Dietary Fat Screening Measure	3d Estimated FR	Data collection in 1998. Students trained on 3d FR and then called in the evening to review each day's recording.	**Correlations** 4 and 21 item Fat Screener and total fat grams on FR not significantly correlated 21 item but not 4 item Fat Screener correlated significantly with percentage of calories from dietary fat ($r = 0.36$, $p<0.01$)	**21 item Fat Screener vs. 3d FR** Fat Screener correctly classified 71% into low and high fat intake groups. Specificity (ability to rule out low fat intake) = 47%

Table 6.1 Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
OTHER QUESTIONNAIRES, CONTINUED						
Johnson et al., 2001 (265a)	13-14 yrs (7th and 8th grade = 98 46% male; students in public school Liverpool, UK	Food Intake Questionnaire (FIQ) Self-administered adapted non-quantitative 24HR method. Questionnaire asks, "Did you at any time yesterday eat any amount of.…"	3d FR	FIQ developed to reveal broad changes in food intake over time, not individual nutrient intakes. FIQ completed in classroom 2 wks before 3d FR. Each student was provided with a pocket-size diary to record all foods eaten. On the 4th day, youth were interviewed to clarify information and to assess portion sizes using a calibrated food atlas. Both FIQ and 3d FR analyzed by aggregated food groups.	**Pearson Correlation** 3d FR and FIQ <u>Fatty Food Group</u> Energy = 0.20 p<.05 Fat% = 0.36 p<.05 Sugars = 0.09 Fiber = -0.57 <u>Sugary Food Group</u> Energy = 0.28 p<.05 Fat% = 0.27 p<.05 Sugars = 0.23 p<.05 Fiber = -0.12 <u>Fiber Food Group</u> Energy = 0.03 p<.05 Fat% = -0.17 p<.05 Sugars = 0.12 Fiber = -0.04	
Smith et al., 2001 (266) Child and Adolescent Trial for Cardio-vascular Health (CATCH)	13-14 yrs. (7th graders) = 365 54% female; 67% non-Hispanic whites; 18.5% Hispanic; 7.5% African American California, Louisiana, Minnesota and Texas	CATCH Food Checklist (CFC) CFC asks students which foods on list consumed the previous day. CFC includes 40 food items (30 foods or food groups, 2 beverages, and 8 condiments)	24HR	Randomized, controlled trial in which participants were assigned to 1 of 3 study protocols that varied the order of administration of CFC and 24HR. CFC administered in classroom; 24HR at school. Criterion outcomes were percent energy from total fat and saturated fat, and milligrams sodium intake. CFC contains foods high in total fat, saturated fat, sodium, and 3 target nutrients.	Pearson correlation CFC Scores and 24HR (Blended weights) Total fat = 0.36 SFA = 0.35 Sodium = 0.34	

Table 6.1 Validation of dietary assessment methods in adolescents (13-18 years), continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
OTHER QUESTIONNAIRES, CONTINUED						
Yaroch et al., 2000 (267)	11-17 yrs = 57 13.6 yrs mean age; 100% black female; residents of low-income public housing; overweight (BMI > 85th percentile for age) Atlanta, GA	Qualitative Dietary Fat Index Questionnaire (QFQ) (Interviewer administered; modified Kristal Food Habits Questionnaire; 18 questions)	3 24HR (By telephone in 51; 6 in-person)	Subjects originally recruited for a nutrition and physical activity intervention. Subjects completed QFQ twice over a 2 wk period. First 24HR administered after first QFQ. Two more 24HR over the same 2 wk period.	**Pearson Correlation 24HRs and 1st QFQ** Log Transformed Total fat r = -0.31 (p>.05) Energy (kcal) r = -0.23 (Not Significant) Fat % kcal r = -0.23 (Not Significant)	

