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PATTERNS OF BEVERAGE CONSUMPTION ASSOCIATED
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PATTERNS OF BEVERAGE CONSUMPTION ASSOCIATED WITH ADOLESCENT OBESITY IN THE U.S.

By

Debra Rose Keast

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ABSTRACT

PATTERNS OF BEVERAGE CONSUMPTION
ASSOCIATED WITH ADOLESCENT OBESITY IN THE U.S.

By

Debra Rose Keast

The aims of this cross-sectional study were to examine the associations of beverages with meal occasions; and to examine associations of beverage patterns with dietary intake, sociodemographic/lifestyle factors, BMI percentile, percent body fat and overweight/risk for overweight. Subjects were adolescents age 12-16 years (n=1,872) in the Third National Health and Nutrition Examination Survey (NHANES III, 1988-94).

BMI percentile and overweight/risk for overweight were determined from measured BMI using CDC Growth Charts, and percentage body fat from two skinfold measurements. Youth were classified by their 'typical' beverage pattern using the 'share' method to identify the combination of beverage types (i.e., milk, juice and/or sugar-sweetened soft drinks/fruit drinks) each reported frequently (i.e., beverage frequency 'share' ≥25% total beverage frequency) in a food frequency questionnaire. The percentage of beverage occasions that were breakfast, lunch, dinner or snack, and mean nutrient intakes of beverage groups were estimated using 24-hr recall data. Chi-square tests were used to examine associations of sociodemographic/lifestyle factors with beverage patterns. Crude and adjusted associations of beverage patterns with body weight and body fat were examined by estimating least-square (LS) mean BMI percentile and percentage body fat, as well as the odds ratios for overweight/risk for overweight.

Energy intakes did not differ, but 'sugar-sweetened beverages' groups had higher added sugars and lower calcium intakes than 'milk' groups. Youth drank milk and juice most frequently with breakfast, while sugar-sweetened beverages were consumed most frequently at the snack occasion. A greater percentage of the 'milk & juice' group than the 'sugar-sweetened beverages' group ate breakfast every day (57% *vs.* 21%), exercised daily (35% *vs.* 28%), played on ≥3 sports teams (37% *vs.* 16%), and watched TV ≤1 hour/day (39% vs. 20%), while less watched TV ≥4 hours/day (34% *vs.* 10%). Beverage patterns were also associated with income and other indicators of SES ($p<0.01$).

Both BMI percentile and percent body fat were lower in the 'milk & juice' group than in the 'other beverages (diet soft drinks, coffee, tea)' group, and BMI percentile was higher in the 'sugar-sweetened beverages' group than in the 'milk & juice' group, in unadjusted models. Overweight/risk for overweight was low in the 'milk & juice' group (OR=0.52, 95% CI = 0.28-0.96), and high in the 'other beverages' group (OR=2.74, 95% CI = 1.12-6.68), compared to the 'milk' group. Adjusted associations of 'milk & juice' with obesity outcomes were significant in most models, except those adjusted for SES, physical activity or TV watching. 'Sugar-sweetened beverages' was not associated with BMI percentile in models adjusted for SES or TV watching. Effects of 'other beverages' were not significant in models adjusted for youth who were trying to lose weight.

This study suggests that the 'milk & juice' pattern was correlated with breakfast and physical activity, while the 'sugar-sweetened beverages' pattern was correlated with snacks and watching TV. SES, lifestyle factors and beverage patterns were inter-related, and all were associated with adolescent obesity. Results suggest youth eat breakfast daily, reduce soft drink intake, and limit TV watching to reduce the risk for overweight.

Dedicated to my three children, Matthew, Sandra, and Richard, who inspired me as they have grown through their adolescent years to become awesome, young individuals

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KEY TO SYMBOLS OR ABBREVIATIONS

AAP	American Academy of Pediatrics
AI	Adequate Intake
ARS	Agricultural Research Service
CDC	Centers for Disease Control and Prevention
CSFII	Continuing Survey of Food Intake by Individuals
BMI	Body Mass Index
CVD	Cardiovascular disease
DFE	Dietary Folate Equivalent
DHHS	Department of Health and Human Services
DRI	Dietary Reference Intake
EAR	Estimated Average Requirement
EGCG	Epigallocatechin gallate
FDA	Food and Drug Administration
FFQ	Food Frequency Questionnaire
GTE	Green tea extract
IOM	Institute of Medicine of the National Academy of Sciences
MEC	Mobile Examination Center
MSJ	'All caloric beverages' pattern
MSj	'Milk & sugar-sweetened beverages' pattern
MsJ	'Milk & juice' pattern
Msj	'Milk' pattern
mSJ	'Sugar-sweetened beverages & juice' pattern

mSj	'Sugar-sweetened beverages' pattern
msJ	'Other beverages & juice' pattern
msj	'Other beverages' pattern
NCHS	National Center for Health Statistics
NFCS	Nationwide Food Consumption Surveys
NHANES	National Health and Nutrition Examination Surveys
NHLBI	National Heart, Lung, and Blood Institute
NRC	National Research Council
RAE	Retinol Adjusted Equivalent
SMA	Sexual maturation
USDA	U.S. Department of Agriculture
WC	Waist circumference
WHR	Waist-hip ratio
YRBS	Youth Risk Behavior Survey

Chapter 1

INTRODUCTION

The prevalence of overweight among adolescents has been steadily increasing over the past three decades in the U.S. Among adolescents age 12-19 years, the current prevalence rate of 17.4% is more than three times higher than the rate of 5.0% observed 30 years ago (Ogden et al., 2002; Hedley et al., 2004; Ogden et al., 2006). Intakes of soft drinks have also increased dramatically over the same time period (Cavadini et al., 2000a; French et al., 2003; Nielsen & Popkin, 2004). In 1994-96, 1998, added sugars intake from soft drinks and other sugar-sweetened beverages was 52.6% of the total amount of added sugars consumed by boys, and 48.5% for girls aged 12-17 years, while the total added sugars intake was 20% of total energy in both boys and girls (Guthrie & Morton, 2000). Some researchers have suggested that consumption of sugar-sweetened beverages is related to the high prevalence of overweight in youth (Harnack et al., 2000; Bray et al., 2004).

Consumption of milk has declined among children and adolescents simultaneously with the increased intake of sugared beverages (Morton & Guthrie, 1998; Moshfegh et al., 2000; Enns et al., 2002; Enns et al., 2003). Further, an inverse relationship between calcium and adiposity has been hypothesized (Zemel et al., 2000), which suggests that low fat milk intakes of youth might be inversely correlated with body fat. Age was associated with decreased intakes of milk and increased intakes of soft drinks, especially in girls (Lytle et al., 2000; Bowman et al., 2002; Forshee & Storey, 2003). If intakes of milk are low and soft drink intakes are high in adolescents compared to children of younger age groups, then the low calcium intakes combined with excess calories from intakes of sugar-sweetened beverages might be associated with the prevalence of overweight in adolescents.

Several prospective studies (Ludwig et al., 2001; Berkey et al., 2004) and intervention studies (James et al., 2004; Ebbeling et al., 2006) have shown an association between soft drinks and weight gain in youth, although cross-sectional studies examining sugar-sweetened beverage consumption in relation to Body Mass Index (BMI) or overweight status have had inconsistent results (Forshee & Storey, 2003; Forshee et al., 2004; Boumtje et al., 2005). Cross-sectional studies using the Continuous Survey of Food Intake by Individuals (CSFII) or National Health and Nutrition Examination Survey (NHANES) data (Forshee & Storey, 2003; Forshee et al., 2004; Boumtje et al., 2005) might have been limited by inaccurate assessment of beverage consumption due to under-reporting (Bandini et al., 1990; Johnson, 2000; Subar et al., 2003) or intra-individual variation in intake (Beaton et al., 1979; Sempos et al., 1985). The current study also used NHANES data, but beverage intakes were assessed using a food frequency questionnaire (FFQ) rather than the 24-hour recall to address intra-individual variation, and a method for defining beverage patterns was developed to address under-reporting of intakes.

Cross-sectional studies using the CSFII data to examine the association of beverage intakes with BMI or overweight in adolescents (Forshee & Storey, 2003; Boumtje et al., 2005) were limited in that self-reported information rather than measured height and weight were used to compute BMI (Kuczmarski et al., 2001; Brener et al., 2003). In addition, analyses of children or adolescents that examined BMI in relation to beverage intakes (Forshee & Storey, 2003; Forshee et al., 2004) were limited, because BMI was not adjusted for gender and age using the CDC Growth Charts reference data

(Kuczmarski et al., 2000; Bachman et al., 2006). In the current study, BMI percentile was calculated from measured height and weight using the gender-specific BMI-for-age percentile reference data provided by the CDC Growth Charts, because criteria based on the BMI-for-age percentiles were recommended to assess overweight/risk for overweight in children and adolescents (Kuczmarski et al., 2000). In addition, percentage body fat was determined from summed triceps and subscapular skinfold measurements (Slaughter et al., 1988), because BMI does not accurately assess body composition, e.g., overweight youth with a high proportion of lean body mass are not overfat (Forbes, 1987).

Conceptual Model

Lifestyle behaviors, such as watching TV and fast food restaurant use, might be associated with food and beverage choices that lead to excess energy intake (Coon et al., 2002; French et al., 2001b). TV watching might be associated with physical inactivity as well (Forshee et al., 2004), and all might contribute to energy imbalance, weight gain, and obesity in youth (Bray & Champagne, 2005). Soft drinks are frequently consumed while snacking and watching TV (Coon et al., 2001; Giammattei et al., 2003; Matheson et al., 2004; Phillips et al., 2004), and with meals eaten at fast food restaurants (French et al., 2001b; Bowman et al., 2004). Youth who are characterized by beverage patterns that include sugar-sweetened beverages might be more overweight than other youth because of the energy intakes contributed by these beverages (Harnack et al., 1999; Troiano et al., 2000; Bowman, 2002), or because of the energy intakes contributed by snack foods and fast foods typically consumed with sugar-sweetened beverages (Hampl et al., 2003; Utter et al., 2003; Bowman et al., 2004; Phillips et al., 2004). A model is needed to address the complexity of these relationships.

The conceptual model in **Figure 1** shows the beverage consumption pattern being hypothetically determined by the meal context in which beverages are consumed. If beverage choice is dependent upon the meal occasion (e.g., breakfast, lunch, dinner, snack) and meal location (e.g., home or places away from home such as school or a fast food restaurant), then the beverage pattern can be a marker for the lifestyle variables that determine the frequency with which that meal context occurs for youth. If milk and 100% fruit juice were frequently consumed at breakfast, a habit of eating breakfast regularly might determine whether youth are classified as milk and 100% fruit juice consumers. If sugar-sweetened beverages were frequently consumed at fast food restaurants and as snacks, fast food restaurant use and TV watching might determine whether youth are classified as sugar-sweetened beverage consumers. In turn, youth classified by beverage patterns associated with fast food restaurant use or snacking behavior might then have higher energy, fat, sugar, and lower calcium intakes from beverages and from the total diet, compared to youth classified by beverage patterns associated with breakfast consumption. Energy intake is the mediator between beverage patterns and obesity. The model shown in **Figure 1** depicts the interrelationships of the study aims described next.

Specific Aims

The current dissertation research used data from NHANES III, 1988-94, in a cross-sectional analysis to examine beverage patterns and other potential risk factors for

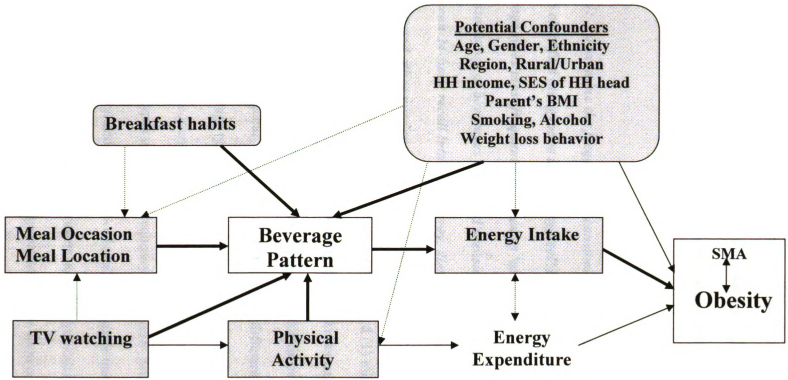

Figure 1. Conceptual model for the association of beverage patterns with obesity

overweight in youth age 12-16 years in the U.S. The overall goal of this research was to examine the association of beverage patterns with adolescent obesity (i.e., overweight and adiposity). The associations of beverage patterns with nutritional, sociodemographic and lifestyle risk factors for overweight were also examined. The following were the three (3) specific aims of this study.

Aim 1: To examine the frequency of consuming beverage types, and the percentage of youth classified into groups by their 'typical' beverage pattern (i.e., the combination of beverage types most frequently reported as 'usual' intake using a FFQ); to examine the association of beverages with meal occasions and meal locations; and to examine the mean 24-hour recall intake of energy, dietary fat, total sugars, added sugar, calcium and other nutrients in beverage pattern groups.

Four main types of beverages examined included (1) milk and milk drinks, (2) 100% fruit juice (3) sugar-sweetened beverages (fruit drinks and regular soft drinks) and (4) other beverages (diet soft drinks, coffee/tea and alcoholic beverages). Youth were classified by their 'typical' beverage pattern using two different methods to identify the combination of beverage types (i.e., milk, juice and/or sugar-sweetened beverages) that were each reported frequently in the FFQ. Criteria to identify the most frequently consumed beverage types using the 'frequency' and 'share' methods, respectively, were frequency ≥1 time/day, and share ≥25% of total beverage frequency.

Mean energy, dietary fat, total sugars, added sugar, calcium and other nutrient intake (in the 24-hour recall) of beverage pattern groups were compared to examine the association of beverage patterns with energy and nutrient intake. The beverage pattern groups' mean intake of water (ounces) and mean intakes of milk, 100% fruit juice, sugar-sweetened beverages, other beverages (e.g., diet soft drinks, coffee/tea and alcoholic beverages) (times/day), in both the FFQ and 24-hour recall, were also examined. The 24-hour recall data were used to examine mean beverage frequency at meals (e.g., breakfast, lunch, dinner/supper and snacks) consumed at-home or at places away-from-home (e.g., school, fast food restaurants).

Aim 2: To examine the distributions of sociodemographic and lifestyle characteristics that are risk factors for overweight among beverage pattern groups defined above in Aim 1.

Youth were classified into groups by their 'typical' beverage pattern using the 'share' method (i.e., share ≥25% total beverage frequency) to identify the combination of beverage types (e.g., milk, 100% fruit juice and sugar-sweetened beverages) most frequently reported as 'usual' intake in the FFQ. To identify risk factors for overweight, the prevalence of overweight/risk for overweight (i.e., BMI ≥85^{th} percentile of BMI-for-age) was estimated for youth classified by each sociodemographic/lifestyle characteristic. To examine the distributions of risk factors for overweight, the percentage of each beverage pattern group classified by each sociodemographic/lifestyle characteristic was estimated, and the percentage of each beverage pattern group classified by weight status (e.g., underweight, normal, at risk for overweight, overweight) was estimated as well. Sociodemographic factors examined were gender, age, race-ethnicity, region, urbanization, parental overweight/obesity, household income and other indicators of social economic status (SES). Lifestyle factors included smoking, alcohol use, weight loss behavior, physical activity (i.e., exercise and team sports participation), TV watching, frequency of breakfast consumption, and type of milk (e.g., whole, 2%, 1%, skim) usually consumed.

Aim 3: To examine the association of adolescent obesity with the beverage pattern groups defined above in Aim 1, adjusted for potential covariates of interest.

Indicators of obesity (i.e., overweight and adiposity) examined separately included BMI percentile, percentage body fat as assessed by skinfold measurements, and overweight/risk for overweight (i.e., BMI ≥85th percentile of BMI-for-age). Youth were classified into groups by their 'typical' beverage pattern using the 'share' method (i.e., share ≥25% total beverage frequency) to identify the combination of beverage types (e.g., milk, 100% fruit juice and sugar-sweetened beverages) most frequently reported as 'usual' intake in the FFQ. In addition to beverage pattern groups, other beverage variables considered in analyses were fluid ounces of water and type of milk (e.g., whole, 2%, 1%, skim) usually consumed. Covariates considered in analyses were gender, age, race-ethnicity, stages of sexual maturation, region, urbanization, parental overweight/ obesity, SES indicators, smoking, alcohol use, weight loss behavior, exercise, team sports participation and TV watching. Covariates were examined separately one at a time to investigate whether each one might potentially confound the relationship between beverage patterns and overweight/adiposity.

Chapter 2

REVIEW OF THE LITERATURE

The purpose of this review is to describe the concurrent trends in adolescent obesity and concomitant factors, such as beverage consumption, and to describe prior investigations of the hypothesized relationship between beverages and overweight in youth. The review of the literature begins with a description of how the prevalence of adolescent obesity in the U.S. has been increasing since the late 1970's (Ogden et al., 2002). Many overweight and obese[1] adolescents remain so throughout adulthood.

Obesity-related health conditions affecting young age groups have an increased lifetime burden, thus an understanding of the risk factors associated with adolescent obesity is important to public health. Potential risk factors for obesity include socio-demographic variables, as well as lifestyle variables, such as physical activity and dietary intake. Beverage intakes are also correlated with lifestyle variables that affect dietary quality and the risk for obesity, such as TV watching, fast food restaurant use and breakfast consumption, thus a short review of these factors is included. Next, the types of beverages consumed by youth are discussed, because each one is either positively or inversely associated with body weight or body fat. This review concludes by describing why the dataset that was selected to investigate the relationship between beverage patterns and obesity in adolescents is appropriate for this analysis. As each section is

[1] The terms overweight and obesity are used interchangeably in this review. Overweight is defined by the Centers for Disease Control and Prevention (CDC) reference criteria for children aged 2-19 years based on age- and sex-specific percentiles for body mass index (BMI) (Kuczmarski et al., 2000). In a recent report from the Institute of Medicine (Koplan et al., 2005), "obesity" in children and adolescents referred to a BMI $\geq 95^{th}$ percentile. By late adolescence, the 95^{th} percentile is approximately 30 kg/m^2, the BMI criteria used to define obesity in adults age 20 years and older (NHLBI, 1998).

related to the research proposal, justifications for aspects of the analysis plan are provided as appropriate throughout the literature review.

A. Adolescent obesity

1. Secular trends in the prevalence of adolescent obesity in the U.S.

The CDC has been tracking the prevalence of overweight among children and adolescents age 2-5, 6-11 and 12-19 years by monitoring trends in the percentage of youth whose Body Mass Index (BMI) exceeds the reference percentiles of BMI-for-age. The subjects of the current study, adolescents age 12-16 years, were a subgroup of the latter age group of youth for which national survey data is available, therefore this section describes the trends among those aged 12-19 years.

The prevalence of overweight among adolescents age 12-19 years has been steadily increasing over the past three decades in the United States. Recent NHANES data indicated that in 1999-2002, 30.9% of adolescents age 12-19 years had a BMI $\geq 85^{th}$ percentile, and 16.1% had a BMI $\geq 95^{th}$ percentile (Hedley et al., 2004). The latest figures from the 2003-2004 NHANES were increased to 34.3% of adolescents age 12-19 years having a BMI $\geq 85^{th}$ percentile, and 17.4% had a BMI $\geq 95^{th}$ percentile (Ogden et al., 2006). Although there were no differences in the prevalence of BMI $\geq 95^{th}$ in children and adolescents between 1999-2000 and 2001-2002 (Hedley et al., 2004), significant tests for trends indicated an increase in the prevalence rates between 1999-2000 and 2003-2004 (Ogden et al., 2006).

There were no significant differences in the prevalence of overweight in adolescents between NHANES I, 1971-74, and NHANES II, 1976-80, but the prevalence of overweight in adolescents doubled between NHANES II, 1976-80, and NHANES III, 1988-94, by increasing from 5.0% to 10.5% (Ogden et al., 2002). The rate increased again by 5.6% to an overweight prevalence of 16.1% in adolescents between NHANES III, 1988-94, and NHANES, 1999-2002 (Hedley et al., 2004), which was more than three times higher than the rate of 5.0% observed in NHANES II, 1976-80. As noted above, the rate has continued to increase in recent years to an overweight prevalence of 17.4% in adolescents in NHANES, 2003-2004 (Ogden et al., 2006).

Over time, the distribution of BMI-for-age has become more skewed to the right for children and adolescents aged 12-19 years (Flegal & Troiano, 2000). This shows that the heaviest children are becoming heavier, which has important health implications, because the risk for comorbities increases for children at the highest levels of BMI. Rates of hypertension and hyperinsulinemia were twice as high for children above the 97th percentile as for children between the 95th and 97th percentiles of BMI-for-age in the Bogalusa Heart Study (Freedman et al., 1999). Thus, as the BMI levels become more extreme in the adolescent population, the rate of obesity-related comorbities will be higher than before.

2. Pathophysiology

The prevalence of obesity-related health conditions has dramatically increased among children. Many obesity-related disorders can occur during childhood and adolescence (Dietz, 1998; Must & Strauss, 1999; Deckelbaum & Williams, 2001; Must & Anderson, 2003). The most common pathophysiologies are glucose intolerance/ insulin resistance, and other aberrations of the metabolic syndrome. Other common pathophysiologies are cardiovascular lesions such as hypertension, dyslipidemia, left ventricular hypertrophy and atherosclerosis (Daniels et al., 2005).

The prevalence of metabolic syndrome was almost 30% among obese adolescents age 12-19 years (Cook et al., 2003). It is diagnosed when at least three of the five following symptoms are present: glucose intolerance, abdominal obesity, hypertriglyceridemia, low high-density lipoprotein (HDL) cholesterol, and high blood pressure (NHLBI, 2002; Cook et al., 2003). Components of the metabolic syndrome contribute to the development of atherosclerosis, thus cardiovascular disease is advanced with obesity in youth as well (Cook et al., 2003). In a population-based sample, approximately 60% of obese children aged 5-10 years had at least one physiological CVD risk factor, such as elevated total cholesterol, triglycerides, insulin, or blood pressure, and 25% had two or more of these CVD risk factors (Freedman et al., 1999).

Increased body fat and insulin resistance are also risk factors for type 2 diabetes in childhood obesity (Goran et al., 2003). Because the degree of insulin resistance in children increases with the severity of body fatness (ADA, 2000), more children will reach the diagnostic threshold for type 2 diabetes as more obese children become even fatter. A 10-fold increase in the prevalence of type 2 diabetes in children occurred between 1982 and 1994 (Pinhas-Hamiel et al., 1996). Although the prevalence of type 2 diabetes is only at the rate of 1-2 cases per 1000 in adolescence (Fagot-Campagna et al., 2001), estimates are that three-fourths of obese adolescents will track to be overweight as adults (Guo et al., 2002). Because type 2 diabetes is a consequence of adolescent obesity occurring later in life, the prevalence of type 2 diabetes has increased greatly among young adults as well (Mokdad et al., 2003). Thus, the burden of developing diabetes at a young age is that major complications of diabetes, such as retinopathy, nephropathy, and neuropathy, end-stage renal failure, cardiovascular disease, and even death will occur earlier in life.

Some less common but still serious physiologic disorders of obesity in children include steatosis and cholelithiasis affecting hepatic function, and proteinuria that can result from damage to the renal system (Must & Anderson, 2003; Daniels et al., 2005). Some obese girls will suffer from menstrual abnormalities and other symptoms of polycystic ovarian syndrome during adolescence (Buggs & Rosefield, 2005). Pseudotumor cerebri is a rare but serious neurological disorder that can occur in childhood obesity, and obstructive sleep apnea is another life-threatening condition (Must & Anderson, 2005; Daniels et al., 2005). Asthma is also exacerbated by childhood obesity (Gold et al., 2003). Excess body weight during adolescence can cause orthopedic problems like slipped capital femoral epiphysis and Blount's disease.

Health professionals have observed that, because of the rapid growth and development that occurs during puberty, adolescence appears to be a critical time for obesity onset that persists into adult years (Dietz, 1994; Lawlor & Chaturvedi, 2006), and up to 75% of overweight adolescents will become obese adults (Guo et al., 2002). Adult obesity is associated with a myriad of health conditions that potentially shorten the lifespan especially among those who become obese at a young age. Thus, early identification and amelioration of easily modifiable factors contributing to childhood obesity is important to reduce the comorbities that occur both in adolescence and later in life.

3. Risk factors.

Potential confounders of the association between beverages and overweight include sociodemographic factors, parental obesity and physical activity. The relationship between beverage patterns and obesity is mediated through dietary factors that affect energy intake. This section reviews how sociodemographic factors, parental obesity, physical activity and dietary factors are correlated with the increased prevalence of childhood and adolescent obesity.

a. Sociodemographic factors.

Overall, both boys and girls have shown similar increased rates of overweight (Ogden et al., 2002; CDC, 2003a). However, children in certain race-ethnic groups, and those living in certain regions of the United States had higher rates of obesity than other groups in the population (Hedley et al., 2004; Strauss & Pollack, 2001). Family composition, number of family members, household income and other parameters of SES all potentially influence the risk for overweight in children of those families (Koplan et al., 2005).

Ethnic groups. Among adolescents age 12-19 years, the prevalence of obesity is 21% among non-Hispanic blacks and 22.5% in Mexican-Americans compared to 13.7% in non-Hispanic whites (Hedley et al., 2004). Among boys, the prevalence of obesity is higher in Mexican-Americans (24.7%) than in non-Hispanic blacks (18.7%), although non-Hispanic black girls (23.6%) have the highest prevalence compared to Mexican-American girls (19.9%) (Hedley et al., 2004). Ethnic disparities evolved from the accelerated increase in prevalence of obesity among minority groups. Between 1986 and 1998, there was a 120% increase in the prevalence of obesity in African American and

Hispanic youth, compared to a 50% increase in non-Hispanic whites (Strauss & Pollack, 2001). It is unclear why these differences consistently appear and to what degree they are driven by the social environment, built environments, income and education of parents and/or familial food and physical activity preferences and practices (Link & Phelan, 1995; Diez Roux, 2005; Sallis & Glanz, 2006; Gordon-Larsen et al., 2003).

Region. In 1998, the obesity prevalence among youth was 17.1% in southern states compared to 10.8% in western states (Strauss & Pollack, 2001). BMI determined from self-reported height and weight of children and adolescents participating in the Youth Risk Behavior Survey (YRBS) reported by states (CDC, 2004) show statewide variations in the prevalence of overweight and obesity, but no clear pattern across broad regions of the U.S. emerged. Reasons for statewide differences in the prevalence of adolescent obesity are not entirely clear, but differences between race-ethnic groups (Hedley et al., 2004), local economies (Finkelstein et al., 2005), climate (Steegman, 2005) and even local school curricula and policies (Kubik et al., 2005) have all been considered as possible contributors to geographic distributions of overweight. After controlling for race-ethnicity, income, diet, physical activity and television viewing, when differences between local communities were averaged over four broad regions (Northeast, Midwest, South and West), the geographic area was not associated with BMI in either children or adolescents in NHANES III, 1988-94, but BMI of children in the West was lower than that of children in the Northeast in CSFII, 1994-96 and 1998 (Storey et al., 2003).

