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Summary of Published Evidence Related to the Dietary Guidelines for Children, 2004-2008

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EXECUTIVE SUMMARY

As part of a broader study to assess the science base of dietary guidance for children ages 2 to 18 years, Mathematica Policy Research, Inc. (MPR) conducted a systematic review of the literature published in 2004-2008 for the Office of the Assistant Secretary for Planning and Evaluation (ASPE) at the U.S. Department of Health and Human Services (HHS). In this report, we provide summaries of studies published since the 2005 *Dietary Guidelines for Americans* (HHS and United States Department of Agriculture (USDA), 2005) with the goal of providing a useful resource for the 2010 Dietary Guidelines Advisory Committee (DGAC).

To conduct this review, we identified and reviewed the evidence published in peer-reviewed literature between 2004 and February 2008 that was not included in the references for the 2005 *Dietary Guidelines* by searching electronic databases, bibliographies of contemporary guidance statements and scientific nutrition reviews, and tables of contents of relevant nutrition and health journals not covered in the electronic databases. We reviewed nearly 6,000 abstracts and determined whether studies met our criteria for further review (i.e., relevant to one of the dietary guidelines topics, conducted with children ages 2 to 18 years, published in English, applicable to populations living in developed countries, and involved study outcomes that were direct measures of health or nutrition status, biologic outcomes, or dietary-related behaviors). For the 104 articles that met the criteria, we reviewed the full article.

We grouped the articles by topic areas similar to the chapters in the 2005 *Dietary Guidelines* with a few notable differences. In an effort to focus resources on food and nutrient intake and weight management, we did not summarize articles with physical activity, alcoholic beverages, or food safety as the measure of interest. We treated the subtopic areas mentioned within chapter 5, “Food Groups to Encourage,” in the *Dietary Guidelines* (“Fruits and Vegetables,” “Whole Grains” “Milk and Milk Products”) as topic areas and included calcium in the dairy section. Finally, we created a topic area to highlight the findings of “tracking” articles, which we defined as articles that measured study participants at more than one point in time. For the purposes of this report, we used the following topic areas: adequate nutrients within calorie needs; weight management; fats; fruits and vegetables; whole grains; dairy and calcium; carbohydrates; sodium and potassium; and tracking. Each topic area is summarized in a section of the report, designed to be a stand-alone synopsis of all new relevant information published in 2004-2008.

Within each topic area, we cataloged the research studies by type of study (tracking studies, systematic reviews or meta-analyses, controlled trials, or observational studies), provided an overview of the recent literature, and grouped the article summaries by outcome measured. For each study, we summarized the design, characteristics, and size of the study population; data collection and statistical methods; and findings. Summary topic sections for which we found many relevant articles were divided into subtopic areas. Study summaries may appear in multiple places in the report because they were included within each relevant topic area and within each relevant outcome.

This report forms one of the major components for MPR’s forthcoming assessment of the science base for dietary guidelines. In the broader report, this information will be interpreted in light of the research for, and the recommendations from, the 2000 and 2005 *Dietary Guidelines* (USDA and HHS 2000; HHS and USDA 2005) and dietary guidance statements from other leading organizations to establish the science base available and identify knowledge gaps in developing dietary guidance for children in the future.

INTRODUCTION

In this report, we provide summaries of studies published since the 2005 *Dietary Guidelines for Americans* (HHS and USDA, 2005) that may be relevant to the 2010 dietary guidelines. We focused on presenting the information succinctly, without making judgments on the strength or importance of individual studies. Instead, we aimed to provide enough information to allow the members of the DGAC to draw their own conclusions or to decide whether further investigation is warranted. The final project report will focus on the evidence base for dietary guidance statements by integrating the information from this report of evidence published in 2004 to February 2008 with information from the 2000 and 2005 *Dietary Guidelines* (USDA and HHS, 2000; HHS and USDA, 2005), dietary guidance statements from publications of various authoritative groups, and additional background literature published since the 2005 *Dietary Guidelines*.

METHODS

As noted in the literature review plan (Dodd et al. 2007), we collected relevant evidence that was not available for the 2005 *Dietary Guidelines*. We gathered "primary" articles that met the following criteria:

- Peer-reviewed work published in 2004 or later
- Published in English
- Applicable to populations living in developed countries, including the United States, Canada, the United Kingdom, Australia, New Zealand, Western European countries, China, and Japan
- Relevant to one of the major dietary guidelines or to a Dietary Reference Intake (DRI) value that played a key role in the setting of a dietary guideline
- Conducted with children or adolescents (ages 2 to 18 years)
- Involved study outcomes that were direct measures of health or nutrition status, biologic outcomes, or dietary-related behaviors (intermediate factors thought to influence health status or biologic outcomes)
- Not cited by the DGAC for the 2005 *Dietary Guidelines* (DGAC 2004)

For each set of search results, a nutritionist on the study team screened the abstracts to verify that the articles met these criteria. An article was classified as "background" if (1) the article did not measure a health outcome, (2) a dietary behavior was not the main focus of the study, (3) the article focused on the risk associated with overweight or obesity (instead of a dietary factor), or (4) the article focused on a dietary behavior that was not a focus of our searches (such as eating breakfast). If it was unclear whether the article should be considered "primary" or "background," we considered the article to be "primary." Each "primary" article was also reviewed by a second team nutritionist to confirm that it met the criteria for the literature review and to determine the most appropriate topic placement, if needed.

We grouped the articles by topic area and, within each topic area, by outcome measured. Each topic area is summarized in a section of the report, designed to be a stand-alone synopsis of all new relevant information published in 2004 to February 2008. If a study was relevant to multiple areas, the study was included within each relevant topic area. If a study had multiple outcomes, a summary of the study was included within each relevant outcome.

The summarized topic areas are grouped by chapters in the 2005 *Dietary Guidelines*, with a few notable differences. We did not summarize articles with physical activity, alcoholic beverages, or food safety as the measure of interest.[1] We created separate sections for the subtopic areas mentioned within chapter 5, "Food Groups to Encourage," in the *Dietary Guidelines* ("Fruits and Vegetables," "Whole Grains," "Milk and Milk Products") and included calcium in the dairy section. Finally, we added a section to highlight the findings of "tracking" articles.

While the 2005 dietary guidelines seem to use the term "tracking" to refer to one behavior tracked over time, we used a broader definition of "tracking". We considered any article that measured study participants at more than one point in time to be tracking articles. We classified the tracking studies into three types: (1) behaviors tracked to a biologic or health outcome, (2) behaviors tracked to behaviors, and (3) biologic or health status tracked to biologic or health outcomes. The tracking age group was also noted to distinguish tracking studies from early to later childhood versus childhood to adulthood.

In the literature review plan, we noted that our goal was to answer the research question, "What is the science base now for dietary guidance to [insert dietary guidance statement here] for children?" In this report, we focus on the recent evidence. Table 1 illustrates how the research questions cited in the literature review plan map to the sections within this report.

Table 1. Mapping of Dietary Guidance Statements to Sections of Report

Dietary Guidance Statement	Report Section
Moderate total fat	Fats
Limit saturated fat	Fats
Encourage unsaturated fat food sources	Fats
Limit trans fat	Fats
Limit cholesterol	Fats
Limit added sugars (including sweetened beverages)	Carbohydrates
Encourage whole grains	Whole Grains
Encourage high fiber foods	Whole Grains

[1] In an effort to conserve resources for topics related to food and nutrient intake and weight management, the project officer and research team decided not to include these areas in the summaries, although a search was completed for alcohol and food safety but yielded few primary articles that met our criteria for children's outcomes of interest. A separate literature review for developing physical activity guidelines was recently released by the Physical Activity Guidelines Advisory Committee (2008).

Dietary Guidance Statement	Report Section
Encourage fruits and vegetables	Fruits and Vegetables
Limit sodium	Sodium and Potassium
Encourage potassium-rich foods	Sodium and Potassium
Abstain from alcoholic beverages	*
Get adequate nutrients within calorie needs	Adequate Nutrients
Maintain a healthy body weight	Weight Management
Engage in physical activity	*
Take steps to maintain food safety	*
Select certain kinds of dairy	Dairy and Calcium
Select certain kinds of meat/protein	Adequate Nutrients
Select certain kinds of oil	Fats
Select certain foods based on nutrient density**	Adequate Nutrients
Include omega-3 fatty acids**	Fats

* Physical activity, alcohol, and food safety were not included in the literature summary.
** Statement was not included in the 2005 *Dietary Guidelines*

For each abstract in our "primary" list, we obtained and reviewed the full article, which sometimes resulted in changes to the initial classifications that were made based on the article abstract. For example, we reclassified some articles as "background" and removed others from the bibliography because they did not meet the inclusion criteria.

In Table 2, we display the number of primary research studies reviewed for the evidence base within each topic area.[2] We also depict the number of tracking studies, systematic reviews and meta-analyses, and other articles reviewed within the total number of studies reviewed in the evidence tables.

Table 2. **Number of Primary Research Studies Reviewed for the Evidence Base Within Each Topic Area**

	Evidence Tables				
Dietary Guideline Topic Area	Number of Primary Research Studies[a]	Tracking Studies[b]	Systematic Reviews and Meta-Analyses	Controlled Trials	Obser-vational Studies
Number of Unique Studies	104	45	7	12	85
1: Adequate Nutrients within Calorie Needs	20	10	1	4	15
2: Weight Management	27	17	2	2	23

[2] One hundred four primary research studies are in the evidence tables. We did not analyze the evidence for three topic areas: alcohol, food safety, and physical activity.

Dietary Guideline Topic Area	Evidence Tables				
	Number of Primary Research Studies[a]	Tracking Studies[b]	Systematic Reviews and Meta-Analyses	Controlled Trials	Observational Studies
3: Fats	17	5	0	5	12
Food Groups to Encourage					
4: Fruits and Vegetables	14	4	0	0	14
5: Whole Grains	2	0	0	0	2
6: Dairy and Calcium	21	7	1	2	18
7: Carbohydrates	32	12	3	3	26
8: Sodium and Potassium	3	0	1	0	2
9: Tracking	(45)[b]		(4)	(2)	(39)
Total	136	55	8	16	112

[a]Total number of unique primary research studies in the evidence tables is 104, but some articles were analyzed under multiple topic areas.
[b]Tracking studies are also included in the systematic reviews and meta-analyses, controlled trials, and observational studies columns.

SUMMARY OF RECENTLY PUBLISHED EVIDENCE

In the following sections, we summarize recently published evidence related to the *Dietary Guidelines* based on studies of 2- to 18-year-olds. Summary topic sections for which we found many relevant articles were divided into subtopic areas. These subtopic areas were determined by an initial review of the articles. Within each subtopic area, we included a summary of the type of studies summarized, a brief overview of the sub-section, and a summary of each article. The article summaries include a brief description of the outcomes and methods. The summaries contain more detailed information than a standard abstract because we thought the committee would find information on the magnitude of effects useful. At the end of each section is a table that gives the citation, title, article identification number (ID), population studied, type of study, and type of tracking study (if applicable). The article ID maps to the article number in the primary citation list.

SECTION 1: ADEQUATE NUTRIENTS WITHIN CALORIE NEEDS
SUBTOPIC #1: DIET RELATED TO BONE, CALCIUM RETENTION

Total number of studies:	**8**
Cross-sectional:	**1**
Cohort:	**4 (4 longitudinal)**
Controlled trials:	**2 (1 randomized, 1 metabolic crossover)**
Review:	**1**

Health-related outcomes addressed: periosteal circumference, cortical area, cortical thickness, total body bone mineral content (BMC), bone mineral density (BMD), fractures, calcium retention

Behaviors addressed: beverage intake

Overview of Recently Published Evidence

Of the eight studies, four reported on BMC and/or BMD. The other studies differed in the variables and outcomes examined. Most focused on calcium intake. One metabolic study provided updated information on calcium retention in young adolescent males. Intakes of the nutrients or foods studied tended to be weakly associated with the outcomes investigated.

Summary of Studies

Calcium retention, bone mineral content, bone mineral density (see also Alexy et al. (2005) below)

a. Bounds et al. (2005)[3] reported statistically significant correlations of energy, calcium, phosphorus, protein, magnesium, and zinc with BMC (r = .32 to .41) in children ages 6 and 8 years. Multiple regression models predicting children's total BMC at age 8 years showed significant effects of individual nutrients (i.e., protein, phosphorus, magnesium, vitamin K, zinc, energy, and iron) when they were substituted for one another in the model. R^2 shown were .05 and .08. Relationships were weaker for BMD. All relationships between nutrient intakes and BMC or BMD were positive; protein had the strongest relationship. BMC and BMD tracked from age 6 to 8 years; strength of relationship not shown.

   Methods: Longitudinal cohort, 52 subjects, 9 in-home interviews that included one 24-hour recall and two diet records collected over 6 years, dual energy X-ray absorptiometry (DEXA). Colinearity of nutrients addressed through substitution in regression equations.

b. Braun et al. (2006) found that boys ages 12 to 15 years achieved maximal calcium retention at an intake of 1,140 mg of calcium per day. Calcium

[3] One author is an employee of Gerber Products Company.

retention at any intake was nearly 15% higher than that found for girls in an earlier study that used the same protocol.

<u>Methods</u>: Metabolic balance studies, crossover design, 2-week washout. 31 boys completed at least one study period, 26 boys completed both study periods. Non-linear regression used to determine the intake at which maximal calcium retention occurred.

c. Cheng et al. (2005) found that for girls ages 10 to 12 years, when compliance was ≥50%, calcium supplementation with cheese resulted in a higher percentage change in cortical thickness of the tibia than did placebo or calcium with or without vitamin D (using both efficacy and intention-to-treat analysis). No significant differences were found for other sites or for BMC, but the efficacy analysis showed that calcium supplementation with cheese resulted in higher adjusted BMD than did placebo.

<u>Methods</u>: Randomized controlled trial (RCT), each of the five groups had approximately 40 subjects, 3-day food diaries, DEXA and peripheral quantitative computed tomography, Bonferroni's correction for multiple comparisons.

d. Fiorito et al. (2006) reported that higher calcium intakes at ages 7 and 9 years were significantly and positively associated with total body BMC at age 11 years (r ranged from .17 to .24). Results were comparable for total calcium and calcium from dairy sources.

<u>Methods</u>: Longitudinal cohort, 151 females, three 24-hour dietary recalls at ages 5, 7, 9, and 11 years, DEXA at ages 9 and 11, adjusted and unadjusted Spearman correlation coefficients.

e. Fisher et al. (2004)[4] reported that mean BMC (controlled for pubertal development and height at age 9 years) and mean BMD at age 9 years (controlled for pubertal development at age 9 years) were significantly higher for the girls who met the adequate intakes than for those who did not. No difference in BMI by calcium intake. After controlling for the stage of pubertal development at age 9 years, mean calcium intake from ages 5 to 9 years was significantly positively related to BMD at age 9 years (B = 0.27). Calcium intake tracked over time as follows: 5 to 7 years, r = .52; 7 to 9 years, r = .48; 5 to 9 years, r = .39.

<u>Methods</u>: Longitudinal cohort, 192 females, three 24-hour dietary recalls at ages 5, 7, and 9 years, DEXA at ages 9, multiple logistical regressions.

Fracture history

a. Goulding et al. (2004) reported that children ages 3 to 13 years who avoided milk and who had limited intake of calcium-rich food substitutes experienced

[4] Research partially supported by the National Dairy Council.

significantly more fractures than did birth cohort controls. (One in three study children had experienced fractures, 82% occurred before age 7 years.)

Methods: Cross-sectional, 50 children with low dietary calcium intakes, low *z* scores for BMC, and low volumetric BMD; short food frequency questionnaire; dual-energy X-ray scans; fracture occurrence by interview.

Bone remodeling

a. Alexy et al. (2005) examined long-term dietary protein intake as related to bone modeling and remodeling at the proximal radius. After adjustments, the protein intake was significantly positively associated with periosteal circumference, cortical area, BMC, and polar strength strain; and potential renal acid load was significantly negatively associated with cortical area and BMC. R^2 ranged from .03 for potential renal acid load to .10 for protein as a percentage of energy.

   Methods: Cohort, 229 subjects, 3-day dietary records collected yearly over 4 years, XCT-2000 device.

b. Lanou et al. (2005)[5] conducted Medline search for studies published on the relationship between milk, dairy products, or calcium intake and bone mineralization or risk of fracture for subjects ages 1 to 25 years. The authors excluded studies that did not control for body weight, pubertal status, and activity level. They report a positive relationship between dairy product consumption and measures of bone health in 1 of 4 cross-sectional studies, 0 of 3 retrospective studies, 0 of 1 prospective study, and 2 of 3 RCT. They report a positive relationship between calcium intake and measures of bone health in 4 of 13 cross-sectional studies, 2 of 4 retrospective studies, and 1 of 9 prospective studies. For the 10 controlled trials of calcium supplementation, 9 showed a positive relationship with BMD or BMC.

   Methods: Review, no tabular information presented, strength of evidence not presented in formal manner.

[5] Two authors from the Physicians Committee for Responsible Medicine.

SECTION 1: ADEQUATE NUTRIENTS WITHIN CALORIE NEEDS
SUBTOPIC #2: DIET RELATED TO WEIGHT

Total number of studies:	**7**
Cross-sectional:	**2**
Cohort:	**4 (longitudinal)**
Randomized controlled trials:	**1**

Health-related outcomes addressed: body mass index (BMI), weight change, fat mass, lean body mass

Behaviors addressed: beverage patterns and diet quality, breakfast and cereal consumption related to intakes

Overview of Recently Published Evidence

Researchers addressed a variety of dietary factors that might influence BMI in children. The five studies that investigated dairy or calcium intake in relation to BMI had mixed findings; the single RCT showed no difference in BMI by calcium intake. Two longitudinal studies suggest that protein intake by children is associated with BMI. Associations appear weak despite statistical significance.

Summary of Studies

Body mass index

a. For children ages 3 to 11 years, Barba et al. (2005) reported a significant inverse association (t = -2.964) of the frequency of milk consumption with age- and sex-specific BMI z-scores. Differences in the association were reported for whole and skim milk (significant and non-significant, respectively) when additional foods were included in the model.

<u>Methods</u>: Cross-sectional, 884 children, 1-year food frequency questionnaire, linear regression analysis, controlled for several variables including physical activity.

b. Barton et al. (2005)[6] reported that, over the course of the 10-year study, days eating cereal daily was predictive of a lower BMI z-score and of risk of overweight (χ^2 (3) = 14.35 and 11.62, respectively). Post hoc analysis showed that girls who ate cereal on any day had lower rates of risk of overweight than did girls who ate no cereal.

[6] Research partially supported by General Mills, Inc.; three authors are employees of General Mills, Bell Institute of Nutrition.

Methods: Longitudinal cohort, 2379 girls ages 9 and 10 years at entry, 3-day food records at each of 10 visits over 10 years (NHLBI Growth and Health Study).

c. Over the 3 years of the study, Berkey et al. (2005) found that children who drank more than 3 servings of milk daily had small (*Beta* ~0.01 to 0.02, depending on the comparison) but significant gains in one-year BMI change compared with children who consumed less milk. This finding held even when 1% and skim milk were consumed. Over the entire 3 years, both boys and girls who consumed more than 3 servings of milk daily every year gained more in BMI (0.26 and 0.21, respectively) than did those who consumed 2 to 3 servings daily, but these results were not statistically significant.

Methods: Longitudinal cohort, 23,829 children ages 9 to 14 years at entry, food frequency questionnaires for intake over past year, (9,166 provided food frequency questionnaires for all 4 years), adjusted for adolescent growth and development, race, physical activity, inactivity, and (in some models) total energy intake.

d. Lappe et al. (2004) provided parents of 9-year-old female subjects with special credit cards to purchase calcium-rich foods, educated them on natural and fortified food sources of calcium, and advised them to consume at least 1,500 mg of calcium daily. Compared with controls, the subjects did not have greater increases in body weight, BMI, or fat or lean mass. (Mean calcium intakes were 1,656 mg for subjects and 961 mg for controls.) The results held when the data were grouped by tertile of calcium intake.

Methods: RCT, 50 girls, 3-day diet diaries once every 3 months for 2 years, DEXA used to estimate fat and lean mass.

e. LaRowe et al. (2007) reported on relationships of beverage patterns to diet quality (Healthy Eating Index (HEI)) and BMI among children ages 2 to 5 years and 6 to 11 years. For preschool children, mean BMI did not differ by beverage pattern. For school-aged children, BMI was significantly higher in the 3 beverage patterns with high amounts of water, sweetened drinks, or soda (adjusted mean BMIs = 19.9, 18.7, and 18.7, respectively) than in the patterns with high amounts of high-fat milk or light overall beverage intake (adjusted mean BMI = 18.2 and 17.8, respectively).

Methods: Cross-sectional, 541 preschool children, 793 school-aged children, single 24-hr diet recall, NHANES data, cluster analysis used to identify beverage patterns. BMI relationship adjusted for age, sex, ethnicity, household income, HEI, physical activity, and birth weight. Tukey-Kramer option used to correct for multiple comparisons in general linear models.

f. Skinner et al. (2004) reported that BMI at age 8 years was negatively predicted by age of adiposity rebound (AR, the age at which BMI increased following the lowest BMI) and positively predicted by BMI at 2 years. In separate regression models, mean protein and fat intakes from 2 to 8 years were positive predictors of BMI, and mean carbohydrate intake over this period was a negative predictor of BMI.

Methods: Longitudinal cohort, 70 children, 15 to 17 sets of growth and dietary data from ages 2 months to 8 years; beginning with the third year, mothers provided two nonconsecutive food records and one diet recall (averaged). AR determined visually and by consensus. Forward selection stepwise regression.

Body fat percentage

a. Gunther et al. (2007) reported that animal protein intake at 5 to 6 years was related to adjusted mean body fat percentage (BF%) at age 7 years. BF% at 7 years was 16.8 for the lowest tertile of animal protein intake as a percentage of energy and 18.0 for the highest tertile.

   Methods: Longitudinal cohort, 203 children studied from birth through age 7 years, 3-day weighed diet records, adjusted for sex, intake of total energy and fat as a percentage of energy, siblings in the dataset, firstborn status, maternal weight BMI≥25, and BF% at baseline. Authors present life-course plots of multiple linear regression analyses with BMI standard deviation (SD) score and the natural log of BF% at 7 years of age as the outcome.

SECTION 1: ADEQUATE NUTRIENTS WITHIN CALORIE NEEDS
SUBTOPIC #3: MISCELLANEOUS RELATIONSHIPS OF DIET/NUTRIENTS TO HEALTH RELATED OUTCOMES

Total number of studies:	**5**
Cross-sectional:	**2**
Cohort:	**2 (retrospective)**
Randomized controlled trials:	**1**

Health-related outcomes addressed: respiratory health (asthma); breast cancer; serum levels of nutrients and cholesterol; insulin-like growth factor

Behaviors addressed: fruit and vegetable consumption; meat, fish and poultry consumption; milk consumption; smoking

Overview of Recently Published Evidence

Few studies examined effects of children's dietary patterns and/or nutrient intake on health outcomes other than those related to body weight or bone health. Single observational studies point to beneficial effects of fruit and of vitamins C and E on a few measures of respiratory health; lower risk of breast cancer with higher intake of vitamin E and vegetable fat; and higher C-reactive protein concentration with lower intake of magnesium. The RCT demonstrated that serum ferritin was maintained on low-fat diets regardless of whether they were rich in lean beef or in lean poultry and fish.

Summary of Studies

Respiratory health

a. Among 12th grade students, Burns et al. (2007) found the lowest quintile of fruit intake (<0.25 servings/day) was associated with lower forced expiratory volume in one second (FEV_1) than were the higher quintiles (adjusted difference – 1.3). Other measures of respiratory status were not significantly different. Intake of less than 85 mg/d of vitamin C was associated with lower forced vital capacity (FVC) and FEV_1 than were lower intakes. The adjusted odds ratio (OR) for chronic bronchitis symptoms was higher for those consuming less than 22 mg/d of n-3 fatty acids per day than for those consuming larger amounts. Compared with higher intake, vitamin E intake less than 5.2 mg/d was associated with an increased OR of reported chronic bronchitis symptoms, wheeze, and asthma. Results for other nutrients and outcomes were not significantly different.

   <u>Methods</u>: Cross-sectional, 2112 subjects, semiquantitative food frequency questionnaires, linear mixed models, fruit intake adjustment for weight, gender, height, height-gender interaction, age, race, ethnicity, overweight, smoking, household smokers. Respiratory adjustments for city, sex, age, race, overweight, smoking household smokers, and mold in the home. No consideration was given to the number of comparisons made: significance reported if $P \leq .05$.

Breast cancer

a. Frazier et al. (2004) reported that when quintile 5 of intake was compared with quintile 1, the relative risk (RR) of breast cancer was lower for the higher intake of vegetable fat (multivariate RR = 0.58), and the RR also was lower for higher intake of vitamin E (multivariate RR = 0.61). Compared with quintile 1, quintile 5 for glycemic index was associated with increased risk of breast cancer (multivariate RR = 1.47).

Methods: Retrospective cohort, 47,355 subjects, 131-item retrospective food frequency questionnaire about diet during high school (Nurses Health Study II), Cox proportional hazards regression used to estimate RR and 95% confidence intervals for incident cases of breast cancer during the 10-year period following high school.

Magnesium intake and serum C-reactive protein concentration

a. King et al. (2007) found that children with a magnesium intake of <75% of the RDA were more likely to have an elevated C-reactive protein concentration (> 3.0 mg/L) than were children with higher magnesium intakes. In adjusted analyses, the odds ratio was 1.58 (CI 1.07 to infinity) for the children with the lower magnesium intakes.

Methods: Cross-sectional, 5,007 children with available laboratory samples, single 24-hour diet recall, data from the National Health and Nutrition Examination Survey, logistic regression analyses controlled for age, race, sex, income level, exercise, fiber intake, BMI, and total calories.

Diet and serum ferritin, zinc, and cholesterol

a. Snetselaar et al. (2004) compared changes in serum ferritin, zinc, and cholesterol values for subjects randomized to a low-fat (maximum of 20 g/d of saturated fat) eating pattern that emphasized either lean beef or lean poultry and fish. Statistically, the serum ferritin value of the lean poultry and fish group was significantly lower than that of the lean beef group, but it was not a clinically significant decrease. No significant differences were observed in the other serum values measured.

Methods: 86 children, one 24-hr dietary recall during baseline and month 3 visit and two telephone recalls within 2 weeks, an immunoradiometric procedure used to determine serum ferritin and flame atomic absorption spectrometry to determine serum zinc.

Insulin-like growth factor (IGF)

a. Martin et al. (2007) examined the association between childhood diet and IGF variables in adulthood, given that IGFs are associated with increased risk of cancer and decreased risk of diabetes and heart disease. They found that energy-rich diets had no association (contrary to the hypothesis of a positive association), diets high in milk had a negative association (which supports existing literature suggesting that milk consumption may reduce cancer risk), and diets high in vegetables had a positive association (which runs contrary to existing literature suggesting that vegetable consumption may reduce cancer risk).

Methods: Longitudinal cohort; 679 English and Scottish adults aged 64-83 years with complete data, who originally participated in a one-week survey when aged 0-19 years, as part of the Boyd Orr cohort of the Carnegie Survey of Diet and Health; examined change in adult IGF (blood test) per SD change in each childhood dietary variable (7-day household inventory translated into per capita daily intakes of various nutrients and food groups); linear regression.