Table 6.2. Summary Table: Studies of adolescent populations

	Adolescents (n)	Age (years)	Ethnically Diverse	Longitudinal Study	Cross sectional Study	Assessment Method					Nutrient Biomarkers	Supplement Intake Assessment Method	Outcomes
						Weighed Food Record (no. days)	Estimated Food Record (no. days)	24-Hour Recall (n)	FFQ Type	Other Questionnaire			
National Surveys													
US National Health and Nutrition Examination Survey (NHANES) 1999-2000 (41)	1,165 1,059	12-15 16-19	✓		✓			1; 2 in 10%			✓	Quest & 24HR	Food, nutrient, physical activity, and chemical exposures
Continuing Survey of Food Intake of Individuals (CSFII) 1994-96, 1998 (42)	800 669	12-15 16-19	✓		✓			2			✓	24HR	Food and nutrient exposures, diet and health knowledge
Household Food Consumption and Anthropometric Survey in Poland, 2000 (268)	484	10-15			✓			1				24HR	Energy and nutrient intake
US School Nutrition Dietary Survey, 1995 (216;222)	3,350	6-18	✓		✓			1		✓		NS*	Dietary intake assessed; other questionnaires collected information on school lunch and breakfast; students in grades 1 and 2 interviewed with parents
Austrian Study of Nutritional Status, 1999 (225)	2,173	6-18			✓	7d					✓	NS	Nutrients and food consumption assessed; biomarkers (cholesterol and fat soluble vitamins)
HEUREKA 1991, Switzerland (Sample recruited from visitors to national exhibit) (227;228)	903	7-18			✓			1 self-adm.	FFQ-like 24HR			NS	Self-administered 24HR with food photographs used; FFQ format listing 240 foods; assessed energy intake, 10 food groups, and main nutrient intake.

*NS = Not Specified

Table 6.2. Summary Table: Studies of adolescent populations, continued

	Adolescents (n)	Age (years)	Ethnically Diverse	Longitudinal Study	Cross sectional Study	Assessment Method					Nutrient Biomarkers	Supplement Intake Assessment Method	Outcomes
						Weighed Food Record (no. days)	Estimated Food Record (no. days)	24-Hour Recall (n)	FFQ Type	Other Questionnaire			
National Surveys, continued													
Cross-National Survey on Health Behavior in School Age Children, 20 countries, 1993-94 (226)	33,084	11-15	✓		✓					✓		NS	Soft drink and sweets consumption recorded on 10-item dietary habits questionnaire similar to FFQ.
General Mills Dietary Intake Study, Market Research Corporation of (MRCA) Menu Census Panel Surveys 1980-1992 (229)	1,946	11-18	NS		✓		14d					NS	Four cross-sectional surveys evaluated dietary Ca intake over a 12-year period; serving size information not collected
Dietary Habits in Denmark, 1985-1998 (269;270)	1,000 to 2,000	15-90	NS		✓				10 item	✓		FFQ	National surveys in Denmark since 1985 have examined energy and nutrient intake; initial surveys used in-person FFQ-like interview to recall intake for past 28 days; more recent surveys are telephone-administered short FFQs.
Population Surveys of Food and Nutrient Exposures													
MIT Growth and Development Longitudinal Study, 1990-1997, Massachusetts (271)	178	8-16		✓					Har. FFQ 116-item			NS	Annual Ca intake from food; % kcal from dairy foods; BMI z-score, % body fat from bioelectrical impedance analysis for 4 yr post menarche.

*NS = Not Specified

Table 6.2. Summary Table: Studies of adolescent populations, continued

	Adolescents (n)	Age (years)	Ethnically Diverse	Longitudinal Study	Cross sectional Study	Assessment Method					Nutrient Biomarkers	Supplement Intake Assessment Method	Outcomes
						Weighed Food Record (no. days)	Estimated Food Record (no. days)	24-Hour Recall (n)	FFQ Type	Other Questionnaire			
Population Surveys of Food and Nutrient Exposures, continued													
Amsterdam Growth and Health Longitudinal Study, 1970-2003 (272-274)	200	13-33		✓						✓	✓	DH	Detailed cross-checked diet history (DH) assessed nutrient intake 8 times from age 13 to age 33; body height, body weight, and 4 skin folds and physical activity measured six times; risk factors for coronary heart disease (obesity, hypertension and hyper cholesterolemia) and nutrient consumption and physical activity trends over time assessed.
General Mills Dietary Intake Study, Market Research Corporation of (MRCA) Menu Census Panel Surveys 1980-1992 (229)	1,946	11-18	NS		✓		14d					NS	Four cross-sectional surveys evaluated dietary calcium intake over a 12-year period; serving size information not collected