Family characteristics. Marital status, and among married, age of marriage, determines family composition of households with children (NRC, 2003). The age and gender of the family reference person, whether he/she is employed, and the household size then potentially influence family meal patterns, which affect overweight in youth (Anderson et al., 2003; Videon & Manning, 2003). The percentage of mothers with children under age 18 who work has increased to 72% from 47% in 1975 (U.S. Department of Labor, 2004). Since 1965, breakfast consumption among adolescents has continued to decline (Siega-Riz et al., 1998), perhaps because more mothers are working, and children of working mothers are more likely to skip meals than those whose mothers are not employed outside the home (Crepinsek & Burstein, 2004). As more women are working outside the home, home-prepared family meal times occur less frequently. More meals are eaten away from home also because smaller households (due to delayed marriage, higher divorce rates and single parenthood) have fewer economies of scale in home preparation of meals than larger families (Sturm, 2004), and with the availability of fast food restaurants, the cost of meals eaten away from home are less than in the past.

Family income and SES. An increase in obesity prevalence among African American youth was greatest for those with the lowest household income (Strauss & Pollack, 2001). The National Longitudinal Study of Adolescent Health also demonstrated an inverse relationship between obesity prevalence and family SES (Goodman, 1999; Goodman et al., 2003). In NHANES III, 1988-1994, an inverse relationship between family income and obesity was observed in adolescents of white but not other race-ethnic groups (Troiano & Flegal, 1998; Alaimo et al., 2001; Miech et al., 2006), but caution interpreting these data was advised because many estimates had a large (>30%) coefficient of variation (Troiano & Flegal, 1998). Prevalence of overweight increased among poor (those living in households with income below the poverty line) compared to nonpoor for non-Hispanic white adolescents age 15-17 ($p<.01$), but not for those age 12-14 years. For non-Hispanic blacks, a trend ($p<.1$) towards increased prevalence of overweight among poor compared to nonpoor among adolescents age 15-17 was reversed among the younger age group in that more nonpoor than poor adolescents age 12-14 were overweight ($p<.1$) (Miech et al., 2006).

An increased prevalence of overweight among low-income adolescents may be due to the quality of their diets, if only less expensive, energy-dense foods and beverages are consumed (Alaimo et al., 2001). More affordable foods and beverages tend to have a higher energy density because of their fat and sugar content, thus the dietary patterns of low-income individuals could result in excessive energy intake and weight gain (Drewnowski & Specter, 2004; Drewnowski & Darmon, 2005). The current study investigated whether sugar-sweetened beverages were associated with greater energy intakes and a greater risk for overweight. Sugar-sweetened beverages but not other energy-dense snack foods such as baked goods, ice cream, chips and candy, were associated with increased BMI z-scores over 4 years in female adolescents without controlling for income (Phillips et al., 2004). Dietary factors associated with poverty among adolescents age 12-17 years in NHANES, 1999-2002, included sugar-sweetened beverage consumption and breakfast skipping, but percentage of calories from snacks and percentage of calories eaten away from home did not differ by poverty group (Miech et al., 2006). If poverty is driving disparities in sugar-sweetened beverage consumption, breakfast skipping and overweight in adolescence (Miech et al., 2006), then poverty might explain a positive association between a sugar-sweetened beverage pattern and overweight and an inverse association between a breakfast beverage pattern and overweight. Relationships between beverage patterns and overweight would then be mitigated because income was included in the model of the current study.

b. Parental obesity

Both genetics and the family environment can affect a child's risk for overweight if one or both parents are obese. Children can inherit obesity susceptibility genes from an obese parent or parents; or can be exposed, after birth, to diet and activity patterns that promote obesity. Moreover, recent research suggests that an altered intrauterine environment may be a third way that parental obesity can affect the child. There are a number of potential mechanisms by which maternal obesity in pregnancy may promote offspring obesity (Whitaker & Dietz, 1998; Levin, 2000; Oken & Gillman, 2003). For example, obese mothers are more likely to experience diabetes in pregnancy, and some evidence suggests that the offspring of mothers who have diabetes in pregnancy may have an increased risk of developing obesity later in life (Silverman et al., 1998). Given these mechanisms that may promote intergenerational obesity, prevention efforts should be targeted towards women of childbearing age as well as their children.

Because parental obesity was found to be a risk factor for overweight in adolescents age 12-16 years, researchers using the NHANES III dataset investigated factors that might potentially protect against overweight in this high risk group (Fiore et al., 2006). Eating breakfast some days or every day was associated with normal body weight only among those having one or two obese parents, while sports team participation was associated with normal body weight only among those with two nonobese parents (Fiore et al., 2006). Other results from this study indicated that overweight adolescents might be over-reporting water consumption and under-reporting energy intake (Fiore et al., 2006). That breakfast consumption was associated with normal body weight (Fiore et al., 2006) suggested that a milk and juice beverage pattern might be protective against adolescent overweight after controlling for parental obesity.

c. Physical activity and sedentary behavior

Youth have opportunities to be physically active while walking or bicycling to and from school, attending physical education classes, participating in team sports or exercising during their free time. Based on the Youth Risk Behavior Survey (YRBS), one-third of high school students are not engaging in recommended levels of moderate or vigorous physical activity and 10% report that they are inactive (CDC, 2003b, 2004). From 1977 to 2001, the percentage of total trips in which children aged 5 to 15 years walked to school declined from 20.2% to 12.5% (Sturm, 2005b). High school students who participated daily in physical education classes declined from 42% in 1991 to 25% in 1995 (DHHS, 1996b) and increased slightly to 28.4% in 2003 (CDC, 2004). A time-use study showed that children aged 3 to 12 years had less free time available to exercise at play, as more time was spent participating in organized sports in 1997 than in 1981 (Sturm, 2005a), but there may be less opportunities for adolescents to participate in team sports (Elkins et al., 2004)

Physical activity levels decline substantially during adolescence, especially in girls (Kimm et al., 2002). Enrollment requirements and resources available for physical education classes are reduced as students move from elementary and middle school grades to the high school level. Whereas recreational sports teams programs are accessible to children of younger ages in many communities, the increased competitiveness of sports preclude many adolescents from participating in high school. As girls in a longitudinal study grew older, a higher BMI was associated with greater reductions in physical activity (Kimm et al., 2002). Among high school students in the YRBS, overweight boys were less likely to engage in moderate physical activity, and girls who were either overweight or at risk for overweight were less likely to participate in sports (Levin et al., 2003). After controlling for age, grade and football, sports participation was associated with lower BMI among African American students of both genders in low-income, inner city high schools (Elkins et al., 2004). While youth with lower BMI might be more likely to participate in sports, because physical activity "enrichment" has effectively reduced percent body fat in higher risk children (Burke et al., 1998), obesity could be prevented if more opportunities for organized exercise programs were available to all high school students (Elkins et al., 2004).

Hours spent watching TV is inversely associated with physical activity (Crespo et al., 2001), thus as a measure of sedentary behavior, TV watching could be correlated with obesity as well. Trends in TV watching have increased in parallel to the rise in adolescent obesity. In 1999, 98% of households had a television (Nielsen Media Research, 2000) compared to 10% in 1950 (Putnam, 1995). There was more than one television in 88% of homes in 1999 (Roberts et al., 1999) compared to 35% in 1970 (Lyle & Hoffman, 1972). The percent of homes with three or more televisions increased ten-fold over the same time period (Rideout et al., 2003). In 2003, 50% of children less than 6 years of age had three or more televisions in their home, and 36% had a television in their bedrooms (Rideout et al., 2003). During a typical day 36% of children watched television for one hour or less, 31% watched TV for one to three hours, 16% watched it for three to five hours, and 17% spent more than 5 hours watching television (Roberts et al., 1999). However, among adolescents, between 1990 and 2001 there has been a decline in watching television 3 hours or more, although there was an increase in television watching for one hour or less (Child Trends, 2002). Children are now using other types of electronic media as well, including video games and computers (Roberts et al., 1999; Rideout et al., 2003), that adds to the amount of time in sedentary activities. Nevertheless, youth spend a significant amount of discretionary time watching television, and this modifiable sedentary behavior has a significant potential impact on overweight in youth.

d. Dietary quality.

Trends in eating patterns, such as increased snacking behavior, increased consumption of meals away from home, and increased portion sizes contribute to increased intakes of energy-dense foods and beverages. Energy-dense snacks comprise a large proportion of total daily calories (Jahns et al., 2001). Trends in away-from-home food consumption are partly due to greater availability of convenient, shelf stable, portable foods that are accessible in many places at any time (Food Marketing Institute, 1996, 2003; French et al., 2001a; Sloan, 2003). Away-from-home foods contributed 20% of children's total caloric intake in 1977-1978 and 32% in 1994-1996 (Lin et al., 1999). Foods eaten outside the home decrease the nutritional quality of children's diets (Lin et al., 1999; French et al., 2001b). Portion sizes of most foods consumed both at home and away from home have increased between 1977 and 1996 (Nielsen & Popkin, 2003;

Smiciklas-Wright et al., 2003), and increased portion sizes are associated with overeating (Rolls, 2003).

Total energy intake. Between 1977-1978 and 1994-1996, total calories consumed by adolescent boys aged 12 to 19 years increased by 243 from 2,523 to 2,766 calories (Enns et al., 2003). At the same time, total calories consumed by adolescent girls aged 12 to 19 years increased by 123 from 1,787 to 1,910 calories (Enns et al., 2003). No significant increased trends in energy intake were observed in children aged 6-11 years between 1977-1978 and 1994-1996, 1998 (Enns et al., 2002).

Total fat consumption. Between 1965 and 1996, the proportion of energy from total fat consumed by children declined from 39% to 32%, and saturated fat from 15% to 12% (Cavadini et al., 2000a). Children aged 6-11 years in 1994-1996, 1998 consumed 25% of calories from discretionary fat (USDA, 2000; Enns et al., 2002). For adolescents aged 12-19 years, girls consumed 25% and boys consumed 26% of their calories from added fat (USDA, 2000; Enns et al., 2002).

Added sugars. Children aged 6-11 in 1994-1996, 1998 consumed 21-23 teaspoons of added sugars in a 1,800-2000 calorie diet, while the Food Guide Pyramid recommended no more than 6-12 teaspoons of added sugars for a 1,600-2,200 calorie diet (USDA, 1996; Enns et al., 2002). Recommendations of the MyPyramid personalized diet plan are expressed as limits on calorie intake from extra fats and sugars. For example, no more than 290 discretionary calories are recommended for a 2,200 calorie diet (Johnston, 2005). The Institute of Medicine (2002) *Dietary Reference Intakes Report* suggested an upper limit of 25% of calories for added sugars to avoid displacement of micronutrients from the diet, but the DRI should not be interpreted as a dietary guideline (Sibbald, 2003). Both the former US Food Guide Pyramid (USDA, 1996) and the World Health Organization (2003) recommended limiting added sugar to 10% of calories, and this guideline for added sugar intake was used in the current study.

The theoretical model that was the basis for the current study suggested that the relationship between beverage patterns and obesity might be mediated through dietary factors that affect energy intake. For example, a hypothesis of the current study was that a sugar-sweetened beverage pattern would be associated with overweight, because youth who consume sugar-sweetened beverages might have greater energy intakes than youth who consume other beverages. Both beverages and non-beverages contribute energy to daily intakes. Energy intakes are derived from added sugars in sugar-sweetened beverages, as well as from the added sugars and dietary fats in foods consumed at meals accompanied by sugar-sweetened beverages. Energy-dense foods high in fat and sugar, as well as sugar-sweetened beverages, are often consumed at the snack occasion and meals eaten at fast food restaurants. Consuming beverages containing added sugar, energy-dense snack foods, and meals away-from-home are all possibly related to the likelihood of being overweight.

4. Assessment of adolescent obesity.

The best data to assess the prevalence of overweight and adiposity among youth in the U.S. are available from the National Health and Nutrition Examination Surveys (NHANES) conducted by the National Center for Health Statistics (NCHS). NHANES anthropometric data included measured, rather than self-reported, height and weight, from which the Body Mass Index (BMI) was determined and compared to the CDC reference criteria of BMI-for-age. In addition, the current study used skinfold thickness measurements to determine percentage body fat. This section will review literature pertinent to the use of BMI and skinfold thickness measures to assess overweight and adiposity in youth.

a. BMI and CDC growth charts.

BMI, defined as weight in kilograms over height in meters squared (kg/m^2), is a surrogate measure of body fatness used to assess the prevalence of overweight in youth. The Centers for Disease Control and Prevention (CDC) reference criteria for overweight in children aged 2-19 years is based on age- and sex-specific percentiles for BMI. A BMI >5^{th} percentile and <85^{th} percentile is considered normal weight for height; the category for those with a BMI between the 85^{th} and 95^{th} percentiles is "at risk for overweight"; and "overweight" is defined as a BMI ≥95^{th} percentile (Kuczmarski et al., 2000). Although pediatricians and other health professionals are encouraged to interpret the "at risk for overweight" and "overweight" criteria as guidelines used to identify patients whose BMI warrant further clinical investigation and monitoring at followup visits, the BMI percentiles are not functional definitions of obesity. The criteria used to define overweight, the percentiles of BMI-for-age, are merely statistics used to describe the extremes of the distribution of BMI-for-age in the reference population (Flegal, 1993; Trioano & Flegal, 1999).

In a recent report from the Institute of Medicine a BMI ≥95^{th} percentile was used to define "obesity" in children and adolescents (Koplan et al., 2005). The term "obesity" was used by the Institute of Medicine to be consistent with international standards

(Lobstein et al. 2004), and also to remind the readers that addressing the increasing prevalence of BMI ≥95th percentile is an urgent priority, because obesity is a serious medical condition. The 95th percentile in the BMI distribution among adults is 30 kg/m^2, and at this point in the BMI distribution, mortality from obesity-related health conditions was found to steadily increase (NHLBI, 1998).

Although only one set of criteria, 25 kg/m^2 and 30 kg/m^2, is used to define overweight and obesity, respectively, in adults of all ages, using BMI as a reference for children and adolescents is complicated, because BMI varies with age in youth. For this reason, gender- and age-specific BMI percentiles are used as references for children age 2 to 19 years. By late adolescence, the 95th percentile approaches 30 kg/m^2, the criteria used to identify obesity in adults. Cole et al. (2000) determined which percentiles corresponded to a BMI of 25 kg/m^2 or 30 kg/m^2 at age 18 years for each of six countries: Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States. For example, 30 kg/m^2 is the 99th percentile for 18-year-old males in Great Britain, thus the 99th percentile would be used over all age groups of British children to define obesity, while 30 kg/m^2 corresponds to the 97th percentile at age 18 years for boys in the U.S. To ease international comparisons, Cole et al. (2000) proposed averaging the six countries' percentile curves that converged with the adult definition of overweight and obesity at age 18 years.

The selection of the 85th and 95th percentiles to define overweight and obesity in children is arbitrary, and the CDC BMI-for-age percentiles pertain only to the reference population in the U.S. Because overweight was already increasing in NHANES III, 1988-94, rather than using the most recent NHANES to revise the growth charts in 2000, CDC based the revised growth references on distributions in national surveys conducted from 1963 through 1980 for children aged 6 to 19 years (Kuczmarski et al., 2000). Appropriate use of the reference percentile distributions include monitoring changes in the prevalence of overweight and obesity over time, or comparing the extent of overweight across population subgroups.

In the current study, adolescents age 12-16 years were classified by patterns of beverages consumed, and the prevalence of overweight and obesity in these beverage pattern groups were compared, to determine whether beverage consumption was associated with overweight and obesity among adolescents in the U.S.

b. Anthropometric indices of adiposity.

BMI does not accurately assess body composition, e.g., overweight youth with a high proportion of lean body mass are not overfat (Forbes, 1987). Intake of calcium from milk might be related to body composition or adiposity in general (Zemel et al., 2000). Intake of fructose from soft drinks might be related to the distribution of body fat (Elliot et al., 2002). Truncal adiposity, i.e. body fat deposited at the waistline, is a component of the metabolic syndrome (Duncan et al., 2004), and as such, it might be positively associated with intakes of sugared beverages (Elliot et al., 2002). Alternatively, milk and dairy foods may protect against the development of metabolic syndrome (Pereira et al., 2002), or milk may appear to be protective because of the inverse association between milk and soft drinks (Huang & McCrory, 2005). A strength of the current study was that the hypothetical relationships between beverages and adiposity were investigated using the anthropometric data available in NHANES III.

Skinfold thickness (mm) measurements were used to assess percentage body fat. Various equations have been developed by regression analyses using skinfold thickness to predict percentage body fat as measured by underwater weighing (Lohman, 1986). In the current study, regression equations for adolescents developed by Slaughter et al. (1988) were used to predict percentage body fat from the summed triceps and subscapular skinfold measurements. These equations are the best to use with adolescents, because separate skinfold equations for predicting body fat in children age 8-18 years were developed for prepubescent, pubescent, and postpubescent white and black male adolescents and all female adolescents whose summed tricep and subscapular skinfolds were 35 mm or less (Slaughter et al., 1988). In order to use the Slaughter et al. (1988) equations, males were classified by race and sexual maturation (SMA) stage.

Roche et al. (1981) conducted a validation study among 6-12 and 13-17 year old boys and girls (n=261) to determine which of the various anthropometric measurements had the highest correlation with percentage body fat obtained by underwater weighing. Measurements included triceps and subscapular skinfolds, weight, relative weight, BMI (kg/m^2), and the ponderal index (kg/m^3). Compared to body weight measures, triceps skinfold had the highest correlation with percentage body fat (from underwater weighing) in all four groups, although the confidence interval of the correlation coefficient overlapped substantially with that of subscapular skinfold, as well as that of BMI for girls (Roche et al., 1981). The Slaughter et al. (1988) equations were based on summed triceps and subscapular skinfold measurements. These equations were cross-validated on samples from the literature, and disagreement was found only with samples using the Lange caliper, rather than the Harpenden skinfold caliper used to develop the equations

(Slaughter et al., 1988). Further cross-validation of the Slaughter skinfold equations for children and adolescents (Janz et al., 1993) found very high intraclass (reliability) correlations (ICC = 0.98-0.99), and high validity correlations (rs = 0.79-0.99) compared to Lohman's Siri age-adjusted body density equations (Lohman, 1986). Thus, the Slaughter et al. (1988) equations are unique in their appropriateness for youth of different genders, races, stages of maturation as well as in their validity and reliability.

B. Beverage intakes of adolescents

1. Trends in beverage intakes

Trends in national surveys show that in recent years, youth drink much more soda and less milk than in the past (Cavadini et al., 2000a; Bowman, 2002; Enns et al., 2002; Enns et al., 2003; French et al., 2003; Nielsen & Popkin, 2004). Some authors have noted that the trend in obesity prevalence is parallel to the trend in added sugars available in the food supply (Harnack et al., 2000; Bray et al., 2004). If the added sugars in soft drinks and other sugar-sweetened beverages consumed by youth contribute an excess of energy intake compared to energy expenditure, the positive energy balance could lead to incremental weight gain in adolescence. This section reviews the evidence that trends in beverage intakes have increased the contribution of beverages to the total energy intake of youth.

Milk consumption decreased by 37% in adolescent boys and 30% in adolescent girls between 1977-1978 and 1994 (Cavadini et al., 2000a). In 1994-1996, for adolescents aged 12-19 years, only 12% of girls and 30% of boys consumed the number of dairy servings recommended by the Food Guide Pyramid (USDA, 2000). In 1977-

1978, children aged 6-11 years consumed 4 times more milk than any other beverage, and adolescents aged 12-19 years drank 1.5 times more milk than any other beverage. These data were compared to those collected 20 years later to identify the secular trends in beverage consumption. In 1994-1996, 1998, children aged 6-11 consumed 1.5 times more milk than soft drinks, and adolescents consumed twice as much soft drinks as milk (French et al., 2003).

While total milk intake of adolescents has declined between 1977-1978 and 1994-96 from 472 to 303 g/day (-36%) for boys, and from 303 to 189 g/day (-38%) for girls, there has been a greater decrease in whole milk consumption. There was a 61% decrease in whole milk intake (from 257 to 100 g/day) for boys and a 60% decrease (from 166 to 67 g/day) for girls. Lowfat/skim milk increased by 188% (from 105 to 197 g/day) for boys, and by 183% (from 66 to 121 g/day) for girls, such that, compared to 1977-78, a greater share of total milk consumed in 1994-96 was lowfat/skim rather than whole milk (Enns et al., 2003). Thus, the contribution of milk to the total energy intake of youth has declined because the fat content of milk consumed by youth has decreased, and total consumption of milk has declined as well.

Soft drink consumption nearly tripled among adolescent boys from 7 to 22 ounces per day between 1977-1978 and 1994 (Guthrie & Morton, 2000; French et al., 2003). Soda was consumed by children as young as 7 months old (Fox et al., 2004). By 14 years of age, 32% of adolescent girls and 52% of adolescent boys consumed 3 or more 8-ounce servings of soda daily (Gleason & Suitor, 2001). Analyses of CSFII data have shown that, from 1977-78 to 1994-96, 1998, energy intakes from sugars added to sugar-sweetened beverages (soft drinks and fruit drinks) have nearly doubled from 70 Kcal/d

(3.9% of total energy) to 136 Kcal/d (6.9% of total energy) among those age 2 years and older in the U.S. (Bray et al., 2004). Also using data from CSFII, 1994-96, 1998, added sugars intakes from sugar-sweetened beverages was 52.6% of the total amount of added sugars consumed by boys aged 12-17 years, and 48.5% for girls in the same age group (Guthrie & Morton, 2000). Added sugars intakes from all foods and beverages were 20% of total energy (Guthrie & Morton, 2000), an amount clearly in excess of the former Food Guide Pyramid recommendations (6% of total energy at 1600 Kcal, 8.7% at 2200 Kcal, and 10.1% at 2800 Kcal) (Johnson & Frary, 2001).

In NHANES III, 1988-1994, beverages contributed 21.6% and 20.5% to the total energy intake of adolescent boys and girls age 12-19 years. The shares of energy intake contributed by beverage categories such as milk, sweetened beverages (soft drinks and fruit drinks), 100% fruit juice, and other beverages (coffee, tea and alcoholic beverages) were 6.9, 10.2, 1.9 and 2.5%, respectively, for boys, and 6.6, 10.6, 2.0, and 1.2% for girls (Troiano et al., 2000). Using CSFII data to compare dietary intakes of adults age 18 years and older between 1989-1991 and 1994-1996, of all the food groups assessed, whole milk and soft drink intakes changed the most during this brief time interval; although reduced-fat milk intake increased by ~85 g/day, whole milk intake decreased by ~100 g/day and soft drink intake increased by ~90 g/day (Chanmugam et al., 2003). Because declines in whole milk consumption were nearly offset by increases in reduced-fat milk intake in adults, the authors asserted that the significant increase in soft drink intake ($p < 0.05$) was responsible for most of the increase in energy intake from beverages between 1989-1991 and 1994-1996 (Chanmugam et al., 2003).

For adolescents age 12-19 years, between 1989-91 and 1994-96, total milk intake decreased by ~75 g/day for boys (-19%; 376 vs. 303 g/day), and girls reduced their milk intake by ~50 g/day (-21%; 239 vs. 189 g/day), while there was no change in lowfat/skim milk intakes (boys: 219 vs. 197 g/day; girls: 131 vs. 121 g/day) (Enns et al., 2003). Over this 5-year period, there was a tremendous increase in fruit drink intakes (boys: 205 vs. 104 g/day; girls: 134 vs. 87 g/day) in addition to the increases in soft drink intakes (boys: 608 vs. 424 g/day; girls: 396 vs. 324 g/day), such that sweetened beverage intakes increased 154% and 129% for boys and girls, respectively, between 1989-91 and 1994-96 (Enns et al., 2003). Because of these shifts between beverage categories, sugar-sweetened beverages continue to contribute a large portion of the energy intakes of youth, which justify the examination of trends in beverage consumption as a possible risk factor for the concomitant increase in obesity.

2. Beverage intakes in relation to life style and dietary quality

Life-style behaviors, such as watching TV and fast food restaurant use, might be associated with food and beverage choices that lead to excess energy intake (Coon & Tucker, 2002; French et al., 2001b), TV watching might be associated with physical inactivity as well (Forshee et al., 2004), and all might contribute to energy imbalance, weight gain, and obesity in youth (Bray & Champagne, 2005). Soft drinks are frequently consumed while snacking and watching TV (Coon et al., 2001; Giammattei et al., 2003; Matheson et al., 2004; Phillips et al., 2004), and with meals eaten at fast food restaurants (French et al., 2001b; Bowman et al., 2004). Youth who are characterized by beverage patterns that include sugar-sweetened beverages might be more overweight than other youth because of the energy intakes contributed by beverages (Harnack et al., 1999; Troiano et al., 2000; Bowman, 2002), or because of the energy intakes contributed by snacks and fast foods typically consumed with sugar-sweetened beverages (Hampl et al., 2003; Utter et al., 2003; Bowman et al., 2004; Phillips et al., 2004).

Just as sugar-sweetened beverages might be associated with TV watching, snacking and fast food restaurant use, beverages like milk or juice might be associated with more healthful lifestyle habits such as frequent breakfast consumption and regular exercise. Due to the need for hydration, drinking water or any beverage, even sugar-sweetened beverages like Gatorade and other sports drinks might be associated with exercise-induced sweating or sports team participation, two measurements of physical activity used in this study. A beverage pattern classification characterized by milk and juice consumption was expected to be specific to regular breakfast consumers, because milk was poured on cereal and orange juice was often consumed at breakfast. Milk and juice consumers were expected to consume more nutrient-dense diets than sweetened beverage consumers, because of the vitamin and mineral intakes derived from milk, juice, cereal and other foods consumed at the breakfast meal occasion. Milk is high in vitamins and minerals like vitamin A, calcium and vitamin D (Miller et al., 2001); juice is high in vitamin C, folate and potassium (Fellers et al., 1990); and cereal is fortified with many vitamins and minerals (Subar et al., 1998).

C. Beverage intakes and adolescent obesity

In the current study, combinations of beverage categories were defined to characterize the beverage consumption pattern consumed most often by youth. The beverage categories included milk, 100% fruit juice, sugar-sweetened beverages (e.g., soft drinks and fruit drinks) and other beverages (e.g., low-calorie "diet" soft drinks, coffee/tea, and alcoholic beverages). This section will review the known relationships between obesity and each individual beverage category, from which hypotheses regarding the beverage patterns were generated.

1. Milk

Researchers have hypothesized that dairy products and calcium may be inversely associated with body weight and body fat (Zemel et al., 2000; Davies et al., 2000; Heaney et al., 2002; Parikh & Yanovski, 2003; Teegarden, 2003). The proposed mechanism involves the activation of vitamin D, affecting the intracellular calcium level to regulate fat metabolism, such that low calcium diets promote lipogenesis, and high calcium diets affect lipolysis in the adipocyte (Zemel et al., 2000; Zemel, 2001; Zemel, 2002; Zemel & Miller; 2004; Zemel, 2004c). A review by Barr (2003) identified 26 studies in the literature that reported dairy product or calcium intakes and also assessed body weight or body composition. These studies and others recently published are summarized in Tables 1 & 2. Table 1 presents results of 19 observational studies, and Table 2 summarizes 37 clinical studies. The purpose of this section is to evaluate whether observational studies and clinical trials provide evidence for the proposed effect of dairy product intake or calcium supplementation on body weight and body fatness in children and adults.

a. Observational studies

As shown in Table 1, many case-control, cross-sectional and prospective studies showed an inverse relationship between dairy or calcium intake and body weight, although no association or even a positive association was observed in the largest prospective cohort study. Of 19 observational studies in children and adults, 10 showed a clear inverse relationship between dairy or calcium intake and body weight, while 4 studies showed an inverse association only in some subpopulations, no association was observed in 4 studies, and a positive relationship was seen in 1 prospective cohort study.