ADEQUATE NUTRIENTS WITHIN CALORIE NEEDS

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	Title			Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
1	Alexy et al. 2005	Long-term protein intake and dietary potential renal acid load are associated with bone modeling and remodeling at the proximal radius in healthy children	2	229 children & adolescents 6-18 y/o			cohort (longitudinal)	X			X	
2	Barba et al. 2005	Inverse association between body mass and frequency of milk consumption in children	8	884 7 y/o not on dietary regimen selected out of 1,087 (M:F 451:433)			cross sectional					
3	Barton et al. 2005	The relationship of breakfast and cereal consumption to nutrient intake and body mass index: the National Heart, Lung, and Blood Institute Growth and Health Study	9	At baseline, 2,379 9-10 y/o girls (1,166 white, 1,213 AA) from Berkeley, CA; Cincinnati, OH; and Washington, DC. Participants from NHLBI Growth and Health Study. F/up at 19 y/o			cohort (longitudinal)			X	X	
4	Berkey et al. 2005	Milk, dairy fat, dietary calcium, and weight gain: a longitudinal study of adolescents	10	12,829 9-14 y/o US children			cohort (longitudinal)					
5	Bounds et al. 2005	The relationship of dietary and lifestyle factors to bone mineral indexes in children	13	52 healthy white children studied from 2 mo to 8 y/o (25 M, 27 F) and their mothers			cohort (longitudinal)	X			X	
6	Braun et al. 2006	Calcium retention in adolescent boys on a range of controlled calcium intakes	14	31 adolescent boys aged 12-15 yrs. Comparison group was 35 adolescent girls previously studied.		metabolic crossover						
7	Burns et al. 2007	Low dietary nutrient intakes and respiratory health in adolescents	15	2,112 12th-graders from 13 US and Canadian communities in 1998-99 school yr			cross sectional					
8	Cheng et al. 2005	Effects of calcium, dairy product, and vitamin D supplementation on bone mass accrual and body composition in 10-12-y-old girls: a 2-y randomized trial	16	195 10-12 y/o, Tanner stage I-II girls w/Ca intakes 50%		RCT						

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	Title			Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
9	Fiorito et al. 2006	Girls' Calcium Intake Is Associated with Bone Mineral Content During Middle Childhood	29	151 non-Hispanic white girls			cohort (longitudinal)	X			X	
10	Fisher et al. 2004	Meeting calcium recommendations during middle childhood reflects mother-daughter beverage choices and predicts bone mineral status	30	192 5, 7, 9 y/o non-Hispanic white girls and mothers			cohort (longitudinal)	X			X	
11	Frazier et al. 2004	Adolescent diet and risk of breast cancer	33	47,355 participants in the Nurses Health Study II			cohort (retro-spective)	X				X
12	Goulding et al. 2004	Children who avoid drinking cow's milk are at increased risk for prepubertal bone fractures	38	50 3-13 y/o (30 girls, 20 boys) who had avoided drinking cow's milk for prolonged periods, and 22/50 overwt; these 50 compared w/ a birth cohort of >1,000 children in same city.			cross sectional					
13	Gunther et al. 2007	Early protein intake and later obesity risk: Which protein sources at which time points throughout infancy and childhood are important for body mass index and body fat percentage at 7 years of age?	40	203 6 mo-7 y/o in the Dortmund Nutritional and Longitudinally Designed Study who had diet information			cohort (longitudinal)	X			X	
14	King et al. 2007	Magnesium intake and serum C-reactive protein levels in children	46	6-17 y/o in NHANES			cross sectional					
15	Lanou et al. 2005	Calcium, dairy products, and bone health in children and young adults: a reevaluation of the evidence	49	1-25 y/o	X	RCT (13)	cross-sectional (22); retrospective (13), and longitudinal prospective studies (10)	X			X	X

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**			**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
16	Lappe et al. 2004	Girls on a high-calcium diet gain weight at the same rate as girls on a normal diet: a pilot study	50	59 9 y/o girls in metropolitan Omaha, NE communities		RCT		X			X	
17	LaRowe et al. 2007	Beverage patterns, diet quality, and body mass index of US preschool and school-aged children	51	541 Two-5 y/o and 793 six-11 y/o children from 2001-2002 NHANES			cross sectional					
18	Martin et al. 2007	Childhood diet and insulin-like growth factors in adulthood: 65-year follow-up of the Boyd Orr Cohort	59	Baseline: 679 2.9-9.6 y/o (median 5.8 y/o) in the Carnegie (Boyd Orr) Survey of Diet and Health 1937-1939 in England and Scotland; f/up 65 for yrs			cohort (retro-spective)					
19	Skinner et al. 2004	Predictors of children's body mass index: a longitudinal study of diet and growth in children aged 2-8 y	84	70 white, middle/upper SES children (37 M, 33 F) participating in longitudinal study from 2-9 y/o			cohort (longitudinal)	X		X	X	
20	Snetselaar et al. 2004	Adolescents eating diets rich in either lean beef or lean poultry and fish reduced fat and saturated fat intake and those eating beef maintained serum ferritin status	86	86 7th and 8th graders		RCT						

SECTION 2: WEIGHT MANAGEMENT
SUBTOPIC #1: WEIGHT STATUS TRACKING

Total number of studies:	**9**
Longitudinal cohort:	**9**

Health-related outcomes addressed: body mass index (BMI), obesity status (at-risk of overweight/overweight, overweight/obesity), adiposity indices

Behaviors addressed: not applicable

Overview of Recently Published Evidence

All of the studies reviewed showed the persistence of overweight/obese status, both within childhood (three studies), and from childhood to adulthood (six studies). In addition, five of the studies found that the prevalence of overweight and obesity within the study populations increased with age.

Summary of Studies

Body mass index, weight status, adiposity indices

a. Crimmins et al. (2007) tracked adolescent BMI and found considerable stability. Specifically, the percent at risk for overweight went from 19.1 in Year 1 to 17.2 in Year 4, and the percent overweight went from 18.2 in Year 1 to 18.8 in Year 4. However, adolescents who were the leanest at baseline, exhibited significant increases in BMI, and this effect was stronger for girls.

   Methods: Longitudinal cohort; 1,746 white and black students in grades 5 thru 12 in school-based study in Cincinnati with complete data for four annual assessments; BMI (health examination); standard CDC classification based on BMI percentile by age and sex into underweight (< 5th percentile), normal weight (>= 5th & < 85th percentile), at risk for overweight (>= 85th & < 95th percentile), and overweight (>= 95th percentile); repeated-measures ANOVA.

b. Deshmukh-Taskar et al. (2006) tracked weight status from childhood to young adulthood (ages 19 to 35 years) and found that rates of overweight increased from childhood to adulthood and childhood overweight tracked into adulthood. Specifically, percentage overweight increased from 24.7% to 57.7%; 35.2% of the children shifted from normal weight in childhood to overweight in adulthood; baseline BMI was strongly positively correlated with follow-up BMI (r = .66); and 61.9% of participants in the highest BMI quartile in childhood remained in the highest BMI quartile in adulthood.

   Methods: Longitudinal cohort; 841 white and black adults ages 19 to 35 years who had completed a baseline assessment at ages 9 to 11 years; data from

Bogalusa (Louisiana) Heart Study; BMI (health examination); for children, standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile) and overweight or at risk for overweight (>= 85th percentile); for adults, classification into normal weight (BMI < 25) and overweight (BMI >= 25); Cohen's kappa and Pearson correlation coefficients.

c. Evers et al. (2007) tracked weight status and found high and increasing prevalence and high persistence in overweight. Specifically, 68.2% of children who were overweight in pre-kindergarten were overweight in 3rd grade (OR = 108.67), and 19.1% of children who were at risk for overweight in pre-kindergarten were overweight in 3rd grade (OR = 5.82); therefore, overweight prevalence increased from 9.9% in pre-kindergarten to 15.2% in 3rd grade. Maternal overweight, but not other SES or demographic indicators, predicted child overweight in pre-kindergarten (OR = 1.13).

   <u>Methods</u>: Longitudinal cohort; 760 pre-kindergarten students from economically-disadvantaged communities in Ontario, Canada, and their mothers; one to five annual assessments through 3rd grade; child BMI (health examination); maternal BMI and various SES and demographic indicators (self-report); for children, standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile), at risk for overweight (>= 85th percentile & < 95th percentile), and overweight (>= 95th percentile); for mothers, classification into normal weight (BMI < 25) and overweight (BMI >= 25); logistic regression.

d. Freedman et al. (2005) tracked weight status and found that childhood BMI *z*-scores and adiposity indices were associated with adult BMIs and adiposity indices, with overall correlations ranging from $r = .44$ to .64, and increasing with childhood age. In addition, regression analyses showed that childhood BMI *z*-scores and adiposity indices were independently associated with adult BMIs and adiposity indices.

   <u>Methods</u>: Longitudinal cohort; 2,610 children ages 2 to 17 years with follow up at ages 18 to 37 years; data from Bogalusa (Louisiana) Heart Study; BMI (health examination); adiposity index—triceps SF for children and mean of triceps and subscapular SF for adults (health examination); for children, classification based on BMI percentile by age and sex into normal weight (< 95th percentile) and overweight (>= 95th percentile); for adults, classification into non-obese (BMI < 30) and obese (BMI >= 30); overfat defined as gender-specific upper quartile for SF; linear regression and Spearman correlation coefficients.

e. Garnett et al. (2007) tracked weight status and found that BMI and waist circumference *z*-scores increased with age, 78.9% who were overweight or obese at age 8 years were overweight or obese at age 15 years (OR = 14.8), and 69.2% who had increased central adiposity at age 8 had increased central adiposity at age 15 (OR = 12.2). In addition, children who were overweight or obese at age 8 were more likely to have CVD risk clustering at age 15 (OR = 6.9), and children who had increased central adiposity at age 8 were more likely to have CVD risk clustering at age 15 (OR = 3.6). However, among those classified as overweight or obese, there was no difference in the likelihood of having CVD risk clustering between those with or without increased central adiposity.

Methods: Longitudinal cohort; 342 Australian children age 8 years with follow up at age 15 years; BMI, waist circumference, and blood pressure (health examination); lipid and glucose profiles (overnight fasting blood test); classified as overweight or obese based on IOTF age-and-sex specific BMI *z*-score cut-points; classified as having increased central adiposity if age-and-sex specific waist circumference *z*-score > 91st percentile; two slightly different CVD risk indices created based on number of scores that met risk cut-points among fasting glucose, insulin, HDL, LDL, triglycerides, diastolic blood pressure, and systolic blood pressure; paired *t* test, logistic regression, and χ^2.

f. Must et al. (2005) tracked weight status and found that adult overweight was predicted by pre-menarchal overweight (OR = 7.70) and adult obesity was predicted by pre-menarchal overweight (OR = 4.30), but neither was predicted by early menarche. Similarly, four models predicting adult percent body fat showed that for age at menarche alone R^2 = .029 (i.e., essentially no predictive value), whereas for pre-menarchal BMI alone R^2 = .277, for both variables together R^2 = .284, and for both variables and the interaction R^2 = .284 (i.e., age at menarche added no predictive value to that contributed by pre-menarchal BMI).

Methods: Longitudinal cohort; 307 girls ages 9 to 10 years with complete data at adult follow-up at approximately 42 years of age; childhood data from Newton (Massachusetts) Girls Study, which involved annual assessments through approximately two years past menarche; BMI (health examination); for children, standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile) and overweight (>= 85th percentile); for adults, classification into normal weight (BMI < 25), overweight (BMI >= 25 & < 30), and obese (BMI >= 30); age at menarche (child self-report), classified as early (< 12 years) or not; percent body fat (adult body scan); logistic regression and linear regression.

g. Nader et al. (2006) tracked weight status and found that overweight at age 12 was predicted by overweight at any pre-school assessment (OR = 5.9) or any elementary school assessment (OR = 106.9). More specifically, overweight at age 12 was predicted by overweight at ages 5 (OR = 2.2), 7 (OR = 3.5), and 9 (OR = 6.5). And, obesity at age 12 was predicted by overweight at ages 5 (OR = 7.9), 7 (OR = 32.8), and 9 (OR = 57.5).

Methods: Longitudinal cohort; 1,042 children born in 1991 and retained in the study sample through age 12, with assessments every 1-2 years in between; data from NICHD Study of Early Child Care and Youth Development, with participants recruited from hospitals in 10 sites in the US; BMI (health examination); standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile), overweight (>= 85th & < 95th percentile), and obese (>= 95th percentile); logistic regression.

h. Rzehak and Heinrich (2006) tracked weight status and found that BMI *z*-scores increased with age, and that children with higher baseline scores had steeper increases with age. Girls had a higher growth rate than boys (.89 vs. .75 BMI per year), but there was no gender difference for overweight (OR = 1.08 per year for all) or obesity (OR = 1.11 per year for all).

Methods: Longitudinal cohort; 2,183 German children ages 5 to 13 years at baseline and 996 adults ages 17 to 25 years at third follow-up; data from Bitterfeld cohort study; BMI (health examination); classification into normal weight, overweight, or obese based on IOTF age-and-sex specific BMI *z*-score cut-points; longitudinal random effects modeling.

i. Thompson et al. (2007) tracked weight status and found that rates of overweight increased through adolescence, and that girls who were overweight were much more likely to be obese as young adults (OR = 14.5 at age 9 & OR = 30.3 at age 18). As adolescents, across ages, overweight was associated with unhealthful systolic blood pressure (>= 95th percentile; OR = 10.0), diastolic blood pressure (>= 95th percentile; OR = 3.0), triglycerides (OR = 3.3), and HDL (OR = 6.3), but not LDL.

Methods: Longitudinal cohort; 1,166 white girls and 1,213 black girls, ages 9 to 10 years, with follow-up through ages 18 to 19 years; 10 annual assessments and follow-up phone interview at ages 21 to 23 years; data from the NHLBI Growth and Health Study clinical sites in Berkeley, CA, Cincinnati, OH, and Rockville, MD; BMI and blood pressure (health assessment); for children, standard CDC classification based on BMI percentile by age and sex into non-overweight (< 95th percentile) and overweight (>= 95th percentile); for adults, classification into non-obese (BMI < 30) and obese (BMI >= 30); unhealthful triglycerides (>= 130 mg/dL), LDL (> 130 mg/dL), and HDL (< 50 mg/dL; fasting blood test); logistic regression.

SECTION 2: WEIGHT MANAGEMENT
SUBTOPIC #2: DIETARY CORRELATES OF WEIGHT STATUS

Total number of studies:	**8**
Cross-sectional:	**5**
Longitudinal cohort:	**3**

Health-related outcomes addressed: overweight or obesity

Behaviors addressed: breakfast; dietary intake patterns; physical activity; TV watching

Overview of Recently Published Evidence

As noted in Subtopic #1, previous weight status is a consistent predictor of current weight status. Higher current weight (BMI) or overweight was associated with greater fast food consumption, higher protein intake, and less vigorous physical activity. Although two studies found a positive association between body fat or overweight and time watching TV or using the computer, one study found no association. A healthy weight (or less overweight) was associated with cereal consumption, consumption of fruits, vegetables, and milk, and eating breakfast. There were mixed results for associations between energy intake and BMI or overweight. One longitudinal study found that overweight adolescents' were more likely to reduce total energy intake and snack food intake (presumably to lose weight) and one study found that energy intake and meal patterns were positively associated with BMI.

Summary of Studies

Consumption of specific types of food, eating breakfast

a. Andersen et al. (2005) found that student overweight was inversely associated with eating breakfast (times/wk, *P*-trend=0.006) and positively associated with time spent watching TV/using computer (*P*-trend=0.008). No significant association was found between overweight and total energy intake.

   Methods: Cross-sectional, 664 Norwegian 4th graders and 825 8th graders, self-reported weight and height measurements, 18-page pre-coded food diary of 4 consecutive days, parent-assisted questionnaire on highest parent education level and TV/computer time and participant frequency of vigorous PA and breakfast eating. Logistic regression between overweight and parent characteristics, student PA, and student dietary behaviors and quartiles of food and nutrient intake.

b. Barton et al. (2005)[7] found that cereal consumption was associated with decreased BMI and overweight at all ages, both unadjusted and adjusted for SES, race, physical activity, and total daily energy intake (adjusted $\chi^2 = 14.35$ for BMI *z*-score and 11.62 for risk of overweight). Cereal consumption declined with age. Breakfast consumption showed an unadjusted association with BMI, but the effect disappeared after adjustments.

Methods: Longitudinal cohort; 2,379 white and black girls ages 9 to10 years in three US cities followed for 10 annual assessments; consumption of breakfast and of cereal (3-day food diaries); BMI (health examination); generalized estimating equations.

c. Li and Wang (2008) found tracking of dietary intake patterns (remained in same quartile at baseline and at one year follow-up) over a one-year period, particularly for energy intake, fat, calcium, vegetables and fruits, snack foods, and Western dietary pattern ($r = .4$ to .6). Overweight adolescents were more likely to reduce intake of energy (OR = .32) and snack foods (OR = .16).

Methods: Longitudinal cohort; 181 low-income black adolescents ages 10 to 14 years, with a one-year follow-up; assessment of dietary intake, including nutrients and food groups, from YAQ FFQ; BMI (health examination); used principal components analysis to identify dietary patterns (Western vs. Eastern vs. dairy); standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile), at risk for overweight (>= 85th percentile & < 95th percentile), and overweight (>= 95th percentile); ANOVA, Spearman correlation, and logistic regression.

d. Niemeier et al. (2006) found that from adolescence to adulthood, consumption of fast food increased (2.15 to 2.48 days in the previous week), consumption of breakfast decreased (4.34 to 3.09 days in the previous week), and overweight prevalence increased (28.7% to 47.0%). An increased BMI *z*-score in adulthood was predicted by greater days of fast food consumption in adolescence, fewer days of breakfast consumption in adolescence, and a decrease in breakfast consumption between adolescence and adulthood.

Methods: Longitudinal cohort; 9,919 adolescents who participated in Wave II (ages 11 to 21 years) of the National Longitudinal Study of Adolescent Health, who also participated as adults in Wave III (ages 18 to 27 years); BMI (health examination); maternal obesity (parental report); fast food consumption and breakfast consumption each assessed by single self-report items regarding number of days in the past week had eaten fast food or breakfast; for adolescents, classification into normal weight, overweight, or obese based on IOTF age-and-sex specific BMI *z*-score cut-points; for adults classification into normal weight (BMI < 25), overweight (BMI >= 25 & < 30), and obese (BMI >= 30); *t* test and linear regression.

[7] Research partially supported by General Mills, Inc.; three authors are employees of General Mills, Bell Institute of Nutrition.

e. Roseman et al. (2007) found that weight status was associated with consuming fruits, vegetables (other than green salad or carrots), milk and breakfast. Healthy weight middle school students consumed more fruits, vegetables, and milk, and ate breakfast more often than overweight students. There were no weight status differences with regard to consumption of soft drinks, green salad, or fruit juices.

<u>Methods</u>: Cross-sectional; 4,049 middle school students ages 11 to 14 years in central Kentucky who completed a modified version of the CDC Youth Risk Behavior Survey; dietary intake of fruits, vegetables, milk, breakfast, and soft drinks (food frequency); demographics, height, and weight; standard CDC classification based on BMI percentile by age and sex into underweight (< 5th percentile), normal weight (>= 5th & < 85th percentile), at risk for overweight (>= 85th & < 95th percentile), and overweight (>= 95th percentile); χ^2 and Spearman correlation.

Total energy intake, physical activity, TV watching (see also Andersen et al. (2005) above)

a. Forshee et al. (2004) reported that BMI was negatively associated with participation in team sports or exercise programs for both males and females (*P*=0.04 and *P*=0.03, respectively) and not significantly associated with television viewing. BMI was positively associated with age (*P*=0.00) for males and females and was negatively associated with family income for females (*P*=0.00).

<u>Methods:</u> Cross-sectional, 2,216 children ages 12 to 16 years sampled in the 1988-1994 NHANES, 24-hour recalls, measured height and weight, and interview for other characteristics. Bivariate regressions between regular carbonated soft drinks and BMI, and multivariate regression models between BMI and variables for beverage consumption, non-beverage energy sources, PA and sedentary behavior, and demographics.

b. Huang et al. (2004) found that 45.3% had plausible dietary reports, and that energy intake (EI) was over-reported more in younger children and under-reported more in overweight older children. Across age-by-sex groups in the total sample, reported energy intake (rEI) was not associated with BMI, and other associations with BMI were weak or inconsistent. In the plausible sample, rEI and meal patterns (but not snack patterns) were associated with BMI for boys ages 6 to 11 years and for both boys and girls ages 12 to 19 years.

<u>Methods</u>: Cross-sectional; data from the USDA CSFII; 1,077 children ages 3 to 5 years (proxy interviews), 537 children ages 6 to 11 years (proxy-assisted interviews), and 318 12- to 19-year-olds (self-reports); rEI from two non-consecutive 24-hour dietary recalls; age-and-sex specific BMI percentile, with >= 85 classified as overweight; predicted energy requirements (pER) imputed based on age, weight, and height, assuming "low active" physical activity for all; classified rEI/pER ratio into plausible (within +/- 1 SD) and implausible (> +1 SD or < -1 SD); linear regression.

c. Stallmann-Jorgensen et al. (2007) found that percent body fat was predicted by less vigorous physical activity, more time watching TV, less total energy intake, and greater protein intake.

Methods: Cross-sectional; 661 white and black adolescents ages 14 to 18 years; percent body fat (health examination); 4-7 non-consecutive 24-hour dietary recalls for different days of the week; dietary recalls analyzed with NDS-R database to generate total energy intake, macronutrient intakes as percentages of energy intake, and servings of dairy, fruits, vegetables, and whole grains; physical activities (self-report) converted to hours of moderate physical activity, vigorous physical activity, watching TV, and playing video games; linear regression.

SECTION 2: WEIGHT MANAGEMENT
SUBTOPIC #3: WEIGHT STATUS AND OTHER HEALTH OUTCOMES

Total number of studies:	**9**
Cross-sectional:	**2**
Longitudinal cohort:	**6**
Meta-analysis:	**1**

Health-related outcomes addressed: overweight or obesity; coronary heart disease (CHD); carotid artery intima-media thickness (IMT); lipid profile; DHEA (steroid hormone secreted by adrenal gland); blood pressure; fasting glucose; metabolic syndrome; diabetes; asthma;

Behaviors addressed: smoking; physical activity

Overview of Recently Published Evidence

All the studies reviewed found substantive long-term negative health impacts of overweight and obesity, including three studies with follow-ups later in childhood or adolescence, three studies with follow-ups into adulthood, and one study with follow-ups in both later childhood and adulthood. Two studies found elevated risk factors (such as blood pressure, DHEA, and lipids) in overweight children

Summary of Studies

Cardiovascular health

a. Baker et al. (2007) found that childhood BMI was associated with an increased risk of having a fatal or non-fatal CHD event in adulthood. Risk increased with BMI and age, adjustment for birth weight strengthened the effects, and associations were somewhat stronger for boys than for girls. Specifically, for a 13 year-old boy, RR per SD increase in BMI was 1.17 for a non-fatal event and 1.24 for a fatal event. For a 13 year-old girl, RR per SD increase in BMI was 1.11 for a non-fatal event and 1.23 for a fatal event.

   <u>Methods</u>: Longitudinal cohort; 276,835 Danish schoolchildren ages 7 to 13 years; BMI in childhood (health examination); fatal or non-fatal CHD event in adulthood (25+ years; vital statistics registry); Cox regression.

b. Garnett et al. (2007) tracked weight status and found that BMI and waist circumference *z*-scores increased with age, 78.9% who were overweight or obese at age 8 years were overweight or obese at age 15 years (OR = 14.8), and 69.2% who had increased central adiposity at age 8 had increased central adiposity at age 15 (OR = 12.2). In addition, children who were overweight or obese at age 8 were more likely to have CVD risk clustering at age 15 (OR = 6.9), and children who had increased central adiposity at age 8 were more likely to have CVD risk clustering at age 15 (OR = 3.6). However, among those classified as overweight or obese, there was no difference in the likelihood of having CVD risk clustering between those with or without increased central adiposity.

<u>Methods</u>: Longitudinal cohort; 342 Australian children age 8 years with follow up at age 15 years; BMI, waist circumference, and blood pressure (health examination); lipid and glucose profiles (overnight fasting blood test); classified as overweight or obese based on IOTF age-and-sex specific BMI *z*-score cut-points; classified as having increased central adiposity if age-and-sex specific waist circumference *z*-score > 91st percentile; two slightly different CVD risk indices created based on number of scores that met risk cut-points among fasting glucose, insulin, HDL, LDL, triglycerides, diastolic blood pressure, and systolic blood pressure; paired *t* test, logistic regression, and χ^2.

c. Viikari et al. (2004) provided high-level summaries of two studies, a longitudinal cohort study and a RCT. For the longitudinal cohort study, they summarized findings from the 21-year follow-up, which showed that carotid IMT in adulthood was associated with childhood clustering of risk factors (BMI above the 80th percentile, LDL cholesterol, blood pressure, and smoking), especially in the cohort of adolescents ages 12 to 18 years. Elevated childhood LDL cholesterol, blood pressure, BMI, and smoking predicted carotid IMT in adulthood as single risk factors as well. These effects were independent of contemporaneous risk factors.

<u>Methods</u>: Longitudinal cohort; 3,596 children ages 3 to 18 years in the Cardiovascular Risk in Young Finns Study, with 2,283 followed up through 24-39 years; baseline and 5 follow-up assessments consisting of questionnaires, health examinations, and fasting blood tests.

DHEA, lipids

a. Garces et al. (2007) found that DHEA levels were significantly higher in overweight children and lipid profiles were significantly adverse in overweight children, and that the association between overweight and adverse lipid profile was strongest for boys with the highest DHEA levels. The authors report that the findings support the role of hormonal influences on the association of overweight and metabolic alterations.

<u>Methods</u>: Cross-sectional; 684 Spanish children ages 6 to 8 years; BMI (health examination), classified as overweight based on age-and-sex specific BMI *z*-score cut-points; HDL, LDL, and DHEA (health examination; 12-hour fasting blood test); oneway ANOVA, paired *t* test, and Spearman correlation coefficients.

b. Koenigsberg et al. (2006) examined risk factors among overweight children, and found that older boys were much more likely than older girls to have high blood pressure (52.6% vs. 32.6%) and had lower HDL levels than girls or younger boys, and that boys had higher triglycerides than girls regardless of age. For blood pressure and HDL, age and BMI *z*-score were the significant predictors;

for LDL, BMI *z*-score was the significant predictor; and for triglycerides, insulin sensitivity was the significant predictor.

<u>Methods</u>: Cross-sectional; 497 overweight children (age-and-sex specific BMI percentile >= 95) ages 2 to 18 years, who were patients at a weight management clinic for children, referred from practices in Delaware and Pennsylvania; de-identified data extracted from clinical records; boys vs. girls and younger (2 to 10 years) vs. older (11 to 18 years); logistic regression.

c. Thompson et al. (2007) tracked weight status and found that rates of overweight increased through adolescence, and that girls who were overweight were much more likely to be obese as young adults (OR = 14.5 at age 9 & OR = 30.3 at age 18). As adolescents, across ages, overweight was associated with unhealthful systolic blood pressure (>= 95th percentile; OR = 10.0), diastolic blood pressure (>= 95th percentile; OR = 3.0), triglycerides (OR = 3.3), and HDL (OR = 6.3), but not LDL.

<u>Methods</u>: Longitudinal cohort; 1,166 white girls and 1,213 black girls, ages 9 to 10 years, with follow-up through 18 to 19 years; 10 annual assessments and follow-up phone interview at ages 21 to 23 years; data from the NHLBI Growth and Health Study clinical sites in Berkeley, CA, Cincinnati, OH, and Rockville, MD; BMI and blood pressure (health assessment); for children, standard CDC classification based on BMI percentile by age and sex into non-overweight (< 95th percentile) and overweight (>= 95th percentile); for adults, classification into non-obese (BMI < 30) and obese (BMI >= 30); unhealthful triglycerides (>= 130 mg/dL), LDL (> 130 mg/dL), and HDL (< 50 mg/dL; fasting blood test); logistic regression.

Respiratory health

a. Flaherman and Rutherford (2006) conducted a meta-analysis of the effect of high weight on asthma in 8 prospective and 4 retrospective cohort studies. For the 9 studies that examined high birth weight, the pooled RR of subsequent asthma was 1.2, and for the 4 studies that examined high body weight during middle childhood, the pooled RR was 1.5.

<u>Methods</u>: Meta-analysis; 402 cohort studies identified that were conducted in developed countries (US, UK, Europe, New Zealand, etc.), 12 met inclusion criteria—birth weight (high body weight defined as >= 2.8 kg or ponderal index >= 27kg/m^3) and/or childhood BMI (high body weight defined as age-and-sex adjusted >= 85th percentile) and asthma at follow-up (later in childhood or adolescence).

Metabolic syndrome

a. Morrison et al. (2005) found that whereas prevalence of multiple metabolic syndrome components was rare among girls ages 9 to 10 years, by the follow-up at 18 to 19 years, 3.5% of the black girls and 2.3% of the white girls had the syndrome. Low HDL levels were prevalent throughout the period, whereas prevalence of other risk variables started low and increased with age. Univariate analyses showed that all baseline variables predicted development of the metabolic syndrome at follow-up. Multivariate analyses showed that waist circumference (OR = 1.16) and triglycerides (OR = 1.12) predicted development of the syndrome. BMI also predicted development of the syndrome (OR = 1.20) in multivariate analyses, but the effect disappeared with waist circumference in the model.

<u>Methods</u>: Longitudinal cohort; 608 white girls and 584 black girls, ages 9 to 10 years, with follow-up through 18 to 19 years; 10 annual assessments; data from the NHLBI Growth and Health Study clinical sites in Cincinnati, OH, and Washington, DC; BMI, waist circumference, and blood pressure (health assessment); insulin, glucose, insulin resistance, triglycerides, and HDL (fasting blood test); ATP criteria for metabolic syndrome; logistic regression.

b. Morrison et al. (2008) tracked metabolic syndrome and found that adult metabolic syndrome was predicted by pediatric metabolic syndrome (OR = 9.40), age at follow-up (OR = 1.06), change in BMI percentile (OR = 1.03), and parental history of diabetes (OR = 2.40). Adult diabetes was predicted by pediatric metabolic syndrome (OR = 11.5), age at follow-up (OR = 1.12), black race (OR = 2.20), and parental history of diabetes (OR = 5.00).

<u>Methods</u>: Longitudinal cohort; 814 children ages 5 to 19 years with complete data at follow-up at ages 30 to 48 years; data from Princeton Lipid Research Clinics study; BMI and blood pressure (health examination); waist circumference for adults only (health examination); glucose, HDL, and triglycerides (fasting blood test); for adults, diabetes for self and parents (self-report and/or fasting blood test)

SECTION 2: WEIGHT MANAGEMENT
SUBTOPIC #4: WEIGHT MANAGEMENT INTERVENTIONS

Total number of studies:	**3**
Controlled trial:	**2 (randomized)**
Review:	**1**

Health-related outcomes addressed: overweight or obesity; lipid profile; fasting glucose

Behaviors addressed: dietary intake patterns; physical activity

Overview of Recently Published Evidence

Overall, the studies reviewed found weight management interventions for children to have only modest and inconsistent success rates. The review study found that the primary factor distinguishing successful interventions was inclusion of a compulsory physical activity component. The RCT that compared diet-alone to diet-plus-exercise found that in the longer term, only those who continued participation in an exercise program were able to maintain improvements.