*NS = Not Specified

Table 6.2. Summary Table: Studies of adolescent populations, continued

	Adolescents (n)	Age (years)	Ethnically Diverse	Longitudinal Study	Cross sectional Study	Assessment Method					Nutrient Biomarkers	Supplement Intake Assessment Method	Outcomes
						Weighed Food Record (no. days)	Estimated Food Record (no. days)	24-Hour Recall (n)	FFQ Type	Other Questionnaire			
Population Surveys of Food and Nutrient Exposures, continued													
Child and Adolescent Trial for Cardiovascular Health (CATCH), 2002, California, Texas, Minnesota, California (214;232)	1,874	8-14	✓	✓			1d 3x	3 Mod.			✓	NS	Food record assisted 24HR at baseline (3rd grade) and follow-up at 5th and 8th grade assessed energy and nutrient intake and compared (3rd and 5th grade) energy intake cholesterol, dietary fat, fatty acid intake, and dietary fiber with serum lipds and height and weight.
Child and Adolescent Trial for Cardiovascular Health, US (CATCH) (275)	1,532	14	✓		✓			1				NS	CATCH post intervention tracking study evaluated Healthy Eating Index scores from 24HR of weekday intake.
Project Eating Among Teens (Project EAT), 1998-1999, Minnesota (276;277;277;278)	4,746	11-18	✓		✓				Youth/ Adol. Ques. 149-item	✓	.	NS	Food (fruits, veg. and grains); fast food restaurant use; energy and nutrient (fat, calcium) intake; anthropometric measurements: Time spent in 3 sedentary behaviors assessed (278); Separate Frequency of Fast Food Restaurant Use (FFFRU) quest. Administered (277).

*NS = Not Specified

Table 6.2. Summary Table: Studies of adolescent populations, continued

	Adolescents (n)	Age (years)	Ethnically Diverse	Longitudinal Study	Cross sectional Study	Assessment Method					Nutrient Biomarkers	Supplement Intake Assessment Method	Outcomes
						Weighed Food Record (no. days)	Estimated Food Record (no. days)	24-Hour Recall (n)	FFQ Type	Other Questionnaire			
Population Surveys of Food and Nutrient Exposures, continued													
Staffordshire 3-Year Study of Adolescent Nutrition, 2001, Straffordshire,UK (252;279)	105 (51 at 2 yr. follow-up)	13-15		✓	✓		3d					NS	3-d diary and interview using a food photograph atlas assessed energy and nutrient intakes; EI:BMI cut offs applied
Belgian Adolux Study, 2001 (280)	1,526	12-17			✓				57 item			NS	Food and nutrient intake; quantitative information collected on a sub-sample of 234
Changes in Food Habits of Swedish Adolescents Between 15-21 Years, 1993-1999 (281)	208	15-21		✓					29 food grps.			NS	Weight, height, BMI, food group intake, meal patterns measured; FFQ included 30 questions on food habits and amounts eaten and was interviewer-administered
Children's Health Study, 1998-2000, California (247;282;283)	3,280	11-20	✓	✓	✓				Youth /Adol. Ques. 131-item		✓	Youth/ Adol. FFQ	Cross-sectional study of children in 10-yr. longitudinal study of long-term air pollution exposure health effects evaluated lung function and dietary intake of magnesium, potassium, and sodium.