Ten observational studies investigated the relationship between dairy or calcium intake and body weight in children and adolescents. An inverse relationship with body weight was observed in two case-control studies (Tanasescu et al., 2000; Lelovics & Tarnavolgyi, 2004) and in two cross-sectional studies (Tsakalou et al., 2004; Barba et al., 2005). Two longitudinal studies showed an inverse relationship between dairy or calcium intake and body fat (Carruth & Skinner , 2001; Skinner et al., 2003). One cross-sectional study showed no relationship with body weight and an inverse relationship with body fat (Novotny et al., 2004), while another cross-sectional study and a prospective study showed no relationship with either body weight or body fat (Venti et al., 2005; Phillips et al., 2003). A positive relationship between body weight and frequency of milk (white and chocolate) consumption was seen in a large prospective study (Berkey et al., 2005).

Ten of the observational studies in Table 1 sampled adults, mostly women, and assessed dairy/ calcium intakes as well as body weight and/or body composition. One cross-sectional study reported no association with body weight (Dicker et al., 2004),

Table 1. Observational studies of associations of body weight or body fat with dairy consumption or calcium intake

First Author (yr)	Setting	Subjects	n-size	Design	Dietary Method	Exposure	Endpoint (method)	Result
Tanasescu (2000)	Hartford CT	Children, Puerto Rican, prepubertal, 7-10 yr	(n=53)	Case-Control	24-hr & FFQ	Dairy foods	Overwt (BMI ≥85th %tile) vs. controls	Inverse
Lelovics (2004)	Hungary	Children, 10-14 yr	(n=78)	Case-Control	3-day record	Calcium	Obese vs. controls	Inverse
Barba (2005)	Italy	Children of 3 primary schools, 3-11 yr (excl. skim milk consumers)	(n=884)	X-sectional	FFQ	Milk svg	BMI	Inverse
Tsakalou (2004)	Greece	Children, 11, 13 &15 yr	(n=3,807)	X-sectional	FFQ	Milk	BMI	Inverse
Novotny (2004)	Hawaii	Children, 9-14 yr, ≥50% Asian or Caucasian	(n=323)	X-sectional	3-day record	Calcium, Dairy calcium	Wt Body fat (iliac skinfold)	No association Inverse
Venti (2005)	U.S.	Children & adults, Pima Indian (36 boys, 42 girls, 35 men, 30 women)	(n=143)	X-sectional	24-hr & FFQ	Calcium	Wt, BMI, % fat (DEXA)	No association
Carruth (2001)	U.S.	Children, 70 mo. (29 boys, 24 girls)	(n=53)	Longitudinal	3-day record	Milk/ Dairy (servings)	% fat (DEXA)	Inverse
Skinner (2003)	U.S.	Children, 8 yr (25 boys, 27 girls)	(n=52)	Longitudinal	3-day record	Calcium	% fat (DEXA)	Inverse

Table 1 (cont'd).

First Author (yr)	Setting	Subjects	n-size	Design	Dietary Method	Exposure	Endpoint (method)	Result
Phillips (2003)	U.S.	Girls, non-obese, premenarcheal, 8-12 yr	(n=178)	Prospective (4 yr post-menarche)	FFQ (annual)	Dairy foods, Calcium	Δ BMI z-score, Δ % body fat (BIA)	No association
Berkey (2005)	U.S.	Children, 9-14 yr	(n=12,829)	Prospective (3 yr)	(4) FFQ	Milk, Ca 1% milk Skim milk	Δ BMI	Positive Positive in boys Positive in girls
Lovejoy (2001)	U.S.	Women, premenopausal (97 white, 52 black)	(n=149)	X-sectional	Food record	Calcium	Body fat (DEXA)	Inverse
Jacqmain (2003)	Quebec	Adults, 20-65 y (235 men, 235 women)	(n=470)	X-sectional		Calcium	Wt, BMI, % fat, abdominal fat (CT)	Inverse in women
Dicker (2004)	Israel	Adults (1332 men, 1324 women)	(n=2,656)	X-sectional	24-hr	Dairy foods Calcium	BMI Waist circumf.	No association Inverse in women
Loos (2004)	U.S.	Men (253 white, 109 black), women (261 white, 201 black)	(n=824)	X-sectional	FFQ	Calcium	BMI, abdominal fat (CT) % fat (skinfolds)	Inverse in black men, white women Inverse in men, white women
Mirmiran (2005)	Iran	Adults >16 y (223 men, 239 women)	(n=462)	X-sectional	FFQ & (2) 24-hr	Dairy svg	Wt, BMI	Inverse

Table 1 (cont'd).

First Author (yr)	Setting	Subjects	n-size	Design	Dietary Method	Exposure	Endpoint (method)	Result
Lin (2000)	U.S.	Women, 18-31 y	(n=54)	Prospective (2 yr)	3-day record	Ca/Kcal, Dairy Ca/ Kcal, Ca, Dairy Ca	Δ wt, Δ fat mass (DEXA)	Inverse Inverse in low Kcal grp
Pereira (2002)	U.S.	Adults, white & black, 18-30 y	(n=3,157)	Prospective (10 yr)	FFQ	Dairy foods	Baseline BMI Δ wt, Δ WHR, obesity incidence	Inverse Inverse in overwt group
Kabrnova (2004)	Czech Republic	Adults, obese (mean BMI 40 kg/m^2)	(n=208)	Prospective (3-6 mos -500 Kcal wt loss pgm)	(2) 1-wk records	Δ Calcium	Δ wt	Inverse
Ochner (2004)	U.S.	Women	(n=103)	Prospective (1-y followup after 6-mos wt loss pgm)	(2) FFQ	Δ Calcium adjusted for Δ Kcal	Δ wt	Inverse

while another cross-sectional study showed no association with either body weight or body fat (Venti et al., 2005). Two cross-sectional studies (Jacqmain et al., 2003; Loos et al., 2004) and two prospective studies (Lin et al., 2000; Pereira et al., 2002) reported an inverse relationship in some subpopulations. Body fat was inversely associated with calcium in one cross-sectional study (Lovejoy et al., 2001), while body weight was inversely associated with either dairy or calcium intakes in another cross-sectional study (Mirmiran et al., 2005), and in two prospective studies (Kabrnova et al., 2004; Ochner et al., 2004).

b. Clinical trials

As shown in Table 2, although a few weight loss studies involving energy restriction showed an inverse relationship between dairy/ calcium and body weight/ fat, most clinical trials showed that neither dairy products nor calcium supplements lowered body weight or adiposity. Table 2 includes 37 clinical trials of dairy products (n=14), calcium supplements (n=19), or both (n=4). Indicators of bone health were the primary endpoints of most of these trials, although weight, BMI and/or body composition was also assessed. Of 37 randomized trials assessing the effect of dairy products or calcium supplementation on body weight, 31 showed no effect, only 4 showed weight loss, and weight gain was the result in 2 studies.

Of the 27 trials of dairy or calcium supplementation in which the treatment did not involve energy restriction, most studies (n=24) showed no difference in body weight or composition. An inverse association between calcium and body weight was seen in only one of these studies; weight loss in the supplemented group was 0.76 *vs.* 0.32 kg/yr

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Table 2. Randomized control trials of effect on body weight or body fat from increased dairy consumption or calcium supplementation

First Author (year)	Setting	Subjects	n-size	Design	Restrict Kcal	Exposure	Dose	Endpoint	Result
Chan (1995)	U.S.	Girls, 11 y	(n=48)	1-y RCT	No	Dairy	1200 mg/d Ca	Δ in wt, ht, body fat, lean tissue	NS
Cadogan (1997)	U.K.	Girls, 12.2 y	(n=82)	18-mo RCT	No	Dairy	568 mL/d extra milk	Δ in wt, ht, body fat, lean tissue	NS
Merrilees (2000)	New Zealand	Girls, 15-16 y	(n=91)	2-y RCT	No	Dairy	1000 mg/d Ca	Δ in wt, ht, body fat, lean tissue	NS
Lappe (2004)	U.S.	Girls, 9 y	(n=59)	2-y RCT	No	Dairy	+695 mg/d Ca	Δ in wt, ht, body fat, lean tissue	NS
Baran (1990)	U.S.	Women, 30-42 y	(n=37)	3-y RCT	No	Dairy	+610 mg/d Ca	Δ in wt	NS
Devine (1996)	Austra-lia	Women, post-menopause >10y	(n=168)	2-y RCT	No	Dairy/ Calcium	1 g/d Ca milk powder, 1 g/d Ca tablets	Δ in BMI	NS
Storm (1998)	U.S.	Women, >66 y postmenopausal	(n=80)	2-y RCT	No	Dairy/ Calcium	~250 mL/d milk, 1 g/d CaCO3	Δ in wt, BMI, % body fat	NS
Barr (2000)	U.S.	Adults, 55-85 y, (129 women, 71 men)	(n=200)	12-wk RCT	No	Dairy	~2 cups/d lowfat milk	Δ in wt	↑
Lau (2001)	China	Women, 55-59y, postmenopause >5 y	(n=185)	2-y RCT	No	Dairy	50 g/d milk powder	Δ in wt, fat mass Δ in lean mass	↑ NS

Table 2 (cont'd).

First Author (year)	Setting	Subjects	n-size	Design	Restrict Kcal	Exposure	Dose	Endpoint	Result
Cleghorn (2001)	Australia	Women, post-menopause >5y	(n=115)	2-y open crossover	No	Dairy	3 L/wk Ca-fortified milk	Δ in wt	NS
Gunther (2005)	U.S.	Women, 18-30y, <800 mg/d Ca	(n=135)	1-y RCT	No	Dairy	med: 1.0-1.1 g/d Ca, high: 1.3-1.4 g/d Ca	Δ in wt, fat mass	NS
Lloyd (1993)	U.S.	Girls, 11.9 y	(n=94)	18-mo RCT	No	Calcium	500 mg/d Ca citrate malate	Δ in wt, ht, % body fat	NS
Lee (1994)	China	Children, 7 y	(n=162)	18-mo RCT	No	Calcium	300 mg/d CaCO3	Δ in wt, ht	NS
Lee (1995)	Hong Kong	Children, 7 y	(n=84)	18-mo RCT	No	Calcium	800 mg/d $CaCO_3$	Δ in wt, ht	NS
Bonjour (1997)	Switzerland	Girls, 7.9 y	(n=149)	1-y RCT	No	Calcium	850 mg/d Ca from milk extract	Δ in wt, ht	NS
Nowson (1997)	Australia	Female twins, 10-17 y	(n=42 pr)	18-mo RCT	No	Calcium	1 g/d $CaCO_3$/Ca lactate gluconate	Δ in wt, ht	NS
Dibba (2000)	Gambia	Children, 8.3-11.9 y (80 boys, 80 girls)	(n=160)	1-y RCT	No	Calcium	1 g CaCO3 (5 d/wk)	Δ in wt, ht, skinfolds, arm circumf.	NS
Johnston (1992)	U.S.	Identical twins, 6-14 y	(n=45 pr)	3-y RCT	No	Calcium	1 g/d Ca citrate malate	Δ in wt, ht	NS
Elders (1994)	Holland	Women, peri-menopausal	(n=214)	3-y RCT	No	Calcium	1 g/d Ca, 2 g/d Ca	Δ in wt, ht, BMI	NS

Table 2 (cont'd).

First Author (year)	Setting	Subjects	n-size	Design	Restrict Kcal	Exposure	Dose	Endpoint	Result
Prentice (1995)	Gambia	Women, lactating	(n=60)	1-y RCT	No	Calcium	~700 mg/d Ca	Δ in wt	NS
Recker (1996)	U.S.	Women, ≥60 y postmenopausal	(n=197)	~4.3-y RCT	No	Calcium	1200 mg/d $CaCO_3$	Δ in wt	↓
Perez-Jaraiz (1996)	Spain	Women w/ rapid bone loss, postmenopausal	(n=98)	1-y RCT	No	Calcium	1 g/d Ca	Δ in wt	NS
Dawson-Hughes (1997)	U.S.	Adults, ≥65 y (176 men, 213 women)	(n=176)	3-y RCT	No	Calcium	500 mg/d Ca + 700 IU/d vitamin D	Δ in wt, % body fat	NS
Kalkwarf (1997)	U.S.	Women, lactating & weaning	(n=327)	6-mo RCT	No	Calcium	1 g/d $CaCO_3$	Δ in wt	NS
Riggs (1998)	U.S.	Women, post-menopausal	(n=236)	4-y RCT	No	Calcium	1600 mg/d Ca citrate	Δ in wt, fat mass Δ in lean mass	NS ↓
Wosje (2004)	U.S.	Women, postpartum (163 lactating, 163 nonlactating)	(n=326)	6-mo RCT	No	Calcium	1 g/d $CaCO_3$	Δ in wt, body fat	NS
Reid (2005)	New Zealand	Women, >55 y, >5y postmeno-pausal	(n=1471)	30-mo RCT	No	Calcium	1 g/d Ca	Δ in wt	NS

Table 2 (cont'd).

First Author (year)	Setting	Subjects	n-size	Design	Restrict Kcal	Exposure	Dose	Endpoint	Result
Ricci (1998)	U.S.	Women, postmenopausal, 28-42 kg/m^2	(n=31)	6-mo RCT	Yes	Calcium	1 g/d Ca citrate malate	Δ in wt, BMI, fat mass, lean mass	NS
Jensen (2001)	Denmark	Women, obese (14 postmenopausal)	(n=52)	3-mo RCT	Yes	Calcium	1 g/d Ca + 4.2 wt loss diet	Δ in wt	NS
Harvey-Berino (2004)	U.S.	Men & women, overwt or obese	(n=45)	RCT	Yes	Dairy	~1 svg vs. 3-4 svg	Δ in wt, body fat	NS
Bowen (2004)	Australia	Men & women, overwt or obese	(n=50)	12-wk RCT	Yes	Dairy	Protein from dairy or mixed sources	Δ in wt, body fat	NS
Shapses (2004)	U.S.	Women, overwt or obese	(n=100)	25-wk RCT	Yes	Calcium	1 g/d Ca	Δ in wt, body fat	NS
Zemel (2004a)	U.S.	Men & women, overwt or obese	(n=68)	12-wk RCT	Yes	Dairy Calcium	3 svg ~600 mg/d Ca vs. 1400 mg/d Ca	Δ in wt Δ in body fat	NS ↓
Thompson (2005)	U.S.	Men & women, obese	(n=62)	48-wk RCT	Yes	Dairy	800 mg/d Ca vs. 1400 mg/d Ca	Δ in wt, body fat	NS
Zemel (2004b)	U.S.	Men & women, obese	(n=32)	12-wk RCT	Yes	Dairy Calcium	1200-1300 mg/d Ca 800 mg/d Ca	Δ in wt, body fat	↓

Table 2 (cont'd).

First Author (year)	Setting	Subjects	n-size	Design	Restrict Kcal	Exposure	Dose	Endpoint	Result
Zemel (2005a)	U.S.	Men & women, obese	(n=34)	12-wk RCT	Yes	Yogurt	1100 mg/d Ca	Δ in wt, body fat	↓
Zemel (2005a)	U.S.	Men & women, obese, African American	(n=29)	24-wk RCT	Yes	Dairy	<1 svg vs. 3 svg	Δ in wt, body fat	↓

in the control group (Recker et al., 1996). Among the 11 trials of dairy products without energy restriction, one study found an increase in body weight (Barr et al., 2000), and another found an increase in both body weight and body fat (Lau et al., 2001). Neither weight nor fat were affected by either dairy or calcium supplementation in 11 of 12 trials that assessed changes in both weight and body composition (Chan et al., 1995; Cadogan et al., 1997; Merrilees et al., 2000; Lloyd et al., 1993; Dibba et al., 2000; Dawson-Hughes et al., 1997; Riggs et al, 1998; Wosje & Kalkwarf, 2004). None of the 11 trials conducted in children or adolescents found an effect of dairy (Chan et al., 1995; Cadogan et al., 1997; Merrilees et al., 2000; Lappe et al., 2004) or calcium supplementation (Johnston et al, 1992; Lloyd et al., 1993; Lee et al., 1994; Lee et al., 1995; Bonjour et al., 1997; Nowson et al., 1997; Dibba et al., 2000) on body weight or body fat.

Ten clinical trials in adults have tested the effect on weight loss of a reduced-calorie diet that included dairy products or calcium supplements. Three used calcium supplements (Ricci et al., 1998; Jensen et al., 2001; Shapses et al., 2004), while five studied the effects of dairy products (Harvey-Berino et al., 2004; Bowen et al., 2004; Thompson et al., 2005; Zemel et al., 2005a; Zemel et al., 2005b), or dairy products and supplements (Zemel et al., 2004a; Zemel et al., 2004b). Only three of the 10 trials found that dairy calcium had a significant association with weight loss (Zemel et al., 2004b; Zemel et al., 2005a; Zemel et al., 2005b). Body composition was also assessed in all except one of these studies (Jensen et al., 2001). Four of these reported significantly greater fat loss between the high dairy consuming groups and low dairy groups in calorie-restricted overweight or obese adults (Zemel et al., 2004a; Zemel et al., 2004b; Zemel et al., 2005a; Zemel et al., 2005b). The remaining studies found no difference between high and low-dairy or calcium supplemented groups in loss of body weight or body fat.

To summarize these findings, the majority of clinical trials have not supported an inverse relationship between body weight and the calcium in dairy products, in contrast to the observations of many cross-sectional and prospective studies, but consistent with a possible positive relationship seen in one large prospective cohort study. Except for those studies conducted by Zemel and colleagues, the evidence accumulated from randomized clinical trials indicates that neither dairy products nor calcium supplements reliably facilitate weight loss or fat loss. Two of the 37 clinical trials demonstrated an increase in body weight with a dairy treatment (Barr et al., 2000; Lau et al., 2001). Without energy restriction, supplementing the diet with dairy products may actually lead to weight gain rather than weight loss, because of the additional calories consumed by the treatment group.

In observational studies, it was difficult to differentiate influences of correlated lifestyle factors such as exercise level, soda consumption, total fat and fiber intake (Novotny et al., 2004). These lifestyle factors, and not the dairy consumption, could be responsible for the variance in body weight (Huang & McCrory, 2005). In the current study, beverage patterns that include both soda and milk were distinguished from those that include soda without milk, or milk without soda, to determine whether milk alone has any relationship with body weight or body fat after adjusting for physical activity and other lifestyle factors.

The inverse relationship between milk and soda consumption in cross-sectional and prospective studies could explain the divergence between findings from observational studies and clinical trials of dairy and calcium supplementation. In conclusion, the hypothesis that dairy or calcium is inversely related to body weight and body fatness in children and adults is not supported by evidence from the current literature review.

2. Fruit Juice

Before the development of technology for the easy extraction and processing of juices a few decades ago, only water would be offered when children were thirsty, but fruit juice is now a common staple in children's diets today (Anonymous, 1995). Most children enjoy the taste of sweet beverages, and many parents consider 100% fruit juice to be healthful. A potential problem exists in that fruit juice can be easily over consumed, suggesting that excess calorie intake from fruit juice consumption might lead to childhood obesity. Obesity in adolescence might result from the persistence of childhood obesity. In addition, preferences for sugar-sweetened beverages, such as fruit drinks and carbonated soft drinks, may persist into adolescence from childhood habits formed when 100% fruit juice rather than water is consistently offered to quench thirst.

Increased intakes of fruit juice consumption (Dennison, 1996) might relate to the high prevalence of childhood obesity, which was 10.4% in 1999-2000 among children aged 2-5 years (Ogden et al., 2002). High intakes of fruit juice (≥12 oz/day) among preschool children have been associated with overweight in one cross-sectional study (Dennison et al., 1997) but not in longitudinal studies (Skinner et al., 1999; Alexy et al., 1999). A recent longitudinal study found that neither fruit juice, nor any other beverage (including fruit drinks, milk, regular or diet soda) were associated with BMI change among low income pre-school WIC-participating children aged 2-5 years living in North Dakota (Newby et al., 2004). A small cross-sectional study (n = 77) among preschool children participating in the Atlanta WIC program also found no association between overweight and fruit juice consumption (Kloeblen-Tarver, 2001). The original research that asserted that consumption of 100% fruit juice was associated with both short stature and childhood obesity (Dennison et al., 1997) was controversial, because parents and nutritionists viewed 100% fruit juice to be more nutritious than other sweetened beverages (Doucette & Dwyer, 2000; Rampersaud et al., 2003). It is important to resolve the fruit juice controversy, to understand whether fruit juice is associated with childhood and adolescent obesity, given the extent to which obesity in adolescence results from the persistence of childhood obesity, or from gradual weight gain over time.

In the controversial study, intakes of 100% fruit juice assessed using seven-day food records were associated with measured height and weight in 168 children age 2 and 5 years attending a well child care visit to physicians practicing in rural upstate New York (Dennison et al., 1997). Nineteen of the children (11%) were consuming at least 12 fluid ounces of fruit juice per day. Short stature (defined as height less than the 20th sex-specific percentile for age) was significantly more common among these heavy juice drinkers than among those drinking less juice (42% vs. 14%). Obesity was also more common among those drinking ≥12 oz/day juice; 32% had a BMI ≥90th age- and sex-specific percentile, as compared to 9% of those drinking less juice. Dennison et al. (1997) concluded that excess fruit juice was associated with increased risks of both short stature and obesity in preschool children. In some children, excess fruit juice may have displaced other, more nutrient-dense foods from the diet, leading to a slowing of growth.

In other children, fruit juice may have been consumed in addition to an already-adequate diet, leading to excessive caloric intake.

Impaired growth due to excessive fruit juice consumption had been previously implied in a report of eight cases of nonorganic failure to thrive in 1-2-year-olds (Smith & Lifshitz, 1994). Impaired growth could result from the displacement of nutrient-dense foods, as well as from diarrhea and other gastrointestinal symptoms of carbohydrate malabsorption, particularly when fruit juices high in both sorbitol (which is nonabsorbable) and fructose (which may be incompletely absorbed), such as apple juice, are overconsumed (Lifshitz et al., 1992; Doucette & Dwyer, 2000). Dennison et al. (1999) conducted a follow-up study to determine whether the effect of fruit juice consumption depended on the type of fruit juice consumed. Orange juice was absolved in this study, as the previously observed association with short stature was specific only to the consumption of apple juice or grape juice, presumably due to malabsorption of carbohydrate, and the association with obesity was observed with apple juice intakes only (Dennison et al., 1999).

The report of excessive fruit juice consumption has remained controversial, and one correspondent wrote, "How can something that causes failure to thrive be associated with obesity?" (Levine, 1997). Letters to the editor of *Pediatrics* raised several questions about the design and interpretation of the Dennison et al. (1997) study (Dhurandhar, 1997; Kennedy et al., 1997; Stinson, 1997). One criticism of the study was that the 75th percentile was used as a cut point to define obesity, rather than the 95th or 85th percentiles used to define "overweight" or "at risk for overweight" today (Kuczmarski et al., 2000), and mother's heights were taken into account in the analyses while fathers' heights were not. The duration of fruit juice intake by the 2-year-olds may have been too brief to produce detectable effects on height and weight, and the number of children who consumed ≥12 oz/day fruit juice was small. Most importantly, the cross-sectional design of the study did not allow for causal inferences, and it was possible that "overweight" children were drinking more fruit juice while reducing intakes of fruit drinks and soda in response to their weight, an example of reverse causation. In response, the authors stated that data had been collected to determine optimal methods of assess children's dietary intake, and the relationship between fruit juice intake and growth parameters was examined only after it was noted that many children seemed to drink excessive amounts of juice. Thus, some data that might have been relevant (such as father's heights) were not collected. The authors agreed that cause-and-effect relationships had not been established, and recommended that longitudinal studies of fruit juice intake and child growth should be conducted.

A longitudinal study of 105 children aged 2-3 years found no relation between daily fruit juice intake and height, BMI or ponderal index (calculated as kg/m^3), nor did they find that fruit juice consumption displaced milk from the diet (Skinner et al., 1999). A similar study by the same authors followed children as they grew from age 2 to 6 years (Skinner & Carruth, 2001). This second study also showed no relationship between fruit juice and growth, but fruit juice intake decreased while soda intake increased, as children grew older (Skinner & Carruth, 2001). In another longitudinal study of 205 German children age 305 years, each with four or more repeated measurements, none consuming 12 oz or more fruit juice per day were overweight, and BMI and height z-scores were not related to excessive juice consumption (Alexy et al., 1999).

Although negative results from longitudinal studies have not supported the original observation, the American Academy of Pediatrics still issued a statement regarding fruit juice consumption (AAP, 2001) in response to the assertions that excessive consumption of 100% fruit juice is associated with failure to thrive (Smith & Lifshitz, 1994) and short stature as well as obesity (Dennison et al., 1997) in children. The AAP advised against introducing fruit juice into the diets of infants less than 6 months old, and recommended limiting 100% fruit juice consumption to 4-6 oz/day for children 1-6 years, and 8-12 oz/day for children 7-18 years (AAP, 2001). Analyses of CSFII 1994-96, 1998 data found that mean daily intakes of 100% fruit juice, 4.6 and 3.4 oz for children 6 months-6 years and 7-18 years, respectively were within the recommended amounts (Rampersaud et al., 2003). Intakes of <6 oz/day were consumed by 73% of children 6 months-6 years, and <12 oz/day were consumed by 91% and 94% of those aged 6 months-6 years and 7-18 years, respectively (Rampersaud et al., 2003). Intakes of sweetened beverages (fruit drinks and carbonated soft drinks) increased, and milk intakes decreased with age such that at age 5 years and older, mean intakes of either of the two sweetened beverages exceeded 100% fruit juice intake, and at age 13, children were drinking more carbonated soft drinks than milk as well (Rampersaud et al., 2003).

Orange juice can be an important source of nutrients in the diets of pre-school children. In a representative sample of 329 Native American and non-Hispanic white children aged 1-6 years living in rural Oklahoma, orange juice contributed 46.2% of total vitamin C intake (Stroehla et al., 2005). Orange juice was the first-ranked dietary source of vitamin C, with the second-ranked dietary source, sweetened fruit drinks, contributing 8.7% and oranges, the only solid fruit contributing more than 2%, ranked fifth at 4.2% of vitamin C intake. Orange juice contributed 15.9% of folate, second only to cold cereals at 17.4%, and orange juice contributed 3.7% of carbohydrate intake. Orange juice was ranked tenth as a source of carbohydrate, and other beverages that ranked higher included nondiet soft drinks (rank 1, 8.8%), sweetened fruit drinks (rank 2, 7.7%), whole milk (rank 4, 5.8%), 1% or 2% milk (rank 5, 4.7%) and 100% apple/grape juice (rank 8, 4.1%). Although orange juice contributed more vitamin C and folate to the diets of these children, other beverages frequently consumed contributed more to energy and carbohydrate intakes (Stroehla et al., 2005).