Summary of Studies

a. Connelly et al. (2007) conducted a systematic review, and found that 11 of 28 eligible controlled trials of weight management interventions for children were effective in reducing adiposity in the intervention group vs. the control group. The primary factor that distinguished effective from ineffective interventions was the inclusion of a compulsory aerobic physical activity component.

   Methods: Review; 28 controlled trials of weight management interventions; inclusion criteria—at least 30 participants ages 0 to 18 years, lasted at least 12 weeks, involved non-clinical child populations, index of adiposity outcome variable, and conducted in US, UK, Europe, or Australia; intervention intensity rating score—theoretically or empirically based, implemented by the researchers, compulsory vs. voluntary physical activity component, and multi-component intervention.

b. Rodearmel et al. (2007) found that both intervention and control children had reductions in BMI *z*-scores. There were no differences between the groups with regard to those reductions, but intervention children were less likely to have experienced weight gains (33% vs. 47% $P<0.05$). Also, intervention children, but not control children, increased physical activity and reported decreased calorie consumption.

   Methods: RCT; families with at least one child age 7 to 14 years who was overweight or at risk for overweight randomly assigned to America on the Move intervention (100 families; 116 children & 140 parents) or self-monitor only control (92 families; 102 children & 122 parents); intervention participants asked to maintain physical activity change (increase by 2000 steps/day) and dietary change (decrease by 100 kcal/day) for 6-month period; BMI (health examination); physical activity (pedometer); dietary assessment (weekly self-assessment regarding perceived goal attainment); *t* test.

c. Woo et al. (2004) found that both interventions resulted in short term (6 weeks) improvements in waist-to-hip ratio (.89 to .86 for diet-only and .88 to .85 for diet-plus-exercise), and the diet-plus-exercise also resulted in improvements in LDL (2.9 to 2.6 mmol/L, i.e., 113 to 101 mg/dL) and fasting glucose (4.8 to 4.4 mmol/L, i.e., 86 to 79 mg/dL). Also, both interventions resulted in short term improvements in arterial function, and the improvement was greater for the diet-plus-exercise group (EDD 6.9 to 7.5 for diet-only and 6.8 to 8.0 for diet-plus-exercise). In the longer term (1 year), those who chose to continue the exercise program continued to improve, whereas improvements achieved by the other children were attenuated. In addition, whereas carotid IMT showed no improvements at short-term follow-up, by long-term follow-up improvements were achieved by children who continued to exercise.

Methods: RCT; 82 overweight children (BMI >= 21) ages 9 to 12 years randomly assigned to 6-week dietary modification only intervention (diet-only) or dietary modification plus exercise intervention (diet-plus-exercise), with 1-year follow-up program (during which all continued diet changes and approximately half the exercise group chose to continue exercise program); assessments at baseline, 6 weeks, and 1 year; BMI, percent body fat, waist-to-hip ratio, carotid IMT (atherosclerosis), and endothelial dependent dilation (EDD; arterial function; health examination); HDL, LDL, triglycerides, and glucose (fasting blood test); *t* test and repeated-measures ANOVA.

WEIGHT MANAGEMENT

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	Title			Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
1	Andersen et al. 2005	Overweight and obesity among Norwegian schoolchildren: Changes from 1993 to 2000	5	Nationally representative sample of 1,489 Norwegian 4th and 8th graders			cross sectional					
2	Baker et al. 2007	Childhood body-mass index and the risk of coronary heart disease in adulthood	7	276,835 Danish schoolchildren w/height and wt measurements			cohort (longitudinal)			X		X
3	Barton et al. 2005	The relationship of breakfast and cereal consumption to nutrient intake and body mass index: the National Heart, Lung, and Blood Institute Growth and Health Study	9	At baseline, 2,379 9-10 y/o girls (1,166 white, 1,213 AA) from Berkeley, CA; Cincinnati, OH; and Washington, DC. Participants from NHLBI Growth and Health Study. F/up at 19 y/o			cohort (longitudinal)			X	X	
4	Connelly et al. 2007	A systematic review of controlled trials of interventions to prevent childhood obesity and overweight: a realistic synthesis of the evidence	17	At least 30 children per trial from non clinical population	X	28 RCTs and controlled trials						
5	Crimmins et al. 2007	Stability of adolescent body mass index during three years of follow-up	18	1,746 adolescents in school-based study			cohort (longitudinal)			X	X	
6	Deshmukh-Taskar et al. 2006	Tracking of overweight status from childhood to young adulthood: the Bogalusa Heart Study	23	841 19-35 y/o (68% Euro-Americans, 32% African-Americans) who also did a survey at 9-11 y/o			cohort (longitudinal) created from cross sectional surveys			X		X
7	Evers et al. 2007	Persistence of overweight among young children living in low income communities in Ontario	28	760 jr kindergarteners-3rd graders; from economically disadvantaged communities in Ontario, Canada in the Better Beginnings, Better Futures project.			cohort (longitudinal)			X	X	
8	Flaherman & Rutherford 2006	A meta-analysis of the effect of high weight on asthma	31	Children	X		cohort studies (12)	X			X	

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**			**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
9	Forshee et al. 2004	The role of beverage consumption, physical activity, sedentary behavior, and demographics on body mass index of adolescents	32	2,216 12-16 y/o sampled in the 1988-1994 NHANES			cross sectional					
10	Freedman et al. 2005	The relation of childhood BMI to adult adiposity: the Bogalusa Heart Study	34	2,610 2-17 y/o (baseline); f/up age 18-37 y/o from Bogalusa Heart Study (1973-1996)			cohort (longitudinal)			X		X
11	Garces et al. 2007	Dehydroepiandrosterone sulfate and high-density lipoprotein-cholesterol levels in overweight children.	36	684 6-8 y/o (350 M, 334 F) categorized by overwt			cross sectional					
12	Garnett et al. 2007	Body mass index and waist circumference in midchildhood and adverse cardiovascular disease risk clustering in adolescence	37	342 8 y/o at baseline. 290 15 y/o at f/up.			cohort (longitudinal)	X			X	
13	Huang et al. 2004	Energy intake and meal portions: associations with BMI percentile in U.S. children	44	Overall sample: 1,077 3-5 y/o, 537 6-11 y/o, 381 12-19 y/o (1,005 M, 990 F) from USDA CSFII 1994-96 and 1998; Sample w/plausible reported energy intake =45.3%			cross sectional					
14	Koenigsberg et al. 2006	Association of age and sex with cardiovascular risk factors and insulin sensitivity in overweight children and adolescents	47	497 overwt 2-18 y/o (268 were 11 y/o and older)			cross sectional					
15	Li & Wang 2008	Tracking of dietary intake patterns is associated with baseline characteristics of urban low-income African-American adolescents	53	181 low-income African-American adolescents			cohort (longitudinal)	X	X		X	

#	Citation			Population Studied	Study Design			Tracking				
	Author	Title	Article ID		Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
16	Morrison et al. 2008	Metabolic syndrome in childhood predicts adult metabolic syndrome and type 2 diabetes mellitus 25 to 30 years later	63	5-19 y/o NHLBI Lipid Research Clinics and 30-48 y/o in Princeton Prevalence Study (1973-1976) and the Princeton Follow-up Study (2000-2004)			cohort (prospective)			X		X
17	Morrison et al. 2005	Development of the Metabolic Syndrome in Black and White Adolescent Girls: A Longitudinal Assessment	64	Black and white girls 9-10 y/o and 18-19 y/o from 2 centers in NHLBI Growth and Health Study			cohort (longitudinal)			X	X	
18	Must et al. 2005	Childhood overweight and maturational timing in the development of adult overweight and fatness: the Newton Girls Study and its follow-up	65	307 women w/ child wt data out of 448 in the 30 yr f/up to the Newton Girls Study (mean age 42.1 y/o, SD 0.76)			cohort (prospective)			X		X
19	Nader et al. 2006	Identifying risk for obesity in early childhood [erratum in Pediatrics 2006 Nov;118(5):2270]	66	1,042 healthy US children from 10 locations born in 1991 from NICHD Study of Early Child Care and Youth Development			cohort (longitudinal)			X	X	
20	Niemeier et al. 2006	Fast Food Consumption and Breakfast Skipping: Predictors of Weight Gain from Adolescence to Adulthood in a Nationally Representative Sample	67	9,919 adolescents in waves II (11–21 y/o) and III (18–27 y/o) of the National Longitudinal Study of Adolescent Health			cohort (prospective)	X				X
21	Rodearmel et al. 2007	Small changes in dietary sugar and physical activity as an approach to preventing excessive weight gain: the America on the Move family study	77	192 families w/at least one 7-14 y/o overwt or at risk for overwt child		RCT						

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**	**Article ID**		**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
22	Roseman et al. 2007	Examination of Weight Status and Dietary Behaviors of Middle School Students in Kentucky	78	4,049 middle school students in central Kentucky			cross sectional					
23	Rzehak & Heinrich 2006	Development of relative weight, overweight and obesity from childhood to young adulthood. A longitudinal analysis of individual change of height and weight	80	2,183 5-25 y/o (5-13 y/o at baseline); 12 yrs of f/up using surveys in 1992-93, 1995-96, 1998-99 and 2004-05 in 3 areas of Germany			cohort (longitudinal)			X	X	X
24	Stallmann-Jorgensen et al. 2007	General and visceral adiposity in black and white adolescents and their relation with reported physical activity and diet	88	661 healthy black and white 14-18 y/o			cross sectional					
25	Thompson et al. 2007	Childhood overweight and cardiovascular disease risk factors: the National Heart, Lung, and Blood Institute Growth and Health Study	95	1,166 Caucasian and 1,213 African-American girls ages 9-23 y/o in NHLBI Growth and Health Study.			cohort (longitudinal)			X	X	X
26	Viikari et al. 2004	Risk factors for coronary heart disease in children and young adults	100	2 ongoing studies in Finland: 1) 3,596 3-18 y/o and f/up in 2,264 24-39 y/o in Cardiovascular Risk in Young Finns study, 2) 1,062 7 mo old - 7 y/o in Special Turku Coronary Risk Factor Intervention Project for Children (STRIP)		RCT (STRIP)	cohort (longitudinal)	X		X		X
27	Woo et al. 2004	Effects of Diet and Exercise on Obesity-Related Vascular Dysfunction in Children	104	82 overwt 9-12 y/o (BMI = 25±3)		Controlled Trials (2 intervention groups)						

SECTION 3: FATS

Total number of studies:	**17**
Cross-sectional:	**3**
Cohort:	**4 (2 longitudinal, 1 retrospective, 1 prospective)**
Case-control:	**5**
Controlled trials:	**5 (3 randomized, 1 random crossover, 1 randomized prospective intervention)**

Health-related outcomes addressed: serum cholesterol and fatty acids; weight (BMI and percentage body fat gain); asthma; cancer (breast and testicular); insulin sensitivity; Crohn's disease; arterial stiffness; exercise induced growth hormone.

Behaviors addressed: meat, fish, poultry consumption; low fat diet

Overview of Recently Published Evidence

Of the 17 studies on dietary fat, five focused on serum cholesterol and fatty acids, three focused on weight (BMI and percentage body fat gain), two focused on asthma, two focused on cancer, two focused on insulin sensitivity, and single articles focused on each of the following: Crohn's disease, arterial stiffness, and exercise induced growth hormone. Mixed results were reported for the relationship between a low saturated fat/low cholesterol diet and lowered serum cholesterol; one 14-year study and one seven-year study showed a beneficial effect for boys only, but another 3-month study showed none. One study showed partial tracking with age for serum DHA:alpha-linolenic acid but not for other fatty acids. Mixed results were reported on relationships between dietary fat intake and BMI and percent body fat gain, with two of three studies showing a positive association between dietary fat intake and BMI and percent body fat gain. Mixed results were reported on the relationship between asthma and fatty acid intake, such that omega-3 and omega-6 fatty acids were shown to have both detrimental and protective effects on the risk of asthma. Mixed results were reported for the risk of cancer and dietary fat intake, noting that studies used different methodologies and studied different fat sources. Findings were mixed on the relationship between fat intake levels and insulin sensitivity, yet studies were conducted for separate study populations (i.e., obese vs. lean, white vs. black ethnicity). Single studies showed detrimental effects of high fat intake on the risk of Crohn's disease, arterial stiffness, and lower increases in exercise induced growth hormone levels.

Summary of Studies

Serum cholesterol and fatty acids

a. Crowe et al. (2006) reported that serum fatty acids predict serum cholesterol concentrations in New Zealand teens.[8] A 1-SD increase in myristic acid (a saturated fatty acid) in serum cholesterol ester, phospholipids, and triacylglycerol corresponded with increases in serum cholesterol (0.19, 0.13, 0.10 mmol/L, respectively). A 1-SD increase in the proportion of linoleic acid (omega-6) corresponded with decreases in serum cholesterol (0.07, 0.07, 0.05 mmol/L, respectively).

   <u>Methods</u>: Cross-sectional, 2,793 adolescents age 15 years and older, 24-hour dietary recall, blood sample from fasting and postprandial states, beta coefficients in adjusted multiple regression analyses.

b. Guerra et al. (2007) observed no tracking over three years for SFA, MUFA or PUFA in preschoolers. Partial tracking was found for DHA:alpha-linolenic acid ratio (r=0.33). Dietary PUFA and plasma PUFA were correlated at age 24 months; there were no other dietary/plasma correlations for PUFA, SFA, and MUFA. Plasma phospholipid fatty acid compositions differed by age; MUFA was lower at age 5 years than age 2 years (mean percentage 11.1 and 13.6 respectively, $p<0.05$) as was SFA (48.5 and 50.2, $P<0.05$). Plasma PUFA levels were higher at age 5 years (39.9 and 35.6, $P<0.05$).

   <u>Methods</u>: Longitudinal cohort, 26 children ages 2 to 5 years, 24-hour dietary recall and blood sample at 24, 36 and 60 months, age specific fatty acid level *z*-scores, mean level differences between time points tested by ANOVA.

c. Niinikoski et al. (2007) reported that a low saturated fat and low cholesterol dietary intervention lowered serum total and LDL cholesterol values and saturated fat intakes more in the intervention group than in the control group ($P<0.001$). Only boys' serum triglyceride values were lowered by the intervention ($P<0.001$). There was no difference in HDL cholesterol between the groups. In the intervention group, boys had lower serum total and LDL cholesterol values ($P<0.001$) and higher ratios of HDL:total cholesterol ($P<0.001$) than girls throughout the intervention, adjusted for energy and % energy from saturated fat intake, height, and BMI.

   <u>Methods</u>: Randomized prospective intervention on Finnish ages 7 months to 14 years, 540 had individualized counseling to control heart disease risk factors and 522 were controls. Parents were counseled in 1 to 3 month intervals until children were 2 years old, then twice/year until 7 years old. Children and parents received counseling once/year between ages 7 and 14 years. Annual 4-day food records after 2 years old, before that was 3-day food records. Blood samples at 7 months, 13 months, 2 years, then annually. Cholesterol oxidase-p-

[8] Although Crowe et al. link serum fatty acid and cholesterol values, as opposed to relating a dietary behavior to serum cholesterol values, we found the study to be relevant and retained it for the literature review.

aminophenazone method (CHOD-PAP) to measure serum cholesterol enzymatically. Multivariate repeated measures ANCOVA.

d. Snetselaar et al. (2004) reported that in two low saturated fat diet intervention groups, there were no significant differences in reductions in serum total, HDL, or LDL cholesterol after 3 months. Both intervention groups reduced fat intake (<30% for total, <10% for saturated). The lean beef group did consume more lean beef (median 26 g, $P<0.01$) and lean poultry/fish group did consume more lean poultry and fish (<10 g, *P* value not reported).

   Methods: RCT of 86 7th and 8th graders asked to comply with a diet of $\leq$ 20 g/d saturated fat and consume either lean beef or lean poultry/fish 5 times/wk minimum and the comparison meat no more than twice/wk. (3 servings were provided a week of intervention meat to improve adherence, and participant kept tallies of eating occasions to monitor compliance). One 24-hr dietary recall at baseline and month 3 visit and two telephone recalls within 2 weeks. Fasting blood sample for lipids, CHOD-PAP method to measure total and HDL cholesterol, triglycerides measured with enzymatic analysis. Linear mixed model analysis for repeated measures to compare dietary, clinical and serum measures.

e. Viikari et al. (2004) provided high-level summaries of two studies, a longitudinal cohort study and a RCT. For the RCT, intervention families received regular individualized counseling sessions with a nutritionist, who recommended reduced saturated fat and cholesterol intake and reduced saturated/unsaturated fat ratio for the child. They found that saturated fat and cholesterol intakes were consistently lower and unsaturated fat intakes were consistently higher in intervention children. Intervention boys had lower LDL and triglyceride levels and higher HDL levels than did control boys, but the group differences for girls were not significant.

   Methods: RCT; 331 intervention group and 335 control group, 7 month-old babies in the Special Torku Coronary Risk Factor Intervention for Children available for follow-up at age 7 years; regular assessments for both groups included food records covering 3-4 consecutive days and blood tests for HDL, LDL, and triglycerides.

Weight

a. Alexy et al. (2004) reported that mean standard deviation scores of BMI measured from childhood to adolescence were highest for children in a cluster with the lowest percentage of energy intake from fat (low fat cluster=0.26 versus -0.30 in the constant fat cluster, 0.11 medium fat, 0.06 high fat, $P<0.05$). BMI differences between child clusters with different percentages of energy from fat were not found between the first and last subject examinations.

   Methods: Longitudinal cohort, 228 German boys and girls ages 2 to 18 years, 10 yearly 3-day weighed dietary records and measured height and weight. Children were clustered by fat intake as a percent of energy to adjust for age - constant fat intake cluster had the least within individual change, medium fat intake cluster had more within individual variation than the constant group, low fat cluster contained mostly individuals with fat intake less than the first quartile, and high fat cluster had most individuals with fat intake above the third quartile. Dietary and anthropometric variables adjusted for age; group differences were tested using non-parametric Kruskal-Wallis one-way ANOVA (continuous variables) and χ^2 tests (categorical variables).

b. Sarnblad et al. (2006) found that in diabetic and healthy girls, high dietary fat intake adjusted for total energy intake similarly predicted percent body fat gain in both groups. High physical activity (PA) levels predicted lean body mass gain but not body fat gain in both groups. Diabetic girls treated with 6 daily insulin dosages had significantly more body fat increase in 1 year than girls with 4 doses (3.6 $\pm$ 2.1% vs. 0.8 $\pm$ 2.6 body fat units).

Methods: Case-control, ages 12 to 19 years, 23 cases and 19 controls, structured 7-day food diary, body composition using DEXA at baseline and 1 year follow up, total PA measured by accelerometry, associations between body composition changes and energy adjusted fat intake in cases and controls using ANCOVA.

c. Skinner et al. (2004) found mean longitudinal dietary fat intake as a percentage of energy was positively related to BMI at age 8 years (R^2= 0.42, p<0.01), as was mean longitudinal dietary fat intake in grams (R^2= 0.43, p<0.01).

Methods: Longitudinal cohort of 70 children ages 2 to 8 years, 15 to 17 sets of growth and dietary data from ages 2 months to 8 years; beginning with the third year mothers provided 2 nonconsecutive food records and one 24-hour dietary recall (averaged) and 11 measures of height and weight. Adiposity rebound determined visually and by consensus. Group means and SDs for energy and macronutrient intakes, and GLM repeated ANOVA to measure mean changes. The R-Square SAS procedure was used to test significance of other independent variables in the full model predicting BMI at age 8 years. Stepwise regression models included predictive variables, such as BMI at age 2 years, adiposity rebound age, and a selected dietary factor.

Asthma

a. Bolte et al. (2006) reported that in the 4th quartile of fatty acid concentration compared to the first quartile, linolenic acid (n-3) levels were positively associated with asthma (OR = 3.35, 95% CI 1.29-8.66), and linoleic acid (n-6) levels were negatively associated with asthma (0.34, 0.14-0.87). Strong positive association between arachidonic acid (n-6 PUFA) and asthma (4.54, 1.77 – 11.62).

Methods: Nested case-control, Germans ages 8 and 11 years, 185 cases and 341 controls, total serum IgE measurement, physician diagnosed asthma and bronchial hyper-responsiveness, ORs and 95% CIs to measure association between quartiles of fatty acid concentration and respiratory outcomes; fatty acid concentration first quartile median was reference in logistic and linear regression models.

b. Oddy et al. (2004) reported a positive association between higher intake quartiles of n-6:n-3 fatty acid ratios and increased risk of asthma (OR=3.36, 95% CI 1.52 – 7.44 *P*=0.003; 2.66, 1.15-6.15 *P*=0.022; 2.37, 0.97 – 5.80 *P*=0.059, 2nd, 3rd, and 4th quartiles respectively; 2.89, 1.44 – 5.80 *P*=0.003 when comparing the combined top three quartiles to the lowest).

Methods: Nested case-control, Australians ages 6 and 8 years, 166 cases and 169 controls, parent questionnaire on 8-year-old respiratory health and diet (semi validated adult FFQ), PUFA intake calculated as g/d using four nutrient databases, logistical regression models on risk of current asthma (OR and 95% CI) with variables on nutrients, fatty acid intake quartiles, BMI, and other covariates.

Cancer

a. Frazier et al. (2004) reported that higher adolescent vegetable fat intake was negatively associated with breast cancer (RR=0.58, 95% CI 0.38-0.86 *P*-trend=0.005, comparing 5th and 1st quintiles), as was higher vitamin E (0.61, 0.42-0.89 *P*-trend=0.003). When vegetable fat and vitamin E were in the model together, only vitamin E retained significance.

Methods: Retrospective cohort, 361 of 47,355 original adolescent participants, 131 item FFQ on high school diet (Nurses Health Study II), breast cancer incidence from medical record review, used quintiles of nutrient intake, χ^2 and t-tests used for risk factor differences between cases and non-cases, Cox proportional hazards regression used to estimate RR and 95% confidence intervals for incident cases of breast cancer during the 10-year period following high school.

b. Stang et al. (2006) found increases in RR of seminoma for each additional 200 g of milk fat consumed in adolescence (RR 1.3, 95% CI 1.15-1.48). Associations between milk fat consumption at age 17 years and testicular cancer was stronger among the age group 15 to 34 years than the age group 35 to 64 years. (And risk was greater for 200g/monthof adolescent galactose consumption, RR 2.01, 95% CI, 1.41-2.86.) Only a slight association existed between meat fat consumption and seminoma risk (RR 1.12, 95% CI, 1.00-1.25).

Methods: Case-control, ages 15 to 69 years, 269 cases and 797 controls, index persons completed a FFQ representing the year before the interview along with a subset of questions rating items including milk products, apples, oranges, salad and meats as “more” “less” and “about the same” when they were age 17 years; used categorical shifts in responses (i.e., next highest frequency category) and Spearman correlation coefficients to assess changes in consumption. FFQ mailed to mothers of 168 cases and 313 controls, and RR estimates for adolescent consumption based on maternal FFQs. Conditional logistic regression used to estimate the relative risk (RR) of testicular cancer, controlled for social status and height.

Insulin Sensitivity

a. Sunehang et al. (2005) reported obese adolescents on a low fat/high carbo diet were unable to increase insulin sensitivity and increased insulin secretion, whereas lean subjects increased insulin sensitivity and did not increase insulin secretion (P=0.05). Neither obese nor lean group glucose effectiveness was affected by diet. Neither obese nor lean group glucose production rates (sum of gluconeogenesis and glycogenolysis) was affected by diet when normalized to lean body weight, but in obese subjects on a high fat/low carbo diet, gluconeogenesis was higher by 32% and glycogenolysis was lower (P<0.001 for both). Visceral fat was inversely correlated with insulin sensitivity in low and high carbo groups (r=-0.57, P=0.007; r=-0.52, P=0.015, respectively), independent of percent body fat.

   Methods: Random crossover study on 13 healthy obese adolescents ages 13 to 17 years, compared to lean adolescents studied previously with identical methods, 7-day diet (% carbo to % fat ratio either 30:55 or 60:25, and all diets 15% protein and equal calories). Meals pre-portioned, sent home, and non-eaten portions returned and measured. 3-day metabolic study in 24 hour calorimeter with same intervention diet, blood samples to measure insulin sensitivity and glucose and lipid metabolism, MRI measured visceral fat. One-way ANOVA to measure obese and lean group differences, regression analysis for relationship between insulin sensitivity and visceral fat.

b. Weigensberg et al. (2005) reported that black children with fat intakes above the AMDR had 32% lower insulin sensitivity (P<0.05) and 62% higher acute insulin response to glucose (P<0.001) compared to black children within the fat intake AMDR. In white children, fat intakes higher than the AMDR did not affect insulin sensitivity and acute insulin response to glucose, compared to white children within the AMDR for fat intake.

   Methods: Cross-sectional, 142 children ages 6 to 14 years, average intake using three 24-hour dietary recalls, body composition measured by DXA, visceral fat measured by computerized tomography, and insulin sensitivity and acute insulin response to glucose measured by fasting blood samples at baseline and frequently sampled intravenous glucose tolerance tests. 2x2 ANOVA adjusted for total body fat, gender, and Tanner stages. Within AMDR for fat = 25-35% of daily calories.

Crohn's disease

a. Amre et al. (2007) showed consuming more omega-3 fatty acids and higher ratios of long chain omega-3:arachidonic acid was associated with lower risks of Crohn's disease (OR=0.44, 95% CI 0.19-1.0 P=0.03; 0.32, 0.14-0.71 P=0.02, respectively). Fruits, vegetables, fish, and fiber had protective effects, and nuts, dairy, energy, carbohydrates, vitamins, and minerals were also studied.

Methods: Case-control, children and adults less than 20 years of age, 130 clinically diagnosed patients, 202 controls (population or orthopedic hospital), self-administered Youth Adolescent 151-item FFQ on past 12 months (administered to case subjects shortly after diagnosis), compared the highest to the lowest levels (tertiles or quartiles) of food consumption, multivariate analysis using conditional logistic regression analysis.

Arterial Stiffness

a. Schack-Nielsen et al. (2005) reported arterial stiffness was positively associated with % energy from fat (regression coefficient in cm/s =3.1, 95% CI 0.9- 5.2 aorto-radial segment, and 1.8, 95% CI 0.2-3.2 aorto-femoral segment). Arterial stiffness in the aorto-femoral segment only was positively associated with breastfeeding duration, and arterial stiffness in both aorto segments was inversely associated with physical activity.

   Methods: Cross-sectional, 136 (of 143) Danish 10-year-olds followed up from birth, 7-day food record by participants and parents and parent-completed questionnaire, Danish 24-hour recall of physical activity, arterial stiffness determined by pulse wave velocity, multiple linear regression to determine arterial stiffness, adjustments for gender, height, weight, percent body fat, blood pressure, infant characteristics, and dietary factors.

Exercise Induced Growth Hormone

a. Galassetti et al. (2006) found exercise induced growth hormone increased less after a high fat meal than after a placebo meal (6.7 +-1.6 ng/l, 11.8 +- 2.4 ng/l, respectively).

   Methods: RCT, 12 healthy and physically active children ages 11 to 15 years, children given moderate exercise protocol 45 minutes after ingesting a high-fat shake or non-caloric placebo, fasting and resting blood sample and samples immediately before, immediately after, and 30 and 60 minutes post exercise, two way ANOVA.