*NS = Not Specified

Table 6.2. Summary Table: Studies of adolescent populations, continued

	Adolescents (n)	Age (years)	Ethnically Diverse	Longitudinal Study	Cross sectional Study	Assessment Method					Nutrient Biomarkers	Supplement Intake Assessment Method	Outcomes
						Weighed Food Record (no. days)	Estimated Food Record (no. days)	24-Hour Recall (n)	FFQ Type	Other Questionnaire			
Population Surveys of Food and Nutrient Exposures, continued													
Young Hearts Project, Northern Ireland (284)	455	12-15		✓						✓		NS	Diet History interview with food photographs administered at 12 years and again at 15 years tracked energy and nutrient intakes.
Growing Up Today Study (GUTS), US, 1996-1999 (236-239)	10,769-16,882	9-14	95 % C	✓					Youth /Adol. FFQ 132-item			Youth/ Adol. FFQ	Survey of offspring of participants in Nurses Health Study II examined energy, dietary patterns, physical activity and weight change over 1 yr (236); energy and nutrient intake (237); self-reported height, weight, and Tanner Index (by drawings) 18 questions on physical activity; changes in fruit and vegetable consumption and changes in BMI over a 3-yr period (238;239)
Study of Adolescent Physical Activity, Fitness and Food Habits, 1999, Switzerland (285)	3540	9-19			✓				19 food grps.				19 food groups assessed in this 15-minute self-administered FFQ

*NS = Not Specified

Table 6.2. Summary Table: Studies of adolescent populations, continued

	Adolescents (n)	Age (years)	Ethnically Diverse	Longitudinal Study	Cross sectional Study	Assessment Method					Nutrient Biomarkers	Supplement Intake Assessment Method	Outcomes
						Weighed Food Record (no. days)	Estimated Food Record (no. days)	24-Hour Recall (n)	FFQ Type	Other Questionnaire			
Population Surveys of Food and Nutrient Exposures, continued													
Survey of Population of Mediterranean Spain, 1999 (286)	439	1-20			✓			3				NS	Food and energy intake, energy density
Canadian Study of Folate Indexes in adolescent females, 1998 (287)	229	14-20	✓		✓	3d				✓	✓	NS	Folate intake; RBC folate assay, buccal cell folate; serum homocyteine; serum B12; oral contraceptive use (information from separate lifestyle questionnaire).
Penn State Young Women's Health Study, 1990-1996, central Pennsylvania (261)	80 F	12-18		✓			3d				✓	3dFR	Anthropometric, endocrine, bone measurement; diet and supplement intake measured; FR collected at 6 mo intervals for 4 years and then annually.
Nutrition Education and Teenagers (NEAT) Project, 1996 (288)	791	12-14			✓					✓		NS	NEAT questionnaire contained 31 food intake questions and 62 questions on food behavior, nutrition knowledge, and food and health beliefs and sources of nutrition information.
Minnesota Adolescent Health Survey, 1986-87 (289)	36,284	12-18	✓		✓				10-item	✓		NS	Health behaviors and eating behaviors assessed; FFQ part of larger questionnaire assessing health behaviors.

*NS = Not Specified

Table 6.2. Summary Table: Studies of adolescent populations, continued

	Adolescents (n)	Age (years)	Ethnically Diverse	Longitudinal Study	Cross sectional Study	Assessment Method					Nutrient Biomarkers	Supplement Intake Assessment Method	Outcomes
						Weighed Food Record (no. days)	Estimated Food Record (no. days)	24-Hour Recall (n)	FFQ Type	Other Questionnaire			
Population Surveys of Food and Nutrient Exposures, continued													
Eating Behavior Project-Stanislas Family Study 1994-95, France (247;290)	560-774	10-20 mean age 15			✓		3d			✓		NS	3d FR and French version of Dutch Eating Behavior Questionnaire assessed relationship between dietary intakes, eating behaviors and overweight; each family member completed 3dFR.
Longitudinal Survey of Swedish Adolescents, 1993-94 (291)	411	15		✓		7d			29 item Int. Adm.		✓		Serum ferritin, bone density, bone markers, height, weight, BMI, and dietary intake of energy, nutrients and foods; FFQ interviewer-administered.
The Bogalusa Heart Study, 1992 (260)	1,108	12-17	✓	✓	✓			✓	64-item		✓	NS	Food groups; correlations of food group and risk factors for cardiovascular disease (total serum cholesterol, blood pressure).
Tasmanian High School Survey of Diet, 1985, Australia (247;292)	1,055	12-15			✓		1d						Energy, nutrient and food intake.

*NS = Not Specified