In a recent prospective study, the association of beverage consumption with annual weight change was studied using a semiquantitative FFQ in 1,345 children aged 2-5 years who visited a North Dakota clinic twice within 6-12 months time (Newby et al., 2004). Because earlier studies had classified consumption of more than 12 oz/day as high fruit juice intake (Dennison et al., 1997; Alexy et al., 1999), fruit juice intakes and intakes of other beverages were dichotomized in a similar manner, as well as being modeled as continuous variables. In this sample of children who visited the WIC clinic between January 1, 1995 and June 30, 1998, about 45% of children consumed 12 oz or more fruit juice per day. Analyses of the association between beverage consumption and weight change were adjusted for sex, change in height, age and total energy intake at baseline, birth weight, maternal years of education, race/ethnicity, residence and poverty level. Energy intake was then excluded because it can be argued that it should not be in the model if total energy is the mediating variable in the pathway between the exposure (beverage consumption) and the outcome (changes in weight or BMI). All beverages were significantly associated with total energy, but there were no significant relations between weight change and intakes of fruit juice, fruit drinks, milk, regular soda or diet soda. There was no association between weight change and beverage consumption, regardless of whether all beverages were considered individually or included in the same model, and results did not change when energy intake was omitted from the model (Newby et al., 2004).

Although the majority of studies have shown that neither 100% fruit juice nor sweetened beverages was associated with obesity in preschool children, some studies have indicated that sweetened beverage consumption was associated with obesity in adolescence. Preferences for consumption of sweetened beverages, such as fruit drinks and carbonated soft drinks, may persist into adolescence due to habits formed in childhood when 100% fruit juice rather than water is consistently offered to quench thirst.

According to Food and Drug Administration (FDA) regulations, only 100% fruit juice can be labeled as a fruit juice, and any product containing less than 100% fruit juice must be labeled with a descriptive term, such as "drink," "beverage," or "cocktail" (AAP, 2001). Like carbonated soft drinks, fruit drinks often contain added sweeteners, and they are nutritionally distinct from 100% fruit juice. For example, orange juice is a good source of folate and potassium, while FDA does not allow fortification of fruit drinks with either of these two nutrients (Rampersaud et al., 2003). Nevertheless, there is a common misperception that fruit drinks are the same as fruit juice, especially among adolescents.

A concern is that adolescents may believe that they are regularly consuming a healthful beverage such as orange juice for breakfast, when in actuality they are consuming fruit drinks, such as Hi-C and Sunny Delight. This is relevant to the current study, because adolescents may have misconstrued a question asked in a FFQ, "How often do you drink fruit juice, such as apple juice or orange juice?" The sequence of the questions in the FFQ was such that the fruit juice question was asked before the one about fruit drink consumption. Thus, the respondent would not realize the mistake until they are later asked, "How often do you drink beverages such as Hi-C, Tang or Sunny Delight?" The result of the misperception and misclassification of the exposure is that fruit juice might be found to be associated with adolescent obesity in the current research, because fruit drinks contain added sweeteners and are often consumed heavily by adolescents. Thus, the "fruit juice controversy" may not be resolved by the current study if fruit juices are mistaken for fruit drinks often consumed by teens.

3. Sugar-sweetened beverages

Sugar-sweetened beverages include soft drinks and fruit drinks that contain added sugars. These beverages are frequently consumed, and contribute a large portion of the total energy intake of youth. For those youth having an excess of energy intake from sugar-sweetened beverages compared to energy expenditure, the positive energy balance could lead to incremental weight gain in adolescence. This section reviews prospective and cross-sectional studies that have investigated the relationship between sugar-sweetened beverage intakes and body weight in youth.

Several prospective studies (Ludwig et al., 2001; Mrdjenovic & Levitsky, 2003; Berkey et al., 2004) and intervention studies (James et al., 2004; Ebbeling et al., 2006) have investigated the relationship between soft drink intakes and weight gain in youth. In a 19-month study of children aged 11-12 years (n=548) in Boston-area middle schools, each additional 12-oz serving/day of soft drink was associated with an increase in BMI of 0.18 kg/m^2 (p=0.03) and a 60% increased obesity risk (p=0.02) (Ludwig et al, 2001). Mrdjenovic & Levitsky (2003) measured the body weight of children aged 6-13 years (n=21) at the beginning and end of their 4-8 week stay at a day camp, and found that those who consumed the highest level of sugar-sweetened beverages (>16 oz/day) gained 1.12±0.7 kg, while those who consumed 6-12 oz/d or 12-16 oz/d sugar-sweetened beverages gained 0.32-0.48±0.4 kg (differences between the latter two groups were not statistically significant). In a large 2-year study, offspring of Nurse's Health Study II participants aged 9-14 years (n= 5,321 boys; n=6,871 girls), each additional serving/day of sugar-sweetened beverages was associated with year-to-year increases in BMI of 0.04 kg/m^2 (p=0.01) for boys, and 0.03 kg/m^2 (p=0.08) for girls (Berkey et al., 2004).

In a 1-year intervention study of children aged 7-11 years (n=644) in six primary schools in southwest England, soft drink consumption and the prevalence of overweight and obesity decreased by 0.6 glasses (150 mL) per day and 0.2% in the treatment group, while increased soft drink consumption of 0.2 glasses (50 mL) per day was associated with a 7.5% increased prevalence of overweight and obesity in the control group (James et al., 2004). A 25-week study of 103 adolescents aged 13-18 years was to provide noncaloric beverages by home delivery to decrease consumption of sugar-sweetened beverages in the intervention group. The intervention compared to the control resulted in a net effect of reducing BMI by –0.75 kg/m2 among the subjects in the upper baseline-BMI tertile, but the net change in BMI was not statistically significant overall. Prospective and intervention studies have shown a direct albeit weak association between soft drink intakes and weight gain in youth. However, all except the most recent study

(Ebbeling et al., 2006) were limited to children aged 14 years and younger, and results cannot be generalized beyond the respective study populations.

Several cross-sectional studies used the national survey databases and reported soft drink intake in relation to BMI or overweight status (Troiano et al., 2000; Forshee & Storey, 2003; Forshee et al., 2004; Boumtje et al., 2005). Descriptive data from a bivariate analysis of NHANES III, 1988-94, data, with no adjustments for covariates, suggested that soft drinks contributed a higher proportion of energy intake for overweight than nonoverweight adolescents aged 12-19 years (males: 10.3% vs. 7.6%; females: 8.6% vs. 7.9%). Standard errors for the descriptive statistics or tests for significant differences were not reported (Troiano et al., 2000). Further analyses of NHANES III data showed no correlation of soft drinks or fruit drinks with BMI for adolescents aged 12-16 years (Forshee & Storey, 2003; Forshee et al., 2004). The same researchers also found no clear relationship between BMI and sugar-sweetened beverage consumption using CSFII, 1994-98, data (Forshee & Storey, 2003). Others using CSFII data in logistic regression models found no relationship between soft drinks and obesity in adolescents aged 12-18 years, but soft drinks were inversely associated with normal weight and positively associated with obesity in children aged 5-11 years (Boumtje et al., 2004).

Using both NHANES and CSFII data, Forshee and Storey (2003) controlled for age, gender and ethnicity and found no relationship between beverage intakes and BMI, but rather than predicting BMI from beverage intakes, BMI was entered along with the covariates as an independent variable, and intakes of each beverage category (fluid milk, regular soft drinks, fruit drinks, 100% fruit juice; g/d assessed using 24-hour recall) were the dependent variables in separate regression models. In a second study by the same authors, NHANES III data were used, and BMI was the dependent variable in a linear regression model, while intakes of the various beverage categories (regular soft drinks, diet soft drinks, fruit drinks, coffee, tea, beer, wine) were included simultaneously in the model (Forshee et al., 2004). Beverage intakes (times/month) were assessed using FFQ in one model, and beverage intakes (g/d) were assessed using 24-hour recall in another model, and both the FFQ and 24-hour recall models also included energy from sources other than beverages (Kcal/day, assessed using the 24-hour recall). Models were adjusted using the usual covariates such as gender, age, race-ethnicity, region and household income (% of poverty threshold), and physical activity. Rather than using the exercise variable, only sports team participation was used to assess physical activity. In addition, TV watching (hours per day) was used as a measure of sedentary behavior.

In another study, intake variables simultaneously included in the model were soft drinks, whole milk, low fat milk, other dairy, grains, vegetables, fruits, meat, fats and oils, legumes, dietary fiber, cholesterol, sodium, with amounts of food and nutrients assessed using 24-hour recall and averaged over 2 days (Boumtje et al., 2005). Analyses were also adjusted for income, race, Hispanic origin, age, gender, region, participation in food stamps or and school lunch programs, exercise and TV watching. Rather than using BMI as the dependent variable in a linear regression model, logistic regression was used to estimate the risk for overweight and obesity based on gender- and age-specific BMI percentile criteria (Boumtje et al., 2005).

The current NHANES III study differs from the research previously conducted using the national survey data sets. Because of the potential for multicollinearity among covariates in the model, in the current study, intakes of the various beverage categories were not included simultaneously in the model. Instead, the beverage pattern classification was entered into the model as a dummy variable to assess the independent effects of consuming different combinations of beverage categories. Usual beverage patterns were assessed using only the FFQ, and energy intake assessed using the 24-hour recall was not included in the model. Because the hypothesized relationship between beverage patterns and obesity is mediated through energy intake, the model would be "overcontrolled" if energy intake were included as a covariate. Instead, a separate investigation contrasted mean energy intakes of groups of youth characterized by the various beverage patterns. If the associations between beverage patterns and BMI were reported, this would have been consistent with previous research, but, because BMI is not adjusted for age and gender, indicators of overweight and adiposity included the BMI percentile and percentage body fat.

It has been hypothesized that intakes of sugar-sweetened beverages are correlated with adolescent obesity, not only because these beverages are frequently consumed and contribute a large portion of the total energy intake of youth, but also because sugar consumed as a liquid seems to promote obesity more consistently than sugar consumed in the form of solid foods. It has been hypothesized that liquids, rather than solids, are less likely to trigger satiety mechanisms, and this hypothesis was explored in the "jellybean" study (DiMeglio & Mattes, 2000). This was a crossover trial in which subjects were fed isoenergetic carbohydrate loads as either a soda (a liquid load) or jelly beans (a solid load) during two 4-wk periods separated by a 4-wk washout. Subjects compensated for the 450 calories contained in the jellybeans by consuming roughly 450 fewer calories form other food, but they failed to compensate for the soft drinks, essentially adding 450 calories to their previous diet. Significant increases in both body weight and BMI occurred only during the liquid load period (DiMegglio & Mattes, 2000). These results and other studies that compared regular soft drinks to low-calorie "diet" soft drinks (discussed in the next section) suggest that calories in sugar-sweetened beverages "add on" energy intake rather than displacing other foods in the diet.

4. Low-calorie "diet" soft drinks

In recent decades, intense sweeteners, such as aspartame, have been marketed as sugar substitutes used to prevent weight gain, but remarkably few long-term studies have examined the efficacy of aspartame in dietary approaches to weight management. Consuming foods and beverages containing artificial sweeteners might have a minimal effect on energy intake and body weight, because dieters might be compensating for the energy deficits by consuming other calorie-containing foods (Rolls, 1989). Another concern is that the perception of sweetness even without calories might actually stimulate the appetite. This section will review clinical trials that investigated the efficacy of aspartame in weight management. Short-term clinical trials that compared sugar-sweetened beverages with low-calorie "diet" soft drinks are emphasized in this review. The use of artificial sweeteners in beverages might lower the energy intake that would occur when calories are provided by sugar-sweetened beverages.

Raben et al. (2002) reported that subjects whose diets were supplemented with sucrose (~152 g sucrose/day, 70% from soft drinks) for 10 weeks had significantly higher energy intakes, body weight, fat mass, and blood pressure; decreases or no changes in these variables occurred when the subjects diets were supplemented with foods and beverages containing artificially sweetened supplements (0 g sucrose/day). The authors noted that energy obtained from sweetened beverages appeared to be less satiating than energy from solid foods (Raben et al., 2002), and others have found that it might be easier to over-consume energy when drinking liquids than when eating solids (DiMeglio & Mattes, 2000).

De Castro (1993) investigated the effects of various beverages and foods on energy displacement and reported that subjects (n = 323) who drank sugar-free soda consumed significantly less carbohydrate throughout the day than individuals who did not drink diet soda. Meanwhile, those who drank sugary sodas consumed more carbohydrate and energy on days when they drank soda than on days when they did not. After subtracting the energy content of beverages from total energy intakes, energy intakes from all other foods and beverages on days when soda was consumed did not differ significantly from total energy intake on days when soda was not consumed. These data indicate that energy derived from beverages lead to elevated energy intakes and does not displace energy ingested from other foods (i.e., individuals do not compensate by reducing food intake).

An investigation on lunchtime beverages consumed by pre-school children (n = 134) found that chocolate milk sweetened with sucrose increased the children's lunchtime energy significantly (~65 extra kcal compared with plain milk and chocolate milk sweetened with aspartame ($p < 0.05$). There was no compensation for energy when the children selected their afternoon snack 3 hours later (Wilson, 1999). A review of the literature suggests that caloric compensation might occur only if a test meal is provided within a short time (0-30 min) following the liquid load ingestion (Almiron-Roig et al., 2003). Timing of the occasion when beverages are consumed in relation to other meals is thus important. CSFII data show that beverages, especially soft drinks, are frequently consumed at a mid-meal snack or beverage break (Hampl et al., 2003), and energy consumed at the next meal would be unaffected if that meal did not take place until hours later. If there is little energy intake compensation for the calories consumed when drinking sugar-sweetened beverages, then artificially sweetened beverages might be efficacious alternatives to prevent the weight gain that might occur when sugar-sweetened beverages are consumed.

Tordoff & Alleva (1990) conducted a crossover trial in which subjects (21 men and 9 women) consumed 4 bottles/day (1135 g) of soda sweetened with either high-fructose corn syrup (HFCS) or aspartame, during each of two 3-week periods. Compared to the 3-week control period in which no soda was given, drinking aspartame-sweetened beverages decreased body weight of men by 0.47 kg ($p < 0.05$) but not women. While drinking sugar-sweetened beverages women gained weight significantly (0.97 kg, $p < 0.01$) and men gained slightly (0.52 kg, NS). These data are difficult to interpret, because women lost significantly more weight than men during the control period, and the weight changes that occurred during one experimental period might be compensating for those changes that occurred during prior periods.

Few long-term studies examined the efficacy of aspartame in dietary approaches to weight management. Blackburn et al. (1997) investigated whether adding the use of aspartame to a multidisciplinary weight-control program would improve weight loss and long-term body weight control. They randomly assigned 163 women who were obese to consume or to abstain from aspartame-sweetened foods and beverage during 16 wk of a

19-wk weight-reduction program (active weight loss), a 1-yr maintenance program, and a 2-yr follow-up period. Women in both groups lost ~10% of their initial body weight (10 kg) during active weight loss. The weight loss was positively correlated with exercise and eating control among women in both groups. In addition, the weight loss was positively correlated with aspartame intake ($r = 0.32$, $p < 0.01$) among women assigned to the aspartame group. During maintenance and follow-up, participants in the aspartame group experienced a 2.6% (2.6 kg) and 4.6% (4.6 kg) regain of initial body weight after 71 and 175 wk, respectively, whereas those in the no-aspartame group gained an average of 5.4% (5.4 kg) and 9.4% (9.4 kg), respectively.

Although there is little evidence that artificial sweeteners reliably decrease appetite or reduce energy intake, drinking low-calorie "diet" beverages might possibly lower the energy intake that would occur if caloric, sweetened drinks were consumed instead. Implementing the substitution of low-calorie "diet" beverages for sugar-sweetened beverages as one strategy in a multidisplinary weight-loss program can improve long-term weight control (Blackburn et al., 1997). Whether weight loss is achieved when "diet" beverages are consumed cannot be investigated in a cross-sectional study. A positive correlation between "diet" soft drinks and the prevalence of overweight observed in a cross-sectional study could easily be explained by *reverse causation*: overweight youth drinking "diet" soft drinks because they are overweight. In the current study, the regression model was adjusted to control for those who were trying to lose weight, in order to explain any positive relationship between overweight and "diet" soft drink intake.

5. Coffee and Tea

Although coffee and tea are not widely consumed by youth, and alone do not provide many calories, the added sugar, cream and flavored syrups consumed with these beverages can be a source of discretionary calories. In addition, both coffee and tea contain stimulants like caffeine and theobromine, all known to increase metabolic rate (Acheson et al., 1980; Astrup et al., 1990; Bracco et al., 1995). This section will review recent studies relevant to their intake and body weight.

Metabolic rate and lipid oxidation are increased by caffeine contained in coffee and tea (Acheson et al., 1980; Astrup et al., 1990; Bracco et al., 1995), but whether long-term caffeine use affects body weight is unclear (Astrup et al., 1992). In contrast to black tea, which is a product of fermentation, green tea and oolong tea are non- and partially fermented/oxidized products, respectively, containing polyphenols, such as epigallocatechin gallate (EGCG), which may confer effects in addition to those attributed to caffeine (St-Onge, 2005). Caffeine acts by inhibiting the degradation of cyclic AMP by phosphodiesterase, and by increasing noradrenalin release through antagonism of adenosine (Dulloo et al., 1992). Tea catechins inhibit the degradation of noradrenalin by catechol O-methyl-transferase (Borchardt & Huber, 1975). Thus, both caffeine and EGCG increase the stimulation by noradrenalin of energy and lipid metabolism.

In an *in vitro* study, green tea extract (GTE) stimulated thermogenesis in brown adipose tissue, while caffeine alone did not, and this effect of green tea was thus attributed to the polyphenolic compounds (Dulloo et al., 2000). In an *in vivo* experiment, GTE with low caffeine and high catechin content elevated hepatic lipid metabolism in mice fed a high-fat diet for 1 month (Murase et al., 2002). Oolong tea prevented an increase in body weight, adipose tissue and fatty liver in mice fed a high-fat diet as well (Han et al., 1999). Young Wistar rats drinking green tea (GT) for 3 weeks had reduced adipose tissue weight compared to controls drinking water (Ashida et al., 2004). GT reduced glucose uptake into adipose tissue, while uptake of glucose by skeletal muscle increased (Ashida et al., 2004). Exercise-induced muscular beta-oxidation activity was increased by catechin supplementation in mice, and whole-body lipid oxidation as determined by indirect calorimetry was also higher in the catechin-exercise group (Murase et al., 2006). Thus, animal models have shown effects of GT on reduced adipose tissue weight and reduced diet-induced obesity mediated via increased energy expenditure in various target tissues, while glucose uptake into adipose tissue and lipogenesis decreased as well.

In a study of 10 men conducted in France using a metabolic chamber, capsules containing GTE were found to increase 24-hr energy expenditure by 2.8% more than caffeine alone, and 3.5% more than the placebo (Dulloo et al., 1999). Urinary norepinephrine increased, and a decreased 24-hr respiratory quotient indicated that the GTE increased fat oxidation. This was a randomized, double-blind, placebo-controlled, cross-over trial, but the duration of each treatment was only 1 day, too short of a time period to assess changes in body weight (Dulloo et al., 1999). An epidemiological study of tea consumption in Taiwan (n=1,103) found that those who consumed tea for more than 10 years had lower percent body fat, smaller waist circumference, and decreased waist-hip ratio (Wu et al., 2003). Most Taiwanese drink either green or oolong tea, but the type of tea, amount consumed and catechin intake were not assessed in this study (Wu et al., 2003).

In a double-blind, controlled trial, 17 Japanese men drank 1 bottle/day of oolong tea containing GTE, while 18 men (controls) drank oolong tea without GTE (Nagao et al., 2005). Both groups were on a low-calorie diet, and both beverages contained the same amount of caffeine, but the GTE group had further reductions than controls in body weight, BMI, waist circumference, body fat mass, and subcutaneous fat area after the 12-week treatment (Nagao et al., 2005).

In the Netherlands, however, among 46 overweight women, GTE consumed for 12 weeks with a low-energy diet had no effect on weight, BMI, waist-hip ratio and fat mass (Diepvens et al., 2005). Further, GTE consumed for 13 weeks had no effect on weight maintenance after 104 overweight and moderately obese male and female subjects had achieved a 7.5% weight loss with a 4-week low-calorie diet (Kovacs et al., 2004). Caffeine intake was 300 mg/d in both the treatment and control groups in the weight loss study (Diepvens et al., 2005), but caffeine intake from other sources was not controlled in the weight maintenance study (Kovacs et al., 2004).

GT consumers regaining the most weight were observed to have higher habitual caffeine intakes, and authors suggested that GT and oolong tea might be effective against obesity only in low-to-moderate caffeine users (Kovacs et al., 2004). The same group of investigators confirmed this hypothesis in a subsequent study by repeating the experiment while controlling for habitual caffeine intake; 4 weeks of a very low-energy diet was followed by GTE or placebo given during a 13-week maintenance period (Westerterp-Platenga et al., 2005). Although habitual high-caffeine consumers had greater reductions in weight, fat mass, and waist circumference on the low-energy diet than habitual low-caffeine consumers, only the low-caffeine GT group continued these reductions during the following 13-week period, while the other 3 groups regained what was lost (Westerterp-Platenga et al., 2005). Whether it was the caffeine or catechins in green tea that prevented weight gain remains unclear.

Short-term thermogenic effects of caffeine have been reported in studies of lean and obese men and women, but the metabolic rate and lipid oxidation are less stimulated by caffeine in obese than in normal-weight subjects (Acheson et al., 1980; Bracco et al, 1995). The thermogenic effects of caffeine are dose-dependent (Astrup et al., 1990), but whether these short-term effects of caffeine translate to long-term changes in body weight are unclear. There was no difference in weight loss after 24-weeks of energy-restriction for those given caffeine (3 x 200 mg/d) compared to placebo (Astrup et al., 1992).

There have been inconsistencies in results of epidemiological studies of the association between body weight and caffeine intake from food and beverages. Over a 12-year period from 1986 through 1998, increases in caffeine intake, as well as increases in coffee or tea consumption, were associated with slightly smaller weight gain in 18,417 male and 39,740 female health professionals participating in two large prospective studies (Lopez-Garcia et al., 2006). A meta-analysis of epidemiological studies has shown an inverse relationship between coffee consumption and type 2 diabetes risk (van Dam & Hu, 2005), and some type 2 diabetes risk reduction can be explained by the hypothesized inverse association between caffeine intake and weight gain. Caffeine intake explained some weight change in the NHANES I Epidemiologic Followup Study (NHEFS), and caffeine intake decreased diabetes risk only among those who had previously lost weight (Greenberg et al., 2005).

A study conducted in northern Italy showed no association between BMI and coffee consumption (Tavani et al., 1994), while in Tromsø, Norway, where boiled coffee is traditionally brewed, a positive association with BMI was observed (Jacobsen & Thelle, 1987; Wilsgaard et al., 2005). A large prospective study conducted in Copenhagen, Denmark, found that coffee intake was positively associated with waist circumference in women (without controlling for BMI), and tea intake was positively associated with BMI-adjusted changes in waist circumference in men (Halkjaer et al., 2004).

Although black, unsweetened coffee and tea contribute little to energy intake, added sugar and cream can transform coffee and tea into high-calorie sweetened beverages. Frequent tea times and coffee breaks of caffeine users could then contribute a large proportion of total calories consumed throughout the day, especially if high-calorie baked goods are also consumed at these snack occasions. College women who drank gourmet coffee beverages had a 206 kcal/d higher energy intake, and 32 g/d higher sugar intake than those who did not (Shields et al., 2004).

The decision to add sugar to coffee or tea was influenced by past dental health experiences, education and parents, although the sweet taste of sugar giving immediate gratification outweighed any negative aspect of sugar consumption in the minds of 16-year-olds who responded to a questionnaire based on Ajzen & Fishbein's 'Theory of Reasoned Action' (Freeman & Sheiham, 1997). Dissatisfaction with their appearance due to acne or obesity was the main factor that persuaded some British teenagers to stop sweetening their coffee or tea, reduce added sugar, or use a sugar substitute (Thomson, 1977). Using coffee or tea to help control weight would not be effective, if sugar is added to caffeinated beverages.

Sweet, iced tea is frequently consumed in Southern regions of the United States, and in a study of eating patterns and obesity in 10-year-old black and white collected in Bogalusa, Louisiana, the sweetened beverage category consisted of 58% soft drinks, 20% fruit drinks, 19% tea, and 3% coffee (Nicklas et al., 2003). Soft drinks such as Coca-Cola, Pepsi, and Mountain Dew contain both added sugars and caffeine. Caffeine is an addictive substance, and many young people are in the habit of consuming soft drinks instead of coffee or tea at breakfast time and throughout the day. Glucose-caffeine "energy drinks" recently marketed would also increase added sugar intakes of consumers who use these beverages as stimulants (Anonymous, 2006).

The 24-hour recall dietary assessment method was used in the Bogalusa Heart Study to determine whether the children consumed beverages containing added sugar (Nicklas et al., 2003). The FFQ item used in the current NHANES III study of adolescent obesity and beverage consumption is specific with regard to caffeine contained in coffee and tea. However, the respondents were not asked how often sugar was added to these beverages. The 24-hour recall data was used to compare mean energy, caffeine, and added sugars intakes of youth who usually consumed the various types of beverages (according to the FFQ). The association between BMI and caffeine intake from coffee and tea would be attenuated, if frequent consumers of coffee/tea have high energy and added sugars intakes.

6. Alcoholic Beverages

Alcohol is a calorie-dense food, and as such alcoholic beverages potentially relate to obesity. Alcohol contains 7 calories per gram, with an energy density approaching that of fat (9 calories per gram), almost twice the 4 calories per gram of carbohydrate or protein. An alcoholic beverage containing 12-15 grams of alcohol would add about 100 calories from the alcohol alone, and calories from carbohydrate and sugars are found in beer, wine and mixers as well. Some coolers contain up to 7% alcohol and >250 kcal per 8-fl oz due to added sugars, compared to 104 kcal per 8-fl oz soda (Popkin et al., 2006). These heavily marketed alcohol-containing beverages are packaged like soft drinks and targeted towards young adults who may have preferred sweetened beverages in adolescence (Popkin et al., 2006). Because alcohol is an addictive substance, it is possible, but not established, that marketing these coolers and other alcoholic beverages toward young adults might engender a link between sugar-sweetened beverage intakes in youth and a pattern of alcohol consumption that continues into adulthood.

Alcoholic beverages and sugar-sweetened beverages were both top sources of energy consumed at snacks by young adults age 19-29 years (Zizza et al., 2001). In some subpopulations of the U.S., obese women reported significantly higher energy intakes than non-obese women due to greater consumption of both alcoholic beverages and sugar-sweetened beverages (Teufel & Dufour, 1990). The following review of literature pertains to the association of obesity with alcohol intake in adults, while the current study was conducted with a sample of adolescents age 12-16 years that includes only a few under-age drinkers.