FATS

#	Citation: Author	Citation: Title	Article ID	Population Studied	Study Design: Systematic Review or Meta-Analysis	Study Design: Controlled Trials	Study Design: Observational (cohort, case control, cross sectional)	Tracking: Behavior effect on biologic/ health outcome	Tracking: Behavior effect on behavior	Tracking: Biologic/ health status on biologic/ health outcome	Tracking: Early to later childhood	Tracking: Childhood to adulthood
1	Alexy et al. 2004	Pattern of long-term fat intake and BMI during childhood and adolescence--results of the DONALD Study	3	228 2-18 y/o in the Dortmund Nutritional Anthropometric Longitudinally Designed Study			cohort (longitudinal)	X			X	
2	Amre et al. 2007	Imbalances in dietary consumption of fatty acids, vegetables, and fruits are associated with risk for Crohn's disease in children	4	130 children <=20 y/o (mean age 14 y/o; 59% male) newly diagnosed w/ Crohns disease recruited from 3 pediatric gastroenterology clinics in Canada; 202 control cases in population or hospital matched for time of diagnosis (+/-6 months) and area of residence			case control					
3	Bolte et al. 2006	Fatty acids in serum cholesteryl esters in relation to asthma and lung function in children	12	8-11 y/o (242 girls and 284 boys) in Munich, Germany.			nested case control					
4	Crowe et al. 2006	Serum fatty acids as biomarkers of fat intake predict serum cholesterol concentrations in a population-based survey of New Zealand adolescents and adults	19	2,793 teens >=15 y/o in the 1997 National Nutrition Survey, New Zealand			cross sectional					
5	Frazier et al. 2004	Adolescent diet and risk of breast cancer	33	47,355 participants in the Nurses Health Study II			cohort (retro-spective)	X				X
6	Galassetti et al. 2006	Effect of a high-fat meal on the growth hormone response to exercise in children	35	Twelve 11-15 y/o (6 M, 6 F)		controlled trial						

#	Citation: Author	Citation: Title	Article ID	Population Studied	Study Design: Systematic Review or Meta-Analysis	Study Design: Controlled Trials	Study Design: Observational (cohort, case control, cross sectional)	Tracking: Behavior effect on biologic/ health outcome	Tracking: Behavior effect on behavior	Tracking: Biologic/ health status on biologic/ health outcome	Tracking: Early to later childhood	Tracking: Childhood to adulthood
7	Guerra et al. 2007	Three-year tracking of fatty acid composition of plasma phospholipids in healthy children	39	26 children; enrolled at birth, tracked to 5 y/o			cohort (prospective)			X	X	
8	Niinikoski et al. 2007	Impact of repeated dietary counseling between infancy and 14 years of age on dietary intakes and serum lipids and lipoproteins: the STRIP study	68	Intervention group 7 mo old infants (n=540) and control children (n=522) from Special Turku Coronary Risk Factor Intervention Project (STRIP); 7 mo olds followed for 14 yrs		random-ized inter-vention		X			X	
9	Oddy et al. 2004	Ratio of omega-6 to omega-3 fatty acids and childhood asthma	73	335 6 and 8 y/o in the Western Australian Pregnancy Cohort Study (166 w/current asthma, 169 controls)			case-control in prospective cohort					
10	Sarnblad et al. 2006	Dietary fat intake predicts 1-year change in body fat in adolescent girls with type 1 diabetes	82	23 12-19 y/o girls w/ type 1 diabetes and 19 age-matched healthy control girls			case control					
11	Schack-Nielsen et al. 2005	Arterial stiffness in 10-year-old children: current and early determinants	83	93 infants w/ f/up at 10 y/o			cross sectional					
12	Skinner et al. 2004	Predictors of children's body mass index: a longitudinal study of diet and growth in children aged 2-8 y	84	70 white, middle/upper SES children (37 M, 33 F) participating in longitudinal study from 2-9 y/o			cohort (longitudinal)	X		X	X	
13	Snetselaar et al. 2004	Adolescents eating diets rich in either lean beef or lean poultry and fish reduced fat and saturated fat intake and those eating beef maintained serum ferritin status	86	86 7th and 8th graders		RCT						

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**			**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
14	Stang et al. 2006	Adolescent milk fat and galactose consumption and testicular germ cell cancer	89	Population based study of 269 cases and 797 controls (response rates 76% and 46%, respectively)			case control					
15	Sunehag et al. 2005	Effects of dietary macronutrient intake on insulin sensitivity and secretion and glucose and lipid metabolism in healthy, obese adolescents	91	13 healthy obese volunteers (6M, 7F, mean age 14.7 y/o; mean BMI of 34, mean body fat 42%) [results were compared w/ those of previously studied lean adolescents]		Random crossover study						
16	Viikari et al. 2004	Risk factors for coronary heart disease in children and young adults	100	2 ongoing studies in Finland: 1) 3,596 3-18 y/o and f/up in 2,264 24-39 y/o in Cardiovascular Risk in Young Finns study, 2) 1,062 7 mo old - 7 y/o in Special Turku Coronary Risk Factor Intervention Project for Children (STRIP)		RCT (STRIP)	cohort (longitudinal)	X		X		X
17	Weigensberg et al. 2005	Dietary fat intake and insulin resistance in black and white children	102	142 healthy children 6.5-14 y/o (81 whites, 61 blacks)			cross sectional					

SECTION 4: FRUITS AND VEGETABLES

Total number of studies:	**14**
Cross-sectional:	**9**
Cohort:	**4 (1 prospective, 3 longitudinal)**
Case-control:	**1**

Health-related outcomes addressed: Crohn's disease; respiratory health/asthma; weight; bone mineral content; blood pressure; dental health

Behaviors addressed: fruit consumption; fruit and vegetable consumption

Overview of Recently Published Evidence

The 14 studies differed greatly in the variables and outcomes examined. Fruit and/or vegetable intake tended to be weakly associated with a moderately favorable effect or had no effect on risk factors or health outcomes. Four studies reported on fruit and/or vegetable intake and weight; two studies found a positive relationship between higher fruit juice intake and BMI, and one found an inverse relationship between vegetable consumption and BMI.

Summary of Studies

Crohn's disease

a. Amre et al. (2007) compared the highest to the lowest levels (tertiles or quartiles) of consumption and found that higher amounts of vegetables and fruits significantly reduced the risk of Crohn's disease (OR 0.9 for vegetables, 0.49 for fruits, 0.12 for dietary fiber). Other food components also studied.

   Methods: Case-control, 130 patients, 202 controls (population or orthopedic hospital), self-administered food frequency questionnaire (administered to case subjects shortly after diagnosis), multivariate analysis using conditional logistic regression analysis.

Respiratory health

a. Burns et al. (2007) found lowest quintile of fruit intake (<0.25 servings/day) was associated with lower FEV_1 than was higher intake (adjusted difference – 1.3) among 12th grade students. Other measures of respiratory status were not significantly different. Intake of less than 0.25 servings of fruit/day was associated with increased odds of reported chronic bronchitic symptoms and asthma.

   Methods: Cross-sectional, 2,112 subjects, semiquantitative food frequency questionnaires, linear mixed models, adjustment for weight, gender, height,

height-gender interaction, age, race, ethnicity, overweight, smoking, household smokers.

b. Nja et al. (2005) found that fresh fruit or vegetable intake in infancy decreased the risk of asthma in children ages 6 to 16 years; risk appears not to differ for fruit or vegetable intakes at older ages (results not reported).

   Methods: Cross-sectional, 4,585 children, dietary questionnaires.

c. Okoko et al. (2007) found that daily versus once monthly intake of apple juice from concentrate or of bananas was negatively associated with "current wheeze" (OR of .53 and .66, respectively) but not significantly associated with "ever wheeze" or "ever asthma" among children ages 5 to 10 years. No significant associations were found for intakes of other fruits.

   Methods: Cross-sectional, 2,640 children, fruit frequency questionnaire covering the previous year, logistic regression analysis controlling for 20 confounders.

Weight

a. Cullen et al. (2004) found that vegetable consumption by African American girls ages 8 to 10 years was associated with lower BMI, but intake explained little of the variation. The study examined several other dietary variables.

   Methods: Cross-sectional, 114 girls, included dietary questionnaires and two 24-hour recalls; the authors raised questions about the reliability of the intake measures.

b. Melgar-Quinonez et al. (2004) reported that the mean percentage of energy contributed by juice was higher for children ages 3 to 5-years with BMI $\geq 85^{th}$ percentile than for children with lower BMI (7.8 ± 5.6 (SD) and 6.1 ± 5.3, respectively), but the highest tertile for percentage of energy from juice did not differ statistically for the two groups.

   Methods: Cross-sectional, 204 children, food frequency questionnaire completed by parents; logistic regression, adjusting for the age of the child.

c. Sanigorski et al. (2007) reported that children with >2 servings of 100% fruit juice/drinks 'yesterday' were more likely to be overweight/obese than children with no fruit juice/drinks yesterday (>2–3 servings OR=1.7, CI 1.2–2.2, >3–4 servings 1.7, 1.2–2.5, and >4 servings 2.1, 1.5–2.9). With regards to usual intake, children who drank 100% fruit juice/drinks twice or more per day were more likely to be overweight/obese compared with those who drank these fruit juice/drinks once or less per week (OR= 1.7, CI 1.2–2.4. There was no significant association between weight status and usual consumption of fruit, vegetables, packaged snacks, fast food, or sweetened drinks.

   Methods: Cross-sectional, 1,944 Australian children from kindergarten and primary schools, parent completed CATI with sociodemographics and assessment of child's usual and recent intake of fruits, fruit juices/drinks (i.e., 100% fruit juice or diluted juice), vegetables, packaged snacks, fast foods, and sweetened drinks, measured height and weight. Logistic regression with child weight status outcome (healthy and overweight/obese) intake comparisons, adjusted for age, gender and socioeconomic (SES) status. Overall sample had over-representation of lowest SES quartile.

d. te Velde et al. (2007) reported tracking coefficients of 0.33 for fruit intake and 0.27 for vegetable intake for males and females between the ages of 12 and 36 years. Fruit intake was not associated with BMI. BMI and the sum of skinfold thickness for women were significantly higher for women (but not for men) in the lowest quartiles of vegetable intake.

Methods: Longitudinal cohort, 168 subjects, relatively homogeneous Dutch population, detailed cross-check dietary history interview. Logistic, generalized estimating equations and time-lag and autoregression models.

Bone mineral content

a. For youth ages 16 to 18 years, Prynee et al. (2006) found significant positive associations of fruit intake and for combined fruit and vegetable intake with spine bone mineral content, bone mineral density, and size adjusted bone mineral content (girls only). Associations ranged from 1.3% to 8.8% change in the dependent variable with each 100% change in the independent variable.

Methods: Cross-sectional, 111 boys, 101 girls, 7-day prospective dietary records, dual-energy X-ray absorptiometry, backward stepwise regression analysis.

b. For girls ages 8 to 13 years consuming $\geq$3 servings of fruits and vegetables per day compared with girls consuming less, Tylavsky et al. (2004)[9] found 6% larger bone area of the whole body and 8.3% larger bone area of the wrist, lower urinary calcium, and lower serum parathyroid hormone (all statistically significant).

Methods: Cross-sectional, 56 females, dual-energy X-ray absorptiometry, 1-day food record.

c. Vatanparast et al. (2005) found that intake of vegetables and fruit was a significant independent predictor of total-body bone mineral content (TBBMC) for boys but not for girls.

Methods: Longitudinal cohort, 85 boys, 67 girls, 5 weekday 24-hr recalls, dual-energy X-ray absorptiometry, multilevel regression analysis of TBBMC aligned on biological maturity.

[9] Supported by LeBonheur Health Systems and Smith Kline Glaxo.

Blood pressure

a. Over an 8-year period, Moore et al. (2005) found the slope of systolic blood pressure per year (mm Hg change/yr) was 2.80±.17 (SE) for children ages 3 to 6 years at baseline consuming fewer than 4 servings of fruits and vegetables per day compared with 2.19±.29 (SE) for children consuming 4 or more servings ("high intake) of fruits and vegetables per day. The combined effect of high fruit and vegetable/high dairy product intake on both systolic and diastolic blood pressure was notably larger.

Methods: Prospective cohort, 95 children, data from Framingham Children's Study, sets of 3-day diet records collected over time (four sets in year 1, one or two sets in each subsequent year), results adjusted for child's baseline blood pressure, mean activity counts per hour, daily intakes of magnesium and sodium at 3 to 6 years of age, and servings of dairy.

Dental health

a. Dugmore and Rock (2004) reported behaviors and factors of 12-year-olds positively associated with tooth erosion prevalence in 14-year-olds. Factors and behaviors at 12 years old positively associated with 12-year-old tooth erosion was dental decay (OR=1.49, CI 1.15-1.90), drinking fruit juice at least 4 times per day (2.52, 1.69-3.75), and drinking any fizzy pop (OR=1.59, CI 1.18-2.13); the presence of calculus and eating fruits besides apples and citrus reduced the chances of dental erosion (*P*<0.001 for both).

Methods: Longitudinal cohort and cross-sectional analyses, 1,149 12-year-olds followed up at age 14 years, questionnaire completed by 12-year-olds on oral health, dietary habits, and history or gastric reflux and asthma, questionnaire completed by 14-year-olds on beverage consumption. Tooth erosion examined in 12- and 14-year-olds visually and using CPITN probe over tooth surface. Erosion assessed using 1993 Survey of Children's Dental Health and erosion index. Aetiological factors were recoded as binary and used in logistic regressions adjusted for all variables regardless of significance.

b. Sohn et al. (2006) found that children's fluid intake of primarily milk, juice, or water was not associated with increased caries, but carbonated soft drinks were. Consumption of fruit juice was not significantly associated with dental caries risk (OR 1.22, 95% CI, 0.94-1.59 for high juice consumption).

Methods: Cross-sectional analysis using data from NHANES 1988-94; dental examination and single 24-hr diet recall; 5,985 children ages 2 to 10 years. Cluster analysis was used to classify children by fluid consumption patterns (milks, juices, carbonated soft drinks, water, coffee and tea, and other (including soups and other homemade beverages). χ^2 tests of associations between consumption and dental caries. Logistic regression controlled for sociodemographic factors.

FRUITS AND VEGETABLES

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**			**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
1	Amre et al. 2007	Imbalances in dietary consumption of fatty acids, vegetables, and fruits are associated with risk for Crohn's disease in children	4	130 children <=20 y/o (mean age 14 y/o; 59% male) newly diagnosed w/ Crohns disease recruited from 3 pediatric gastroenterology clinics in Canada; 202 control cases in population or hospital matched for time of diagnosis (+/-6 months) and area of residence			case control					
2	Burns et al. 2007	Low dietary nutrient intakes and respiratory health in adolescents	15	2,112 12th-graders from 13 US and Canadian communities in 1998-99 school yr			cross sectional					
3	Cullen et al. 2004	Anthropometric, parental, and psychosocial correlates of dietary intake of African-American girls	20	114 8-10 y/o African-American girls			cross sectional					
4	Dugmore & Rock 2004	A multifactorial analysis of factors associated with dental erosion	26	1,149 12 y/o (out of 1,753 randomly sampled at baseline) w/usable data; f/up at 14 y/o			cohort (longitudinal)	X			X	
5	Melgar-Quinonez & Kaiser 2004	Relationship of child feeding practices to overweight in low-income Mexican- American preschool-aged children	60	204 low-income Mexican-American families from California w/at least 1 child 3-5 y/o			cross sectional					
6	Moore et al. 2005	Intake of fruits, vegetables, and dairy products in early childhood and subsequent blood pressure change	62	95 children in Framingham study enrolled when 3-6 y/o			cohort (prospective)	X			X	

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	Title			Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
7	Nja et al. 2005	Effects of early intake of fruit or vegetables in relation to later asthma and allergic sensitization in school-age children	69	502 Swedish primary school children selected from survey of 4,585 school children (6-16 y/o) reporting diagnosed asthma (n=166), wheeze in the last 12 mo (n=155) and no asthma/no wheeze (n=181). Children from urban Oslo (37%), the mountainous area of Hallingdal (42%), and the industrial, coastal area of Odda (21%)			cross sectional					
8	Okoko et al. 2007	Childhood asthma and fruit consumption	74	2,640 school children 5-10 y/o in UK			cross sectional					
9	Prynne et al. 2006	Fruit and vegetable intakes and bone mineral status: a cross sectional study in 5 age and sex cohorts	76	Adolescents 16-18 y/o; young women 23-37 y/o; older men and women 60-83 y/o			cross sectional					
10	Sanigorski et al. 2007	Association of key foods and beverages with obesity in Australian schoolchildren	81	Representative sample of 2,184 school children from Victoria, Australia			cross sectional					
11	Sohn et al. 2006	Carbonated soft drinks and dental caries in the primary dentition	87	2-10 y/o in NHANES III 1988-94			cross sectional					
12	te Velde et al. 2007	Tracking of fruit and vegetable consumption from adolescence into adulthood and its longitudinal association with overweight	94	168 12 y/o boys and girls tracked over 24 yrs			cohort (longitudinal)	X				X
13	Tylavsky et al. 2004	Fruit and vegetable intakes are an independent predictor of bone size in early pubertal children	96	56 prepubertal Tanner Stage 2 white females			cross sectional					

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**			**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
14	Vatanparast et al. 2005	Positive effects of vegetable and fruit consumption and calcium intake on bone mineral accrual in boys during growth from childhood to adolescence: the University of Saskatchewan Pediatric Bone Mineral Accrual Study	99	85 boys & 67 girls 8-20 y/o, Canadian			cohort (longitudinal)	X				X

SECTION 5: WHOLE GRAINS

Total number of studies: 2
Cross-sectional: 2

Health-related outcomes addressed: respiratory function and asthma; serum homocysteine; serum B vitamins (B-6, B-12, and folate)

Behaviors addressed: whole grain consumption; smoking

Overview of Recently Published Evidence

The two observational studies on whole grain consumption reported beneficial health effects of whole grains. One study found significantly lower serum homocysteine concentrations, and higher serum folate concentrations among American adolescents ages 15 to 20 years with greater intake of whole grains. The other study reported significantly lower asthma, wheeze, and bronchial hyperresponsiveness among Dutch children ages 8 to 13 years with a high intake of whole grains. Serum folate was also positively associated with intake of refined grains.

Summary of Studies

Serum homocysteine, serum B vitamins

a. Lutsey et al. (2006) conducted cross-sectional data analysis to determine the association between adolescent's food intake and serum levels of B vitamins to study the effects of folate fortification of grain products. Greater intakes of whole-grains were associated with lower serum homocysteine (a risk factor for CVD in adults), after adjustment for lifestyle factors, BMI, and other food groups (*P*-trend=0.002). Significantly lower serum homocysteine concentrations were also found for refined grain intake, but the relationship was weakened after adjusting for folate and vitamin B-12 concentrations. Whole grains were significantly related to serum folate and serum vitamin B-6 (both P for trend <0.001) and serum vitamin B-12 (*P*=0.001). Refined grains were significantly related to serum folate (*P*-trend=0.001) but not vitamins B-6 or B-12.

   Methods: Cross-sectional, 2,695 youth ages 15 to 20 years enrolled in Child and Adolescent Trial for Cardiovascular Health (CATCH), 149-item Youth/Adolescent FFQ, 149-item food frequency questionnaire previously validated with 2 FFQs and three 24-hr dietary recalls over a year's period; quintiles of food group intake for 10 food groups; non-fasting blood specimen, multiple regression analyses with adjustments for demographics, lifestyle factors, BMI, and serum B vitamins. Statistics are based on P for trend, no correlations between diet and serum nutrient levels are reported.

Asthma and respiratory health

a. Tabak et al. (2006) found that intake of whole grains (and fish) was inversely associated with current wheezing and asthma. Adjusted odds ratios for whole grains and bronchial hyperresponsiveness (BHR) were 0.46 (95% CI, 0.19-1.10) and for whole grains and atopic asthma with BHR 0.28 (95% CI, 0.08, 0.99). Intake of citrus fruits, vegetables, and dairy products were not related to asthma outcomes.

   Methods: Cross-sectional, parents completed a 178-item semi-quantitative food frequency questionnaire (validated for Dutch adults) for 598 Dutch children enrolled in the International Study on Allergy and Asthma in Childhood 2. Whole grains included wholemeal bread and unrefined grains. Questionnaire on asthma and related respiratory symptoms and treatment. Lung function tests measured forced expiratory volume and bronchial hyperresponsiveness. Skin prick tests for allergens. Odds ratios and logistic regression analysis to test association between diet and respiratory outcomes adjusted for demographics, energy intake, BMI, other risk factors including the presence of pets in the home, parents' asthma, and passive smoking.

WHOLE GRAINS

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	Title			Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
1	Lutsey et al. 2006	Serum homocysteine is related to food intake in adolescents: the Child and Adolescent Trial for Cardiovascular Health	54	2,695 adolescents 15-20 y/o (mean = 18 y/o) in the Child and Adolescent Trial for Cardiovascular Health study			cross sectional					
2	Tabak et al. 2006	Diet and asthma in Dutch school children (ISAAC-2)	92	598 Dutch children 8-13 y/o			cross sectional					

SECTION 6: DAIRY AND CALCIUM

Total number of studies:	**21**
Cross-sectional:	**8**
Cohort:	**7 (6 longitudinal, 1 retrospective)**
Case-control:	**3**
Randomized controlled trials:	**2**
Review:	**1**

Health-related outcomes addressed: bone health (cortical bone mass accrual and measures of bone mineral status or fracture risk); weight (BMI, measures of adiposity); testicular cancer, cancer incidence and mortality serum values related to selected B vitamins; type 1 diabetes; dental caries.

Behaviors addressed: milk and dairy food consumption; beverage consumption

Overview of Recently Published Evidence

Of the 21 studies, seven focused on outcomes related to bone health, eight focused on weight-related outcomes, two focused on cancer, one related to selected serum values, one focused on hytpertension, one focused on type 1 diabetes, and one focused on dental caries. Most of the bone health studies showed a small benefit to one or more outcomes from a higher intake of milk products and/or calcium, but reported findings were mixed. Six of seven studies reported no effect or an inverse relationship between milk intake and BMI among children. The two cancer studies found increased risk with higher intakes of milk products. Single studies showed that milk product intake was associated with a benefit for blood pressure and serum homocysteine value and reduced risk of type 1 diabetes and dental caries.

Summary of Studies

Bone health

a. Lanou et al. (2005)[10] conducted Medline search for studies published on the relationship between milk, dairy products, or calcium intake and bone mineralization or risk of fracture for subjects ages 1 to 25 years. They report a positive relationship between dairy product consumption and measures of bone health in 1 of 4 cross-sectional studies, 0 of 3 retrospective studies, 0 of 1 prospective study, and 2 of 3 RCT. They report a positive relationship between calcium intake and measures of bone health in 4 of 13 cross-sectional studies, 2 of 4 retrospective studies, and 1 of 9 prospective studies. For the 10 controlled trials of calcium supplementation, 9 showed a positive relationship with BMD or BMC.

[10] Two authors from the Physicians Committee for Responsible Medicine.

Methods: Review, no tabular information presented, strength of evidence not presented in a formal manner, the authors excluded studies that did not control for body weight, pubertal status, and activity level.

b. Cheng et al. (2005) found that when compliance was $\geq$50%, calcium supplementation with cheese resulted in a higher percentage change in cortical thickness of the tibia than did placebo or supplemental calcium with or without vitamin D (using both efficacy and intention-to-treat analysis). No significant differences were found for other sites or for bone mineral content (BMC), but the efficacy analysis showed that calcium supplementation with cheese resulted in higher adjusted bone mineral density (BMD) than did placebo.

   Methods: RCT, girls ages 10 to 12 years, each of the five groups had approximately 40 subjects, 3-day food diaries, DEXA and peripheral quantitative computed tomography, Bonferroni's correction for multiple comparisons.

c. Fiorito et al. (2006) reported that higher calcium intakes at ages 7 and 9 years were significantly positively associated with total body BMC at age 11 years (r ranged from 0.17 to 0.24). Results were comparable for total calcium and calcium from dairy sources.

   Methods: Longitudinal cohort, 151 females, three 24-hr dietary recalls at ages 5, 7, 9, and 11 years, DEXA at ages 9 and 11, adjusted and unadjusted Spearman correlation coefficients.

d. Fisher et al. (2004)[11] reported that mean BMC (controlled for pubertal development and height at age 9 years) and mean BMD at age 9 years (controlled for pubertal development at age 9 years) were significantly higher for the girls who met the adequate intakes than for those who did not. No difference in BMI by calcium intake. After controlling for the stage of pubertal development at age 9 years, mean calcium intake from ages 5 to 9 years was significantly positively related to BMD at age 9 years (B = 0.27). Calcium intake tracked over time as follows: 5 to 7 years, r = 0.52; 7 to 9 years, r = 0.48; 5 to 9 years, r = 0.39.

   Methods: Longitudinal cohort, 192 females, three 24-hr dietary recalls at ages 5, 7, and 9 years, DEXA at ages 9, multiple logistical regressions.

e. Goulding et al. (2004) reported that children who avoided milk and who had limited intake of calcium-rich food substitutes experienced significantly more fractures than did birth cohort controls. (One in three study children had experienced fractures, 82% before age 7 years.)

   Methods: Cross-sectional, 50 children ages 3 to 13 years with low dietary calcium intakes, low *z* scores for BMC, and low volumetric BMD; short food

[11] Research partially supported by the National Dairy Council.

frequency questionnaire; dual-energy X-ray scans; fracture occurrence by interview.

f. Ma and Jones (2004) reported no significant differences were found between cases and controls when testing associations between total fractures and cola, noncola carbonated beverages, and milk drinks. Adjusted partial correlations showed cola consumption was not associated with bone mineral density or milk drinks, but both cola and carbonated drinks were associated with TV, computer and video watching (r=0.20, P<0.01 for both drinks). Dairy drinks were positively correlated with total body bone mineral density (r=0.15, P<0.05) and total body bone mineral adjusted density (r=0.19, P<0.01).

Methods: Case-control, 68 female cases and 138 male cases of Tasmanians ages 9 to 16 years with upper limb fractures, 206 controls randomly selected from same school class by gender. Untested FFQ on cola, non-cola carbonated drinks, and milk, measured height and weight, DXA to measure total body, lumbar spine, and right femoral neck bone mass (using measures of bone mineral content, density and apparent density), left hand metacarpal measurements, PA and sedentary activity assessed over past year using modified questionnaire validated in the US. Paired t-tests to measure case and control differences, z-scores for bone measures, partial correlations between milk, soft drinks, PA, and bone mineral density z-score, controlled for age, weight, gender, and case status. Univariate logistic regression on fracture for each drink variable, and significant variables entered into multivariate models adjusted for milk intake, TV watching, and bone mass.

g. Novotny et al. (2004b) found that dairy intake was the only dietary factor influencing the bone measurement calcaneal broadband ultrasound attenuation (BUA, partial r^2 was 1.538)), but dairy intake did not have a significant effect on the measurement of speed of sound. Other significant factors in the BUA model were weight, Tanner pubic hair stage, Asian ethnicity, and activity (MET-h/week).

Methods: Cross-sectional, 323 girls ages 9 to 14 years, 3-day diet records, bone status of the right calcaneus measured using the Lunar Achilles Ultrasonometer, multiple regression analysis used to identify factors influencing bone mass.

Weight, body fat mass

a. Barba et al. (2005) reported a significant inverse association (t = -2.964) of the frequency of milk consumption with age- and sex-specific BMI z-scores. Differences in the association were reported for whole and skim milk (significant and non-significant, respectively) when additional foods were included in the model.

Methods: Cross-sectional, 884 children ages 3 to 11 years, 1-year food frequency questionnaire, linear regression analysis, controlled for several variables including physical activity.

b. Berkey et al. (2005) found that over the 3 year study period, children who drank more than 3 servings of milk daily had small (*Beta* ~0.01 to 0.02, depending on the comparison) but significant gains in one-year BMI change compared with children who consumed less milk. This finding held even when 1% and skim milk were consumed. Over the entire 3 years, both boys and girls who consumed more than 3 servings of milk daily every year gained more in BMI (0.26 and 0.21, respectively) than did those who consumed 2 to 3 servings daily, but these results were not statistically significant.

Methods: Longitudinal cohort, 23,829 children ages 9 to 14 years at entry, food frequency questionnaires for intake over past year, (9166 provided food frequency questionnaires for all 4 years), adjusted for adolescent growth and development, race, physical activity, inactivity, and (in some models) total energy intake.

c. Dixon et al. (2005) examined relationships of calcium and dairy intake with measures of obesity in hypercholesterolemic (HC) and normocholesterolemic (non-HC) children. For non-HC children ages 7 to 10 years, they reported an inverse relationship between intake of both calcium and dairy foods and BMI, sum of skinfolds, and trunk skinfolds both at baseline and over 1 year. These associations were not observed in the non-HC children ages 4 to 6 years or in the HC children ages 4 to 10 years.

Methods: Cohort, 342 children (about 20 to 25% of whom were HC, depending on the measurement date), three 24-hour dietary recalls at baseline and at 3, 6, and 12 months, cross-sectional multivariate linear regression analysis, separate models run for HC and non-HC children; separate random effects mixed regression models for HC and non-HC children to evaluate association of year-long calcium intake with the obesity measures. Adjustments for age, sex, energy intake, and percentage of energy from fat.

d. Lappe et al. (2004) provided parents of 9 year-old female subjects with special credit cards to purchase calcium-rich foods, educated them on natural and fortified food sources of calcium, and advised them to consume at least 1,500 mg of calcium daily. Compared with controls, the subjects did not have greater increases in body weight, BMI, or fat or lean mass. (Mean calcium intakes were 1,656 mg for subjects and 961 mg for controls.) The results held when the data were grouped by tertile of calcium intake.

Methods: RCT, 50 girls, 3-day diet diaries once every 3 months for 2 years, DEXA used to estimate fat and lean mass.

e. Johnson et al. (2007) examined consumption of beverages at ages 5 and 7 years as predictors of fat mass at age 9 years, controlling for demographic and other dietary intake variables. Milk consumption at ages 5 and 7 predicted lower fat mass at age 9, but no effect was found for any of the remaining beverage categories, including sugar-sweetened beverages.

Methods: Longitudinal cohort; 1,432 British children from the Avon Longitudinal Study of Parents and Children, assessed at ages 5, 7, and 9 years; BMI and body fat mass (health examination); classification into normal weight or overweight based on IOTF age-and-sex specific BMI *z*-score cut-points; energy, macronutrient, and food servings (3-day food diary); beverages categorized into sugar-sweetened, low energy, fruit juice, milk, and water; family demographics (questionnaire completed by parent); linear regression.

f. LaRowe et al. (2007) reported on relationships of beverage patterns to diet quality (Healthy Eating Index (HEI)) and BMI among children ages 2 to 5 years and 6 to 11 years. For preschool children, mean BMI did not differ by beverage pattern (mix/light drinker, high-fat milk, water, and fruit juice). For school-aged children, BMI was significantly higher in the three beverage patterns with high amounts of water, sweetened drinks, or soda (adjusted mean BMIs = 19.9, 18.7, and 18.7, respectively) than in the patterns with high amounts of high-fat milk or light intake of many beverages (adjusted mean BMI = 18.2 and 17.8, respectively).