Although heavy drinkers might substitute alcohol for food and therefore become emaciated and malnourished, moderate alcohol consumers usually add ethanol calories to their normal diet and potentially gain weight (Suter et al., 1997). Whether alcohol consumption leads to weight gain depends on a lack of compensation for liquid calories at subsequent meals. Unlike other macronutrients, alcohol may bypass satiety mechanisms mediated by gastrointestinal hormones, such as cholecystokinin or gastrin, and a low hormonal response could lead to under-compensation for alcohol calories consumed (Astrup et al., 2002). On the other hand, consumption of high-energy preload drinks of either alcohol or sweetened carbonated beverages did not result in a compensatory decrease in the *ad libitum* intake of energy at a subsequent meal, thus there may be insufficient compensation for both alcohol and carbohydrate calories when presented in a liquid form (Mattes, 1996; Poppitt et al., 1996). That liquid calories do not trip satiety mechanisms was shown in an experiment that compared *ad libitum* food intake after ingesting either soda or jelly beans, in which there was compensation only for calories in a solid form (Di Meglio & Mattes, 2000).

The metabolism of alcohol favors the accumulation of fat over its combustion, because acetate formed from alcohol replaces fat as a substrate for oxidation, and the accumulation of reduced NADH suppresses lipid oxidation (Suter et al., 1997). Acute alcohol improved insulin sensitivity in type 2 diabetic subjects, and this effect may be due in part to the inhibition of lipolysis, because alcohol also increased lactate and decreased free fatty acid concentrations without affecting insulin secretion (Avogaro et al., 2004). However, most cross-sectional studies have shown an inverse association between alcohol consumption and BMI in women, while findings are inconsistent in men

(Hellerstedt et al. 1990). For example, in Wisconsin, a strong inverse relationship between drinking and body weight in women was found, but weight was not different between drinking and non-drinking men (Hansen & Remington, 1992). Another cross-sectional study showed an inverse association of beer intake with BMI in women, but no relationship between beer and BMI was found in men (Bobak et al., 2003). Another recent study of women found an inverse relationship between alcohol and BMI in cross-sectional analyses of BMI (Wannamethee et al., 2004).

Prospective analyses, however, resulted in a J-shaped relationship between alcohol and weight gain, such that consumers of a moderate amount (< 30 g/d) had the lowest risk of weight gain compared to non-drinkers or heavy consumers, and for heavy consumers, the risk of weight gain increased with the amount of alcohol consumed (Wannamethee et al., 2004). The inverse association of alcohol with weight gain observed between non-drinkers and moderate drinkers may be due to reverse causality, as women who are more susceptible to weight gain may abstain from alcohol to avoid the additional calories (Hellerstedt et al., 1990).

A common belief that alcohol consumption leads to weight gain is epitomized by the expression 'beer belly' to describe the abdominal obesity observed in men who are heavy beer consumers. Because alcohol consumption often results in abdominal obesity, waist circumference (WC) or the waist-hip ratio (WHR) may have a clearer relationship with alcohol consumption than BMI. A study of male self-defense officials in Japan showed that alcohol intake was positively and strongly associated with WHR, but not BMI (Sakurai et al., 1997). A recent cross-sectional study of beer and obesity, also found that beer was associated with WHR but not BMI, but only in men who were nonsmokers

(Bobak et al., 2003). Beer intake was not related to WHR in women, but there was a weak inverse association with BMI (Bobak et al., 2003). In a prospective study, WC, WHR and BMI was evaluated in relation to alcohol intake in France, where wine is most commonly consumed, and it was found that increases in both WC and WHR were associated with alcohol intake in both men and women (Dallongeville et al., 1998). Again, an inverse relationship between BMI and alcohol was observed in women, while no association of BMI with alcohol was seen in men (Dallongeville et al., 1998). A recent study found a J-shaped relationship in both men and women between WHR and both total alcohol consumption and wine, such that men and women consuming less than 100 g day had a lower WHR than non-drinkers or those consuming more (Lukasiewics et al., 2005). The same J-shaped relationship between BMI and both total alcohol consumption and wine existed only in men (Lukasiewics et al., 2005). In contrast, another recent study found that beer and spirits associated with increases in WC among women, but not men (Halkjaer et al., 2004). The Copenhagen City Heart Study showed, however, that beer and spirits was associated with increases in WC among both men and women, and no relationship was found with wine (Vadstrup et al., 2003).

Drinking alcohol increased energy intake at meals and snacks, not only by the amount of energy derived from the alcohol itself, but also because food intake may be less restrained when alcohol is consumed (Astrup et al., 2002). Theoretically, wine could be more weight gain inducing, because wine has a higher energy density than beer. Total energy intake at a meal was higher when red wine was served *ad libitum* rather than beer or carbonated soft drinks, because energy intake from the beverage was higher with wine, and it was not compensated for in the food intake (Buemann et al., 2002). However, a 6-

week cross-over trial in which 14 free-living male subjects drank 2 glasses (270 mL) red wine daily at dinner, there were no differences in body weight, body fat or energy intake assessed by a 3 d dietary record (Cordain et al. 1997). BMI and body composition also did not change in a 4-week crossover trial of 450 mL red wine in 34 men (Beulens et al., 2006), and in a 10-week cross-over trial of 190 mL red wine consumed 5 days per week by 20 overweight women (Cordain et al., 2000). Further, moderate intake of red wine at meals is a component of the traditional Mediterranean diet, and this diet was inversely associated with BMI and obesity (Schroder et al., 2004), and with a smaller weight gain in a prospective study (Sanchez-Villegas et al., 2006).

Data collected from 3,327 men participating in the British Regional Heart Study were used to evaluate the association between adiposity and alcohol consumption at meals (Wannamethee et al., 2005). At a 5-year follow-up when these men were middle-aged, it had been shown that heavy alcohol intake (>30 g/d) was associated with weight gain and increased BMI (Wannamethee & Shaper, 2003). All types of alcoholic beverages were associated with WC, WHR, BMI and %BF, regardless of whether the alcoholic beverage was consumed at meals (Wannamethee et al., 2005). Again, effects were stronger for WC and WHR (measures of central adiposity) than for measures of general adiposity (BMI, %BF) (Wannamethee et al., 2005). Although beer and spirits were more strongly related to measures of adiposity than wine (Wannamethee et al., 2005), in contrast, previous studies had shown an inverse association of wine and BMI among men of Northern Ireland (Marques-Vidal et al., 2001) and Wisconsin (Hansen & Remington, 1992).

In summary, most prospective studies have found that alcohol consumption is associated with weight gain, particularly in men, while many cross-sectional studies have shown an inverse association between alcohol and BMI in women. Measures of central adiposity, including WC and WHR, are more strongly correlated with alcohol intake than BMI. A J-shaped relationship may exist such that consumers of a moderate amount of alcohol gain less weight than abstainers, light drinkers or heavy drinkers. Stronger effects in men than in women, and stronger effects of beer than wine, can be explained by the fact that more women than men prefer to drink wine, and moderate amounts are consumed especially when wine accompanies a meal.

The NHANES includes a series of questionnaire items to assess the frequency of alcohol consumption and the prevalence of heavy drinking. Estimates of the prevalence of underage drinking using these data were low, because only a few respondents among the sample of adolescents age 12-16 years included in the current study reported frequent consumption of alcoholic beverages. The relationship between alcoholic beverage consumption and obesity is not relevant to the adolescent population. Should future studies link sweetened beverage intakes of youth with alcohol intake in adults, then this review may be more relevant to the current study of the relationship between beverage patterns and adolescent obesity.

D. NHANES dataset selected for research

The National Health and Nutrition Examination Survey (NHANES) is a series of nationally representative, cross-sectional surveys conducted by the National Center of Health Statistics (NCHS) that include anthropometric measurements made by physical examination, as well as dietary assessment to monitor the nutritional status of the U.S. population. The current NHANES is a continuous survey beginning in 1999, and previous surveys include NHANES III, 1988-1994, NHANES II, 1976-1980 and NHANES I, 1971-1975. This section compares the NHANES with the series of national food and nutrient surveys conducted by USDA. Unique features of the NHANES III, 1988-1994, led us to conclude that this dataset is best for the current study.

National nutrition surveys, such as NHANES, provide critical information to monitor food consumption, dietary intake, and the related health status of the U.S. population. It is important to assess trends in energy intake to understand the relationship of diet to overweight and obesity. A series of national food consumption surveys conducted since the early 1970s are used to identify changes in dietary intake that have occurred over the years. Although dietary assessment methods used in the national surveys have been improved, some inconsistencies in the methods warrant caution in interpretation of data on trends. Changes in dietary intake methodology include the automation of data collection with the use of standardized probes to assist respondent's recall and improved visual aids for estimating portion-sizes (Briefel et al., 1997; Dwyer et al., 2003b). These methodological improvements were necessary to address underreporting of intakes, especially among overweight persons, which have also made it difficult to assess trends.

NHANES dietary intake data are available from the National Center for Health Statistics (NCHS) for the years 1971-75 (NHANES I), 1976-80 (NHANES II), 1982-84 (Hispanic HANES), 1988-94 (NHANES III), and 1999-2002 (Briefel & Johnson, 2004). The U.S. Department of Health and Human Services (DHHS) has been conducting national health examination surveys since 1960, and after the Ten State Nutrition Survey in 1968-70, the nutrition component was added to the health examination survey to form the first NHANES (Wotecki, 2003). The USDA Nationwide Food Consumption Surveys (NFCS) and the Continuing Survey of Food Intake by Individuals (CSFII) were conducted by the U.S. Department of Agriculture (USDA) in 1977-78 (NFCS), 1985-86 (CSFII), 1987-88 (NFCS), 1989-1991 (CSFII), 1994-1996 (CSFII), and the CSFII Supplemental Children's Survey was conducted in 1998 (Tippett et al., 1999). Prior to the 1977-78 NFCS, USDA had been conducting household food consumption surveys since the 1930s, and both household food use and the intake of individuals were components of the Nationwide Food Consumption Surveys (NFCS). However, the household food-use portion of the survey may have contributed to respondent burden, and it was dropped after the 1987-88 NFCS had a very low response rate. With the collaboration of DHHS and USDA per the National Nutrition Monitoring and Related Research Act of 1990, and integration of the CSFII dietary component (What We Eat in America) into the NHANES, dietary intake data is now collected continuously (Madans et al., 2003). The 24-hour recall information from NHANES 2003-2004 will be available with the next data release.

Unlike the CSFII, in addition to the assessment of dietary intake, the NHANES includes anthropometry, blood and urine assessments, and many health status measurements (Bialostosky et al., 2001; Briefel, 2001). Nutritional status is assessed not only by dietary intake but also by biochemical, anthropometric, clinical and functional indicators. Because both dietary and health information is available for the same person, and a link to vital statistics is planned for the future, one of the uses of the NHANES data is to examine the cross-sectional or longitudinal relationships between food intake, nutritional status, health status, occurrence of disease, and mortality (Dwyer et al., 2003a). With each representative sample of the U.S. population continuously providing data, another use of NHANES is to monitor trends in food intake coupled with trends in risk factors for disease (Dwyer et al., 2003a).

NHANES dietary assessment methods have always included 24-hr dietary recall interviews. In addition, food frequency questionnaires (FFQ) have been included in the survey since 1971. A comprehensive semi-quantified FFQ, known as the food propensity questionnaire, was developed by NCI, pilot-tested in NHANES 2002, and implemented in NHANES 2003-04 (Krebs-Smith et al., 2004; Subar et al., 2004). The propensity questionnaire contains more than 100 questions, and it is mailed after the examination to be self-administered by the respondent (Subar et al., 2004). The FFQ used in NHANES I-III and in the Hispanic HANES was extensive, but only a targeted FFQ on milk, green leafy vegetables, legumes, fish, shellfish, and alcohol is in the NHANES 1999-2001. Other diet-related questionnaire content include water intake, salt use, dietary supplements, medications, food security, special diets, food program and school feeding program participation, and a history of milk consumption. The Diet and Health Knowledge Survey (DHKS) ascertained dietary knowledge, attitudes and behaviors of the main meal planner/preparer in CSFII 1989-91 and adults 20 years and older in CSFII 1994-96, and the DHKS had been considered for future integrated NHANES.

At least two 24-hour recalls for a portion of the sample are needed to estimate day-to-day variation and remove its effect when estimating usual intakes of groups using the methods recommended by the National Academy of Sciences. The usual intake distribution provides estimates of the percentage of the population whose intakes are above the UL or below the EAR or some other reference amounts, and these estimates are more representative than intakes that are not adjusted for intra-individual variation. The C-SIDE software has been developed at Iowa State University to perform these adjustments (Carriquiry, 1999; Carriquiry, 2003). Because the adjustment does not affect means, it is not necessary to use NAS method and ISU software when mean intakes of the group are compared to the AI (Murphy, 2003). Unfortunately, it is not possible to use the method to estimate the usual intake of an individual, as it is valid only for estimating the usual intake of groups. Because of an individual's day-to-day variation in dietary intake, there is usually an attenuation of associations between diet and health outcomes. By averaging an individual's intake on more than one day, however, there will be less attenuation of associations than with the use of only a single 24-hour recall. Although two or three days does not accurately capture true, usual intake (Basiotis et al., 1987), the use of more than a single day will improve estimates.

In the past, the NFCS and 1989-1991 CSFII included three consecutive days of dietary intake consisting of a 24-h dietary recall followed by a 2-day diet record. Beginning with the 1994-96 CSFII there were two non-consecutive 24-h recalls. Both were in-person dietary interviews, with the second conducted 3-10 days after the first but not on the same day of the week. NHANES I and II had only a single 24-hour recall. Although NHANES III and NHANES 1999-2001 had a second 24-hour recall for 5% and 10%, respectively, of the samples (there was also a Supplemental Nutrition Survey of adults 50 years and older in NHANES III), beginning in 2002, 100% of the sample (n=5,000/y) had two 24-h recalls. Day 1 was an in-person interview conducted with 3-

dimensional food models, while Day 2 was a telephone follow-up using a food model booklet. Because the dietary assessment method used to collect intakes have been consistent on only Day 1 of the various surveys conducted over the years, trends data are based on only the first day of intake.

The current USDA/ARS Automated Multiple Pass Method has five passes, and it is based on a triple-pass method that had been used successfully in NHANES III, 1988-1994, and CSFII, 1994-96, to help the respondent remember foods consumed in the 24-hour recall period. Automated coding in NHANES III with the Dietary Data Collection system used the University of Minnesota Nutrition Coordinating Center (NCC) code generator program, and this enabled NCHS to link the NHANES III intakes to food composition data for vitamin D and other nutrients available only in the NCC database. The CSFII and current NHANES use the Food Intake Analysis System of the University of Texas for automated coding of foods. In the 5-pass method, first, respondents are asked to list, without interruption, all foods and beverages consumed in 24 h on the day before the interview ("quick list"). Second, the respondent is asked about consumption of commonly forgotten foods, such as nonalcoholic and alcoholic beverages, sweets, salty snacks, fruit, vegetables, cheese, bread and rolls. Third, they are asked to give the time and name of the meal occasion. The fourth pass is the "detail cycle" in which probes elicit details about each meal occasion and each food, including method of preparation, where it was obtained and amount consumed. In the fifth pass the respondent is asked whether the respondent drank or ate anything else during the 24-hour period. Thus, by providing a variety of memory cues at different times throughout the interview, the 5-

pass method assists the respondent in remembering foods, and it has significantly reduced underreporting.

In summary, the utility of the NHANES dietary data is that it can be linked with anthropometric, biochemical, clinical and disease history information. NHANES includes measured rather than self-reported height and weight, in addition to waist circumference and skinfold thickness measurements used to assess body composition. Thus, a cross-sectional analysis of the relationship between dietary factors and obesity are possible because intake and anthropometric data are available for the same individual. Further, detailed food intake records can also be linked to the Nutrient Database for Standard Reference and Pyramid Servings databases to estimate energy intake and consumption of added sugars (Murphy, 2003). Although only a single 24-hour recall was available for NHANES I and NHANES II, in NHANES III and beyond, a second day is available on at least a portion of the sample to estimate usual intake using the methods recommended by the National Academy of Sciences. In addition, an extensive FFQ was available in NHANES III, and this was the main reason why this dataset was selected for use in this study. Data from the food propensity questionnaire will not be available until the release of NHANES 2003-2004 dataset (Krebs-Smith et al., 2004; Subar et al., 2004).

Chapter 3

METHODS

A. Study design

This study was a cross-sectional, secondary data analysis of beverage intakes and obesity among U.S. adolescents age 12-16 years. Data from the Third National Health and Nutrition Examination Survey (NHANES III, 1988-94) (DHHS, 1994) were used in these analyses. Aim 1 was to examine the mean frequency of consuming beverage types, including milk, 100% fruit juice, sugar-sweetened beverages (regular soft drinks and fruit drinks) and other beverages (diet soft drinks, coffee/tea, and alcoholic beverages), and the prevalence of beverage patterns (i.e., the combination of beverage types most frequently consumed); to examine the association of beverages with meal occasions and meal locations; and to examine mean energy, dietary fat, total sugars, added sugar, calcium and other nutrient intake of beverage pattern groups. Aim 2 was to examine the distributions of sociodemographic and lifestyle characteristics that are risk factors for overweight among beverage pattern groups. Aim 3 was to examine the association of obesity outcomes (BMI percentile, percentage body fat, and overweight/risk for overweight) with these beverage pattern groups used as "dummy" variables in regression analyses adjusted for potential covariates of interest.

B. Subjects/ study participants

1. Dataset

The NHANES III, 1988-94, data were used for these analyses, rather than the more recent NHANES, 1999-2002, data, because the food frequency questionnaire used to assess each youth's typical beverage pattern is available only in NHANES III. The National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention conducts NHANES to obtain nationally representative information on the health and nutritional status of the U.S. population. The NHANES III survey received human subject approval from the Centers for Disease Control and Prevention.

a. NHANES interview and examination components

Data pertaining to youth participating in NHANES III were obtained from household interview component, and from the health examination, anthropometric and interview components conducted at a mobile examination center (MEC). Household interview data were collected using the Household Screener Questionnaire, Family Questionnaire and Household Youth Questionnaire. The Household Youth Questionnaire was administered to a proxy respondent, usually the parent or guardian of children and youths 2 months to 16 years of age. Youth were interviewed in a private setting at the MEC without a proxy respondent. Interview components conducted at the MEC included the MEC Youth Questionnaire (ages 8-16 years), the 24-Hour Dietary Recall (all ages) and Dietary Food Frequency (ages 12-16 years). The Dietary Food Frequency interview and other interviews of NHANES III participants age 17 years and older were conducted using the Household Adult Questionnaire and MEC Adult Questionnaire.

b. NHANES dataset for public use

The NHANES III dataset that is available for public use can be downloaded from the NCHS website, or it can be retrieved from the NHANES III 1988-94 CD-ROM using the NCHS Statistical Export and Tabulation System (NCHS, 1997). Variables pertaining to the current analysis of adolescents 12-16 years were obtained from three separate files on the NHANES III, 1988-94, CD-ROM: the Household Youth Data File, the Examination Data File, and the Dietary Recall Data Files. The Household Youth Data File contained the individual and family demographic information. The Examination Data File included the FFQ data for youth 12-16 years, and the physical activity, smoking and alcohol data from the MEC Youth Questionnaire. In addition, the Examination Data File included sexual maturation stage data from the physician's examination for ages 8-18 years, and for all ages, body measurements, as well as the total nutrient intakes, and intakes of plain drinking water obtained in the dietary interview. Detailed information about the individual foods reported by respondents was obtained from the Dietary Recall Data Files.

c. Sample design

NHANES III was conducted in 2 phases: 1988-1991 and 1991-1994. Subgroups of the population, such as non-Hispanic blacks, Mexican-Americans, children and the elderly were over-sampled to allow increased precision in estimates for these groups. With the use of the sampling weights, participants were a representative sample of the civilian, non-institutionalized U.S. population age 2 months and over, selected using a complex, stratified, multistage, probability cluster sample design (DHHS, 1994). The first stage of the sample design was to select the Primary Sampling Unit (PSU) or survey location, the second stage was to select areas within the PSU, the third stage was to select households, and the fourth stage was to select individuals within these households. There were 89 survey locations, and over the six years, 39,695 sample persons were selected, 33,994 (86%) participated in the household interview, and 30,818 of these participants (78% of the selected sample) were later examined in the mobile examination center (MEC).

2. Analytic sample

Adolescents age 12-16 years who were interviewed and examined in NHANES III comprised the analytic sample for this study. This age group was selected partly because of the availability of dietary data for youth 12 years and older, and partly because physical activity was measured differently for youth age 8-16 and adults age 17 years and older. In addition, the TV watching item was not available in NHANES III, 1988-94, for those age 17 years and older. The FFQ was not available in the CSFII or more recent NHANES, 1999-2002, and in NHANES III, 1988-94, the FFQ was not administered to children younger than 12 years. Although children age 6-11 years often participated with a proxy in the 24-hour recall dietary interview, the proxy was the primary respondent for children younger than 12 years.

The NHANES III sample included 2,216 adolescents aged 12-16 years selected for examination, and of those, 2,079 (93.8% of 2,216) were examined in the MEC. Upon examination, 19 respondents (0.9% of 2,216) found to be ineligible (16 teenage girls were pregnant, and three were lactating) were excluded from the current study. Teenage girls who were pregnant or lactating were excluded from this study, to avoid misclassification of overweight and obesity, as the expansion of the waistline, and increased body weight in childbearing and in the postnatal period are not due to increased adiposity.

Because the current study used both 24-hour recall and FFQ data, the analytic sample was limited to adolescents age 12-16 years who completed a 24-hour recall dietary interview as well as all beverage items in the FFQ. Among the 2,060 non-pregnant, non-lactating youth, there were 1,997 youth (90.1% of 2,216; 941 boys and 1,056 girls) who had a complete, reliable 24-hour recall dietary interview, and of these, 97 (4.4% of 2,216) were missing beverage frequency data (79 left at least one of the beverage items blank, and another 18 gave a "don't know" response to at least one beverage item) and another 28 (1.3% of 2,216) were missing data on water intake. The 24-hour recall interview was reliable, but incomplete (missing information for one or more meals, foods or beverages) for 11 respondents (0.5% of 2,216), and unreliable for 10 respondents (0.5% of 2,216). The 24-hour recall data collected from 20 respondents (0.9% of 2,216) was lost due to a computer malfunction or file transfer problem, and there were 22 non-respondents (1.0% of 2,216) to the 24-hour recall dietary interview. These 22 non-respondents included those who refused, those whose proxy did not know what they ate, and those who were not interviewed for some other reason. After excluding those with missing data, the remaining analytic sample of 1,872 youth (84.5% of 2,216) included 871 boys (46.5% of 1,872) and 1,001 girls (53.5% of 1,872) aged 12-16 years.

Tests for differences between participants and non-participants, and tests for differences between the analytic sample and those who were excluded were conducted. Some characteristics of adolescents were ascertained at the household interview, and those who were examined in the MEC (participants: n =2,079) were compared to those who were interviewed but not examined (non-participants: n=137). The household interview data showed that characteristics of participants and non-participants were not significantly different ($p<0.05$). Tests for differences in characteristics ascertained at either the interview or examination were used to compare the analytic sample (n=1,872) and those excluded due to ineligibility or missing data (n=207), and no differences were found ($p<0.05$).

C. NHANES data collection procedures

This research was a secondary data analysis of NHANES III data. Therefore, the data collection procedures were those followed by NHANES staff, while data analysis procedures were those followed in conducting the research plan of current study. The NHANES data collection procedures discussed below include anthropometric assessment methods and dietary assessment methods. Data analysis procedures were steps undertaken to prepare the data for statistical analysis, such as exporting the variables of interest from the NHANES III dataset on CD-ROM and merging the data into a SPSS system file, recoding extreme values reported in the FFQ and recoding continuous measures into categorical variables. Further data analysis procedures included determining overweight status and percentage body fat from BMI and skinfold thickness measures, categorizing beverage items, defining beverage patterns, updating the NHANES III food composition database, and calculating intakes of nutrients that were appended to the database. The data analysis procedures pertaining to each specific aim will be discussed in the variable definition and statistical analysis sections that follow this section on data collection procedures.

1. Anthropometric assessment methods

Body measurements included weight, height, and skinfold thickness. Standard procedures followed for the anthropometric measurements in NHANES III were described in the NHANES III Body Measurements (Anthropometry) reference manual (DHHS, 1998).

a. Weight

Kilogram body weight was measured with accuracy to 2 decimal places using a Toledo electronic-load cell scale. No adjustment was made for 0.1-0.2 kg weight of clothing (underpants, a disposable paper examination gown, paper pants, and foam rubber slippers).

b. Height

Stature was measured using a Holtain Height Stadiometer. Participants stood on the floorboard of the stadiometer with heels, buttocks, scapulae and the back of the head placed against the vertical backboard of the stadiometer. The head was positioned in the Frankfort horizontal plane. Hair ornaments, buns, braids, etc. were removed to obtain an accurate measurement. The examiner read the measurement to the assistant who recorded it to the nearest 0.1 cm, and a photograph of the measurement tape was taken to verify the accuracy of the reading.

c. Skinfold thickness

Measurements of body fat included skinfold thickness at four different anatomic body sites: triceps, subscapular, suprailiac, and thigh. All skinfolds were measured using Holtain skin calipers. The measurements were taken on the right side of the body. The fold of skin and underlying subcutaneous adipose tissue was gently grasped between the examiner's left thumb and forefingers about 2.0 cm above the place where the measurement was to be taken. The jaws of the calipers were placed at the marked level, perpendicular to the length of the fold, and the skinfold thickness was measured to the nearest 0.1 mm while the fingers continued to hold the skinfold. The actual measurement was read from the caliper about 1-2 seconds after the caliper tension was released.

2. Dietary assessment methods

a. The food frequency questionnaire (FFQ)

The FFQ was administered to youth aged 12-16 years as part of the interview that took place in the MEC. The subjects were asked to think about their usual diet over the past month, and to respond with how often they usually consumed the FFQ items per day, per week, per month, or not at all. NHANES staff converted the frequency data to times per month, by multiplying times per day by a factor of 30.4, for example: 3 times per day = round (3 * 30.4) times per month = 91 times per month. Amounts reported per week were divided by 7 and then multiplied by 30.4 to convert to times per month: 5 times per week = round (5/7 * 30.4) times per month = 22 times per month.

The FFQ included 12 beverage items, as listed in **Table 1.** The categories of FFQ beverage items listed in **Table 1** included milk and milk drinks (chocolate and regular), 100% fruit juice (citrus and non-citrus), sugar-sweetened beverages (fruit drinks and regular soft drinks), and other beverages (diet soft drinks, coffee/tea, and beer/wine/

Table 1. Beverage categories and beverage subcategories corresponding to beverage items in the NHANES III food frequency questionnaire (FFQ)

Beverage categories & beverage subcategories	FFQ beverage items
1. Milk and milk drinks, chocolate & regular	1a. How often did you have chocolate milk and hot cocoa? 1b. How often did you have milk to drink or on cereal? Do not count small amounts of milk added to coffee or tea.
2. 100% fruit juice, citrus & non-citrus	2a. How often did you have orange juice, grapefruit juice and tangerine juice? 2b. Other fruit juices such as grape juice, apple juice, cranberry juice, and fruit nectars?
3. Sugar-sweetened bevg.	
3a. Fruit drinks	3a. How often did you have Hi-C, Tang, Hawaiian Punch, Koolaid, and other drinks with added vitamin C?
3b. Regular soft drinks	3b. Regular colas and sodas, not diet?
4. Other beverages	
4a. Diet soft drinks	4a. Diet colas, diet sodas, and diet drinks such as Crystal Light?
4b. Coffee/ tea	4b (1). Regular coffee with caffeine? 4b (2). Regular tea with caffeine?
4c. Alcoholic beverages	4c (1). Beer and lite beer? 4c (2). Wine, wine coolers, Sangria, and champagne? 4c (3). Hard liquor such as tequila, gin, vodka, scotch, rum, whiskey and liqueurs, either alone or mixed?

liquor). An additional item in the FFQ asked what type of milk was usually consumed: whole milk, reduced fat (2%), low fat (1%), or skim/nonfat milk. The FFQ fruit drinks item asked specifically about Hi-C, Tang, Hawaiian Punch, Koolaid and other drinks with added vitamin C. The FFQ coffee/tea items asked specifically about regular coffee with caffeine, and regular tea with caffeine. An open-ended section of the FFQ permitted the respondent to list items usually consumed, but not specifically mentioned in the questionnaire, thus, consumption of fruit drinks without added vitamin C, decaffeinated coffee or decaffeinated tea may have been reported as an open-ended response. Only the responses to the FFQ items that were solicited, and not the responses to the open-ended section of the FFQ were used in this study, because the responses to the open-ended section were "voluntary and sporadic" (Velie, personal communication).

b. The 24-hour recall dietary interview

The 24-hour recall dietary interviews were conducted in English and Spanish by bilingual dietary interviewers in a private room to ensure confidentiality. Children aged 12 years and older were permitted to report their own intake without a proxy respondent. The dietary interviewers contacted other information sources such as care providers and schools to obtain complete dietary intake data for respondents. Interviewers reviewed and edited the dietary recall data to ensure that they were as complete as possible. The interviewers made initial determinations regarding the completeness and reliability of the dietary recalls, and final determinations were dependent on review by NCHS staff. For quality control, NCHS and contractor staff were present to observe dietary interviews, and interviews were also audiotaped for retrospective reviews. The dietary interviewers worked in two-person teams; performing 10-percent cross-check reviews of their partners' work using printed recall reports, and verification problem forms were submitted if there were any discrepancies between partners. Extreme values that were flagged in the editing process were then verified by reviewing the interviewer's documentation of any unusual entries, by reviewing the audiotape of the interview to check the information presented by the respondent, and by reviewing any verification problem forms submitted by the interviewer's partner who cross-checked the work. Finally, newsletters, field memoranda, telephone calls, and staff retraining sessions were other methods used to maintain quality control during the survey (DHHS, 1996a).

The dietary interview was conducted while using a microcomputer and the NHANES III Dietary Data Collection (DDC) System. The protocol of the DDC System used in NHANES III, 1988-94, incorporated the three components of the multiple-pass 24-hour recall method: the quick list, detailed description, and review (Johnson et al., 1996). However, the multiple-pass method was not denoted as such until it was later described and implemented for the 1994-96 Continuing Survey of Food Intakes by Individuals (CSFII) (Guenther et al., 1995). USDA continued to validate the multiple-pass method as an expanded five-step protocol: the quick list, forgotten foods list, time and occasion, detail cycle, and final probe review (Conway et al, 2003; Conway et al., 2004). This method was not used officially by NCHS for dietary data collection until the CSFII was integrated into the NHANES in January 2002 (Dwyer et al., 2001). However, it seems that the DDC of the NHANES, 1988-94, was actually a forerunner of the multiple-pass method.

A quick list of foods consumed in the previous 24-hour period was first recorded in the DDC. After the quick list was entered, the DDC then provided food specification screens with a series of standardized prompts and choices that allowed the interviewer to select and enter specific foods, amounts, ingredients and preparation methods. The DDC prompts helped to determine the level of detail about specific foods necessary for the computer system to assign numerical codes linking the foods consumed to the nutrient composition database. The primary source of food composition data for NHANES III was the U.S. Department of Agriculture (USDA) Survey Nutrient Database; USDA provided two nutrient files (first in 1993, second in 1995) for use in NHANES III (NCHS, 1997). Because the Nutrition Coordinating Center (NCC) of the University of Minnesota had developed the DDC, the NHANES III survey foods were also cross-referenced to the NCC nutrient composition files. Although vitamin D was not in the USDA Survey Nutrient Database, the second release of the NHANES III 24-hour recall dietary data included vitamin D intakes, because vitamin D was in the NCC nutrient composition database (NCHS, 1998).

c. Assessment of water intakes

Although water intakes were not ascertained using the 24-hour recall method, the dietary interview included a question to respondents about how many glasses/cups or fluid ounces of plain water they usually drank daily. If the response was in terms of glasses or cups, participants were asked to specify the fluid ounces per glass or cup. Before release of the public-use data, responses reported in terms of numbers of glasses/cups per day were converted to fluid ounces per day, by multiplying the volume of water in the glass/cup by the number of glasses/cups consumed per day.

D. Variable definition

1. Beverage categories and beverage patterns

Aim 1 of this study included an examination of the mean frequency of beverage consumption, and mean nutrient intake of beverage pattern groups, so youth were classified by the beverage pattern (i.e., combination of beverage types) most frequently consumed, as reported in the FFQ. The 4 main categories (and 7 subcategories) of the 12 FFQ beverage items listed in **Table 1** included (1) milk and milk drinks, chocolate and regular, (2) 100% fruit juice, citrus and non-citrus, (3) sugar-sweetened beverages (3a. fruit drinks, 3b. regular soft drinks), and (4) other beverages (4a. diet soft drinks, 4b. coffee/ tea, and 4c. beer/ wine/ liquor). The FFQ chocolate milk and regular milk items were combined to form the milk category. Citrus fruit juice and non-citrus fruit juice were combined to form the 100% fruit juice category. The coffee and tea items were combined, and the alcoholic beverage items (beer, wine and hard liquor) were combined. For the purposes of defining beverage patterns, fruit drinks and regular soft drinks were combined to form the sugar-sweetened beverages category.

a. Categorization of beverages reported in 24-hour recall dietary interviews

Aim 1 included an examination of the frequency with which beverages were consumed at meal occasions (breakfast, lunch, dinner, snack) eaten at locations at-home and away-from-home. The 24-hour recall data were used, because the FFQ does not specify meal occasion and meal location. The USDA survey food codes for beverages reported in the 24-hour recall dietary interview were classified into the beverage categories and subcategories listed in **Table 1.** The 24-hour recall beverage categories were identical to those described by the FFQ items, except that the fruit drinks category included fruit drinks without vitamin C, and the coffee/tea subcategory included decaffeinated coffee and tea. The milk category included milk poured on cereal as well as milk consumed as a beverage. Milk combined with cereal was identified using the code for the type of combination known as cereal with additions. Beverage mixtures, such as coffee with milk, were identified using the code for this type of combination, and the USDA survey food code for the main component of the beverage mixture was used to classify the combination into the appropriate category.

b. Classification of youth by beverage pattern frequently consumed

Beverage patterns were defined *a priori* by identifying all possible combinations of three categories of beverages: milk (milk & milk drinks), sugar-sweetened beverages (fruit drinks & regular soft drinks) and juice (100% fruit juice). To classify youth into beverage pattern groups, the FFQ beverage frequencies were used to identify combinations of beverages that characterized a youth by his/her 'typical' beverage pattern. Two different methods, the 'frequency' method, and the 'share' method, were developed to classify youth by the combination of beverage types most frequently consumed. For each beverage, the 'share' was determined by expressing the beverage frequency as a percentage of the summed frequency for all beverages. Criteria to identify the most frequently consumed beverage types using the 'frequency' and 'share' methods, respectively, were frequency ≥1 time/day, and share ≥25% of total beverage frequency. Notations for beverage patterns were combinations of capital letters M, S and J to represent milk, sugar-sweetened beverages and juice, respectively, consumed at a level meeting the criteria, and lowercase letters m, s and j represented consumption of less than the specified amount. The beverage patterns were named according to the eight beverage combinations: 'all caloric beverages' (MSJ), 'milk & sugar-sweetened beverages' (MSj), 'milk & juice' (MsJ), 'milk' (Msj), 'sugar-sweetened beverages & juice' (mSJ), 'sugar-sweetened beverages' (mSj), 'other beverages & juice' (msJ) and 'other beverages' (msj). Other beverage variables in the model in which beverage patterns were correlated with body weight or body fat included ounces of water, and type of milk (whole, 2%, 1%, skim) usually consumed.

2. Meal occasion and meal location

Aim 1 included an examination of the mean frequency of beverage consumption at meal occasions and at meal locations reported in the 24-hour recall dietary interview. In the same way that the contribution of food groups to total nutrient intakes were estimated from the mean nutrient intakes obtained from each food group (Block et al., 1985a; Block et al., 1985b), mean frequency of beverage consumption at meal occasions and at meal locations among consumers of the various types of beverages was estimated to determine the percentage contribution of meal occasions and meal locations to the total beverage frequency. The meal occasions' and meal locations' shares of the total beverage frequency were estimated to examine the association between meal context and beverage choice. Hypotheses were that milk or 100% fruit juice would be consumed more frequently than sweetened beverages at breakfast and other meals eaten at home, and sweetened beverages would be consumed more frequently than milk or 100% juice at the snack occasion and at locations away from home.

Meal occasions were self-reported by the respondent. After he/she was handed a card listing the various meal occasions, he/she was asked to name the meals that comprised the foods and beverages reported during the 24-hour recall interview. The list of meal occasions included breakfast/brunch, lunch, dinner/ supper, and snack/beverage break. Spanish translations of meal occasion names were desayuno/almuerzo (breakfast/brunch), comida (lunch), cena/merienda (dinner/supper), and entre comidas/bebida (snack/beverage break). Meal locations included home, work, school, a fast food or take-out establishment, a restaurant (with table service) or cafeteria, someone's home, transit, and other meal places.

3. Dietary quality assessment

Although youth were classified by their 'typical' beverage pattern based on beverage frequencies reported in response to the FFQ, because the FFQ in NHANES III was not designed to assess nutrient intake, the 24-hour recall method was used instead to estimate mean nutrient intakes of beverage pattern groups. Intakes of food energy (Kcal), fat (g), sugars (g), caffeine (mg), vitamin A (μg RAE), vitamin C (mg), folate (μg DFE), calcium (mg), potassium (mg) and vitamin D (μg) from the total diet, from beverages, and from non-beverages were assessed using the 24-hour recall dietary intake data.

Because of the risk for overweight, intakes of food energy (Kcal) and macronutrients such as total fat (g), saturated fat (g), carbohydrate (g), total sugars (g), and added sugars (g) are primarily of interest. It's recommended that the diet contain <30% calories from total fat, and <10% calories from saturated fat or added sugars. Intakes of caffeine (mg) from soft drinks, coffee and tea might also be a concern for teens. Teenagers, especially girls, are at risk for inadequate intake of some key nutrients. Many of these vitamins and minerals can be obtained from the diet by drinking milk or juice. Thus, additional nutrients of interest included vitamin A (μg RAE), vitamin C (mg), folate (μg DFE), calcium (mg), potassium (mg) and vitamin D (μg). The mean and median of the distribution of daily nutrient intake were compared to Dietary Reference Intake (DRI) criteria, such as the age- and gender-specific Estimated Average Requirement (EAR) or Adequate Intake (AI) level shown in **Table 2** (Institute of Medicine (IOM) of the National Academies of Science, 1997; IOM, 1998; IOM, 2000; IOM, 2001; IOM, 2002).

The primary source of food composition data for NHANES III was the U.S. Department of Agriculture (USDA) Survey Nutrient Database; USDA provided two nutrient files (first in 1993, second in 1995) for use in NHANES III (NCHS, 1997). Because the Nutrition Coordinating Center (NCC) of the University of Minnesota had developed the Dietary Data Collection system for NHANES III, survey foods were also cross-referenced to the NCC nutrient composition files (NCHS, 1998). Although vitamin D was not in the USDA Survey Nutrient Database, the second release of the NHANES III 24-hour recall dietary data included vitamin D intakes, because vitamin D was in the NCC nutrient composition database (NCHS, 1998). The USDA Food and Nutrition Database for Dietary Studies (FNDDS) (USDA, 2004) was used to access food composition data for vitamin A (μg RAE), folate (μg DFE), caffeine and total sugars,

Table 2. Dietary Reference Intakes (DRI) for adolescents aged 12-16 years

	Age (y) of Boys		Age (y) of Girls	
Nutrient	12-13	14-16	12-13	14-16
	Estimated Average Requirement (EAR)			
Carbohydrate (g)	100	100	100	100
Vitamin A (μg RAE)	445	630	420	485
Vitamin C (mg)	39	63	39	56
Folate (μg DFE)	250	330	250	330
	Adequate Intake			
Calcium (mg)	1300	1300	1300	1300
Potassium (mg)	4.5	4.7	4.5	4.7
Vitamin D (μg)	5	5	5	5

SOURCES: Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Flouride (1997). Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B_6, Folate, Vitamin B_{12}, Pantothenic Acid, Biotin, and Choline (1998). Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids (2000). Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (2001). Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Protein and Amino Acids (Macronutrients) (2002). DRI reports from the Institute of Medicine of the National Academies may be accessed via www.nap.edu.

because intakes are either unavailable in the NHANES III dataset, or if available, units are inconsistent with DRI recommendations.

The added sugars content of food was obtained from the USDA Pyramid Food Group Servings Database, Version 2.0 (Cook and Friday, 2004). Added sugars include sugars and other sweeteners eaten separately or added to foods at the table as well as sweeteners used as ingredients in prepared and processed foods such as breads, cakes and other grain desserts, soft drinks, jams and jellies, candies and ice cream. Added sugars and other sweeteners include white sugar, brown sugar, raw sugar, corn syrup, corn syrup solids, high fructose corn syrup, malt syrup, maple syrup, pancake syrup, fructose sweetener, liquid fructose, honey, molasses, anhydrous dextrose, crystal dextrose, and dextrin eaten separately or used as ingredients in prepared or processed food. Added sugars do not include naturally occurring sugars such as lactose in milk and fructose in fruit. In the USDA Pyramid Servings database, a serving of added sugars was defined as the quantity of sweetener that contains the same amount of total sugars (4.196 grams) provided by a teaspoon (4.2 grams) of table sugar. Therefore, a serving of added sugars is equivalent to 4.2 grams of table sugar 0 (Cook and Friday, 2004).

4. Sociodemographic variables

Sociodemographic factors examined were gender, age, race-ethnicity, region, urbanization, parental overweight/obesity, household income and other indicators of social economic status (SES). Categories for race-ethnicity included non-Hispanic white, non-Hispanic black, Hispanic and other race-ethnic groups. Four broad regions of the

U.S. included the Northeast, Midwest, South and West. The urban/rural classification was a metropolitan area having a population ≥1 million *vs.* all other areas. The poverty income ratio was the ratio of household income to the poverty level for household size in an urban or rural area. Other indicators of SES included the family size and characteristics of the household head or family reference person (FRP), such as their gender, age group, marital status, education and employment status. BMI was calculated from reported weight and height of the youth's mother and father to determine whether both or one of two parents were overweight (BMI ≥25 kg/m^2) or obese (BMI ≥30 kg/m^2).

5. Lifestyle variables

Lifestyle factors examined were smoking, alcohol use, weight loss behavior, frequency of breakfast consumption, type of milk usually consumed, physical activity and TV watching. The questionnaire that included lifestyle questions, such as those asking youth whether they currently smoked cigarettes or drank alcohol in the past year, was administered in a private setting at the mobile examination center (MEC) without a proxy respondent. Youth were also asked whether they were currently trying to lose weight and how often they ate breakfast (e.g., every day, some days, rarely, never, weekends only). The FFQ included a question asking whether whole, 2%, 1% or skim/nonfat milk was usually consumed.

a. Physical activity

Physical activity was assessed using the following questionnaire items asking youth about their exercise habits and participation in team sports:

1. How many times per week do you play or exercise enough to make you sweat or breath hard?

2. In the past year, how many sports teams or organized exercise programs have you been involved in (not including physical education or gym classes)?

The first item above was termed "self-reported exercise-induced sweating" when it was developed and validated (Ainsworth et al., 1993; Gruner et al., 2002). This measure of physical activity is used in national surveys, such as CSFII and NHANES, as well as several epidemiological studies, including the Male Physicians' study (Lee et al., 1999; Liu et al., 2000). Responses to a questionnaire item asking, "How often do you exercise vigorously enough to work up a sweat?" has been shown to be correlated with measures of physical fitness, such as maximal oxygen uptake and treadmill time during a maximal exercise test (Siconolfi et al, 1985; Kohl et al., 1988), and the item has more recently been validated among patients with coronary artery disease (Gruner et al., 2002). The sweat frequency question was investigated in relation to the frequency and duration of different physical activities with known intensity ratings coded in terms of metabolic equivalents (MET) (Ainsworth et al., 1993). Although there was no association with light (<4 MET) physical activity, both moderate (4.0-5.9 MET) and intense (≥6 MET) physical activity correlated well with self-reported exercise-induced sweating (Gruner et al., 2002).

b. TV watching

Youth were asked twice, once in the household and again at the MEC, about time spent watching TV the previous day, and the average hours/day in two days was used in the current study. Hours of "screen time" watching TV or playing video games has been shown to be a reliable and valid indicator of sedentary behavior (Robinson, 1999).

6. Overweight and adiposity

Obesity outcome variables defined for the purposes of this study included both overweight and adiposity (i.e., percentage body fat). To adjust weight for height, the Body Mass Index (BMI) was calculated from measured height and weight using the formula: BMI = weight (kg)/ height $(m)^2$. To adjust BMI for age and gender, the SAS program available from NCHS was run to calculate the youth's BMI percentile gender-specific BMI-for-age percentile reference data provided by the 2000 CDC Growth Charts for boys and girls, 2-20 years, because criteria based on the BMI-for-age percentiles were recommended to assess overweight/risk for overweight in children and adolescents (NCHS; Kuczmarski et al., 2000). In addition, percentage body fat was determined from summed triceps and subscapular skinfold measurements (Slaughter et al., 1988), because BMI does not accurately assess body composition, e.g., overweight youth with a high proportion of lean body mass are not overfat (Forbes, 1987).

The BMI percentile and percentage body fat were dependent variables in two separate linear regression analyses. The BMI percentile was used to classify youth by weight status (i.e., underweight: BMI <5th percentile, normal body weight: BMI ≥5th percentile and BMI <85th percentile, at risk for overweight: BMI ≥85th percentile and <95th percentile, and overweight: BMI ≥95th percentile). The presence of overweight/risk for overweight (i.e., BMI ≥85th percentile) was the dependent variable for logistic regression analyses. Underweight youth were excluded from logistic regression analyses.

Percentage body fat was determined from summed triceps and subscapular skinfold thickness (mm) measurements using prediction equations for children and adolescents age 8 to 18 years developed by Slaughter et al. (1988). There were 35 youth whose triceps or subscapular skinfold thickness was too large for the calipers. Rather than excluding these obese adolescents from analyses, percentage body fat was calculated using the group's maximum skinfold thickness (mm) measurements in place of the missing values.

Slaughter et al. (1988) developed separate skinfold equations for prepubescent, pubescent, and postpubescent white and black male children/adolescents and all female children/adolescents whose summed tricep and subscapular skinfolds were 35 mm or less, and male and female children/adolescents whose summed tricep and subscapular skinfolds were greater than 35 mm. Adolescent boys age 12-16 years were classified by race and sexual maturation (SMA) stage to use the Slaughter equations. White and black male adolescents were classified by the composite pubic hair and genitalia rating as follows: prepubescent (SMA stages 1.0 - 2.0), pubescent (SMA stages 2.5-3.5) and postpubescent (SMA stages 4.0-5.0) (Boileau et al., 1984; Slaughter et al., 1984).

The physician's examination included an assessment of SMA according to the 5-stages of developing pubic hair (male and female), male genitalia, and female breasts (Tanner, 1962; DHHS, 1991). The Physician Examiner's Training Manual (DHHS, 1991) described the 5-stage coding of the sexual maturation stages for each of the three areas of assessment as shown in **Table 3.** A composite score was calculated by

Table 3. Physician's assessment of sexual maturation and 5-stage classification of pubic hair (male and female), male genitalia and female breasts.

Stage	Description of sexual maturation stage
	Pubic hair (male and female)
1	Preadolescent. The vellus over the pubis is no further developed than that over the abdominal wall, i.e., no pubic hair.
2	Sparse growth of long, slightly pigmented downy hair, straight or only slightly curled, appearing chiefly at the base of the penis or along the labia.
3	Considerably darker, coarser, and more curled. The hair spreads sparsely over the junction of the pubis or mons.
4	Hair now resembles adult in type, but the area covered by it is still considerably smaller than in the adult. Still limited to pubis or mons. No spread to the medial surface of the thighs.
5	Adult in quality, quantity and type with distribution in the classically "male" or "female" pattern, with spread to the medial aspect of the thighs.
	Male genitalia
1	Preadolescent. Testes, scrotum, and penis are about the same size and proportion as in early childhood.
2	Enlargement of scrotum and testes. The skin of the scrotum reddens and changes in texture. There is little or no enlargement of the penis at this stage.
3	Enlargement of penis (occurs at first mainly in length). There is further growth of the testes and scrotum.

Table 3, cont'd.

Stage	Description of sexual maturation stage
4	Enlargement of penis, with growth in breadth and development of glans. There is further enlargement of testes and scrotum; there is increased darkening of scrotal skin.
5	Genitalia is adult-like in size and shape. No further enlargement takes place after Stage 5 is reached; it seems, on the contrary, that the penis size decreases slightly from the immediate postadolescent peak.
	Female breasts
1	Preadolescent. There is elevation of papilla only.
2	Breast bud stage. Elevation of breast and papilla appear as a small mound. There is widening and elevation of the areola, with pigmentation.
3	Further enlargement and elevation of breast and areola with no separation of their contours.
4	Projection of areola and papilla to form a secondary mound above the level of the breast.
5	Mature stage. Projection of papilla only due to recession of the areola to the general contour of the breast.

SOURCES: Physician Examiner's Training Manual (DHHS, 1991) and Tanner (1962) averaging the pubic hair rating with the genitalia rating for boys and with the breast rating for girls (Tanner, 1962). Pubertal status of those missing both SMA ratings was determined by age (years).

Listed below are the skinfold equations for predicting body fat in prepubescent, pubescent, and postpubescent white and black male, and all female children and adolescents age 8-18 years whose summed tricep and subscapular skinfolds were 35 mm or less (Slaughter et al., 1988).

Prepubescent White Males:

$1.21\,(\text{triceps} + \text{subscapular}) - .008\,(\text{triceps} + \text{subscapular})^2 - 1.7$

Prepubescent Black Males:

$1.21\,(\text{triceps} + \text{subscapular}) - .008\,(\text{triceps} + \text{subscapular})^2 - 3.2$

Pubescent White Males:

$1.21\,(\text{triceps} + \text{subscapular}) - .008\,(\text{triceps} + \text{subscapular})^2 - 3.4$

Pubescent Black Males:

$1.21\,(\text{triceps} + \text{subscapular}) - .008\,(\text{triceps} + \text{subscapular})^2 - 5.2$

Postpubescent White Males:

$1.21\,(\text{triceps} + \text{subscapular}) - .008\,(\text{triceps} + \text{subscapular})^2 - 5.5$

Postpubescent Black Males:

$1.21\,(\text{triceps} + \text{subscapular}) - .008\,(\text{triceps} + \text{subscapular})^2 - 6.8$

All Females:

$1.33\,(\text{triceps} + \text{subscapular}) - .013\,(\text{triceps} + \text{subscapular})^2 - 2.5$

The following equations were used for male and female adolescents with a sum of tricep and subscapular skinfold greater than 35 mm (Slaughter et al., 1988).

All Obese Males:

0.783 (triceps + subscapular) + 1.6

All Obese Females:

0.546 (triceps + subscapular) + 9.7

Roche et al., (1981) conducted a validation study among 6-12 and 13-17 year old boys and girls (n=261) to determine which of the various anthropometric measurements had the highest correlation with percentage body fat obtained by underwater weighing. Measurements included triceps and subscapular skinfolds, weight, relative weight, BMI (kg/m^2), and the ponderal index (kg/m^3). Compared to body weight measures, triceps skinfold had the highest correlation with percentage body fat (from underwater weighing) in all four groups, although the confidence interval of the correlation coefficient overlapped substantially with that of subscapular skinfold, as well as that of BMI for girls (Roche et al., 1981). The equations above are based on summed triceps and subscapular skinfold measurements (Slaughter et al., 1988). These equations were cross-validated on samples from the literature, and disagreement was found only with samples using the Lange caliper, rather than the Harpenden skinfold caliper used to develop the equations (Slaughter et al., 1988). Further cross-validation of the Slaughter skinfold equations for children and adolescents (Janz et al., 1993) found very high intraclass (reliability) correlations (ICC = 0.98-0.99), and high validity correlations (rs = 0.79-0.99) compared to Lohman's Siri age-adjusted body density equations (Lohman, 1986).

E. Statistical analysis

The current dissertation research used data from NHANES III, 1988-94, in a cross-sectional analysis to examine beverage patterns and other potential risk factors for overweight in youth age 12-16 years in the U.S. The Statistical Package for the Social Sciences, SPSS for Windows, Version 12.0 (SPSS Inc. Chicago, IL, USA) was used to prepare the dataset for analysis, while all statistical analyses were performed using SUDAAN version 8 (Research Triangle Institute, Research Triangle Park, NC), to account for the effect of the complex sampling design while conducting statistical tests. The six-year MEC-examined sample weights were applied to the calculation of all population parameters, such as the mean, median, or percentage of the population. The sample weights account for unequal probability of selection, non-coverage and non-response and adjust the data to the 1990 U.S. Census figures, therefore the estimates were representative of adolescents in the 1990 U.S. population. The linearization (Taylor series) method was used in SUDAAN to account for effects of the clustered sample design in estimating the variance of population parameters (Shah et al., 1997).

The overall goal of this research was to examine the association of beverage patterns with adolescent obesity (i.e., overweight and adiposity). The associations of beverage patterns with nutritional, sociodemographic and lifestyle risk factors for overweight were also examined. The following were the three (3) specific aims of this study.

Aim 1: To examine the frequency of consuming beverage types, and the percentage of youth classified into groups by their 'typical' beverage pattern (i.e., the combination of

beverage types most frequently reported as 'usual' intake using a FFQ); to examine the association of beverages with meal occasions and meal locations; and to examine the association of beverage patterns with energy, dietary fat, total sugars, added sugar, calcium and other nutrient intake.

Four main types of beverages examined included (1) milk and milk drinks, (2) 100% fruit juice (3) sugar-sweetened beverages (fruit drinks and regular soft drinks) and (4) other beverages (diet soft drinks, coffee/tea and alcoholic beverages). Youth were classified by their 'typical' beverage pattern using two different methods to identify the combination of beverage types (i.e., milk, juice and/or sugar-sweetened beverages) that were each reported frequently in the FFQ. Criteria to identify the most frequently consumed beverage types using the 'frequency' and 'share' methods, respectively, were frequency ≥1 time/day, and share ≥25% of total beverage frequency.