Methods: Cross-sectional, 541 preschool children, 793 school-aged children, single 24-hr diet recall, NHANES data, cluster analysis used to identify beverage patterns categorized into sugar-sweetened, soda, diet soda, high-fat milk, reduced-fat milk, coffee or tea, and water; age-and-sex adjusted BMI; *k*-means cluster analysis and general linear model. BMI relationship adjusted for age, sex, ethnicity, household income, HEI, physical activity, and birth weight. Tukey-Kramer option used to correct for multiple comparisons in general linear models.

g. Novotny et al. (2004a) reported that iliac skinfold thickness was negatively associated with total calcium intake and PA, positively associated with height and Tanner breast stage, and weakly associated with age and Pacific Islander status (P=0.001, R^2 = 0.17). Using dairy calcium intake instead of total calcium intake explained 16% of the variability in iliac skinfold thickness (P=0.001, R^2=0.16). One mg of total and dairy calcium was associated with a 0.0025 mm (P=0.01) and a 0.0026 mm (P=0.02) decrease in iliac skinfold thickness, respectively. Weight was positively associated with Pacific Islander status, height, Tanner breast stage, and energy and soda intake (P=0.001, R^2 =0.57). Nondairy calcium was not associated with weight or iliac skinfold thickness.

Methods: Cross-sectional, 323 Hawaiian girls with Asian or Caucasian ancestry ages 9 to 14 years, parent-assisted 3-day diet record including 2 weekdays and 1 weekend day, measured weight, height and skinfold thickness. Multiple regression analysis predicting weight and iliac skinfold thickness; predictors were age, ethnicity, height, Tanner breast stage, PA (hrs/wk), energy intake, soda intake, and calcium (including supplement) intake, and a calcium intake-Asian ancestry interaction.

h. O'Connor et al. (2006) found that weight status was unrelated to total beverages, milk (or percentage of fat in the milk), 100% fruit juice, sweetened fruit-flavored drinks, or soda among US preschoolers. Preschoolers consumed a mean of 26.9 oz/day of beverages (12.3 oz of milk, 4.7 oz of 100% fruit juice, 4.98 oz of fruit drinks, and 3.25 oz of soda). Daily energy intake increased as milk, 100% fruit juice, fruit drinks, and soda increased but was not statistically related to increase in BMI.

Methods: Cross-sectional study, NHANES 1999-2002, 1,160 preschoolers ages 2 to 5 years. Single 24-hr dietary recall. Measured BMI and BMI percentile based on CDC growth charts. Beverages were categorized as: 100% fruit juices, sodas, fruit-flavored drinks with added sugars, milks (and flavored milks as a separate category), and diet drinks – in categories or reported ounces consumed. χ^2 analysis to relate beverages to BMI. Analysis of covariance to test the association of beverage serving size to energy intake and BMI.

Cancer

a. Stang et al. (2006) found that higher milk intake at age 17 years was associated with elevated relative risk of testicular cancer (RR = 1.37 per additional twenty 200 mL servings of milk per month, CI 1.12-1.68), primarily because of an increased risk of one type of testicular cancer, seminoma (RR = 1.66). For each additional 200 g of milk fat consumed in adolescence, the relative risk of seminoma increased (RR 1.3, CI 1.15-1.48) and for each additional 200 g/monthof galactose the risk of seminoma was greater (2.01, 1.41-2.86). Adolescent intake of milk, low-fat milk, cream, and cheese reported by index persons were associated with increased risk of testicular cancer, as was their frequent consumption of eggs, milk, and low-fat milk reported by their mothers. Frequent yogurt and orange consumption reported by index persons was associated with decreased risk of testicular cancer.

   Methods: Case-control, ages 15 to 69 years, 269 cases and 797 controls, index persons completed a FFQ representing the year before the interview along with a subset of questions rating items including milk products, apples, oranges, salad and meats as "more", "less", and "about the same" when they were age 17 years; used categorical shifts in responses (i.e. next highest frequency category) and Spearman correlation coefficients to assess changes in consumption. FFQ mailed to mothers of 168 cases and 313 controls, and RR estimates for adolescent consumption based on maternal FFQs. Conditional logistic regression used to estimate the relative risk (RR) of testicular cancer, controlled for social status and height.

b. van der Pols et al. (2007) found that high intake of dairy foods during childhood was associated with increased odds of colorectal cancer (multivariate OR = 2.90, 2 sided *P*-trend=0.005 compared with low intake). Total median dairy intakes for the four groups analyzed were 89, 163, 255, and 471 g/d.

   Methods: Retrospective cohort, 4,374 traced subjects with full data, 7-day weighed household inventory obtained in 1937–1939, reanalysis of food records to include more nutrients and to update findings if foods likely not to have changed in composition over time, cancer deaths and registrations occurring up to July 31, 2005; logistic regression models (tested other regression models and found little difference in conclusions).

Blood pressure

a. Moore et al. (2006) found over an 8 year period the slope of systolic blood pressure per year (mm Hg change/yr) was 2.95±.19 (SE) for children consuming fewer than two servings of dairy per day compared with 2.13±.25 (SE) for children consuming more than two servings ("high intake") of dairy foods per day. The combined effect of high fruit and vegetable/high dairy product intake on both systolic and diastolic blood pressure was notably larger.

   Methods: Longitudinal cohort, 95 children ages 3 to 6 years at baseline, data from Framingham Children's Study, sets of 3-day diet records collected over time (four sets in year 1, one or two sets in each subsequent year), results adjusted for child's baseline blood pressure, mean activity counts per hour, daily intakes of magnesium and sodium at 3 to 6 years of age, and servings of fruits and vegetables.

Selected serum values

a. Lutsey et al. (2006) found that serum homocysteine concentrations were lower with greater intakes of dairy foods (*P*-trend < 0.001). (Greater intakes of whole grains and of refined grains also were associated with lower homocysteine concentrations.)

   Methods: Cross-sectional, 2695 youth ages 15 to 20 years enrolled in Child and Adolescent Trial for Cardiovascular Health, 149-item Youth/Adolescent FFQ, dairy group included dairy group included milk, cheese, yogurt, and ice cream products, dairy consumption analyzed in quintiles of intake with the lowest quintile as a reference category, non-fasting blood specimen, multiple regression analyses. Regression model adjustments for demographics, lifestyle factors, BMI, and serum B vitamins attenuation the relationship of homocysteine with most food groups.

Type 1 diabetes

a. Rosenbauer et al. (2007) investigated the association between risk of type 1 diabetes and a number of nutritional and environmental exposures. They reported that current cow's milk consumption of ≥200 ml/d was associated with a reduced diabetes risk. Adjusted OR based on multiple logistic regression appear to be non-significant.

   Methods: Case-control, 760 cases newly diagnosed with type 1 diabetes before the age of 5 years, 630 controls (acquaintances of case families). The only dietary information obtained for children, by questionnaire, was current level of customary milk intake.

Dental caries

a. Sohn et al. (2006) found that children's fluid intake of primarily milk, juice, or water was not associated with increased caries, but carbonated soft drinks were significantly related to caries. Consumption of milk was not significantly associated with dental caries risk (OR 0.98, 95% CI, 0.76-1.27 for high milk consumption).

   <u>Methods</u>: Cross-sectional analysis using data from NHANES 1988-94; dental examination and single 24-hr diet recall; 5,985 children ages 2 to 10 years. Cluster analysis was used to classify children by fluid consumption patterns (milks, juices, carbonated soft drinks, water, coffee and tea, and other (including soups and other homemade beverages). χ^2 tests of associations between consumption and dental caries. Logistic regression controlled for sociodemographic factors.

DAIRY AND CALCIUM

#	Citation			Population Studied	Study Design			Tracking				
	Author	Title	Article ID		Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
1	Barba et al. 2005	Inverse association between body mass and frequency of milk consumption in children	8	884 7 y/o not on dietary regimen selected out of 1,087 (M:F 451:433)			cross sectional					
2	Berkey et al. 2005	Milk, dairy fat, dietary calcium, and weight gain: a longitudinal study of adolescents	10	12,829 9-14 y/o US children			cohort (longitudinal)					
3	Cheng et al. 2005	Effects of calcium, dairy product, and vitamin D supplementation on bone mass accrual and body composition in 10-12-y-old girls: a 2-y randomized trial	16	195 10-12 y/o, Tanner stage I-II girls w/Ca intakes 50%		RCT						
4	Dixon et al. 2005	Calcium and dairy intake and measures of obesity in hyper- and normocholesterolemic children	24	342 non-obese hypercholesterolmic (HC) and non-hypercholesterolmic (non-HC) 4-10 y/o in NHLBI Children's Health project study			cohort (longitudinal)					
5	Fiorito et al. 2006	Girls' Calcium Intake Is Associated with Bone Mineral Content During Middle Childhood	29	151 non-Hispanic white girls			cohort (longitudinal)	X			X	
6	Fisher et al. 2004	Meeting calcium recommendations during middle childhood reflects mother-daughter beverage choices and predicts bone mineral status	30	192 5, 7, 9 y/o non-Hispanic white girls and mothers			cohort (longitudinal)	X			X	

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**			**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
7	Goulding et al. 2004	Children who avoid drinking cow's milk are at increased risk for prepubertal bone fractures	38	50 3-13 y/o (30 girls, 20 boys) who had avoided drinking cow's milk for prolonged periods, and 22/50 overwt; these 50 compared w/ a birth cohort of >1,000 children in same city.			cross sectional					
8	Johnson et al. 2007	Is sugar-sweetened bvg consumption associated with increased fatness in children?	45	subsample of British children from the Avon Longitudinal Study of Parents and Children; enrolled at 5 y/o (n = 521) and 7 y/o (n = 682) ; assessed at 9 y/o			cohort (longitudinal)	X			X	
9	Lanou et al. 2005	Calcium, dairy products, and bone health in children and young adults: a reevaluation of the evidence	49	1-25 y/o	X	RCT (13)	cross-sectional (22); retrospective (13), and longitudinal prospective studies (10)	X			X	X
10	Lappe et al. 2004	Girls on a high-calcium diet gain weight at the same rate as girls on a normal diet: a pilot study	50	59 9 y/o girls in metropolitan Omaha, NE communities		RCT		X			X	
11	LaRowe et al. 2007	Beverage patterns, diet quality, and body mass index of US preschool and school-aged children	51	541 Two-5 y/o and 793 six-11 y/o children from 2001-2002 NHANES			cross sectional					
12	Lutsey et al. 2006	Serum homocysteine is related to food intake in adolescents: the Child and Adolescent Trial for Cardiovascular Health	54	2,695 adolescents 15-20 y/o (mean = 18 y/o) in the Child and Adolescent Trial for Cardiovascular Health study			cross sectional					

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	Title			Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
13	Ma & Jones 2004	Soft drink and milk consumption, physical activity, bone mass, and upper limb fractures in children: a population-based case-control study	55	9-16 y/o from Tasmania, 206 case-control pairs			case control					
14	Moore et al. 2006	Low dairy intake in early childhood predicts excess body fat gain	61	99 of 106 families in Framingham Children's Study w/a 6 y/o at baseline, followed to 13 y/o			cohort (longitudinal)	X			X	
15	Novotny et al. 2004a	Dairy intake is associated with lower body fat and soda intake with greater weight in adolescent girls	70	323 9-14 year old Hawaiian girls with Asian or Caucasian ancestry			cross sectional					
16	Novotny et al. 2004b	Adolescent dairy consumption and physical activity associated with bone mass	71	323 girls examined at Kaiser Permanente, Oahu, Hawaii (Mean age =11.6 y/o; mean Asian=48%; White =43%; other=10%)			cross sectional					
17	O'Connor et al. 2006	Beverage intake among preschool children and its effect on weight status	72	1,160 2-5 y/o boys and girls from 1999-2002 NHANES; 24% were overwt or at risk of overwt			cross sectional					
18	Rosenbauer et al. 2007	Early nutrition and risk of Type 1 diabetes mellitus--a nationwide case-control study in preschool children	79	Newly diagnosed type 1 diabetes <5 y/o (760 cases); 630 age matched controls selected by case families' acquaintance; studied in 1992-1995			case control					
19	Sohn et al. 2006	Carbonated soft drinks and dental caries in the primary dentition	87	2-10 y/o in NHANES III 1988-94			cross sectional					
20	Stang et al. 2006	Adolescent milk fat and galactose consumption and testicular germ cell cancer	89	Population based study of 269 cases and 797 controls (response rates 76% and 46%, respectively)			case control					
21	van der Pols et al. 2007	Childhood dairy intake and adult cancer risk: 65-y follow-up of the Boyd Orr cohort	97	4,383 out of 4,999 children in England and Scotland in study of family fd consumption btw 1937-1939 (770 registered w/ cancer btw 1948-2005)			cohort (retro-spective)	X				X

SECTION 7: CARBOHYDRATES
SUBTOPIC #1: ADDED SUGARS AND SUGAR-SWEETENED BEVERAGES

Total number of studies:	**29**
Cross-sectional:	**13**
Cohort:	**10 (longitudinal)**
Case-control:	**1**
Controlled trial:	**2 (randomized)**
Review:	**2**
Meta-analysis:	**1**

Health-related outcomes addressed: weight and anthropometrics (body mass index (BMI), BMI percentile, BMI *z*-score); adiposity; adiposity rebound; insulin sensitivity; glucose metabolism (insulin sensitivity, insulin response, beta cell function, insulin level, plasma glucose, DHEA-S); type 2 diabetes; metabolic syndrome; oral health (dental caries); serum lipids; bone fractures

Behaviors addressed: beverage consumption (sugar-sweetened beverages, milks, 100% fruit juices, fruit-flavored drinks, diet soda, diet drinks); breakfast/cereal; dessert consumption; TV watching; snacking

Overview of Recently Published Evidence

Of the 29 studies, most included one or more biologic or health measures, and some also reported on beverage intakes as behavioral outcomes. The evidence includes one qualitative review and one meta-analysis of studies on the association between sugar-sweetened beverages or soft drinks and weight status, and one systematic review on sugar intake and caries and other oral health outcomes. Seventeen studies reported on weight or weight status (BMI, BMI *z*-score), six reported on oral health (dental caries), two reported on insulin sensitivity and glucose metabolism, one reported on serum lipids, and one reported on bone fractures. The preponderance of evidence from cross-sectional and longitudinal studies is that sugar-sweetened beverages and items with added sugar (such as candy) are associated with increased BMI and increased caries among children and adolescents. Findings from two studies of Latino children at high risk of diabetes (based on being overweight or having a family history of diabetes) found that total sugar intake was associated with a lower acute insulin response and decreased beta cell function. However, these studies also found that total sugar intake or total carbohydrate intake was not significantly associated with insulin sensitivity or insulin dynamics. In one cross-sectional study, overweight children were reported to have higher percent of added fructose from sweetened beverages and sweets than non-overweight children.

Summary of Studies

Weight (BMI, BMI z-score, BMI percentile), adiposity, and other anthropometric outcomes

a. Malik et al. (2006) reviewed 30 studies on intake of sugar-sweetened beverages (SSBs) and weight on children and adults published from 1966 to 2005. Of the 21 studies that included children or adolescents, 6 of 13 cross-sectional studies found a positive association between SSBs and weight gain and obesity, three suggested positive associations but the results were not statistically significant, three found no associations, and one had inconsistent findings (and adults). Four of 6 prospective studies of children found positive associations between intake of SSBs and greater overweight or obesity. A 3-y follow-up of more than 11,600 children found a 0.04 increase in BMI per daily serving of SSB ($P<0.01$). In one study, children who increased their soda consumption from the previous year by two or more servings gained weight (0.14 increase in boys, P=0.01 and 0.10 increase in girls, P=0.046). In one clustered RCT of 644 children over a school year there was a 0.7 mean greater consumption of soda (95% CI, 0.1, 1.3) and a 7,7% higher rate of overweight and obesity in control subjects. In the other RCT, decreasing SSB significantly reduced body weight in adolescents with BMI >30 (*see Ebbeling et al. summary).*

   <u>Methods</u>: Qualitative assessment (review) of results from 21 studies on children and adolescents (13 were cross-sectional, 6 were prospective, and 2 were RCT interventions) since a meta-analysis was not possible due to heterogeneity in design, ages of participants, length of duration, and outcome measures. Most studies measured BMI, BMI percentiles, and SSB or soda consumption, some also assessed consumption of other beverages (milk, juice, water).

b. Vartanian et al. (2007) conducted a meta-analysis to examine the effect of soft drink consumption on nutrition and health. They found that the overall effect size for the association between soft drink consumption and energy intake was r = .16, and the overall effect size for the association between soft drink consumption and body weight was r = .08. Soft drink consumption was also associated with lower nutrient intakes and increased diabetes risk. In general, effect sizes were smaller for associations that involved children and adolescents, larger for studies with stronger methods, and smaller for studies funded by the food industry, but the same patterns held.

   <u>Methods</u>: Review (meta-analysis); included both published and unpublished research; 88 studies met inclusion criteria—examined association of soft drink consumption with 4 primary outcomes (energy intake, milk intake, calcium intake, and body weight) and 2 secondary outcomes (nutrition and health); examined various potential moderators of effect size, including population studied (children and adolescents vs. adults), methodology, and food industry funding.

c. Andersen et al. (2005) found that student overweight was inversely associated with the consumption of sweets (candy and chocolate) (g/d, highest intake quartile had 48% lower odds of being overweight compared to lowest intake quartile, *P*-trend=0.02). No significant association was found between overweight and total energy intake.

Methods: Cross-sectional, 664 Norwegian 4th graders and 825 8th graders, self-reported weight and height measurements, 18-page pre-coded food diary of 4 consecutive days, parent-assisted questionnaire on highest parent education level and TV/computer time and participant frequency of vigorous PA and breakfast eating. Logistic regression between overweight and parent characteristics, student PA, and student dietary behaviors and quartiles of food and nutrient intake.

d. Ariza et al. (2004) found that overweight was predicted by only two of the many physical activity and eating pattern variables assessed, i.e., overweight children were more likely to watch TV more than 3 hours/day (48% vs. 22%, *P*=0.03) and to consume sweetened beverages on a daily basis (67% vs. 39%; *P*=0.03). When both variables were entered into the model together, only consumption of sweetened beverages on a daily basis remained (OR = 3.7).

Methods: Cross-sectional; 80 Hispanic kindergarten students in Chicago; BMI (health examination); child's physical activity and eating patterns (interview with mother); standard CDC classification based on BMI percentile by age and sex into normal weight (<95th percentile) and overweight (>= 95th percentile); *t* test and logistic regression.

e. Blum et al. (2005) reported that elementary school children who were overweight or normal weight at both baseline and follow-up increased diet soda consumption over the two years (overweight 2.3 oz/d $\pm$ 7.3, normal weight 1.1 oz/d $\pm$3.9) as did the all children as a whole (1.7 oz/d $\pm$ 5.3). Weight gainers increased diet soda consumption but not significantly (*P*=0.058), and weight losers did not significantly change diet soda consumption. All children decreased milk intake (-3.4 oz/d $\pm$ 14.1) and caloric intake (-126.3 kcal/d $\pm$ 710.8). Predictors of follow-up BMI *z*-score were baseline BMI and diet soda consumption at year 2 (R^2 = 0.83, *P*<0.001). Inverse correlations were found for changes in milk and sugar-sweetened beverage consumption in all children (oz/d Pearson r = -0.27, and r = -0.76, %, *P*<0.05 for both values).

Methods: Longitudinal cohort, convenience sample of 166 in children in the 3rd and 5th grades. 24-hour dietary recall at baseline and year 2 follow up, and each recall involved 2 interviews to cover different parts of the day. Measure weight and height. 4 groups were classified by BMI *z*-score at baseline and follow-up – normal, overweight, gained weight, and lost weight – and differences in BMI *z*-score for beverage and caloric intake were tested with repeated measures ANOVA. Regression analysis to determine predictors of BMI *z*-score at follow-up.

f. Davis et al. (2007) reported that total sugar intake (g/d) was positively correlated with with BMI, BMI z scores, and total fat mass (kg) (r = 0.20, *P*=0.034, r = 0.22, *P*=0.018, and r = 0.21 *P*=0.025, respectively) after covariate adjustments. Total sugar intake explained an additional 3.4%, 4.6%, and 2.4% of the variance in BMI, BMI z scores, and total fat mass, respectively. Dietary fiber, total carbohydrates, specific types of sugar intake, glycemic load, and glycemic index were not significantly correlated to adiposity variables, glucose values, or insulin dynamics regardless of covariate adjustments. (*See Davis et al. under insulin sensitivity below*).

Methods: Cross-sectional, 120 Latino children ages 10 to 17 years in the University of California SOLAR Diabetes Project cohort with BMIs ≥85th percentile and a family history of type 2 diabetes. 24-hour dietary recalls on 2 weekdays with the first in person and second by phone. Measured weight and height, fasting blood samples of glucose and insulin values to determine diabetic status, and non-diabetics given an insulin-modified frequently sampled intravenous-glucose-tolerance test to measure insulin sensitivity, acute insulin response, and disposition index (index of beta cell function), total body DXA to measure fat and lean body mass. Hierarchical multiple regression analyses tested dietary predictors on insulin sensitivity outcomes, with adjustments for age, sex, Tanner stage, fat mass, and total lean tissue.

g. DuBois et al. (2007) found that regular consumption of sugar-sweetened beverages at all ages was predicted by low parental education and income, but not parental age or overweight. In addition, being overweight at age 4-5 was predicted by regular consumption of sugar-sweetened beverages at all ages (OR = 2.1 to 2.4, adjusted for various combinations of demographic and dietary intake variables).

Methods: Longitudinal cohort; 1,944 children ages 4 to 5 years in the Longitudinal Study of Child Development in Quebec who participated in the baseline at age 2-3 years and both annual follow-ups; BMI (health examination); standard CDC classification based on BMI percentile by age and sex into normal weight (<95th percentile) and overweight (>=95th percentile); energy, macronutrient, and food servings (24-hour food recall; parental proxy); frequency of consumption of sugar-sweetened beverages, classified into regular consumers and non-consumers (FFQ; parent proxy); family demographics and parental overweight (questionnaire completed by parent); χ^2 and logistic regression.

h. Ebbeling et al. (2006) reported the difference in BMI change between intervention and control groups after a 25-week non-caloric beverage intervention was not significant. However, baseline BMI was a significant effect modifier, and intervention subjects in the upper baseline-BMI tertile (BMI>25.6 kg/m^2) decreased BMI whereas control group subjects increased BMI, with a net difference of –0.75 + 0.34 kg/m^2 (P=0.03). Energy intake from sugar-sweetened beverages decreased 82% in the intervention group (P<0.001), and there was no change in control group.

Methods: Randomized controlled intervention, 103 adolescents ages 13 to 18 years consuming at least one sugar-sweetened beverage per day. Intervention group received 25 weekly home deliveries of noncaloric beverages to displace sugar-sweetened beverages consumed by subjects and household members, and subjects were told not to buy or drink sugar sweetened beverages. Control group had usual beverage consumption. Two 24-hour dietary recalls at baseline and at the intervention end. Study designed to detect a BMI effect size of 0.57 kg/ m^2. Multiple linear regression predicted BMI, adjusting for age and gender and baseline BMI x subject group interaction.

i. Forshee et al. (2004) reported that consumption of regular carbonated soft drinks and fruit drink/ades were not significantly associated with BMI in any models. Consumption of diet carbonated soft drinks was positively associated with BMI in girls. Girls with average and low BMIs consumed very few diet carbonated soft drinks. BMI was negatively associated with participation in team sports or exercise programs for both males and females (P=0.04 and P=0.03, respectively) and not significantly associated with television viewing. BMI was positively associated with age (P=0.00) for males and females and was negatively associated with family income for females (P=0.00).

Methods: Cross-sectional, 2,216 children ages 12 to 16 years sampled in the 1988-1994 NHANES, 24-hour recalls, measured height and weight, and interview for other characteristics. Bivariate regressions between regular carbonated soft drinks and BMI, and multivariate regression models between BMI and variables for beverage consumption, non-beverage energy sources, PA and sedentary behavior, and demographics.

j. Johnson et al. (2007) examined beverage category consumption at ages 5 and 7 years as predictors of fat mass at age 9 years, controlling for demographic and other dietary intake variables. They found that milk consumption at ages 5 and 7 predicted lower fat mass at age 9, but found no effect for any of the remaining beverage categories. including sugar-sweetened beverages.

Methods: Longitudinal cohort; 1,432 British children from the Avon Longitudinal Study of Parents and Children, assessed at ages 5, 7, and 9 years; BMI and body fat mass (health examination); classification into normal weight or overweight based on IOTF age-and-sex specific BMI *z*-score cut-points; energy, macronutrient, and food servings (3-day food diary); beverages categorized into sugar-sweetened, low energy, fruit juice, milk, and water; family demographics (questionnaire completed by parent); linear regression.

k. LaRowe et al. (2007) reported on relationships of beverage patterns to diet quality (Healthy Eating Index (HEI)) and BMI among children ages 2 to 5 years and 6 to 11 years. For preschool children, mean BMI did not differ by beverage pattern (mix/light drinker, high-fat milk, water, and fruit juice). For school-aged children, BMI was significantly higher in the 3 beverage patterns with high amounts of water, sweetened drinks, or soda (adjusted mean BMIs = 19.9, 18.7, and 18.7, respectively) than in the patterns with high amounts of high-fat milk or light overall beverage intake (adjusted mean BMI = 18.2 and 17.8, respectively).

Methods: Cross-sectional, 541 preschool children, 793 school-aged children, single 24-hr diet recall, NHANES data, cluster analysis used to identify beverage patterns categorized into sugar-sweetened, soda, diet soda, high-fat milk, reduced-fat milk, coffee or tea, and water; age-and-sex adjusted BMI; *k*-means cluster analysis and general linear model. BMI relationship adjusted for age, sex, ethnicity, household income, HEI, physical activity, and birth weight.

Tukey-Kramer option used to correct for multiple comparisons in general linear models.

l. Novotny et al. (2004a) reported that weight was positively associated with Pacific Islander status, height, Tanner breast stage, and energy and soda intake (P=0.001, R^2 =0.57). Iliac skinfold thickness was negatively associated with total calcium intake and PA, positively associated with height and Tanner breast stage, weakly associated with age and Pacific Islander status, and was not associated with soda intake (P=0.001, R^2 = 0.17).

Methods: Cross-sectional, 323 Hawaiian girls with Asian or Caucasian ancestry ages 9 to 14 years, parent-assisted 3-day diet record including 2 weekdays and 1 weekend day, measured weight, height and skinfold thickness. Multiple regression analysis predicting weight and iliac skinfold thickness; predictors were age, ethnicity, height, Tanner breast stage, PA (hrs/wk), energy intake, soda intake, and calcium (including supplement) intake, and a calcium intake-Asian ancestry interaction.

m. O'Connor et al. (2006) found that weight status was unrelated to total beverages, milk (or percentage of fat in the milk), 100% fruit juice, sweetened fruit-flavored drinks, or soda among US preschoolers. Preschoolers consumed a mean of 26.9 oz/day of beverages (12.3 oz of milk, 4.7 oz of 100% fruit juice, 4.98 oz of fruit drinks, and 3.25 oz of soda). Soda was consumed by 29% of preschoolers. Daily energy intake increased as milk, 100% fruit juice, fruit drinks, and soda increased but was not statistically related to increase in BMI.

Methods: Cross-sectional study, NHANES 1999-2002, 1,160 preschoolers ages 2 to 5 years. Single 24-hr dietary recall. Measured BMI and BMI percentile based on CDC growth charts. Beverages were categorized as: 100% fruit juices, sodas, fruit-flavored drinks with added sugars, milks (and flavored milks as a separate category), and diet drinks – in categories or reported ounces consumed. χ^2 analysis to relate beverages to BMI. Analysis of covariance to test the association of beverage serving size to energy intake and BMI.

n. Rodearmel et al. (2007) found that both overweight intervention and control children had reductions in BMI *z*-scores. There were no differences between the groups with regard to those reductions, but intervention children were less likely to have experienced weight gains (33% vs. 47%, P<0.05). Also, intervention children, but not control children, increased physical activity, reported decreased calorie consumption, and reported eating fewer sugar-sweetened desserts and fewer sweetened foods other than dessert, and using less table sugar.

Methods: RCT; families with at least one child age 7 to 14 years who was overweight or at risk for overweight randomly assigned to America on the Move intervention (100 families; 116 children & 140 parents) or self-monitor only control (92 families; 102 children & 122 parents); intervention participants asked to maintain physical activity change (increase by 2000 steps/day) and dietary change (decrease by 100 kcal/day, with emphasis on reduction of sugar intake) for 6-month period; BMI (health examination); physical activity (pedometer); dietary assessment (intake of sugar-sweetened and noncalorically-sweetened foods and beverages); *t* test.

o. Sanigorski et al. (2007) reported that children with $\geq$3 soft drinks 'yesterday' were more likely to be overweight/obese (OR=2.2, CI 1.3 -3.9). There was no significant association between weight status and usual soft drink intake (or usual consumption of fruit, vegetables, packaged snacks or fast food), but children who drank 100% fruit juice/drinks twice or more per day were more likely to be overweight/obese compared with those who drank these fruit juice/drinks once or less per week (OR= 1.7, CI 1.2–2.4).