Mean energy, dietary fat, total sugars, added sugar, calcium and other nutrient intake (in the 24-hour recall) of beverage pattern groups were compared to examine the association of beverage patterns with energy and nutrient intake. The beverage pattern groups' mean intake of water (ounces) and mean intakes of milk, 100% fruit juice, sugar-sweetened beverages, other beverages (e.g., diet soft drinks, coffee/tea and alcoholic beverages) (times/day), in both the FFQ and 24-hour recall, were also examined. The 24-hour recall data were used to examine mean beverage frequency at meals (e.g., breakfast, lunch, dinner/supper and snacks) consumed at home or at places away-from-home (e.g., school, fast food restaurants).

a. Frequency of beverage consumption

The FFQ data was used to examine the mean frequency of consuming types of beverages, and the percentage of youth who frequently consumed each beverage type. Four (4) main types and 7 subtypes of beverages were examined. The main beverage types included (1) milk, chocolate and regular, (2) 100% fruit juice, citrus and non-citrus, (3) sugar-sweetened beverages, and (4) other beverages. Subtypes of (3) sugar-sweetened beverages were (3a) fruit drinks, and (3b) regular soft drinks, and subtypes of (4) other beverages were (4a) diet soft drinks, (4b) coffee/ tea, and (4c) beer/ wine/ liquor. Therefore the 7 subtypes of beverages included (1) milk, chocolate and regular, (2) 100% fruit juice, citrus and non-citrus, (3a) fruit drinks, (3b) regular soft drinks, (4a) diet soft drinks, (4b) coffee/ tea, and (4c) beer/ wine/ liquor. The FFQ items corresponding to beverage types (and subtypes) are listed in **Table 1.**

For each beverage type (and for each subtype of beverages), the mean beverage frequency was estimated from the frequency of consumption each youth reported in the FFQ. The mean beverage share was estimated from the beverage's share of total consumption determined for each youth by expressing the beverage frequency as a percentage of the summed frequency for all beverages. Two different methods, the 'frequency' method, and the 'share' method, were used to classify youth as frequent beverage consumers. Criteria for frequent beverage consumption using the 'frequency' and 'share' methods, respectively, were frequency ≥1 time/day, and share ≥25% of total beverage frequency. Therefore, in the 'frequency' method, the prevalence of frequent beverage consumption was defined as the percentage of youth consuming the beverage at least once per day, and in the 'share' method, prevalence of frequent beverage consumption was the percentage of youth having a beverage share that was at least 25% of the total beverage frequency.

b. Prevalence of beverage patterns

Beverage patterns were defined *a priori* by identifying all possible combinations of three types of beverages: milk (milk & milk drinks), sugar-sweetened beverages (fruit drinks & regular soft drinks) and juice (100% fruit juice). To classify youth into beverage pattern groups, the FFQ beverage frequencies were used to identify the combination of beverage types that characterized a youth by his/her 'typical' beverage pattern. Two different methods, the 'frequency' method, and the 'share' method, were developed to classify youth by the combination of beverage types that were each reported frequently in the FFQ. For each beverage, the 'share' was determined by expressing the beverage frequency as a percentage of the summed frequency for all beverages. Criteria to identify the most frequently consumed beverage types using the 'frequency' and 'share' methods, respectively, were frequency ≥1 time/day, and share ≥25% of total beverage frequency. Beverage pattern prevalence estimates were the percentage of youth classified by the combination of beverage types that were each reported frequently, using the two different criteria of the 'frequency' and 'share' methods to define frequent beverage consumption.

Notations for beverage patterns were combinations of capital letters M, S and J to represent milk, sugar-sweetened beverages and juice, respectively, consumed at a level meeting the criteria, and lowercase letters m, s and j represented consumption of less than the specified amount. The beverage patterns were named according to the eight beverage combinations: 'all caloric beverages' (MSJ), 'milk & sugar-sweetened beverages' (MSj), 'milk & juice' (MsJ), 'milk' (Msj), 'sugar-sweetened beverages & juice' (mSJ), 'sugar-sweetened beverages' (mSj), 'other beverages & juice' (msJ) and 'other beverages' (msj).

c. Frequency of beverage consumption in beverage pattern groups

Mean beverage frequency of consumption in both the FFQ and 24-hour recall were estimated for beverage pattern groups defined using the 'share' method to classify youth by the combination of beverages that were each reported frequently in the FFQ. To estimate the 24-hour recall frequency (# times/day) of beverage types and subtypes, the USDA survey codes for beverages reported in the 24-hour recall dietary interview were classified into the beverage categories and subcategories listed in **Table 1**. The 24-hour recall beverage categories were identical to those described by the FFQ items, except that the fruit drinks category included fruit drinks without vitamin C, and the coffee/tea subcategory included decaffeinated coffee and decaffeinated tea. The milk category included milk poured on cereal as well as milk consumed as a beverage. Milk combined with cereal was identified using the code for the type of combination known as cereal with additions. Beverage mixtures, such as coffee with milk, were identified using the code for this type of combination, and the USDA survey food code for the main component of the beverage mixture was used to classify the combination into the appropriate category.

The sample-weighted mean beverage frequency, and standard error of the mean were estimated using the linearization method of SUDAAN. The 95% confidence interval of the mean beverage frequency was calculated from the standard error adjusted for the design effect using SUDAAN. Because SUDAAN was designed to test only for significant differences between groups, and paired t-tests for significant differences between repeated measures (using the FFQ and 24-hour recall) can not be done using SUDAAN, the 95% confidence intervals were used to determine whether the mean beverage frequency in the FFQ and 24-hour recall were significantly different. It was determined that the mean beverage frequency estimated using the FFQ was not significantly different from mean beverage frequency estimated using the 24-hour recall when the 95% confidence intervals overlap. Paired t-tests conducted using sample-weighted data in SPSS would have the same result as those tests of the 95% confidence intervals constructed using SUDAAN, because the sample design would have the same effect on both measures of mean beverage frequency estimated for the same group (Herman, personal communication).

The mean beverage frequency of a beverage pattern group was not biased by intraindividual variation (Guenther et al., 1997). The standard error of the mean was estimated using SUDAAN to adjust the standard error for the sample design in testing for significant differences between beverage pattern groups. T-tests for significant differences in mean beverage frequencies were used to compare beverage pattern groups. Mean beverage frequency of beverage pattern groups were compared using the Bonferroni method to adjust statistical significance tests for the number of comparisons. The Bonferonni method was used to adjust the critical value for determining statistical significance, as follows: α / k, where $\alpha = 0.05$ and k = # of comparisons.

Three comparisons of interest were 'caloric beverage' patterns *vs.* 'other beverage' patterns, 'milk' patterns *vs.* 'sugar-sweetened beverage' patterns, and 'juice' patterns *vs.*

'non-juice' patterns. For these comparisons, the 8 beverage patterns were collapsed into categories, as follows. To compare the 'caloric beverages' (K) and 'other beverages' (O) categories, the 'all caloric beverages' (MSJ) pattern was combined with the 'milk & sugar-sweetened beverages' (MSj) pattern to form the 'caloric beverages' (K) category, and the 'other beverages & juice' (msJ) and 'other beverages' (msj) patterns were combined to form the 'other beverages' (O) category. To compare the 'milk' (M) and 'sugar-sweetened beverages' (S) categories, the 'milk & juice' (MsJ) pattern was combined with the 'milk' (Msj) pattern to form the 'milk' (M) category, and the 'sugar-sweetened beverages & juice' (mSJ) and 'sugar-sweetened beverages' (mSj) patterns were combined to form the 'sugar-sweetened beverages' (S) category. The 'milk & juice' (MsJ) pattern was combined with the 'sugar-sweetened beverages & juice' (mSJ) pattern, and the 'milk' (Msj) pattern was combined with the 'sugar-sweetened beverages' (mSj) pattern to compare juice (J) and. non-juice (N) categories.

Mean beverage frequency of beverage pattern groups were estimated using both FFQ and 24-hour recall data to validate the classification of beverage types. It was expected that the 'juice' groups would drink juice more frequently than the 'non-juice' groups, and the 'milk' groups would drink milk more frequently than 'sugar-sweetened beverages' groups, for example. However, if the 'sugar-sweetened beverages' groups drank fruit drinks more frequently than the 'milk' groups in the FFQ, but not in the 24-hr recall, this might indicate that fruit drinks were misclassified in the FFQ. If the 24-hour recall intakes of fruit drinks were higher for 'juice' groups than 'non-juice' groups, then some misclassification of fruit drink consumers to 'juice' groups might have occurred. The concern is that youth might mistakenly report fruit drink frequency in response to the

100% fruit juice question in the FFQ, because 100% fruit juice is listed before fruit drinks in the sequence of ordering the FFQ beverage items. Nutritionists who assign food codes to beverages mentioned in the 24-hour recall interview use probes to solicit specific details, such as brand names. If the brand name Sunny Delight was given for what the respondent thought was orange juice, then Sunny Delight would be correctly classified with other fruit drinks in the 24-hour recall.

d. Frequency of beverage consumption at meals

Mean frequency of beverage consumption at meal occasions eaten at-home and away-from-home were estimated to determine the meal occasions' and meal locations' shares of the total beverage frequency. Because the meal occasion and meal location is not specified in the FFQ, the frequency with which beverages are consumed at specific meals was determined using 24-hour recall data. Mean 24-hour recall intakes of groups are not biased by intraindividual variation (Guenther et al., 1997). Meal occasions included breakfast/brunch, lunch, dinner/supper, and snack/beverage break. Meal locations included home, work, school, a fast food or take-out establishment, a restaurant (with table service) or cafeteria, someone's home, transit, and other meal places.

In the same way that the contribution of food groups to total nutrient intakes are estimated from the mean nutrient intakes obtained from each food group (Block et al., 1985a; Block et al., 1985b), mean frequency of beverage consumption at meal occasions and at meal locations among consumers of the various types of beverages was estimated to determine the percentage contribution of meal occasions and meal locations to the total beverage frequency. The meal occasions' and meal locations' shares of the total beverage frequency were estimated to examine the association between meal context and beverage choice. Hypotheses were that milk or 100% fruit juice would be consumed more frequently than sweetened beverages at breakfast and other meals eaten at home, and sweetened beverages would be consumed more frequently than milk or 100% juice at the snack occasion and at locations away from home.

e. Mean nutrient intake of beverage pattern groups

Beverage pattern groups were defined using the 'share' method to classify youth by the combination of beverages that were each reported frequently in the FFQ, but because the FFQ in NHANES III was not designed to assess nutrient intake, intakes of food energy (Kcal), fat (g), sugars (g), caffeine (mg), vitamin A (μg RAE), vitamin C (mg), folate (μg DFE), calcium (mg), potassium (mg) and vitamin D (μg) were assessed using the 24-hour recall dietary intake data instead. The 24-hour recall intakes of the beverage pattern groups were used to estimate mean daily nutrient intake; mean nutrient intake from beverages and from non-beverages; and mean percentage energy from fat, total sugars, and added sugars. Mean 24-hour recall intake of a beverage pattern group was not biased by intraindividual variation (Guenther et al., 1997).

The standard error of the mean was estimated using SUDAAN to adjust the standard error for the sample design in testing for significant differences between beverage pattern groups. T-tests for significant differences in mean nutrient intake were used to compare beverage pattern groups. Mean nutrient intakes of beverage pattern groups were compared using the Bonferroni method to adjust statistical significance tests for the number of comparisons. The Bonferonni method was used to adjust the critical value for determining statistical significance, as follows: α / k, where $\alpha = 0.05$ and k = # of comparisons.

Three comparisons of interest were 'caloric beverage' patterns *vs.* 'other beverage' patterns, 'milk' patterns *vs.* 'sugar-sweetened beverage' patterns, and 'juice' patterns *vs.* 'non-juice' patterns. For these comparisons, the 8 beverage patterns were collapsed into categories, as follows. To compare the 'caloric beverages' (K) and 'other beverages' (O) categories, the 'all caloric beverages' (MSJ) pattern was combined with the 'milk & sugar-sweetened beverages' (MSj) pattern to form the 'caloric beverages' (K) category, and the 'other beverages & juice' (msJ) and 'other beverages' (msj) patterns were combined to form the 'other beverages' (O) category. To compare the 'milk' (M) and 'sugar-sweetened beverages' (S) categories, the 'milk & juice' (MsJ) pattern was combined with the 'milk' (Msj) pattern to form the 'milk' (M) category, and the 'sugar-sweetened beverages & juice' (mSJ) and 'sugar-sweetened beverages' (mSj) patterns were combined to form the 'sugar-sweetened beverages' (S) category. The 'milk & juice' (MsJ) pattern was combined with the 'sugar-sweetened beverages & juice' (mSJ) pattern, and the 'milk' (Msj) pattern was combined with the 'sugar-sweetened beverages' (mSj) pattern to compare juice (J) and. non-juice (N) categories.

Mean and median nutrient intake of boys/girls age 12-13 and 14-16 years were estimated to distinguish gender-age groups having different DRI levels. The mean and median of the distribution of daily nutrient intake were compared to Dietary Reference Intake (DRI) criteria, such as the age- and gender-specific Estimated Average Requirement (EAR) or Adequate Intake (AI) level shown in **Table 2** (Institute of

Medicine (IOM) of the National Academies of Science, 1997; IOM, 1998; IOM, 2000; IOM, 2001; IOM, 2002).

Aim 2: To examine the distributions of sociodemographic and lifestyle characteristics that are risk factors for overweight among beverage pattern groups defined above in Aim 1.

Youth were classified into groups by their 'typical' beverage pattern using the 'share' method (i.e., share ≥25% total beverage frequency) to identify the combination of beverage types (e.g., milk, 100% fruit juice and sugar-sweetened beverages) most frequently reported as 'usual' intake in the FFQ. To identify risk factors for overweight, the prevalence of overweight/risk for overweight (i.e., BMI ≥85^{th} percentile of BMI-for-age) was estimated for youth classified by each sociodemographic/lifestyle characteristic. To examine the distributions of risk factors for overweight, the percentage of each beverage pattern group classified by each sociodemographic/lifestyle characteristic was estimated, and the percentage of each beverage pattern group classified by weight status (e.g., underweight, normal, at risk for overweight, overweight) was estimated as well.

Sociodemographic factors examined were gender, age, race-ethnicity, region, urbanization, parental overweight/obesity, household income and other indicators of social economic status (SES). Lifestyle factors included smoking, alcohol use, weight loss behavior, physical activity (i.e., exercise and team sports participation), TV watching, frequency of breakfast consumption, and type of milk (e.g., whole, 2%, 1%, skim) usually consumed.

Categories for race-ethnicity included non-Hispanic white, non-Hispanic black, Hispanic and other race-ethnic groups. Four broad regions of the U.S. included the Northeast, Midwest, South and West. The urban/rural classification was a metropolitan area having a population ≥1 million *vs.* all other areas. The poverty income ratio was the ratio of household income to the poverty level for household size in an urban or rural area. Other indicators of SES included the family size and characteristics of the household head or family reference person (FRP), such as their gender, age group, marital status, education and employment status. BMI was calculated from reported weight and height of the youth's mother and father to determine whether both or one of two parents were overweight (BMI ≥25 kg/m^2) or obese (BMI ≥30 kg/m^2).

The survey included lifestyle questions, such as those asking youth whether they currently smoked cigarettes or drank alcohol in the past year. Youth were also asked whether they were currently trying to lose weight and how often they ate breakfast (e.g., every day, some days, rarely, never, weekends only). The FFQ included a question asking whether whole, 2%, 1% or skim/nonfat milk was usually consumed. Physical activity was assessed using the following questionnaire items asking youth about their exercise habits and participation in team sports:

1. How many times per week do you play or exercise enough to make you sweat or breathe hard?
2. In the past year, how many sports teams or organized exercise programs have you been involved in (not including physical education or gym classes)?

Youth were asked twice, once in the household and again at the MEC, about time spent watching TV the previous day, and the average hours/day in two days was used in the current study.

The prevalence of overweight/risk for overweight (BMI $\geq 85^{th}$ percentile) was estimated for youth classified by categories of each sociodemographic/lifestyle factor, and the percentage distribution of each sociodemographic/lifestyle factor was estimated for all youth and for each beverage pattern group. The percentage of each beverage pattern group classified by weight status (e.g., underweight, normal, at risk for overweight, overweight) was estimated as well. The Chi-square test for the association of categorical variables was performed to determine whether the observed and expected distributions were different ($p<0.05$).

Aim 3: To examine the association of adolescent obesity with the beverage pattern groups defined above in Aim 1, adjusted for potential covariates of interest.

Indicators of obesity (i.e., overweight and adiposity) examined separately included BMI percentile, percentage body fat as assessed by skinfold measurements, and overweight/risk for overweight (i.e., BMI $\geq 85^{th}$ percentile of BMI-for-age). Youth were classified into groups by their 'typical' beverage pattern using the 'share' method (i.e., share ≥25% total beverage frequency) to identify the combination of beverage types (e.g., milk, sugar-sweetened beverages and/or 100% fruit juice) most frequently reported as 'usual' intake in the FFQ. In addition to beverage pattern groups, other beverage variables considered in analyses were fluid ounces of water and type of milk (e.g., whole, 2%, 1%, skim) usually consumed. Covariates considered in analyses were gender, age, race-ethnicity, sexual maturation stage, region, urbanization, parental overweight/ obesity, SES indicators, smoking, alcohol use, weight loss behavior, exercise, team sports participation and TV watching. Covariates were examined separately one at a time to investigate whether each one might potentially confound the relationship between beverage patterns and overweight/ adiposity.

The association of obesity outcomes with beverage pattern groups was examined after controlling for covariates using regression analysis. Multiple regression analysis was used to implement a multiple analysis of variance (MANOVA) with categorical variables (i.e., dummy variables) in a general linear model. The p-value of the Wald F test for the treatment effect was interpreted to test for a significant association between any one of the beverage pattern groups and obesity. Because the p-value to test whether the effect of a particular beverage pattern group was significant indicates only whether the beta coefficient was different from zero, Bonferroni contrasts of least square (LS) means were performed to indicate whether the 'milk & juice' beverage pattern group was significantly different from each of the other seven beverage pattern groups. LS mean BMI percentile and LS mean body fat (%) were adjusted for effects of covariates. The 95% confidence intervals for odds ratios were calculated and interpreted to indicate whether a beverage pattern group's risks were significantly different from 1.0. Odds ratios for overweight/risk for overweight were adjusted for effects of covariates as well.

In addition to examining the independent effects on obesity of beverage patterns, the independent effects of sexual maturation, and confounding variables were also examined. A true confounder must have independent effects on both beverage patterns and obesity, and it might not be necessary to include a potential confounder in the final model if it is not a true confounder. For each potential confounder, it was first determined whether it had an effect on obesity by including it alone in the regression model. Beverage patterns were then added to the model.

Each covariate was added individually to the model that included only the beverage pattern, amount of water and type of milk usually consumed (Model 1). Covariates were examined separately one at a time to investigate whether each one might potentially confound the relationship between beverage patterns and overweight/ adiposity. If the effect of beverage patterns was no longer significant with the inclusion of the potential confounder in the model then it was concluded that this covariate was indeed confounding the relationship between beverage patterns and overweight/adiposity. Covariates not found to be confounders were added to Model 1 together to form an adjusted model (Model 2), and the remaining covariates were each added individually one at a time to the adjusted model (Model 2).

Whether an effect of TV watching on obesity was mediated through both beverage patterns and physical activity was investigated. This was done by first determining whether TV watching has an effect on obesity without including physical activity in the model. The effect of physical activity was also determined without including TV watching in the model. Then, both TV watching and physical activity were included in the model together, to examine whether the effect of TV watching on obesity was associated with the level of physical activity. If the effect of physical activity was diminished, then it was concluded that TV watching explained the level of physical activity. If TV watching was still significant after including physical activity in the model then it was concluded that TV watching has an effect independent of physical activity. An independent effect of TV watching after controlling for physical activity might be due to an association between TV watching and beverage patterns. It was then determined whether an effect of beverage patterns is diminished when TV watching is included in the model. This would indicate that the effect of TV watching on obesity was partially mediated through beverage patterns. Whether TV was significant after including both beverage patterns and physical activity in the model would indicate whether the effect of TV watching on obesity was mediated fully through beverage patterns and physical activity. If that were the case, it might be 'over-controlling' the model if TV watching were included.

Whether physical activity is an effect modifier was also investigated. Physical activity could potentially affect both beverage patterns and obesity. Youth who exercise frequently would require beverages for hydration, and may choose to drink sports beverages, which are classified with sugar-sweetened beverages. Consumption of sports beverages may not necessarily be associated with body fatness, because youth who exercise frequently would have more lean than fat mass.

F. Modeling the relationship between beverage patterns and obesity

Results of this study provide much needed data regarding interrelationships between sociodemographic/lifestyle factors, beverage patterns, dietary intakes, and adolescent obesity in the U.S. The following description of aims is to show how they relate to the conceptual model shown in **Figure 1**.

As shown in **Figure 1**, energy intake is hypothetically the mediator between beverage patterns and adolescent obesity, and **Aim 1** was to investigate whether beverage

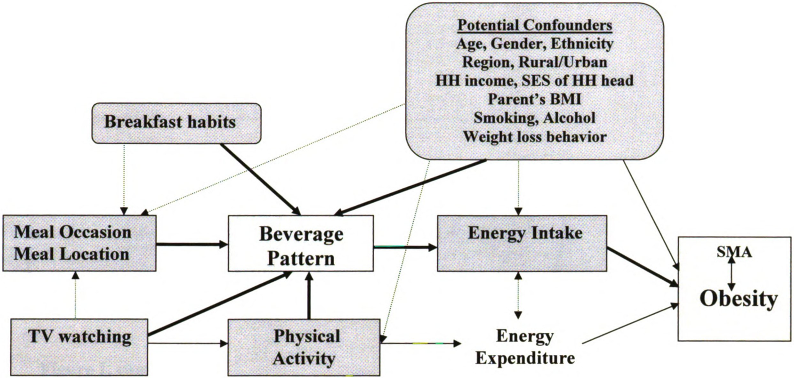

Figure 1. Conceptual model for the association of beverage patterns with obesity

Figure 1, cont'd.

Aim 1 was to examine the association of beverages with the meal context (meal occasion and meal location), and to examine the association of beverage patterns with energy intake.

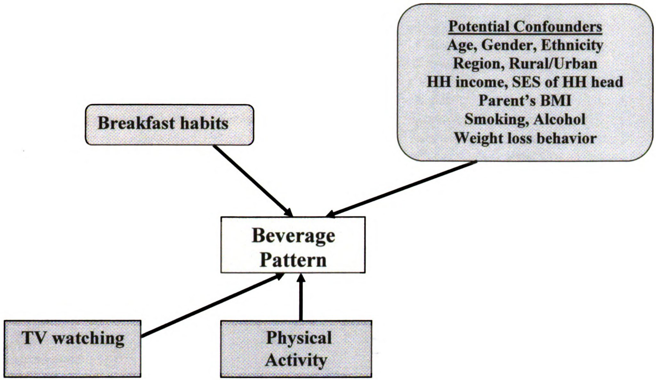

Figure 1, cont'd.

Aim 2 was to determine whether the sociodemographic and lifestyle risk factors for overweight were distributed differently among the various beverage pattern groups.

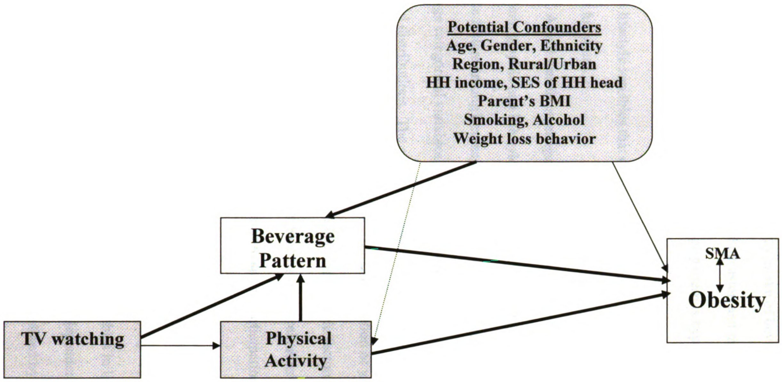

Figure 1, cont'd.

Aim 3 was to examine the association of beverage patterns with obesity, adjusted for potential covariates of interest.

patterns (i.e., the types of beverages most frequently consumed) were associated with energy intake by examining the mean energy intake of beverage pattern groups. The associations of the meal context (e.g., meal occasion and meal location) with beverages were also examined in **Aim 1**. The beverage pattern is hypothetically determined by the meal context in which beverages are consumed, and the beverage pattern can be a marker for the lifestyle variables that determine the frequency with which that meal context occurs for youth.

Aim 2 was to investigate the association of beverage patterns with sociodemographic and lifestyle risk factors for overweight by examining the distribution of these factors among beverage pattern groups. Chi-square tests of association between beverage categorical variables are based on the differences between the observed and expected distributions. The sociodemographic and lifestyle factors were examined to investigate whether and how they affected the classification of youth to the various beverage pattern groups. Sociodemographic and lifestyle factors examined included those listed in **Figure 1** as potential confounders of the relationship between beverage patterns and obesity, as well as exercise, team sports participation, TV watching and the frequency of breakfast consumption.

Aim 3 was to examine the association of beverage patterns with adolescent obesity. The beverage pattern groups were used as "dummy" variables in regression analyses. Obesity outcomes included as dependent variables in linear regression models were the BMI percentile and percentage body fat. The dependent variable in a logistic regression model was overweight/risk for overweight defined by the 85^{th} percentile of the reference BMI-for-age distribution (Kuczmarski et al., 2000). The associations of obesity outcomes with beverage pattern groups were adjusted for physical activity (i.e., exercise and team sports), TV watching, sexual maturation, and potential confounders. As shown in **Figure 1**, not only the independent effects on obesity of beverage patterns, but also the independent effects on obesity of TV watching, physical activity, sexual maturation and confounding variables were determined. Regression models were used to investigate whether an effect of TV watching on obesity was mediated through both beverage patterns and physical activity. Whether potential confounders led to a spurious correlation between beverage patterns and obesity was also examined. The relationships of beverage patterns with sociodemographic and lifestyle factors examined in Aim 2 provided insight regarding the covariates that affected the association of beverage patterns with obesity outcomes in Aim 3.

G. Strengths and Limitations

Strengths of an analysis of NHANES III data are that a multitude of health and nutrition data are provided for a large national sample, and results are representative of the U.S. population. Using NHANES, measured height and weight, not self-reported data as in CSFII, were used to compute BMI. An advantage of NHANES is that there is not just BMI, but a variety of anthropometric data available, including skinfold thickness measures used to compute percentage body fat in adolescents.

A comprehensive food frequency questionnaire available only in NHANES III was used to assess usual beverage consumption, but the FFQ was not validated or quantified to estimate nutrient intakes. Use of the FFQ increases the precision of population parameter estimates by reducing the potential for error due to intraindividual in dietary intake. In classification of youth by beverage patterns, the frequencies of each beverage consumed were converted to percentages of the total beverage frequency to address the potential for bias due to under- or over-reporting. Classification of youth into mutually exclusive beverage pattern groups addressed the potential for bias due to multicollinearity among the single beverage items. Classification of youth into beverage pattern groups also allowed for the use of the 24-hour recall data, because 24-hour recall intakes of groups are not biased by intraindividual variation (Guenther et al., 1997).