   Methods: Cross-sectional, 1,944 Australian children from kindergarten and primary schools, parent completed CATI with sociodemographics and assessment of child's usual and recent intake of fruits, vegetables, packaged snacks, fast foods, and sweetened drinks, measured height and weight. Logistic regression with child weight status outcome (healthy and overweight/obese) intake comparisons, adjusted for age, gender and socioeconomic (SES) status. Overall sample had over-representation of lowest SES quartile.

p. Striegel-Moore et al. (2006) found that milk consumption decreased and both regular and diet soda consumption increased over time, and that there were some differences between black and white girls with regard to changes in beverage consumption patterns over time. Across time, regular soda was the only beverage associated with BMI, and all beverages except diet soda were associated with increased intake of sugar.

   Methods: Longitudinal cohort; 1,210 black girls and 1,161 white girls, ages 9 to 10 years, with follow-up through 18 to 19 years; 10 annual assessments; data from the NHLBI Growth and Health Study clinical sites in Berkeley, CA, Cincinnati, OH, and Rockville, MD; BMI (health assessment); beverage consumption and carbohydrate intake (3-day food diary); beverages classified into milk, regular soda, diet soda, fruit juice, fruit drinks, and coffee/tea; mixed linear model.

q. Tam et al. (2006) found that baseline median carbohydrate intake from soft drinks was higher among children who were overweight at follow-up than among those who were of normal weight at both points in time (30 g vs. 20 g), but there were no parallel group differences with regard to fruit juice or milk consumption.

   Methods: Longitudinal cohort; 281 children age 7 years who were followed up at age 13 years; data from the Australian (Sydney) Nepean Study; BMI (health examination); classification into normal weight or overweight based on IOTF age-and-sex specific BMI *z*-score cut-points; beverage consumption and carbohydrate intake at baseline (3-day food diary); beverages classified into fruit juice or fruit drink, sugar-sweetened soft drink, and milk; one way ANOVA.

r. Warner et al. (2006) found that 15.5% of the children in this Mexican-American sample were overweight and another 14.4% were at risk for overweight, which is a considerably higher prevalence than national statistics for other ethnic groups. Child overweight was predicted by daily consumption of soft drinks (OR = 3.39) and maternal pre-pregnancy obesity (OR = 5.14), when adjusted for all the other variables.

Methods: Cross-sectional; 354 Mexican-American children age 2 years; data from the Center for the Health Assessment of Mothers and Children of Salinas (California) Study; BMI (health assessment); standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile), at risk for overweight (>= 85th percentile & < 95th percentile), and overweight (>= 95th percentile); family demographics, maternal pre-pregnancy weight status, child's physical activity, and child's consumption of soda, fast food, and sweets (interview with mother); logistic regression.

s. Welsh et al. (2005) found that children who were at risk for overweight at baseline who consumed 3+ sweet drinks per day (vs. <1 drink/day) were more likely to become overweight by the follow-up (OR = 1.8), and children who were overweight at baseline who consumed 3+ sweet drinks per day (vs. <1 drink/day) were more likely to still be overweight at the follow-up (OR = 1.8).

Methods: Longitudinal cohort; 10,904 children ages 2-3 years, who were enrolled in the Missouri WIC Program, with a 1-year follow-up; data from the Missouri Pediatric Nutrition Surveillance System and the Missouri Demonstration Project; BMI (health examination); standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile), at risk for overweight (>= 85th percentile & < 95th percentile), and overweight (>= 95th percentile); Harvard Food Frequency Questionnaire (maternal proxy; baseline); analyzed for sweet drinks (fruit or soda), high-fat foods, sweet foods and total energy intake; logistic regression.

Oral health, dental caries

a. Harris et al. (2004) found that 106 risk factors were significantly related to the prevalence or incidence of dental caries, including 29 dietary factors and 15 breast/bottle feeding factors. The main dietary factor identified was sugar consumption (including candy), although low magnesium intake, high iron intake, and low milk intake were also found to be significantly related in a few studies. Two dietary studies had opposing conclusions about tooth brushing outweighing the damaging effect of frequent sugar consumption. Review authors concluded that dietary habits and oral hygiene may interact, such that developing dental caries is balanced by plaque control (good habits) and a cariogenic diet (bad habits). They also concluded that Streptococcous Mutans is an important indicator for the risk of dental caries.

Methods: Systematic review of 43 cross-sectional studies, 19 cohort studies, 8 case-control studies, and 7 intervention studies on children developing caries in deciduous teeth by the time they were 6 years old. Studies reviewed from computerized searches and handsearches for articles published between 1966 and 2002. Developed quality checklist and scored studies for design rigor, statistical analysis, and level of selection bias. Statistical analysis across studies was not performed because of the heterogeneity of studies.

b. Dugmore and Rock (2004) reported behaviors and factors of 12-year-olds positively associated with tooth erosion prevalence in 14-year-olds, including decay experience (OR=1.55, CI 1.2-2.02) and drinking fizzy pop (50% increase in odds of tooth erosion for each additional daily fizzy pop drink $P<0.01$). Drinking carbonated drinks at age 14 years was positively associated with tooth erosion at age 14 ($P<0.001$, OR 2.21 to 5.13 for any fizzy pop and fizzy pop at least 4 times a day, respectively). Factors and behaviors at 12 years of age positively associated with tooth erosion at age 12 were dental decay (OR=1.49, CI 1.15-1.90), drinking any fizzy pop (OR=1.59, CI 1.18-2.13), and drinking fruit juice at least 4 times per day (2.52, 1.69-3.75).

Methods: Longitudinal cohort and cross-sectional analyses, 1,149 children age 12 years followed up at age 14 years, questionnaire completed by 12-year-olds on oral health, dietary habits, and history or gastric reflux and asthma, questionnaire completed by 14-year-olds on beverage consumption. Tooth erosion examined in children at age 12 years and 14 years visually and using CPITN probe over tooth surface. Erosion assessed using 1993 Survey of Children's Dental Health and erosion index. Aetiological factors were recoded as binary and used in logistic regressions adjusted for all variables regardless of significance.

c. Levine et al. (2007) found that caries at ages 11 to 15 years was predicted by consumption of sugared drinks at bedtime at ages 7 to 11 years (OR = 1.92, P=0.33) and by dairy consumption (OR = .61, P=0.49), i.e., dairy consumption had a protective effect.

Methods: Longitudinal cohort; 315 British children ages 7 to 11 years, with follow-up 4 years later, for whom had complete data; consumption of dairy, and consumption of sugared foods or drinks, anytime and at bedtime, i.e., within the hour before bed (three non-consecutive 24-hour dietary recalls and teacher assisted 3-day food diaries; caries in permanent teeth at ages 11 to 15 years (dental exam at follow-up using BASCD survey methods and DMFT, a measure of tooth decay); logistic regression.

d. Marshall and Broffitt et al. (2005) found that children in the highest quartile of snack eating events at individual years 1,2,3,4 and 1-5 years together had increased of caries compared to the lowest intake quartile ($P<0.05$). Higher daily total eating events at 2,3,4 and 1-5 years was associated with increased caries risk. Children 2 years of age in the highest quartile of 100% juice exposure at snacks had increased caries risk ($P<0.05$), and soda-pop or sugared beverages exposure at meals, snacks, and daily total had increased risk of caries at multiple ages. Children 2 years of age in the highest quartile of daily total exposures to all sugared beverages had an increase risk of caries compared to the first quartile $P<0.05$). Caries risk for being in the highest quartile of consumption compared to the lowest for 1-5 years of age was 3.76 (95% CI, 1.66, 8.50) for soda-pop, 2.06 (95% CI, 0.95, 4.46) for sugared beverages, 0.90

(95% CI, 0.44, 1.85) for 100% juices, and 0.54 (95% CI, 0.25, 1.14) for milk/formula.

Methods: Longitudinal cohort, 634 children ages 1 to 6 years in the Iowa Fluoride Study, parent completed mailed 3-day food diaries at 4 times prior to 1 year of age, 3 times per year through age 3 years, and twice a year thereafter; median average daily exposures to beverage and food categories by meal and snack events were calculated for 1 to 5 years old. Dental examinations from ages 4 to 6 years, fluoride intake assessed with a questionnaire, logistic regression models (caries versus none) testing differences between the 1st and 4th quartiles of food and beverage exposure.

e. Marshall and Eichenberger-Gilmore et al. (2007) found that children with caries had higher soda-pop intakes at 2, 3, and for 1-5 years than children without caries ($P<0.05$), but that mothers'education and risk of overweight was more important. Energy intake and 100% fruit juice intake were unrelated to caries. Neither soda-pop (or 100% fruit juice consumption) was related to BMI categories at any age.

Methods: Longitudinal cohort of 427 children in the Iowa Fluoride Study with dental exams and 3-day food and beverage diaries completed by parents. Mailed questionnaires and food diaries at 6 weeks of age, 3, 6, 8, and 12 months, quarterly through 3 years, and biennially through age 1 years. Measured height and weight; BMI categorized using CDC definitions. Dental exam by dentist plus transillumination with DenLite system. Dietary estimates of energy, soda-pop, and 100% juice intake were weighted for weekday-weekend consumption. Spearman correlation coefficients were used to test associations between caries and BMI with age-adjustment for BMI comparisons. Stepwise logistic regression adjusted for parents' BMI and education levels, child's age and BMI, and family income.

f. Sohn et al. (2006) found that children with high carbonated soft drink consumption had significantly higher risk of dental caries (OR 1.79, 95% CI, 1.27-2.52). A fluid intake of primarily milk, juice, or water was not associated with increased caries.

Methods: Cross-sectional analysis using data from NHANES 1988-94; dental examination and single 24-hr diet recall; 5,985 children ages 2 to 10 years. Cluster analysis was used to classify children by fluid consumption patterns (milks, juices, carbonated soft drinks, water, coffee and tea, and other (including soups and other homemade beverages). χ^2 tests of associations between consumption and dental caries. Logistic regression controlled for sociodemographic factors.

Insulin Sensitivity

a. Davis et al. (2005) reported in overweight Latino children that dietary sugar was associated with lower acute insulin response (regression coefficient= -0.296, P=0.045, explaining 5.9% variance) and decreased beta cell function (disposition index regression coefficient= -0.421, *P*=0.043, explained 12% of variance). When sugar-sweetened beverages were entered into regression in place of nonsugar and sugar carbohydrate intakes, each accounted for less than 5% of the variance and approached significance when predicting acute insulin response (*P*=0.07) and disposition index (*P*=0.08). Other macronutrient and micronutrient intake was not associated with any insulin dynamic variable. Higher total sugar intake and insulin sensitivity were not significantly associated.

Methods: Cross-sectional, 63 Latino children ages 9 to 13 years in the University of California SOLAR Diabetes Project cohort, with BMIs $\geq$ 85th percentile and a family history of type 2 diabetes. 3-day diet record (including 2 weekdays), measured weight and height, fasting blood samples of glucose and insulin values to determine diabetic status, and non-diabetics given an insulin-modified frequently sampled intravenous-glucose-tolerance test to measure insulin sensitivity, acute insulin response, and disposition index (index of beta cell function). Hierarchical multiple regression analyses tested dietary predictors on insulin sensitivity outcomes, with adjustments for age, sex, Tanner stage, fat mass, and total lean tissue.

b. Davis et al. (2007) reported that total sugar intake (g/d) was inversely correlated with insulin sensitivity (S_I) and disposition index (r = -0.289 *P*=0.01, r = -0.244, *P*=0.039, respectively) after covariate adjustments. Total sugar intake explained an additional 5.6% and 4.8% of variance in S_I and disposition index respectively (*P*<0.05 for both), after controlling for covariates. Dietary fiber, total carbohydrates, specific types of sugar intake, glycemic load, and glycemic index were not significantly correlated to adiposity variables, glucose values, or insulin dynamics regardless of covariate adjustments.

Methods: Cross-sectional, 120 Latino children ages 10 to 17 years in the University of California SOLAR Diabetes Project cohort with BMIs $\geq$85th percentile and a family history of type 2 diabetes. 24-hour dietary recalls on 2 weekdays with the first in person and second by phone. Measured weight and height, fasting blood samples of glucose and insulin values to determine diabetic status, and non-diabetics given an insulin-modified frequently sampled intravenous-glucose-tolerance test to measure insulin sensitivity, acute insulin response, and disposition index (index of beta cell function), total body DXA to measure fat and lean body mass. Hierarchical multiple regression analyses tested dietary predictors on insulin sensitivity outcomes, with adjustments for age, sex, Tanner stage, fat mass, and total lean tissue.

Bone fractures

a. Ma and Jones (2004) reported a positive association between cola consumption (but not total carbonated beverage consumption) and wrist and forearm fracture (OR 1.39/unit, 95% CI, 1.10-1.91). The association appears to be mediated by television watching and bone mineral density, but not by decreased milk intake (OR 1.31/unit, 95% CI, 0.94, 1.83 after controlling for bone mineral density, and TV, computer, and video watching). No significant differences were found between cases and controls when testing associations between total fractures and cola, noncola carbonated beverages, and milk drinks. Adjusted partial correlations showed cola consumption was not associated with bone mineral density or milk drinks, but both cola and carbonated drinks were associated with TV, computer and video watching (r=0.20, P<0.01 for both drinks).

Methods: Case-control, 68 female cases and 138 male cases of Tasmanians ages 9 to 16 years with upper limb fractures, 206 controls randomly selected from same school class by gender. Untested FFQ on cola, non-cola carbonated drinks, and milk, measured height and weight, DXA to measure total body, lumbar spine, and right femoral neck bone mass (using measures of bone mineral content, density and apparent density), left hand metacarpal measurements, PA and sedentary activity assessed over past year using modified questionnaire validated in the US. Paired t-tests to measure case and control differences, z-scores for bone measures, partial correlations between milk, soft drinks, PA, and bone mineral density z-score, controlled for age, weight, gender, and case status. Univariate logistic regression on fracture for each drink variable, and significant variables entered into multivariate models adjusted for milk intake, TV watching, and bone mass.

Serum lipids

a. Aeberli et al. (2007) found that overweight children had lower HDL, higher triglycerides, and smaller LDL particle size, and that LDL particle size was associated with BMI (r = -.31) and waist-to-hip ratio (r = -.44). Overweight children also had greater intake of protein and lower intake of fiber, and although there were no differences with regard to carbohydrate, glucose, or fructose intake, overweight children had a lower percent of fructose consumed from fruits and vegetables and a higher percent from sweets and sweetened drinks. And, after controlling for adiposity, LDL particle size was not predicted by physical activity, and the only dietary predictor was total fructose intake.

   Methods: Cross-sectional; 74 Swiss children ages 6 to 14 years; BMI, waist-to-hip ration, body fat percent via SF measures, and blood pressure (health examination); dietary intake (two 24-hour food recalls and 1-day food diary); analysis of dietary intake assessments to extract intake of macronutrients, with more specific breakdown of carbohydrates; physical activity (reported time spent in organized sports, watching TV, and playing computer games); HDL, LDL, triglycerides, and LDL particle size (fasting blood test); standard CDC classification based on BMI percentile by age and sex into underweight (< 5th percentile), normal weight (>= 5th & < 85th percentile), overweight (>= 85th & < 95th percentile), and obese (>= 95th percentile); oneway ANOVA, Pearson correlation, and linear regression.

Beverage Intake Tracking

a. Kvaavik et al. (2005) found the tracking of sugar-sweetened carbonated soft drink intake from adolescence to early adulthood (25 years) and from early adulthood to later adulthood (33 years) was moderate to high, while the tracking from adolescence to later adulthood was low. The frequency of sugar-sweetened carbonated soft drink intake was lower among 25-year-olds who reported a lower soft drink intake at age 15 years compared to those who reported a high intake at age 15 years. Among women, the mean soft drink intake at 25 years of age was 2.5 times per week for those reporting previous day intake at age 15 years compared to 1.6 times per week for those reporting that they did not drink soft drinks in the previous day at age 15 years (*P*=0.029). For men, 15-year-old seldom drinkers had an average of 2.8 drinks in the past week at age 25 years compared to a mean intake of 4.2 times per week at age 25 years for those who reported previous day intake at age 15 years (*P*=0.004).

Methods: Longitudinal cohort on 422 Norwegians from adolescence to early and later adulthood. At age 15 years (baseline), height and weight measured and two questions on frequency of carbonated soft drink intake with 3 response categories. At age 25 years, one question on frequency of sugar sweetened carbonated soft drinks with 5 response categories. At age 33 years, a semi-quantitative FFQ on whole diet, including sugar-sweetened carbonated soft drink intake, with 10 frequency response categories, and self-reported height and weight. Unpaired t-test and Pearson's bivariate correlation coefficient used in tracking analysis.

SECTION 7: CARBOHYDRATES
SUBTOPIC #2: TOTAL CARBOHYDRATES

Total number of studies:	**3**
Cross-sectional:	**1**
Cohort:	**1 longitudinal**
Controlled trials:	**1 randomized crossover**

Health-related outcomes addressed: BMI, adiposity, insulin sensitivity, serum lipids (HDL, LDL, triglycerides)

Behaviors addressed: high fat/low carbohydrate diet

Overview of Recently Published Evidence

In three studies, researchers reported on the association between total carbohydrate intake and health outcomes among children and adolescents, all among very small sample sizes. Total carbohydrate intake was a negative predictor of BMI in a longitudinal study of young children and was negatively related to HDL level in a cross-sectional sample. Obese adolescents on a low-carbohydrate/high-fat diet showed increased gluconeogenesis, which may lead to hyperglycemia observed in type 2 diabetes.

Summary of Studies

Weight (BMI), adiposity

a. Skinner et al. (2004) reported that BMI at age 8 years was negatively predicted by age of adiposity rebound (AR, the age at which BMI increased following the lowest BMI) and positively predicted by BMI at 2 years. In separate regression models, mean protein and fat intakes from 2 to 8 years were positive predictors of BMI, and mean carbohydrate intake over this period was a negative predictor of BMI.

Methods: Longitudinal cohort, 70 children, 15 to 17 sets of growth and dietary data from ages 2 months to 8 years; beginning with the third year mothers provided two nonconsecutive food records and one diet recall (averaged). AR determined visually and by consensus. Forward selection stepwise regression.

Insulin sensitivity and glucose metabolism

a. Sunehang et al. (2005) reported obese adolescents on a low fat/high carbohydrate diet were unable to increase insulin sensitivity and increased insulin secretion, whereas lean subjects increased insulin sensitivity and did not increase insulin secretion (P=0.05). Neither obese nor lean group glucose effectiveness was affected by diet. Neither obese nor lean group glucose production rates (sum of gluconeogenesis and glycogenolysis) was affected by diet when normalized to lean body weight, but in obese subjects on a high fat/low carbohydrate diet, gluconeogenesis was higher by 32% and glycogenolysis was lower (*P*<0.001 for both). Visceral fat was inversely correlated with insulin sensitivity in low and high carbohydrate groups (R=-0.57 *P*=0.007, R=-0.52 *P*=0.015, respectively), independent of percent body fat.

<u>Methods</u>: Random crossover study on 13 healthy obese adolescents ages 13 to 17 years, compared to lean adolescents studied previously with identical methods, 7-day diet (% carbohydrate to % fat ratio either 30:55 or 60:25, and all diets 15% protein and equal calories). Meals pre-portioned, sent home, and non-eaten portions returned and measured. 3-day metabolic study in 24-hour calorimeter with same intervention diet, blood samples to measure insulin sensitivity and glucose and lipid metabolism, MRI measured visceral fat. One-way ANOVA to measure obese and lean group differences, regression analysis for relationship between insulin sensitivity and visceral fat.

Serum lipids

a. Slyper et al. (2005) found that HDL cholesterol was negatively related to glycemic load (*r* = –0.46, p<0.01) and glycemic index, total sugars, total carbohydrates, and fructose (-0.366, -0.382, -0.412, -0.407, respectively, all *P*<0.05). There were negative correlations between glycemic load and percentage protein (*r*= -0.614, *P*=0.001) and percentage fat (*r*= -0.376, *P*=0.03), and positive correlations between dietary fat (*r*=0.524, *P*=0.002) and dietary protein (*r*= 0.565, *P*=0.001). Glycemic load accounted for 21% of the variation in HDL cholesterol in regression. Other correlations between dietary factors and blood lipids were not significant.

<u>Methods</u>: Cross-sectional, 32 participants ages 11 to 25 years, blood draw after 12-hour fast to determine serum lipids, 3-day food diary (2 weekdays, 1 weekend day), white bread was used as standard for glycemic load, stepwise multiple regression analysis. Data are not shown separately for younger children and adolescents (small sample sizes).

CARBOHYDRATES

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**			**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
1	Aeberli et al. 2007	Fructose intake is a predictor of LDL particle size in overweight schoolchildren	1	74 normal-wt and overwt 6-14 y/o Swiss children			cross sectional					
2	Andersen et al. 2005	Overweight and obesity among Norwegian schoolchildren: Changes from 1993 to 2000	5	Nationally representative sample of 1,489 Norwegian 4th and 8th graders			cross sectional					
3	Ariza et al. 2004	Risk factors for overweight in five- to six-year-old Hispanic-American children: A pilot study	6	250 5-6 y/o Hispanic (mostly Mexican-American) kindergarteners from Chicago, IL.			cross sectional					
4	Blum et al. 2005	Beverage consumption patterns in elementary school aged children across a two-year period.	11	164 children			cohort (longitudinal)	X			X	
5	Davis et al. 2007	Associations of dietary sugar and glycemic index with adiposity and insulin dynamics in overweight Latino youth.	21	120 10-17 y/o overwt Latinos w/family history of type 2 diabetes			cross sectional					
6	Davis et al. 2005	The relation of sugar intake to beta cell function in overweight Latino children.	22	63 overwt Latino children 9-13 y/o			cross sectional					
7	Dubois et al. 2007	Regular sugar-sweetened bvg consumption between meals increases risk of overweight among preschool-aged children.	25	Representative sample of infants from Quebec, Canada born in 1998 (n= 2,103) and a subsample of 1,944 4-5 y/o children			cohort (longitudinal)	X			X	
8	Dugmore & Rock 2004	A multifactorial analysis of factors associated with dental erosion	26	1,149 12 y/o (out of 1,753 randomly sampled at baseline) w/usable data; f/up at 14 y/o			cohort (longitudinal)	X			X	

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**			**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
9	Ebbeling et al. 2006	Effects of decreasing sugar-sweetened bvg consumption on body weight in adolescents: a randomized, controlled pilot study.	27	103 adolescents 13-18 y/o who regularly consumed sugar-swtnd bvgs		RCT						
10	Forshee et al. 2004	The role of beverage consumption, physical activity, sedentary behavior, and demographics on body mass index of adolescents	32	2,216 12 -16 y/o sampled in the 1988-1994 NHANES			cross sectional					
11	Harris et al. 2004	Risk factors for dental caries in young children: a systematic review of the literature	41	6 y/o and younger	X	interven-tional studies (7)	cross sectional (43), cohort (19) case control (8)	X			X	
12	Johnson et al. 2007	Is sugar-sweetened bvg consumption associated with increased fatness in children?.	45	subsample of British children from the Avon Longitudinal Study of Parents and Children; enrolled at 5 y/o (n = 521) and 7 y/o (n = 682) ; assessed at 9 y/o			cohort (longitudinal)	X			X	
13	Kvaavik et al. 2005	The stability of soft drinks intake from adolescence to adult age and the association between long-term consumption of soft drinks and lifestyle factors and body weight	48	15 y/o in Oslo Norway Youth study, with follow-up at 25 and 33 y/o			cohort (longitudinal)		X			X
14	LaRowe et al. 2007	Beverage patterns, diet quality, and body mass index of US preschool and school-aged children.	51	541 2-5 y/o and 793 6-11 y/o children from 2001-2002 NHANES			cross sectional					

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**	**Article ID**		**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
15	Levine et al. 2007	Dietary patterns, toothbrushing habits and caries experience of schoolchildren in West Yorkshire, England	52	437 7-11 y/o selected from 6 (or 18?) schools over a wide geographic area who had consent and all dietary data. F/up 4 yrs later.			cohort (longitudinal)	X			X	
16	Ma & Jones 2004	Soft drink and milk consumption, physical activity, bone mass, and upper limb fractures in children: a population-based case-control study	55	9-16 y/o from Tasmania, 206 case-control pairs			case control					
17	Malik et al. 2006	Intake of sugar-sweetened beverages and weight gain: a systematic review	56	Children and adults	X	5 experi-mental studies	15 cross-sectional, 10 prospective	X			X	X
18	Marshall et al. 2005	The roles of meal, snack, and daily total food and bvg exposures on caries experience in young children.	58	634 1-6 y/o in the Iowa Fluoride Study.			cohort (longitudinal)					
19	Marshall et al. 2007	Dental caries and childhood obesity: roles of diet and socioeconomic status.	59	1-10 y/o in the Iowa Fluoride Study			cohort (longitudinal)					
20	Novotny et al. 2004	Dairy intake is associated with lower body fat and soda intake with greater weight in adolescent girls	70	323 9-14 year old Hawaiian girls with Asian or Caucasian ancestry			cross sectional					
21	O'Connor et al. 2006	Beverage intake among preschool children and its effect on weight status.	72	1,160 2-5 y/o boys and girls from 1999-2002 NHANES; 24% were overwt or at risk of overwt			cross sectional					

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	**Title**			**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
22	Rodearmel et al. 2007	Small changes in dietary sugar and physical activity as an approach to preventing excessive weight gain: the America on the Move family study.	77	192 families w/at least one 7-14 y/o overwt or at risk for overwt child		RCT						
23	Sanigorski et al. 2007	Association of key foods and beverages with obesity in Australian schoolchildren	81	Representative sample of 2,184 school children from Victoria, Australia			cross sectional					
24	Skinner et al. 2004	Predictors of children's body mass index: a longitudinal study of diet and growth in children aged 2-8 y.	84	70 white, middle/upper SES children (37 M, 33 F) participating in longitudinal study from 2-9 y/o			cohort (longitudinal)	X		X	X	
25	Slyper et al. 2005	Influence of glycemic load on HDL cholesterol in youth.	85	32 11-25 y/o healthy M and F w/range of LDL-cholesterol values (1.71-6.67 mmol/L) and BMI z scores (-1.18 to 2.64)			cross sectional					
26	Sohn et al. 2006	Carbonated soft drinks and dental caries in the primary dentition	87	2-10 y/o in NHANES III 1988-94			cross sectional					
27	Striegel-Moore et al. 2006	Correlates of beverage intake in adolescent girls: the National Heart, Lung, and Blood Institute Growth and Health Study	90	9-19 y/o black (n=1,210) & white (n=1,161) girls in the National Heart, Lung, and Blood Institute Growth and Health Study			cohort (longitudinal)	X			X	
28	Sunehag et al. 2005	Effects of dietary macronutrient intake on insulin sensitivity and secretion and glucose and lipid metabolism in healthy, obese adolescents	91	13 healthy obese volunteers (6M, 7F, mean age 14.7 y/o; mean BMI of 34, mean body fat 42%) [results were compared w/ those of previously studied lean adolescents]		Random crossover study						

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	Title			Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
29	Tam et al. 2006	Soft drink consumption and excess weight gain in Australian school students: results from the Nepean study	93	268 children (136 males) from Sydney, Australia. Mean/SD age = 7.7+/-0.6 y/o			cohort (longitudinal)	X			X	
30	Vartanian et al. 2007	Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis	98	Children and adults	X							
31	Warner et al. 2006	Soda consumption and overweight status of 2-year-old Mexican-American children in California	101	354 2 y/o Mexican-American children from Salinas Valley, CA			cross sectional					
32	Welsh et al. 2005	Overweight among low-income preschool children associated with the consumption of sweet drinks	103	10,904 children 2-3 y/o			cohort (longitudinal)	X			X	

SECTION 8: SODIUM AND POTASSIUM
SUBTOPIC #1: SODIUM

Total number of studies:	**3**
Cross-sectional:	**1**
Controlled trial:	**1**
Meta-analysis:	**1**

Health-related outcomes addressed: blood pressure; pulse pressure; sodium retention

Behaviors addressed: salt intake

Overview of Recently Published Evidence

One meta-analysis study of 13 controlled trials (12 randomized) from the 1980s and one cross-sectional study from 1997 demonstrated that modest decreases in salt intake reduced blood pressure and pulse pressure in children and adolescents. One randomized study showed greater sodium retention in black adolescent females than white adolescent females.

Summary of Studies

a. He et al. (2006) conducted a literature search of relevant articles on sodium interventions among children (published between 1966 and 2006) and meta-analysis of 13 controlled trials to examine the relationship between modest decreases in salt intake (duration of at least two weeks) and blood pressure reductions in infants and children. Study periods ranged from two weeks to three years. In children and adolescents, lowered salt intake was significantly associated with reduced BP (systolic -1.17 mm Hg (95% CI: -1.78 to -0.56 mm Hg); diastolic: -1.29 mm Hg (95% CI: -1.94 to -0.65 mm Hg). Salt intake reduced by 42% (interquartile range [IQR]: 7% to 58%). Salt intake was reduced by 42% (interquartile range [IQR]: 7% to 58%) in children and adolescents.

   Methods: Meta-analysis of 10 controlled trials (including one non-randomized) on 966 children ages 8 to 16 years and 3 controlled trials on 551 infants. Nine of 13 studies occurred in the 1980s and one in 2004. Three trials assessed the amount of dietary intake of salt using 24-hour urinary sodium, and two of these three reported children's usual salt intake. Meta-analysis used urinary sodium results if available. Fixed-effect models.

b. He et al. (2008) analyzed data from a national study of British children ages 4 to 18 years and found that a one gram/day increase in salt intake was significantly related to 0.4 mm Hg increase in systolic BP and 0.6 mm Hg increase in pulse pressure, after adjusting for age, sex, BMI and potassium intake. Mean salt intake increased from 4.7$\pm$0.2 g/day at age 4 years to 6.8$\pm$0.2 g/day at age 18 years.

Methods: Sample of 1,658 children ages 4 to 18 years in Great Britain's 1997 National Diet and Nutrition Survey. Salt intake, measured by 7-day diet records, excluded salt added in cooking and at the table. Three BP measurements, BMI, systolic BP and pulse pressure. Multiple linear regression analysis controlling for potential confounders (age, sex, BMI and potassium intake). ANOVA comparisons of tertiles of salt intake, sex-standardized *z*-scores of BP by tertile of salt intake.

c. Palacios et al. (2004) reported differences for mean urinary sodium excretion based on race and sodium treatment. Mean urinary sodium excretion was significantly lower in blacks than whites in the high-sodium intake group (2.5 vs. 3.3 g/d in blacks and whites, respectively, $P<0.001$) indicating greater sodium retention in black adolescent females than white adolescent females. Mean urinary sodium excretion was similar between blacks and whites for the low-sodium intake group. Fecal sodium excretion differences between groups were similar to urinary sodium excretion. Total body sweat sodium excretion did not differ by race but was significantly higher for the high-sodium groups within each race. The difference in cumulative sodium retention between the high- and low-sodium diet was greater in black females (9.96 $\pm$ 1.86g) than white females (1.84 $\pm$ 2.19g)($P<0.05$). Blood pressure and weight decreased from baseline to the end of the study.

Methods: Randomized crossover study, 15 black and 8 white girls ages 11 to 15 years. Participants were in a 3- week study session, starting with a 1- week equilibration period and then either a low (1310 $\pm$ 43 mg/d) or high (3945 $\pm$ 47 mg/d) sodium (Na^+) diet with fixed amounts of other nutrients. After 2 weeks of self-selected diets, participants were placed in another 3 week session. Usual sodium intake was estimated at baseline using 6-d dietary records and 24-h urine collections. Measured weight, height, and blood pressure, 2 blood samples at the end of each 3-week period, urine, fecal, and total body sweat samples, Tanner score. Mixed model ANOVA to assess effects of treatment, with race, session, sodium treatment, subject order, and response in the model. Weight and blood pressure changes tested using repeated measures ANOVA.

SECTION 8: SODIUM AND POTASSIUM
SUBTOPIC #2: POTASSIUM

Total number of studies: 0

Overview of Recently Published Evidence

No new evidence meeting the inclusion criteria was found for potassium.

SODIUM AND POTASSIUM

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	Title			Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
1	He et al. 2008	Salt and blood pressure in children and adolescents	42	1,658 4-18 y/o w/salt and blood pressure recorded in Great Britain's 1997 National Diet and Nutrition Survey for young people			cross sectional					
2	He & MacGregor 2006	Importance of salt in determining blood pressure in children: meta-analysis of controlled trials [see comment]	43	966 8-16 y/o (median age: 13 y/o); 551 infants	X	10 controlled trials for 8-16 y/o, 3 controlled trials for infants						
3	Palacios 2004	Sodium retention in black and white female adolescents in response to salt intake	75	22 black and 14 white girls ages 11-15 years old		Random-ized crossover design						

SECTION 9: TRACKING
SUBTOPIC #1: MISCELLANEOUS HEALTH RELATED OUTCOMES

Total number of studies:	**20**
Cohort:	**16 (11 longitudinal, 3 prospective, 2 retrospective)**
Controlled trial:	**1**
Meta-analysis:	**1**
Review:	**2**

Health-related outcomes addressed: blood pressure**;** bone health; bone mineral content (BMC); bone remodeling; breast cancer; colorectal cancer; coronary heart disease (CHD); carotid artery intima-media thickness (IMT); metabolic syndrome; tooth erosion; dental caries; asthma; serum cholesterol and fatty acids

Behaviors addressed: calcium consumption; dairy consumption; fruit and vegetable consumption; beverage consumption; vegetable fat consumption

Overview of Recently Published Evidence

Many of the studies focused on the impact of a dietary pattern in childhood on a risk factor in childhood. Studies found that lower consumption of dairy products and fruits and vegetables was associated with larger increases in blood pressure per year in children. A diet that was low in saturated fat and cholesterol was associated with lower total and LDL cholesterol values. Drinking high amounts of fruit juice and drinking soda were associated with tooth erosion, although eating fruits other than apples and citrus lowered the risk. Sugar consumption and low dairy consumption were associated with dental caries as well. There were many positive associations with diet and bone health including energy; protein, calcium, magnesium, and zinc intake; and dairy product consumption. Some studies focused on the association between a diet in childhood and health issues in adulthood. A diet high in vegetable fat and vitamin E was negatively associated with breast cancer, but a higher consumption of dairy foods in childhood was associated with increased odds of colorectal cancer. A higher BMI in childhood was associated with an increased risk of a CHD event and was one of the risk factors associated with increased carotid IMT. High body weight in middle childhood was associated with asthma. Waist circumference predicted metabolic syndrome in adolescence. Adult metabolic syndrome was predicted by pediatric metabolic syndrome.

Summary of Studies

Blood pressure

a. Moore et al. (2006) found over an 8 year period the slope of systolic blood pressure per year (mm Hg change/yr) was 2.95$\pm$.19 (SE) for children consuming fewer than two servings of dairy per day compared with 2.13$\pm$.25 (SE) for children consuming more than two servings (“high intake”) of dairy foods per day. The combined effect of high fruit and vegetable/high dairy product intake on both systolic and diastolic blood pressure was notably larger.

Methods: Longitudinal cohort, 95 children ages 3 to 6 years at baseline, data from Framingham Children's Study, sets of 3-day diet records collected over time (four sets in year 1, one or two sets in each subsequent year), results adjusted for child's baseline blood pressure, mean activity counts per hour, daily intakes of magnesium and sodium at 3 to 6 years of age, and servings of fruits and vegetables.

b. Over an 8-year period, Moore et al. (2005) found the slope of systolic blood pressure per year (mm Hg change/yr) was 2.80$\pm$.17 (SE) for children ages 3 to 6 years at baseline consuming fewer than 4 servings of fruits and vegetables per day compared with 2.19$\pm$.29 (SE) for children consuming 4 or more servings ("high intake) of fruits and vegetables per day. The combined effect of high fruit and vegetable/high dairy product intake on both systolic and diastolic blood pressure was notably larger.

Methods: Prospective cohort, 95 children, data from Framingham Children's Study, sets of 3-day diet records collected over time (four sets in year 1, one or two sets in each subsequent year), results adjusted for child's baseline blood pressure, mean activity counts per hour, daily intakes of magnesium and sodium at 3 to 6 years of age, and servings of dairy.

Bone health, bone mineral content, bone remodeling

a. Alexy et al. (2005) examined long-term dietary protein intake as related to bone modeling and remodeling at the proximal radius. After adjustments, the protein intake was significantly positively associated with periosteal circumference, cortical area, BMC, and polar strength strain; and potential renal acid load was significantly negatively associated with cortical area and BMC. R^2 ranged from .03 for potential renal acid load to .10 for protein as a percentage of energy.

Methods: Cohort, 229 subjects, 3-day dietary records collected yearly over 4 years, XCT-2000 device.

b. Bounds et al. (2005)[12] reported statistically significant correlations of energy, calcium, phosphorus, protein, magnesium, and zinc with BMC (r = .32 to .41) in children ages 6 and 8 years. Multiple regression models predicting children's total BMC at age 8 years showed significant effects of individual nutrients (i.e., protein, phosphorus, magnesium, vitamin K, zinc, energy, and iron) when they were substituted for one another in the model. R^2 shown were .05 and .08. Relationships were weaker for BMD. All relationships between nutrient intakes and BMC or BMD were positive; protein had the strongest relationship. BMC and BMD tracked from age 6 to 8 years; strength of relationship not shown.

[12] One author is an employee of Gerber Products Company.

Methods: Longitudinal cohort, 52 subjects, 9 in-home interviews that included one 24-hour recall and two diet records collected over 6 years, dual energy X-ray absorptiometry (DEXA). Colinearity of nutrients addressed through substitution in regression equations.

c. Fiorito et al. (2006) reported that higher calcium intakes at ages 7 and 9 years were significantly positively associated with total body BMC at age 11 years (r ranged from 0.17 to 0.24). Results were comparable for total calcium and calcium from dairy sources.

Methods: Longitudinal cohort, 151 females, three 24-hr dietary recalls at ages 5, 7, 9, and 11 years, DEXA at ages 9 and 11, adjusted and unadjusted Spearman correlation coefficients.

d. Fisher et al. (2004)[13] reported that mean BMC (controlled for pubertal development and height at age 9 years) and mean BMD at age 9 years (controlled for pubertal development at age 9 years) were significantly higher for the girls who met the adequate intakes than for those who did not. No difference in BMI by calcium intake. After controlling for the stage of pubertal development at age 9 years, mean calcium intake from ages 5 to 9 years was significantly positively related to BMD at age 9 years ($B = 0.27$). Calcium intake tracked over time as follows: 5 to 7 years, r = .52; 7 to 9 years, r = .48; 5 to 9 years, r = .39.

Methods: Longitudinal cohort, 192 females, three 24-hour dietary recalls at ages 5, 7, and 9 years, DEXA at ages 9, multiple logistical regressions.

e. Lanou et al. (2005)[14] conducted Medline search for studies published on the relationship between milk, dairy products, or calcium intake and bone mineralization or risk of fracture for subjects ages 1 to 25 years. The authors excluded studies that did not control for body weight, pubertal status, and activity level. They report a positive relationship between dairy product consumption and measures of bone health in 1 of 4 cross-sectional studies, 0 of 3 retrospective studies, 0 of 1 prospective study, and 2 of 3 RCT. They report a positive relationship between calcium intake and measures of bone health in 4 of 13 cross-sectional studies, 2 of 4 retrospective studies, and 1 of 9 prospective studies. For the 10 controlled trials of calcium supplementation, 9 showed a positive relationship with BMD or BMC.

Methods: Review, no tabular information presented, strength of evidence not presented in formal manner.

f. Vatanparast et al. (2005) found that intake of vegetables and fruit was a significant independent predictor of total-body bone mineral content (TBBMC) for boys but not for girls.

[13] Research partially supported by the National Dairy Council.

[14] Two authors from the Physicians Committee for Responsible Medicine.

Methods: Longitudinal cohort, 85 boys, 67 girls, 5 weekday 24-hr recalls, dual-energy X-ray absorptiometry, multilevel regression analysis of TBBMC aligned on biological maturity.

Cancer

a. Frazier et al. (2004) reported that higher adolescent vegetable fat intake was negatively associated with breast cancer (RR=0.58, 95% CI 0.38-0.86 *P*-trend=0.005, comparing 5th and 1st quintiles), as was higher vitamin E (0.61, 0.42-0.89 *P*-trend=0.003). When vegetable fat and vitamin E were in the model together, only vitamin E retained significance.

   Methods: Retrospective cohort, 361 of 47,355 original adolescent participants, 131 item FFQ on high school diet (Nurses Health Study II), breast cancer incidence from medical record review, used quintiles of nutrient intake, χ^2 and t-tests used for risk factor differences between cases and non-cases, Cox proportional hazards regression used to estimate RR and 95% confidence intervals for incident cases of breast cancer during the 10-year period following high school.

b. van der Pols et al. (2007) found that high intake of dairy foods during childhood was associated with increased odds of colorectal cancer (multivariate OR = 2.90, 2 sided *P*-trend=0.005 compared with low intake). Total median dairy intakes for the four groups analyzed were 89, 163, 255, and 471 g/d.

   Methods: Retrospective cohort, 4,374 traced subjects with full data, 7-day weighed household inventory obtained in 1937–1939, reanalysis of food records to include more nutrients and to update findings if foods likely not to have changed in composition over time, cancer deaths and registrations occurring up to July 31, 2005; logistic regression models (tested other regression models and found little difference in conclusions).

Cardiovascular health

a. Baker et al. (2007) found that childhood BMI was associated with an increased risk of having a fatal or non-fatal CHD event in adulthood. Risk increased with BMI and age, adjustment for birth weight strengthened the effects, and associations were somewhat stronger for boys than for girls. Specifically, for a 13 year-old boy, RR per SD increase in BMI was 1.17 for a non-fatal event and 1.24 for a fatal event. For a 13 year-old girl, RR per SD increase in BMI was 1.11 for a non-fatal event and 1.23 for a fatal event.

   Methods: Longitudinal cohort; 276,835 Danish schoolchildren ages 7 to 13 years; BMI in childhood (health examination); fatal or non-fatal CHD event in adulthood (25+ years; vital statistics registry); Cox regression.

b. Viikari et al. (2004) provided high-level summaries of two studies, a longitudinal cohort study and a RCT. For the longitudinal cohort study, they summarized findings from the 21-year follow-up, which showed that carotid

IMT in adulthood was associated with childhood clustering of risk factors (BMI above the 80th percentile, LDL cholesterol, blood pressure, and smoking), especially in the cohort of adolescents ages 12 to 18 years. Elevated childhood LDL cholesterol, blood pressure, BMI, and smoking predicted carotid IMT in adulthood as single risk factors as well. These effects were independent of contemporaneous risk factors.

<u>Methods</u>: Longitudinal cohort; 3,596 children ages 3 to 18 years in the Cardiovascular Risk in Young Finns Study, with 2,283 followed up through 24-39 years; baseline and 5 follow-up assessments consisting of questionnaires, health examinations, and fasting blood tests.

Metabolic Syndrome

a. Morrison et al. (2008) tracked metabolic syndrome and found that adult metabolic syndrome was predicted by pediatric metabolic syndrome (OR = 9.40), age at follow-up (OR = 1.06), change in BMI percentile (OR = 1.03), and parental history of diabetes (OR = 2.40). Adult diabetes was predicted by pediatric metabolic syndrome (OR = 11.5), age at follow-up (OR = 1.12), black race (OR = 2.20), and parental history of diabetes (OR = 5.00).

   <u>Methods</u>: Longitudinal cohort; 814 children ages 5 to 19 years with complete data at follow-up at ages 30 to 48 years; data from Princeton Lipid Research Clinics study; BMI and blood pressure (health examination); waist circumference for adults only (health examination); glucose, HDL, and triglycerides (fasting blood test); for adults, diabetes for self and parents (self-report and/or fasting blood test)

b. Morrison et al. (2005) found that whereas prevalence of multiple metabolic syndrome components was rare among girls ages 9 to 10 years, by the follow-up at 18 to 19 years, 3.5% of the black girls and 2.3% of the white girls had the syndrome. Low HDL levels were prevalent throughout the period, whereas prevalence of other risk variables started low and increased with age. Univariate analyses showed that all baseline variables predicted development of the metabolic syndrome at follow-up. Multivariate analyses showed that waist circumference (OR = 1.16) and triglycerides (OR = 1.12) predicted development of the syndrome. BMI also predicted development of the syndrome (OR = 1.20) in multivariate analyses, but the effect disappeared with waist circumference in the model.

   <u>Methods</u>: Longitudinal cohort; 608 white girls and 584 black girls, ages 9 to 10 years, with follow-up through 18 to 19 years; 10 annual assessments; data from the NHLBI Growth and Health Study clinical sites in Cincinnati, OH, and Washington, DC; BMI, waist circumference, and blood pressure (health assessment); insulin, glucose, insulin resistance, triglycerides, and HDL (fasting blood test); ATP criteria for metabolic syndrome; logistic regression.

Oral Health

a. Dugmore and Rock (2004) reported behaviors and factors of 12-year-olds positively associated with tooth erosion prevalence in 14-year-olds. Factors and behaviors at 12 years old positively associated with 12-year-old tooth erosion was dental decay (OR=1.49, CI 1.15-1.90), drinking fruit juice at least 4 times per day (2.52, 1.69-3.75), and drinking any fizzy pop (OR=1.59, CI 1.18-2.13); the presence of calculus and eating fruits besides apples and citrus reduced the chances of dental erosion (*P*<0.001 for both).

   Methods: Longitudinal cohort and cross-sectional analyses, 1,149 12-year-olds followed up at age 14 years, questionnaire completed by 12-year-olds on oral health, dietary habits, and history or gastric reflux and asthma, questionnaire completed by 14-year-olds on beverage consumption. Tooth erosion examined in 12- and 14-year-olds visually and using CPITN probe over tooth surface. Erosion assessed using 1993 Survey of Children's Dental Health and erosion index. Aetiological factors were recoded as binary and used in logistic regressions adjusted for all variables regardless of significance.

b. Harris et al. (2004) found that 106 risk factors were significantly related to the prevalence or incidence of dental caries, including 29 dietary factors and 15 breast/bottle feeding factors. The main dietary factor identified was sugar consumption (including candy), although low magnesium intake, high iron intake, and low milk intake were also found to be significantly related in a few studies. Two dietary studies had opposing conclusions about tooth brushing outweighing the damaging effect of frequent sugar consumption. Review authors concluded that dietary habits and oral hygiene may interact, such that developing dental caries is balanced by plaque control (good habits) and a cariogenic diet (bad habits). They also concluded that Streptococcous Mutans is an important indicator for the risk of dental caries.

   Methods: Systematic review of 43 cross-sectional studies, 19 cohort studies, 8 case-control studies, and 7 intervention studies on children developing caries in deciduous teeth by the time they were 6 years old. Studies reviewed from computerized searches and handsearches for articles published between 1966 and 2002. Developed quality checklist and scored studies for design rigor, statistical analysis, and level of selection bias. Statistical analysis across studies was not performed because of the heterogeneity of studies.

c. Levine et al. (2007) found that caries at ages 11 to 15 years was predicted by consumption of sugared drinks at bedtime at ages 7 to 11 years (OR = 1.92, *P*=0.33) and by dairy consumption (OR = .61, *P*=0.49), i.e., dairy consumption had a protective effect.

   Methods: Longitudinal cohort; 315 British children ages 7 to 11 years, with follow-up 4 years later, for whom had complete data; consumption of dairy, and consumption of sugared foods or drinks, anytime and at bedtime, i.e., within the hour before bed (three non-consecutive 24-hour dietary recalls and teacher assisted 3-day food diaries; caries in permanent teeth at ages 11 to 15 years (dental exam at follow-up using BASCD survey methods and DMFT, a measure of tooth decay); logistic regression.

Respiratory Health

a. Flaherman and Rutherford (2006) conducted a meta-analysis of the effect of high weight on asthma in 8 prospective and 4 retrospective cohort studies. For the 9 studies that examined high birth weight, the pooled RR of subsequent asthma was 1.2, and for the 4 studies that examined high body weight during middle childhood, the pooled RR was 1.5.

Methods: Meta-analysis; of 402 cohort studies identified that were conducted in developed countries (US, UK, Europe, New Zealand, etc.), 12 met inclusion criteria—birth weight (high body weight defined as >= 2.8 kg or ponderal index >= 27kg/m^3) and/or childhood BMI (high body weight defined as age-and-sex adjusted >= 85th percentile) and asthma at follow-up (later in childhood or adolescence).

Serum cholesterol and fatty acids

a. Guerra et al. (2007) observed no tracking over three years for SFA, MUFA or PUFA in preschoolers. Partial tracking was found for DHA: alpha-linolenic acid ratio (r=0.33). Dietary PUFA and plasma PUFA were correlated at age 24 months; there were no other dietary/plasma correlations for PUFA, SFA, and MUFA. Plasma phospholipid fatty acid compositions differed by age; MUFA was lower at age 5 years than age 2 years (mean percentage 11.1 and 13.6 respectively, $p<0.05$) as was SFA (48.5 and 50.2, $P<0.05$). Plasma PUFA levels were higher at age 5 years (39.9 and 35.6, $P<0.05$).

Methods: Longitudinal cohort, 26 children ages 2 to 5 years, 24-hour dietary recall and blood sample at 24, 36 and 60 months, age specific fatty acid level *z*-scores, mean level differences between time points tested by ANOVA.

b. Niinikoski et al. (2007) reported that a low saturated fat and low cholesterol dietary intervention lowered serum total and LDL cholesterol values and saturated fat intakes more in the intervention group than in the control group ($P<0.001$). Only boys' serum triglyceride values were lowered by the intervention ($P<0.001$). There was no difference in HDL cholesterol between the groups. In the intervention group, boys had lower serum total and LDL cholesterol values ($P<0.001$) and higher ratios of HDL:total cholesterol ($P<0.001$) than girls throughout the intervention, adjusted for energy and % energy from saturated fat intake, height, and BMI.

Methods: Randomized prospective intervention on Finnish ages 7 months to 14 years, 540 had individualized counseling to control heart disease risk factors and 522 were controls. Parents were counseled in 1 to 3 month intervals until children were 2 years old, then twice/year until 7 years old. Children and parents received counseling once/year between ages 7 and 14 years. Annual 4-day food records after 2 years old, before that was 3-day food records. Blood samples at 7 months, 13 months, 2 years, then annually. Cholesterol oxidase-p-aminophenazone method (CHOD-PAP) to measure serum cholesterol enzymatically. Multivariate repeated measures ANCOVA.

SECTION 9: TRACKING
SUBTOPIC #2: WEIGHT STATUS, DIETARY PATTERNS

Total number of studies:	**25**
Cohort:	**23 (20 longitudinal, 2 prospective, 1 retrospective)**
Controlled trial:	**1 (randomized)**
Review:	**1**

Health-related outcomes addressed: body mass index (BMI); obesity status (at-risk of overweight/overweight, overweight/obesity); adiposity indices

Behaviors addressed: sweetened beverage consumption; energy consumption; breakfast consumption; animal protein consumption; calcium consumption; milk consumption; fruit consumption; dietary patterns

Overview of Recently Published Evidence

Numerous studies found tracking of BMI and other adiposity indices through childhood to adolescence and into adulthood. Studies found both high persistence of overweight through childhood and into adulthood as well as an increasing prevalence of overweight. In other words, overweight children are more likely to be overweight adults. However, non-overweight children may become overweight as they age as well. Certain studies assessed the impact of a childhood dietary pattern on adiposity measures within a few years. Increases in weight (BMI) were associated with an increase in soda consumption and high animal protein intake but not fruit or calcium intake. A review study as well as a cohort study found associations with sugar-sweetened beverages and overweight. However, another study that found that milk consumption predicted lower fat mass did not find an association with sugar-sweetened beverages. From adolescence to adulthood, intake of sugar-sweetened carbonated soft drinks tracked, consumption of fast-food increased, and consumption of breakfast decreased. Breakfast and cereal consumption were associated with a lower BMI.

Summary of Studies

Body mass index, weight status, adiposity indices

a. Alexy et al. (2004) reported that mean standard deviation scores of BMI measured from childhood to adolescence were highest for children in a cluster with the lowest percentage of energy intake from fat (low fat cluster=0.26 versus -0.30 in the constant fat cluster, 0.11 medium fat, 0.06 high fat, $P<0.05$). BMI differences between child clusters with different percentages of energy from fat were not found between the first and last subject examinations.

   <u>Methods</u>: Longitudinal cohort, 228 German boys and girls ages 2 to 18 years, 10 yearly 3-day weighed dietary records and measured height and weight.

Children were clustered by fat intake as a percent of energy to adjust for age - constant fat intake cluster had the least within individual change, medium fat intake cluster had more within individual variation than the constant group, low fat cluster contained mostly individuals with fat intake less than the first quartile, and high fat cluster had most individuals with fat intake above the third quartile. Dietary and anthropometric variables adjusted for age; group differences were tested using non-parametric Kruskal-Wallis one-way ANOVA (continuous variables) and χ^2 tests (categorical variables).

b. Barton et al. (2005)[15] reported that, over the course of the 10-year study, days eating cereal daily was predictive of a lower BMI *z*-score and of risk of overweight (χ^2 (3) = 14.35 and 11.62, respectively). Post hoc analysis showed that girls who ate cereal on any day had lower rates of risk of overweight than did girls who ate no cereal.

<u>Methods</u>: Longitudinal cohort, 2379 girls ages 9 and 10 years at entry, 3-day food records at each of 10 visits over 10 years (NHLBI Growth and Health Study)

c. Blum et al. (2005) reported that elementary school children who were overweight or normal weight at both baseline and follow-up increased diet soda consumption over the two years (overweight 2.3 oz/d $\pm$ 7.3, normal weight 1.1 oz/d $\pm$3.9) as did the all children as a whole (1.7 oz/d $\pm$ 5.3). Weight gainers increased diet soda consumption but not significantly (P=0.058), and weight losers did not significantly change diet soda consumption. All children decreased milk intake (-3.4 oz/d $\pm$ 14.1) and caloric intake (-126.3 kcal/d $\pm$ 710.8). Predictors of follow-up BMI *z*-score were baseline BMI and diet soda consumption at year 2 (R-squared = 0.83, P<0.001). Inverse correlations were found for changes in milk and sugar-sweetened beverage consumption in all children (oz/d Pearson r = -0.27, and r= -0.76, P<0.05 for both values).

<u>Methods</u>: Longitudinal cohort, convenience sample of 166 in children in the 3rd and 5th grades. 24-hour dietary recall at baseline and year 2 follow up, and each recall involved 2 interviews to cover different parts of the day. Measure weight and height. 4 groups were classified by BMI *z*-score at baseline and follow-up – normal, overweight, gained weight, and lost weight – and differences in BMI *z*-score for beverage and caloric intake were tested with repeated measures ANOVA. Regression analysis to determine predictors of BMI *z*-score at follow-up.

d. Crimmins et al. (2007) tracked adolescent BMI and found considerable stability. Specifically, the percent at risk for overweight went from 19.1 in Year 1 to 17.2 in Year 4, and the percent overweight went from 18.2 in Year 1 to 18.8 in Year 4. However, adolescents who were the leanest at baseline, exhibited significant increases in BMI, and this effect was stronger for girls.

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[15] Research partially supported by General Mills, Inc.; three authors are employees of General Mills, Bell Institute of Nutrition.

Methods: Longitudinal cohort; 1,746 white and black students in grades 5 thru 12 in school-based study in Cincinnati with complete data for four annual assessments; BMI (health examination); standard CDC classification based on BMI percentile by age and sex into underweight (< 5th percentile), normal weight (>= 5th & < 85th percentile), at risk for overweight (>= 85th & < 95th percentile), and overweight (>= 95th percentile); repeated-measures ANOVA.

e. Deshmukh-Taskar et al. (2006) tracked weight status from childhood to young adulthood (ages 19 to 35 years) and found that rates of overweight increased from childhood to adulthood and childhood overweight tracked into adulthood. Specifically, percentage overweight increased from 24.7% to 57.7%; 35.2% of the children shifted from normal weight in childhood to overweight in adulthood; baseline BMI was strongly positively correlated with follow-up BMI (r = .66); and 61.9% of participants in the highest BMI quartile in childhood remained in the highest BMI quartile in adulthood.

   Methods: Longitudinal cohort; 841 white and black adults ages 19 to 35 years who had completed a baseline assessment at ages 9 to 11 years; data from Bogalusa (Louisiana) Heart Study; BMI (health examination); for children, standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile) and overweight or at risk for overweight (>= 85th percentile); for adults, classification into normal weight (BMI < 25) and overweight (BMI >= 25); Cohen's kappa and Pearson correlation coefficients.

f. DuBois et al. (2007) found that regular consumption of sugar-sweetened beverages at all ages was predicted by low parental education and income, but not parental age or overweight. In addition, being overweight at age 4-5 was predicted by regular consumption of sugar-sweetened beverages at all ages (OR = 2.1 to 2.4, adjusted for various combinations of demographic and dietary intake variables).

   Methods: Longitudinal cohort; 1,944 children ages 4 to 5 years in the Longitudinal Study of Child Development in Quebec who participated in the baseline at age 2-3 years and both annual follow-ups; BMI (health examination); standard CDC classification based on BMI percentile by age and sex into normal weight (<95th percentile) and overweight (>=95th percentile); energy, macronutrient, and food servings (24-hour food recall; parental proxy); frequency of consumption of sugar-sweetened beverages, classified into regular consumers and non-consumers (FFQ; parent proxy); family demographics and parental overweight (questionnaire completed by parent); χ^2 and logistic regression.

g. Evers et al. (2007) tracked weight status and found high and increasing prevalence and high persistence in overweight. Specifically, 68.2% of children who were overweight in pre-kindergarten were overweight in 3rd grade (OR = 108.67), and 19.1% of children who were at risk for overweight in pre-kindergarten were overweight in 3rd grade (OR = 5.82); therefore, overweight prevalence increased from 9.9% in pre-kindergarten to 15.2% in 3rd grade. Maternal overweight, but not other SES or demographic indicators, predicted child overweight in pre-kindergarten (OR = 1.13).

Methods: Longitudinal cohort; 760 pre-kindergarten students from economically-disadvantaged communities in Ontario, Canada, and their mothers; one to five annual assessments through 3rd grade; child BMI (health examination); maternal BMI and various SES and demographic indicators (self-report); for children, standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile), at risk for overweight (>= 85th percentile & < 95th percentile), and overweight (>= 95th percentile); for mothers, classification into normal weight (BMI < 25) and overweight (BMI >= 25); logistic regression.

h. Freedman et al. (2005) tracked weight status and found that childhood BMI *z*-scores and adiposity indices were associated with adult BMIs and adiposity indices, with overall correlations ranging from $r = .44$ to .64, and increasing with childhood age. In addition, regression analyses showed that childhood BMI *z*-scores and adiposity indices were independently associated with adult BMIs and adiposity indices.

Methods: Longitudinal cohort; 2,610 children ages 2 to 17 years with follow up at ages 18 to 37 years; data from Bogalusa (Louisiana) Heart Study; BMI (health examination); adiposity index—triceps SF for children and mean of triceps and subscapular SF for adults (health examination); for children, classification based on BMI percentile by age and sex into normal weight (< 95th percentile) and overweight (>= 95th percentile); for adults, classification into non-obese (BMI < 30) and obese (BMI >= 30); overfat defined as gender-specific upper quartile for SF; linear regression and Spearman correlation coefficients.

i. Garnett et al. (2007) tracked weight status and found that BMI and waist circumference *z*-scores increased with age, 78.9% who were overweight or obese at age 8 years were overweight or obese at age 15 years (OR = 14.8), and 69.2% who had increased central adiposity at age 8 had increased central adiposity at age 15 (OR = 12.2). In addition, children who were overweight or obese at age 8 were more likely to have CVD risk clustering at age 15 (OR = 6.9), and children who had increased central adiposity at age 8 were more likely to have CVD risk clustering at age 15 (OR = 3.6). However, among those classified as overweight or obese, there was no difference in the likelihood of having CVD risk clustering between those with or without increased central adiposity.

Methods: Longitudinal cohort; 342 Australian children age 8 years with follow up at age 15 years; BMI, waist circumference, and blood pressure (health examination); lipid and glucose profiles (overnight fasting blood test); classified as overweight or obese based on IOTF age-and-sex specific BMI *z*-score cut-points; classified as having increased central adiposity if age-and-sex specific waist circumference *z*-score > 91st percentile; two slightly different CVD risk indices created based on number of scores that met risk cut-points among fasting glucose, insulin, HDL, LDL, triglycerides, diastolic blood pressure, and systolic blood pressure; paired *t* test, logistic regression, and χ^2.

j. Gunther et al. (2007) reported that animal protein intake at 5 to 6 years was related to adjusted mean body fat percentage (BF%) at age 7 years. BF% at 7 years was 16.8 for the lowest tertile of animal protein intake as a percentage of energy and 18.0 for the highest tertile.

Methods: Longitudinal cohort, 203 children studied from birth through age 7 years, 3-day weighed diet records, adjusted for sex, intake of total energy and fat as a percentage of energy, siblings in the dataset, firstborn status, maternal weight BMI≥25, and BF% at baseline. Authors present life-course plots of multiple linear regression analyses with BMI standard deviation (SD) score and the natural log of BF% at 7 years of age as the outcome.

k. Johnson et al. (2007) examined consumption of beverages at ages 5 and 7 years as predictors of fat mass at age 9 years, controlling for demographic and other dietary intake variables. Milk consumption at ages 5 and 7 predicted lower fat mass at age 9, but no effect was found for any of the remaining beverage categories, including sugar-sweetened beverages.

Methods: Longitudinal cohort; 1,432 British children from the Avon Longitudinal Study of Parents and Children, assessed at ages 5, 7, and 9 years; BMI and body fat mass (health examination); classification into normal weight or overweight based on IOTF age-and-sex specific BMI *z*-score cut-points; energy, macronutrient, and food servings (3-day food diary); beverages categorized into sugar-sweetened, low energy, fruit juice, milk, and water; family demographics (questionnaire completed by parent); linear regression.

l. Lappe et al. (2004) provided parents of 9-year-old female subjects with special credit cards to purchase calcium-rich foods, educated them on natural and fortified food sources of calcium, and advised them to consume at least 1,500 mg of calcium daily. Compared with controls, the subjects did not have greater increases in body weight, BMI, or fat or lean mass. (Mean calcium intakes were 1,656 mg for subjects and 961 mg for controls.) The results held when the data were grouped by tertile of calcium intake.

Methods: RCT, 50 girls, 3-day diet diaries once every 3 months for 2 years, DEXA used to estimate fat and lean mass.

m. Malik et al. (2006) reviewed 30 studies on intake of sugar-sweetened beverages (SSBs) and weight on children and adults published from 1966 to 2005. Of the 21 studies that included children or adolescents, 6 of 13 cross-sectional studies found a positive association between SSBs and weight gain and obesity, three suggested positive associations but the results were not statistically significant, three found no associations, and one had inconsistent findings (and adults). Four of 6 prospective studies of children found positive associations between intake of SSBs and greater overweight or obesity. A 3-y follow-up of more than 11,600 children found a 0.04 increase in BMI per daily serving of SSB ($P<0.01$). In one study, children who increased their soda consumption from the previous year by two or more servings gained weight (0.14 increase in boys, $P=0.01$ and 0.10 increase in girls, $P=0.046$). In one clustered RCT of 644 children over a school year there was a 0.7 mean greater consumption of soda (95% CI, 0.1, 1.3) and a

7,7% higher rate of overweight and obesity in control subjects. In the other RCT, decreasing SSB significantly reduced body weight in adolescents with BMI >30 (*see Ebbeling et al. summary).*

Methods: Qualitative assessment (review) of results from 21 studies on children and adolescents (13 were cross-sectional, 6 were prospective, and 2 were RCT interventions) since a meta-analysis was not possible due to heterogeneity in design, ages of participants, length of duration, and outcome measures. Most studies measured BMI, BMI percentiles, and SSB or soda consumption, some also assessed consumption of other beverages (milk, juice, water).

n. Must et al. (2005) tracked weight status and found that adult overweight was predicted by pre-menarchal overweight (OR = 7.70) and adult obesity was predicted by pre-menarchal overweight (OR = 4.30), but neither was predicted by early menarche. Similarly, four models predicting adult percent body fat showed that for age at menarche alone R^2 = .029 (i.e., essentially no predictive value), whereas for pre-menarchal BMI alone R^2 = .277, for both variables together R^2 = .284, and for both variables and the interaction R^2 = .284 (i.e., age at menarche added no predictive value to that contributed by pre-menarchal BMI).

Methods: Longitudinal cohort; 307 girls ages 9 to 10 years with complete data at adult follow-up at approximately 42 years of age; childhood data from Newton (Massachusetts) Girls Study, which involved annual assessments through approximately two years past menarche; BMI (health examination); for children, standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile) and overweight (>= 85th percentile); for adults, classification into normal weight (BMI < 25), overweight (BMI >= 25 & < 30), and obese (BMI >= 30); age at menarche (child self-report), classified as early (< 12 years) or not; percent body fat (adult body scan); logistic regression and linear regression.

o. Nader et al. (2006) tracked weight status and found that overweight at age 12 was predicted by overweight at any pre-school assessment (OR = 5.9) or any elementary school assessment (OR = 106.9). More specifically, overweight at age 12 was predicted by overweight at ages 5 (OR = 2.2), 7 (OR = 3.5), and 9 (OR = 6.5). And, obesity at age 12 was predicted by overweight at ages 5 (OR = 7.9), 7 (OR = 32.8), and 9 (OR = 57.5).

Methods: Longitudinal cohort; 1,042 children born in 1991 and retained in the study sample through age 12, with assessments every 1-2 years in between; data from NICHD Study of Early Child Care and Youth Development, with participants recruited from hospitals in 10 sites in the US; BMI (health examination); standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile), overweight (>= 85th & < 95th percentile), and obese (>= 95th percentile); logistic regression.

p. Rzehak and Heinrich (2006) tracked weight status and found that BMI *z*-scores increased with age, and that children with higher baseline scores had steeper increases with age. Girls had a higher growth rate than boys (.89 vs. .75 BMI per year), but there was no gender difference for overweight (OR = 1.08 per year for all) or obesity (OR = 1.11 per year for all).

<u>Methods</u>: Longitudinal cohort; 2,183 German children ages 5 to 13 years at baseline and 996 adults ages 17 to 25 years at third follow-up; data from Bitterfeld cohort study; BMI (health examination); classification into normal weight, overweight, or obese based on IOTF age-and-sex specific BMI *z*-score cut-points; longitudinal random effects modeling.

q. Skinner et al. (2004) reported that BMI at age 8 years was negatively predicted by age of adiposity rebound (AR, the age at which BMI increased following the lowest BMI) and positively predicted by BMI at 2 years. In separate regression models, mean protein and fat intakes from 2 to 8 years were positive predictors of BMI, and mean carbohydrate intake over this period was a negative predictor of BMI.

<u>Methods</u>: Longitudinal cohort, 70 children, 15 to 17 sets of growth and dietary data from ages 2 months to 8 years; beginning with the third year, mothers provided two nonconsecutive food records and one diet recall (averaged). AR determined visually and by consensus. Forward selection stepwise regression.

r. Striegel-Moore et al. (2006) found that milk consumption decreased and both regular and diet soda consumption increased over time, and that there were some differences between black and white girls with regard to changes in beverage consumption patterns over time. Across time, regular soda was the only beverage associated with BMI, and all beverages except diet soda were associated with increased intake of sugar.

<u>Methods</u>: Longitudinal cohort; 1,210 black girls and 1,161 white girls, ages 9 to 10 years, with follow-up through 18 to 19 years; 10 annual assessments; data from the NHLBI Growth and Health Study clinical sites in Berkeley, CA, Cincinnati, OH, and Rockville, MD; BMI (health assessment); beverage consumption and carbohydrate intake (3-day food diary); beverages classified into milk, regular soda, diet soda, fruit juice, fruit drinks, and coffee/tea; mixed linear model.

s. Tam et al. (2006) found that baseline median carbohydrate intake from soft drinks was higher among children who were overweight at follow-up than among those who were of normal weight at both points in time (30 g vs. 20 g), but there were no parallel group differences with regard to fruit juice or milk consumption.

<u>Methods</u>: Longitudinal cohort; 281 children age 7 years who were followed up at age 13 years; data from the Australian (Sydney) Nepean Study; BMI (health examination); classification into normal weight or overweight based on IOTF age-and-sex specific BMI *z*-score cut-points; beverage consumption and carbohydrate intake at baseline (3-day food diary); beverages classified into fruit juice or fruit drink, sugar-sweetened soft drink, and milk; one way ANOVA.

t. te Velde et al. (2007) reported tracking coefficients of 0.33 for fruit intake and 0.27 for vegetable intake for males and females between the ages of 12 and 36 years. Fruit intake was not associated with BMI. BMI and the sum of skinfold thickness for women were significantly higher for women (but not for men) in the lowest quartiles of vegetable intake.

  <u>Methods</u>: Longitudinal cohort, 168 subjects, relatively homogeneous Dutch population, detailed cross-check dietary history interview. Logistic, generalized estimating equations and time-lag and autoregression models.

u. Thompson et al. (2007) tracked weight status and found that rates of overweight increased through adolescence, and that girls who were overweight were much more likely to be obese as young adults (OR = 14.5 at age 9 & OR = 30.3 at age 18). As adolescents, across ages, overweight was associated with unhealthful systolic blood pressure (>= 95th percentile; OR = 10.0), diastolic blood pressure (>= 95th percentile; OR = 3.0), triglycerides (OR = 3.3), and HDL (OR = 6.3), but not LDL.

  <u>Methods</u>: Longitudinal cohort; 1,166 white girls and 1,213 black girls, ages 9 to 10 years, with follow-up through ages 18 to 19 years; 10 annual assessments and follow-up phone interview at ages 21 to 23 years; data from the NHLBI Growth and Health Study clinical sites in Berkeley, CA, Cincinnati, OH, and Rockville, MD; BMI and blood pressure (health assessment); for children, standard CDC classification based on BMI percentile by age and sex into non-overweight (< 95th percentile) and overweight (>= 95th percentile); for adults, classification into non-obese (BMI < 30) and obese (BMI >= 30); unhealthful triglycerides (>= 130 mg/dL), LDL (> 130 mg/dL), and HDL (< 50 mg/dL; fasting blood test); logistic regression.

v. Welsh et al. (2005) found that children who were at risk for overweight at baseline who consumed 3+ sweet drinks per day (vs. <1 drink/day) were more likely to become overweight by the follow-up (OR = 1.8), and children who were overweight at baseline who consumed 3+ sweet drinks per day (vs. <1 drink/day) were more likely to still be overweight at the follow-up (OR = 1.8).

  <u>Methods</u>: Longitudinal cohort; 10,904 children ages 2-3 years, who were enrolled in the Missouri WIC Program, with a 1-year follow-up; data from the Missouri Pediatric Nutrition Surveillance System and the Missouri Demonstration Project; BMI (health examination); standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile), at risk for overweight (>= 85th percentile & < 95th percentile), and overweight (>= 95th percentile); Harvard Food Frequency Questionnaire (maternal proxy; baseline); analyzed for sweet drinks (fruit or soda), high-fat foods, sweet foods and total energy intake; logistic regression.

Dietary patterns

a. Kvaavik et al. (2005) found the tracking of sugar-sweetened carbonated soft drink intake from adolescence to early adulthood (25 years) and from early adulthood to later adulthood (33 years) was moderate to high, while the tracking from adolescence to later adulthood was low. The frequency of sugar-sweetened carbonated soft drink intake was lower among 25-year-olds who reported a lower soft drink intake at age 15 years compared to those who reported a high intake at age 15 years. Among women, the mean soft drink intake at 25 years of age was 2.5 times per week for those reporting previous day intake at age 15 years compared to 1.6 times per week for those reporting that they did not drink soft drinks in the previous day at age 15 years (*P*=0.029). For men, 15-year-old seldom drinkers had an average of 2.8 drinks in the past week at age 25 years compared to a mean intake of 4.2 times per week at age 25 years for those who reported previous day intake at age 15 years (*P*=0.004).

Methods: Longitudinal cohort on 422 Norwegians from adolescence to early and later adulthood. At age 15 years (baseline), height and weight measured and two questions on frequency of carbonated soft drink intake with 3 response categories. At age 25 years, one question on frequency of sugar sweetened carbonated soft drinks with 5 response categories. At age 33 years, a semi-quantitative FFQ on whole diet, including sugar-sweetened carbonated soft drink intake, with 10 frequency response categories, and self-reported height and weight. Unpaired t-test and Pearson's bivariate correlation coefficient used in tracking analysis.

b. Li and Wang (2008) found tracking of dietary intake patterns (remained in same quartile at baseline and at one year follow-up) over a one-year period, particularly for energy intake, fat, calcium, vegetables and fruits, snack foods, and Western dietary pattern (r = .4 to .6). Overweight adolescents were more likely to reduce intake of energy (OR = .32) and snack foods (OR = .16).

Methods: Longitudinal cohort; 181 low-income black adolescents ages 10 to 14 years, with a one-year follow-up; assessment of dietary intake, including nutrients and food groups, from YAQ FFQ; BMI (health examination); used principal components analysis to identify dietary patterns (Western vs. Eastern vs. dairy); standard CDC classification based on BMI percentile by age and sex into normal weight (< 85th percentile), at risk for overweight (>= 85th percentile & < 95th percentile), and overweight (>= 95th percentile); ANOVA, Spearman correlation, and logistic regression.

c. Niemeier et al. (2006) found that from adolescence to adulthood, consumption of fast food increased (2.15 to 2.48 days in the previous week), consumption of breakfast decreased (4.34 to 3.09 days in the previous week), and overweight prevalence increased (28.7% to 47.0%). An increased BMI *z*-score in adulthood was predicted by greater days of fast food consumption in adolescence, fewer days of breakfast consumption in adolescence, and a decrease in breakfast consumption between adolescence and adulthood.

Methods: Longitudinal cohort; 9,919 adolescents who participated in Wave II (ages 11 to 21 years) of the National Longitudinal Study of Adolescent Health, who also participated as adults in Wave III (ages 18 to 27 years); BMI (health examination); maternal obesity (parental report); fast food consumption and breakfast consumption each assessed by single self-report items regarding number of days in the past week had eaten fast food or breakfast; for adolescents, classification into normal weight, overweight, or obese based on IOTF age-and-sex specific BMI *z*-score cut-points; for adults classification into normal weight (BMI < 25), overweight (BMI >= 25 & < 30), and obese (BMI >= 30); *t* test and linear regression.

TRACKING

#	Citation: Author	Citation: Title	Article ID	Population Studied	Study Design: Systematic Review or Meta-Analysis	Study Design: Controlled Trials	Study Design: Observational (cohort, case control, cross sectional)	Tracking: Behavior effect on biologic/ health outcome	Tracking: Behavior effect on behavior	Tracking: Biologic/ health status on biologic/ health outcome	Tracking: Early to later childhood	Tracking: Childhood to adulthood
1	Alexy et al. 2005	Long-term protein intake and dietary potential renal acid load are associated with bone modeling and remodeling at the proximal radius in healthy children	2	229 children & adolescents 6-18 y/o			cohort (longitudinal)	X			X	
2	Alexy et al. 2004	Pattern of long-term fat intake and BMI during childhood and adolescence--results of the DONALD Study	3	228 2-18 y/o in the Dortmund Nutritional Anthropometric Longitudinally Designed Study			cohort (longitudinal)	X			X	
3	Baker et al. 2007	Childhood body-mass index and the risk of coronary heart disease in adulthood	7	276,835 Danish schoolchildren w/height and wt measurements			cohort (longitudinal)			X		X
4	Barton et al. 2005	The relationship of breakfast and cereal consumption to nutrient intake and body mass index: the National Heart, Lung, and Blood Institute Growth and Health Study	9	At baseline, 2,379 9-10 y/o girls (1,166 white, 1,213 AA) from Berkeley, CA; Cincinnati, OH; and Washington, DC. Participants from NHLBI Growth and Health Study. F/up at 19 y/o			cohort (longitudinal)			X	X	
5	Blum et al. 2005	Beverage consumption patterns in elementary school aged children across a two-year period	11	164 children			cohort (longitudinal)	X			X	
6	Bounds et al. 2005	The relationship of dietary and lifestyle factors to bone mineral indexes in children	13	52 healthy white children studied from 2 mo to 8 y/o (25 M, 27 F) and their mothers			cohort (longitudinal)	X			X	
7	Crimmins et al. 2007	Stability of adolescent body mass index during three years of follow-up	18	1,746 adolescents in school-based study			cohort (longitudinal)			X	X	

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	Author	**Title**	**Article ID**		**Systematic Review or Meta-Analysis**	**Controlled Trials**	**Observational (cohort, case control, cross sectional)**	**Behavior effect on biologic/ health outcome**	**Behavior effect on behavior**	**Biologic/ health status on biologic/ health outcome**	**Early to later childhood**	**Childhood to adulthood**
8	Deshmukh-Taskar et al. 2006	Tracking of overweight status from childhood to young adulthood: the Bogalusa Heart Study	23	841 19-35 y/o (68% Euro-Americans, 32% African-Americans) who also did a survey at 9-11 y/o			cohort (longitudinal) created from cross sectional surveys			X		X
9	Dubois et al. 2007	Regular sugar-sweetened bvg consumption between meals increases risk of overweight among preschool-aged children	25	Representative sample of infants from Quebec, Canada born in 1998 (n= 2,103) and a subsample of 1,944 4-5 y/o children			cohort (longitudinal)	X			X	
10	Dugmore & Rock 2004	A multifactorial analysis of factors associated with dental erosion	26	1,149 12 y/o (out of 1,753 randomly sampled at baseline) w/usable data; f/up at 14 y/o			cohort (longitudinal)	X			X	
11	Evers et al. 2007	Persistence of overweight among young children living in low income communities in Ontario	28	760 jr kindergarteners-3rd graders; from economically disadvantaged communities in Ontario, Canada in the Better Beginnings, Better Futures project.			cohort (longitudinal)			X	X	
12	Fiorito et al. 2006	Girls' Calcium Intake Is Associated with Bone Mineral Content During Middle Childhood	29	151 non-Hispanic white girls			cohort (longitudinal)	X			X	
13	Fisher et al. 2004	Meeting calcium recommendations during middle childhood reflects mother-daughter beverage choices and predicts bone mineral status	30	192 5, 7, 9 y/o non-Hispanic white girls and mothers			cohort (longitudinal)	X			X	
14	Flaherman & Rutherford 2006	A meta-analysis of the effect of high weight on asthma	31	Children	X		cohort studies (12)	X			X	
15	Frazier et al. 2004	Adolescent diet and risk of breast cancer	33	47,355 participants in the Nurses Health Study II			cohort (retrospective)	X				X

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16	Freedman et al. 2005	The relation of childhood BMI to adult adiposity: the Bogalusa Heart Study	34	2,610 2-17 y/o (baseline); f/up age 18-37 y/o from Bogalusa Heart Study (1973-1996)			cohort (longitudinal)			X		X
17	Garnett et al. 2007	Body mass index and waist circumference in midchildhood and adverse cardiovascular disease risk clustering in adolescence	37	342 8 y/o at baseline. 290 15 y/o at f/up.			cohort (longitudinal)	X			X	
18	Guerra et al. 2007	Three-year tracking of fatty acid composition of plasma phospholipids in healthy children	39	26 children; enrolled at birth, tracked to 5 y/o			cohort (prospective)			X	X	
19	Gunther et al. 2007	Early protein intake and later obesity risk: Which protein sources at which time points throughout infancy and childhood are important for body mass index and body fat percentage at 7 years of age?	40	203 6 mo-7 y/o in the Dortmund Nutritional and Longitudinally Designed Study who had diet information			cohort (longitudinal)	X			X	
20	Harris et al. 2004	Risk factors for dental caries in young children: a systematic review of the literature	41	6 y/o and younger	X	inter-ventional studies (7)	cross sectional (43), cohort (19) case control (8)	X			X	
21	Johnson et al. 2007	Is sugar-sweetened bvg consumption associated with increased fatness in children?	45	subsample of British children from the Avon Longitudinal Study of Parents and Children; enrolled at 5 y/o (n = 521) and 7 y/o (n = 682) ; assessed at 9 y/o			cohort (longitudinal)	X			X	

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22	Kvaavik et al. 2005	The stability of soft drinks intake from adolescence to adult age and the association between long-term consumption of soft drinks and lifestyle factors and body weight	48	15 year olds in Oslo Norway Youth study, with follow-up at 25 and 33 years old			cohort (longitudinal)		X			X
23	Lanou et al. 2005	Calcium, dairy products, and bone health in children and young adults: a reevaluation of the evidence	49	1-25 y/o	X	RCT (13)	cross-sectional (22); retrospective (13), and longitudinal prospective studies (10)	X			X	X
24	Lappe et al. 2004	Girls on a high-calcium diet gain weight at the same rate as girls on a normal diet: a pilot study	50	59 9 y/o girls in metropolitan Omaha, NE communities		RCT		X			X	
25	Levine et al. 2007	Dietary patterns, toothbrushing habits and caries experience of schoolchildren in West Yorkshire, England	52	437 7-11 y/o selected from 6 (or 18?) schools over a wide geographic area who had consent and all dietary data. F/up 4 yrs later.			cohort (longitudinal)	X			X	
26	Li & Wang 2008	Tracking of dietary intake patterns is associated with baseline characteristics of urban low-income African-American adolescents	53	181 low-income African-American adolescents			cohort (longitudinal)	X	X		X	
27	Malik et al. 2006	Intake of sugar-sweetened beverages and weight gain: a systematic review	56	Children and adults	X	5 exper-imental studies	15 cross-sectional, 10 prospective	X			X	X
28	Moore et al. 2006	Low dairy intake in early childhood predicts excess body fat gain	61	99 of 106 families in Framingham Children's Study w/a 6 y/o at baseline, followed to 13 y/o			cohort (longitudinal)	X			X	

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	Author	Title			Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
29	Moore et al. 2005	Intake of fruits, vegetables, and dairy products in early childhood and subsequent blood pressure change	62	95 children in Framingham study enrolled when 3-6 y/o			cohort (prospective)	X			X	
30	Morrison et al. 2008	Metabolic syndrome in childhood predicts adult metabolic syndrome and type 2 diabetes mellitus 25 to 30 years later	63	5-19 y/o NHLBI Lipid Research Clinics and 30-48 y/o in Princeton Prevalence Study (1973-1976) and the Princeton Follow-up Study (2000-2004)			cohort (prospective)			X		X
31	Morrison et al. 2005	Development of the Metabolic Syndrome in Black and White Adolescent Girls: A Longitudinal Assessment	64	Black and white girls 9-10 y/o and 18-19 y/o from 2 centers in NHLBI Growth and Health Study			cohort (longitudinal)			X	X	
32	Must et al. 2005	Childhood overweight and maturational timing in the development of adult overweight and fatness: the Newton Girls Study and its follow-up	65	307 women w/ child wt data out of 448 in the 30 yr f/up to the Newton Girls Study (mean age 42.1 y/o, SD 0.76)			cohort (prospective)			X		X
33	Nader et al. 2006	Identifying risk for obesity in early childhood [erratum in Pediatrics 2006 Nov;118(5):2270]	66	1,042 healthy US children from 10 locations born in 1991 from NICHD Study of Early Child Care and Youth Development			cohort (longitudinal)			X	X	
34	Niemeier et al. 2006	Fast Food Consumption and Breakfast Skipping: Predictors of Weight Gain from Adolescence to Adulthood in a Nationally Representative Sample	67	9,919 adolescents in waves II (11–21 y/o) and III (18–27 y/o) of the National Longitudinal Study of Adolescent Health			cohort (prospective)	X				X

#	Citation			Population Studied	Study Design			Tracking				
	Author	Title	Article ID		Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
35	Niinikoski et al. 2007	Impact of repeated dietary counseling between infancy and 14 years of age on dietary intakes and serum lipids and lipoproteins: the STRIP study	68	intervention group 7 mo old infants (n=540) and control children (n=522) from Special Turku Coronary Risk Factor Intervention Project (STRIP); 7 mo olds followed for 14 yrs		random-ized inter-vention		X			X	
36	Rzehak & Heinrich 2006	Development of relative weight, overweight and obesity from childhood to young adulthood. A longitudinal analysis of individual change of height and weight	80	2,183 5-25 y/o (5-13 y/o at baseline); 12 yrs of f/up using surveys in 1992-93, 1995-96, 1998-99 and 2004-05 in 3 areas of Germany			cohort (longitudinal)			X	X	X
37	Skinner et al. 2004	Predictors of children's body mass index: a longitudinal study of diet and growth in children aged 2-8 y	84	70 white, middle/upper SES children (37 M, 33 F) participating in longitudinal study from 2-9 y/o			cohort (longitudinal)	X		X	X	
38	Striegel-Moore et al. 2006	Correlates of beverage intake in adolescent girls: the National Heart, Lung, and Blood Institute Growth and Health Study	90	9-19 y/o black (n=1,210) & white (n=1,161) girls in the National Heart, Lung, and Blood Institute Growth and Health Study			cohort (longitudinal)	X			X	
39	Tam et al. 2006	Soft drink consumption and excess weight gain in Australian school students: results from the Nepean study	93	268 children (136 males) from Sydney, Australia. Mean/SD age = 7.7+/-0.6 y/o			cohort (longitudinal)	X			X	
40	te Velde et al. 2007	Tracking of fruit and vegetable consumption from adolescence into adulthood and its longitudinal association with overweight	94	168 12 y/o boys and girls tracked over 24 yrs			cohort (longitudinal)	X				X

#	Citation		Article ID	Population Studied	Study Design			Tracking				
	Author	Title			Systematic Review or Meta-Analysis	Controlled Trials	Observational (cohort, case control, cross sectional)	Behavior effect on biologic/ health outcome	Behavior effect on behavior	Biologic/ health status on biologic/ health outcome	Early to later childhood	Childhood to adulthood
41	Thompson et al. 2007	Childhood overweight and cardiovascular disease risk factors: the National Heart, Lung, and Blood Institute Growth and Health Study	95	1,166 Caucasian and 1,213 African-American girls ages 9-23 y/o in NHLBI Growth and Health Study.			cohort (longitudinal)			X	X	X
42	van der Pols et al. 2007	Childhood dairy intake and adult cancer risk: 65-y follow-up of the Boyd Orr cohort	97	4,383 out of 4,999 children in England and Scotland in study of family fd consumption btw 1937-1939 (770 registered w/ cancer btw 1948-2005)			cohort (retro-spective)	X				X
43	Vatanparast et al. 2005	Positive effects of vegetable and fruit consumption and calcium intake on bone mineral accrual in boys during growth from childhood to adolescence: the University of Saskatchewan Pediatric Bone Mineral Accrual Study	99	85 boys & 67 girls 8-20 y/o, Canadian			cohort (longitudinal)	X				X
44	Viikari et al. 2004	Risk factors for coronary heart disease in children and young adults	100	2 ongoing studies in Finland: 1) 3,596 3-18 y/o and f/up in 2,264 24-39 y/o in Cardiovascular Risk in Young Finns study, 2) 1,062 7 mo old - 7 y/o in Special Turku Coronary Risk Factor Intervention Project for Children (STRIP)		RCT (STRIP)	cohort (longitudinal)	X		X		X
45	Welsh et al. 2005	Overweight among low-income preschool children associated with the consumption of sweet drinks	103	10,904 children 2-3 y/o			cohort (retro-spective)	X			X	

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