The most important limitation of this study is that cross-sectional data lack temporality, and cannot be used to make causal inferences. Interpretation of results of this study would be difficult when an unexpected finding can be explained by reverse causality. For example, if low calorie "diet" soft drinks were positively associated with body weight, there would be two possible explanations to consider, i.e., "diet" soft drinks promote weight gain (contradictory to what was expected), or overweight youth drink "diet' beverages because they are trying to lose weight (reverse causality). Cross-sectional data cannot be used to determine which of the two explanations would be responsible for a positive association between "diet' soft drinks and obesity.

Chapter 4

THE MEAL CONTEXT OF BEVERAGES CONSUMED BY ADOLESCENTS IN THE U.S., BEVERAGE CONSUMPTION PATTERNS AND ENERGY INTAKE

ABSTRACT

Objective To examine the meal context in which beverages were consumed; and to examine associations of beverage patterns (i.e., the types of beverages most frequently consumed) with energy and nutrient intake.

Design Cross-sectional analysis of data from the Third National Health and Nutrition Examination Survey (NHANES III, 1988-94). Both food frequency questionnaire (FFQ) and 24-hour recall data were used to examine how often beverages were consumed. The meal context of beverage intake was examined using 24-hour recall data, and youth were classified by beverage pattern using FFQ data. Energy and nutrient intakes from the total diet, beverages and non-beverages were assessed using 24-hr recall data.

Subjects A U.S. population-based sample of adolescents age 12-16 years (n=1,872).

Statistical analysis Sample-weighted means, medians and standard errors were estimated using SUDAAN software. Descriptive statistics included the mean frequency of consuming each beverage type, and the percentage contribution of meal occasions and meal locations to the total beverage frequency. The Bonferroni method was used to test for differences in mean energy and nutrient intake of beverage pattern groups ($p<0.05$).

Results Types of beverages consumed by adolescents, and their percentage share of the total beverage frequency, included milk (39%), sugar-sweetened fruit drinks/soft drinks (30%), juice (20%), and other beverages (e.g., diet soft drinks, coffee and tea) (11%). Milk and juice were consumed most frequently at the breakfast meal, while sugar-

sweetened beverages were consumed most frequently at the snack occasion. Soft drinks were consumed at fast food restaurants more frequently than any other beverage. Comparisons of 'milk' and 'sugar-sweetened beverages' patterns showed that fat intake from beverages was greater for 'milk' groups, and added sugar intake from beverages was greater for 'sugar-sweetened beverages' groups. Daily fat and energy intakes from the total diet did not differ, but calcium, potassium and vitamin D intakes were higher in 'milk' groups, and percent calories from added sugars were higher in 'sugar-sweetened beverages' groups. Daily energy, calcium and vitamin D intakes were lower, and caffeine intakes were higher in 'other beverages' groups than in 'caloric beverages' groups.
Implications Because beverage choice was associated with the meal context, the beverage pattern could be used to indicate how often youth consume different types of meals (e.g., breakfast, snacks, meals eaten at fast food restaurants). Higher added sugar and lower calcium intakes in 'sugar-sweetened beverages' groups than in 'milk' groups suggest that the beverage pattern could potentially be a risk factor for overweight. Consumption of 'other beverages' patterns might put youth at risk for inadequate calcium, potassium or vitamin D intakes.

INTRODUCTION

Trends in national surveys have shown a dramatic increase in the intakes of soft drinks by youth in the U.S. (Cavadini et al., 2000a; Bowman, 2002; Enns et al., 2002; Enns et al., 2003; French et al., 2003; Nielsen & Popkin, 2004). Some authors have noted that the trend in obesity prevalence parallels the trend in added sugars available in the food supply (Harnack et al., 2000; Bray et al., 2004). If the added sugars in soft drinks and other sugar-sweetened beverages consumed by youth contribute an excess of energy intake compared to energy expenditure, the positive energy balance could lead to incremental weight gain in adolescence. Soft drinks are frequently consumed while snacking and watching TV (Coon et al., 2001; Giammattei et al., 2003; Matheson et al., 2004; Phillips et al., 2004), and with meals eaten at fast food restaurants (French et al., 2001b; Paeratakul et al., 2003; Bowman et al., 2004). Caloric intakes from energy-dense snack foods (Hampl et al., 2003; Phillips et al., 2004) and fast foods (Bowman et al., 2004; Paeratakul et al., 2003; Schmidt et al., 2005) are then added to calories contributed by soft drinks (Harnack et al., 1999; Troiano et al., 2000). Thus, youth who drink soft drinks are expected to have higher energy intakes than youth who do not.

Intakes of soft drinks increase with age, while milk intakes decline during adolescence, especially in girls (Lytle et al., 2000; Bowman et al., 2002). This inverse relationship between intakes of soft drinks and milk might have negative implications for nutritional status (Harnack et al., 1999). Girls might reduce intakes of milk during adolescence because they think milk is fattening (Clark, 1999; AAP, 1999), but if they drank low-fat milk, the calcium in it might be beneficial for weight control (Zemel et al., 2000). The decline in milk intake might relate to the increased prevalence of breakfast skipping in adolescence (Siega-Riz et al., 1998), an additional negative influence on nutritional status (Rampersaud et al., 2005). Youth consume milk more often if they had cereal with milk for breakfast (Ortega et al., 1998).

If youth consumed both milk and orange juice frequently at breakfast, then those youth who regularly eat breakfast might be distinguished from breakfast skippers by identifying those who do or do not consume milk and juice in combination. In addition to milk and juice, cereal and other foods consumed at the breakfast meal occasion would then contribute to vitamin and mineral intakes of milk and juice consumers. Milk is high in vitamins and minerals like vitamin A, calcium and vitamin D (Miller et al., 2001); juice is high in vitamin C, folate and potassium (Fellers et al., 1990); and cereal is fortified with many vitamins and minerals (Subar et al., 1998).

Previous research examined nutrient intakes of youth who did or did not drink sugared-sweetened beverages and milk in combination (Bowman et al., 2002). The current study of beverage patterns also considered the independent nutritional effects of drinking juice. A milk and juice pattern was expected to be associated with a nutrient-dense diet, if milk and juice were frequently consumed at breakfast. Sugar-sweetened beverage patterns were expected to be associated with energy intake from both beverages and non-beverages, if energy-dense snack foods or fast foods were eaten frequently with sugar-sweetened beverages.

The aims of this study were to examine the meal context in which 12-16-year-old adolescents in the U.S. consumed beverages; and to examine associations of beverage patterns (i.e., the types of beverages most frequently consumed) with energy and nutrient intake. How often youth consumed milk, 100% fruit juice, sugar-sweetened fruit drinks/soft drinks, and other beverages (e.g., diet soft drinks, coffee/tea and alcoholic beverages) (times/day) at meals (e.g., breakfast, lunch, dinner/supper and snacks) eaten at home or at places away-from-home (e.g., school, fast food restaurants) were examined. Youth were classified by their 'typical' beverage pattern according to the combination of beverage types that were each reported frequently as 'usual' intake in the FFQ. Mean food energy, dietary fat, total sugars, added sugar, calcium and other nutrient intakes of beverage pattern groups were compared.

METHODS

Dataset

The Third National Health and Nutrition Examination Survey (NHANES III, 1988-1994) data were used for analyses, rather than the more recent 1999-2002 NHANES data, because the dietary food frequency questionnaire used to assess the youth's usual beverage pattern is available only in NHANES III. The National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC) conducts NHANES to obtain nationally representative data on the nutritional and health status of the civilian, non-institutionalized U.S. population. Participants were selected using a complex, stratified, multistage, probability cluster sample design (DHHS, 1994). The survey included interviews conducted in the household and at a mobile examination center (MEC).

Subjects

Adolescents age 12-16 years who were interviewed and examined in NHANES III comprised the analytic sample for this study. The NHANES III sample included 2,216 adolescents aged 12-16 years selected for examination, and, of those, 2,079 (93.8% of 2,216) were examined in the MEC. Upon examination, 19 respondents (0.9% of 2,216) found to be ineligible (16 teenage girls were pregnant, and three were lactating) were excluded from the current study. Because the current study used both 24-hour recall and

FFQ data, the analytical sample was limited to adolescents age 12-16 years who completed a 24-hour recall dietary interview as well as all beverage items in the FFQ. There were 1,997 youth (90.1% of 2,216) who had a complete, reliable 24-hour recall dietary interview, and of these, 97 (4.4% of 2,216) were missing beverage frequency data and another 28 (1.3% of 2,216) were missing data on water intake. After excluding those with missing data, the remaining analytic sample of 1,872 youth (84.5% of 2,216) included 871 boys (46.5% of 1,872) and 1,001 girls (53.5% of 1,872) aged 12-16 years.

Dietary assessment methods

The FFQ and 24-hour recall dietary interviews were administered to youth at the MEC.

Food frequency questionnaire

Twelve (12) beverage items in the FFQ are listed in **Table 1**. The subjects were asked to think about their usual diet over the past month, and to respond with how often they usually drank the beverages per day, per week, per month, or not at all. NHANES staff converted the frequency data to times per month, by multiplying times per day by a factor of 30.4, for example: 3 times per day = round (3 * 30.4) times per month = 91 times per month. Amounts reported per week were divided by 7 and then multiplied by 30.4 to convert to times per month: 5 times per week = round (5/7 * 30.4) times per month = 22 times per month. In the current study, beverage frequency (times per month) divided by 30.4 converted the data to provide intakes in terms of times per day.

Four main categories (and seven subcategories) of the 12 FFQ beverage items listed in **Table 1** included (1) milk and milk drinks, chocolate and regular, (2) 100% fruit juice, citrus and non-citrus, (3) sugar-sweetened beverages (3a. fruit drinks, 3b. regular

Table 1. Beverage categories and beverage subcategories corresponding to beverage items in the NHANES III food frequency questionnaire (FFQ)

Beverage categories & beverage subcategories	FFQ beverage items
1. Milk and milk drinks, chocolate & regular	1a. How often did you have chocolate milk and hot cocoa?
	1b. How often did you have milk to drink or on cereal? Do not count small amounts of milk added to coffee or tea.
2. 100% fruit juice, citrus & non-citrus	2a. How often did you have orange juice, grapefruit juice and tangerine juice?
	2b. Other fruit juices such as grape juice, apple juice, cranberry juice, and fruit nectars?
3. Sugar-sweetened bevg.	
3a. Fruit drinks	3a. How often did you have Hi-C, Tang, Hawaiian Punch, Koolaid, and other drinks with added vitamin C?
3b. Regular soft drinks	3b. Regular colas and sodas, not diet?
4. Other beverages	
4a. Diet soft drinks	4a. Diet colas, diet sodas, and diet drinks such as Crystal Light?
4b. Coffee/ tea	4b (1). Regular coffee with caffeine?
	4b (2). Regular tea with caffeine?
4c. Alcoholic beverages	4c (1). Beer and lite beer?
	4c (2). Wine, wine coolers, Sangria, and champagne?
	4c (3). Hard liquor such as tequila, gin, vodka, scotch, rum, whiskey and liqueurs, either alone or mixed?

soft drinks) and (4) other beverages (4a. diet soft drinks, 4b. coffee/tea and 4c. beer/ wine/liquor). Regular milk included both milk to drink and milk on cereal. An additional item in the FFQ asked what type of milk was usually consumed: whole, 2%, 1% or skim/nonfat milk.

Beverage patterns were defined *a priori* by identifying all possible combinations of three types of beverages: milk (milk & milk drinks), sugar-sweetened beverages (fruit drinks & regular soft drinks) and juice (100% fruit juice). To classify youth into beverage pattern groups, the FFQ beverage frequencies were used to identify the combination of beverage types that characterized a youth by his/her 'typical' beverage pattern. Two different methods, the 'frequency' method, and the 'share' method, were developed to classify youth by the combination of beverage types that were each reported frequently in the FFQ. For each beverage, the 'share' was determined by expressing the beverage frequency as a percentage of the summed frequency for all beverages. Criteria to identify the most frequently consumed beverage types using the 'frequency' and 'share' methods, respectively, were frequency ≥1 time/day, and share ≥25% of total beverage frequency. Notations for beverage patterns were combinations of capital letters M, S and J to represent milk, sugar-sweetened beverages and juice, respectively, consumed at a level meeting the criteria, and lowercase letters m, s and j represented consumption of less than the specified amount. The beverage patterns were named according to the eight beverage combinations: 'all caloric beverages' (MSJ), 'milk & sugar-sweetened beverages' (MSj), 'milk & juice' (MsJ), 'milk' (Msj), 'sugar-sweetened beverages & juice' (mSJ), 'sugar-sweetened beverages' (mSj), 'other beverages & juice' (msJ) and 'other beverages' (msj).

24-hour recall dietary interview

The 24-hour recall data were used to examine beverages consumed at meal occasions eaten at locations at-home and away-from home, because the FFQ does not specify meal occasion and meal location. Respondents reported the meal occasion (e.g., breakfast/brunch, lunch, diner/supper, snack/beverage break) and place where the meal was eaten, and Spanish translations were available as needed. Meal locations included home, work, school, a fast food or take-out establishment, a restaurant (with table service) or cafeteria, someone's home, transit, and other meal places.

The USDA survey codes for beverages reported in the 24-hour recall dietary interview were classified into the beverage categories and subcategories listed in **Table 1**. The 24-hour recall beverage categories were identical to those described by the FFQ items, except that the fruit drinks category included fruit drinks without vitamin C, and the coffee/tea subcategory included decaffeinated coffee and decaffeinated tea. The milk category included milk poured on cereal as well as milk consumed as a beverage. Milk combined with cereal was identified using the code for the type of combination known as cereal with additions. Beverage mixtures, such as coffee with milk, were identified using the code for this type of combination, and the USDA survey food code for the main component of the beverage mixture was used to classify the combination into the appropriate category.

Assessment of water intakes

Although water intakes were not ascertained using the 24-hour recall method, the dietary interview included a question to respondents about how many glasses/cups or fluid ounces of plain water they usually drank in a 24-hour period. If the response was in terms of glasses or cups, participants specified the fluid ounces per glass or cup, and numbers of glasses/cups were converted to fluid ounces.

Nutrient intake assessment

Although youth were classified by their 'typical' beverage pattern based on beverage frequencies reported in response to the FFQ, because the NHANES III FFQ was not designed to assess nutrient intake, the 24-hour recall method was used instead to estimate mean nutrient intakes of beverage pattern groups. Intakes of food energy (Kcal), fat (g), sugars (g), caffeine (mg), vitamin A (μg RAE), vitamin C (mg), folate (μg DFE), calcium (mg), potassium (mg) and vitamin D (μg) from the total diet, from beverages, and from non-beverages were assessed using the 24-hour recall dietary intake data.

Because of the risk for overweight, intakes of food energy (Kcal) and macronutrients such as total fat (g), saturated fat (g), carbohydrate (g), total sugars (g) and added sugars (g) are primarily of interest. It's recommended that the diet contain <30% calories from total fat, and <10% calories from saturated fat or added sugars. Intakes of caffeine (mg) from soft drinks, coffee and tea might also be a concern for teens. Teenagers, especially girls, are at risk for inadequate intake of some key nutrients. Many of these vitamins and minerals can be obtained from the diet by drinking juice or eating cereal with milk for breakfast. Thus, additional nutritional risk factors that might distinguish the 'milk & juice' (MsJ) group from other beverage pattern groups include intakes of vitamin A (μg RAE), vitamin C (mg), folate (μg DFE), calcium (mg), potassium (mg) and vitamin D (μg). The mean and median of the distribution of daily nutrient intake were compared to Dietary Reference Intake (DRI) criteria, such as the age- and gender-specific Estimated Average Requirement (EAR) or Adequate Intake (AI) level (Institute of Medicine (IOM) of the National Academies of Science, 1997; IOM, 1998; IOM, 2000; IOM, 2001; IOM, 2002).

The primary source of food composition data for NHANES III was the U.S. Department of Agriculture (USDA) Survey Nutrient Database; USDA provided two nutrient files (first in 1993, second in 1995) for use in NHANES III (NCHS, 1997). Because the Nutrition Coordinating Center (NCC) of the University of Minnesota had developed the Dietary Data Collection system for NHANES III, survey foods were also cross-referenced to the NCC nutrient composition files (NCHS, 1998). Although vitamin D was not in the USDA Survey Nutrient Database, the second release of the NHANES III 24-hour recall dietary data included vitamin D intakes, because vitamin D was in the NCC nutrient composition database (NCHS, 1998). The USDA Food and Nutrition Database for Dietary Studies (FNDDS) (USDA, 2004) was used to access food composition data for vitamin A (μg RAE), folate (μg DFE), caffeine and total sugars, because intakes are either unavailable in the NHANES III dataset, or if available, units are inconsistent with DRI recommendations.

The added sugars content of food was obtained from the USDA Pyramid Food Group Servings Database, Version 2.0 (Cook & Friday, 2004). Added sugars include sugars and other sweeteners eaten separately or added to foods at the table as well as sweeteners used as ingredients in prepared and processed foods such as breads, cakes and other grain desserts, soft drinks, jams and jellies, candies and ice cream. Added sugars and other sweeteners include white sugar, brown sugar, raw sugar, corn syrup, corn syrup solids, high fructose corn syrup, malt syrup, maple syrup, pancake syrup, fructose sweetener, liquid fructose, honey, molasses, anhydrous dextrose, crystal dextrose, and dextrin eaten separately or used as ingredients in prepared or processed food. Added sugars do not include naturally occurring sugars such as lactose in milk and fructose in fruit. In the USDA Pyramid Servings database, a serving of added sugars was defined as the amount equivalent to 4.2 grams of sugar.

Statistical analysis

The Statistical Package for the Social Sciences, SPSS for Windows, Version 12.0 (SPSS Inc. Chicago, IL, USA) was used to prepare the dataset for analysis, while all statistical analyses were performed using SUDAAN version 8 (Research Triangle Institute, Research Triangle Park, NC), to account for the effect of the complex sampling design while conducting statistical tests.

For each beverage type (and for each subtype of beverages), the mean beverage frequency was estimated from the frequency of consumption each youth reported in the FFQ. The mean beverage share was estimated from the beverage's share of total consumption determined for each youth by expressing the beverage frequency as a percentage of the summed frequency for all beverages. Two different methods, the 'frequency' method, and the 'share' method, were used to classify youth as frequent beverage consumers. Criteria for frequent beverage consumption using the 'frequency' and 'share' methods, respectively, were frequency ≥1 time/day, and share ≥25% of total beverage frequency. Therefore, in the 'frequency' method, the prevalence of frequent beverage consumption was defined as the percentage of youth consuming the beverage at least once per day, and in the 'share' method, prevalence of frequent beverage consumption was the percentage of youth having shares that were least 25% of the total beverage frequency. Beverage pattern prevalence estimates were the percentage of youth classified by the combination of beverage types that were each reported frequently, using the two different criteria of the 'frequency' and 'share' methods to define frequent beverage consumption.

Mean beverage frequency and mean nutrient intakes of beverage pattern groups were contrasted using the Bonferroni method to adjust statistical significance tests for the number of comparisons. Three Bonferroni contrasts of interest were 'caloric beverage' patterns *vs.* 'other beverage' patterns, 'milk' patterns *vs.* 'sugar-sweetened beverage' patterns, and 'juice' patterns *vs.* 'non-juice' patterns. Mean and median nutrient intake of boys/girls age 12-13 and 14-16 years were estimated to distinguish gender-age groups having different DRI levels. Mean frequency of beverage consumption at meal occasions eaten at-home and away-from-home were estimated to determine the meal occasions' and meal locations' share of the total beverage frequency.

The six-year MEC-examined sample weights were applied to the calculation of all population parameters, such as the mean, median, or percentage of the population. The sample weights account for unequal probability of selection, non-coverage and non-response and adjust the data to the 1990 U.S. Census figures, therefore the estimates were representative of adolescents in the 1990 U.S. population. The linearization (Taylor series) method was used in SUDAAN to account for effects of the clustered sample design in estimating the variance of population parameters (Shah et al., 1997).

RESULTS

Mean beverage frequencies and the beverage's percentage share of total beverage frequency are presented in **Table 2**. The mean percentages of total beverage frequency indicate that, on average, adolescents reported milk most frequently (39%), sugar-sweetened beverages was second (30%), juice was consumed 20% of the time, with other beverages contributing the remaining share (11%).

The distribution of beverage consumption frequency and the distribution of the beverages' percentage share of total beverage consumption are presented in **Table 3**. Cumulative percentage distributions show, for example, milk was consumed <1 time/day by 31% of youth, and conversely, 69% had milk ≥1 time/day. Two different methods used to classify youth as frequent beverage consumers, the 'frequency' and 'share' methods, resulted in similar estimates of the prevalence of frequent beverage consumption. Youth classified as frequent milk, sugar-sweetened beverage or juice consumers using the 'frequency' method (i.e., frequency ≥1 time/day) were 69%, 49%, and 35%, respectively, while 69%, 52% and 32% were classified as frequent consumers of milk, sugar-sweetened beverage or juice, respectively, using the 'share' method (i.e., share ≥25% of total beverage frequency).

Beverage pattern prevalence estimates are shown in **Table 4**. Beverage patterns were defined using the two different methods to classify youth as consumers of each beverage combination. Based on beverage consumption data presented above, it was expected that 'milk' patterns would be most prevalent, followed by 'sugar-sweetened beverages' and 'juice' patterns, and beverage patterns using the 'share' method (share ≥25% of total) were ranked in that order. The 'all caloric beverages' (MSJ) pattern was

Table 2. Mean frequency of beverage consumption (# of times/day) and the beverage's percentage share of total beverage consumption (% of total frequency), using food frequency questionnaire (FFQ) data of adolescents aged 12-16 years[1]

Type of Beverage	Frequency (# times/d) Mean ± SE	Share (% of total) Mean ± SE
All beverages	4.2 ± 0.1	100.0 ± 0.0
Milk & milk drinks	1.6 ± 0.1	38.8 ± 1.1
Fruit juice (100%)	0.9 ± 0.0	19.9 ± 0.8
Sugar-sweetened beverages	1.2 ± 0.1	29.9 ± 1.0
Fruit drinks	0.5 ± 0.0	12.0 ± 0.5
Regular soft drinks	0.7 ± 0.0	17.9 ± 0.7
Other beverages	0.5 ± 0.0	11.3 ± 0.7
Diet soft drinks	0.2 ± 0.0	4.5 ± 0.4
Coffee and tea	0.3 ± 0.0	6.4 ± 0.6
Beer, wine, liquor	0.0 ± 0.0	0.5 ± 0.1

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872) Means and standard errors are sample-weighted and estimated by linearization method of SUDAAN.

Table 3. Distribution (% of adolescents aged 12-16 years in categories) of the frequency (# of times) of consuming beverage (sub)types in the FFQ, and distribution (% of adolescents aged 12-16 years in categories) of the beverage (sub)type's percentage share of total beverage frquency in the FFQ

Category of Beverage Consumption	Types of Beverages				Subtypes of Sugar-Sweetened Bevg		Subtypes of Other Beverages		
	Milk & Milk Drinks	100% Fruit Juice	Sug-Swt Beverages	Other Beverages	Fruit Drinks	Reg. Soft Drinks	Diet Soft Drinks	Coffee & Tea	Beer, Wine & Liquor
Frequency (# of times) category	Percentage (%) of adolescents in 'frequency' category								
Zero	2.2	7.5	3.8	33.8	23.4	10.3	65.2	56.4	87.1
1-3 per month	3.2	9.8	4.5	11.5	11.1	7.1	7.3	9.9	7.6
1 per week	4.0	17.6	9.3	16.1	13.8	13.8	8.8	11.3	3.3
2-4 per week	15.1	22.0	21.8	15.9	24.4	32.5	9.4	9.3	1.7
5-6 per week	6.8	8.0	11.3	3.6	6.6	7.5	1.3	1.2	0.1
1 per day	32.5	24.2	30.9	11.2	12.9	16.1	4.8	7.5	0.3
2 per day	19.5	4.4	5.9	4.4	3.6	7.0	1.9	2.4	0.0
3 per day	10.6	3.8	6.9	1.9	2.4	3.8	0.6	1.1	0.0
≥ 4 per day	6.2	2.7	5.5	1.6	1.8	2.0	0.8	0.8	0.0
Frequent consumer category using 'frequency' method									
≥ 1 per day	68.7	35.1	49.3	19.2	20.6	28.9	8.1	11.9	0.3

Table 3, cont'd.

Category of Beverage Consumption	Types of Beverages				Subtypes of Sugar-Sweetened Bevg		Subtypes of Other Beverages		
	Milk & Milk Drinks	100% Fruit Juice	Sug-Swt Beverages	Other Beverages	Fruit Drinks	Reg. Soft Drinks	Diet Soft Drinks	Coffee & Tea	Beer, Wine & Liquor
Share (% of total beverage frequency) category	Percentage (%) of adolescents in 'share' category								
Zero	2.2	7.5	3.8	33.8	23.4	10.3	65.2	56.4	87.1
>0-<10%	6.7	29.6	15.4	32.6	32.6	32.6	20.5	25.1	12.1
10-<25%	22.5	31.1	28.7	17.2	29.0	29.7	9.1	10.2	0.7
25-<50%	37.3	24.5	33.7	11.9	11.8	20.7	4.0	6.0	0.2
50-<75%	23.6	5.9	14.1	3.6	2.9	5.4	0.9	2.0	0.0
≥ 75.0%	7.7	1.4	4.3	0.9	0.3	1.3	0.3	0.4	0.0
Frequent consumer category using 'share' method									
≥ 25.0%	68.5	31.8	52.1	16.4	14.9	27.4	5.2	8.4	0.2

Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872)

Table 4. Percentage of adolescents aged 12-16 years classified by beverage pattern, i.e., the combination of beverages frequently consumed in the FFQ, based on criteria for frequent consumption using the 'frequency' method (frequency ≥1 time/day) and 'share' method (share ≥25% of total frequency)[1]

Beverage Pattern[2]	Comb. Code[3]	'Frequency' Method		'Share' Method	
		Rank	Percent ± SE	Rank	Percent ± SE
All youth (%)			100.0 ± 0.0		100.0 ± 0.0
All caloric beverages	MSJ	3	14.2 ± 1.3	7	4.8 ± 0.8
Milk & sugar-swt bevg	MSj	2	20.4 ± 1.6	1	24.7 ± 1.6
Milk & juice	MsJ	4	12.8 ± 1.4	4	14.8 ± 1.7
Milk	Msj	1	21.4 ± 1.5	2	24.2 ± 1.7
Sugar-swt bevg & juice	mSJ	7	4.3 ± 0.8	5	6.5 ± 0.8
Sugar-swt bevg	mSj	6	10.4 ± 1.1	3	16.1 ± 1.8
Other beverages & juice	msJ	8	3.8 ± 0.8	6	5.7 ± 0.9
Other beverages	msj	5	12.8 ± 1.1	8	3.2 ± 0.6

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872) Percentages and standard errors are sample-weighted and estimated by linearization method of SUDAAN.

[2] Beverage patterns are combinations of milk (milk & milk drinks), sugar-swt bevg (fruit drinks & regular soft drinks) and juice (100% fruit juice). Other beverages include diet soft drinks, coffee/ tea, beer/ wine/ liquor & water.

[3] Combination code refers to the pattern of beverages consumed or not consumed at the specified level. Capital letters M, S and J refer to milk, sugar-swt bevg and juice, respectively, consumed at the specified level, and lowercase letters m, s and j represent consumption of less than the specified amount.

ranked high using the 'frequency' method (frequency ≥1 time/d), but this pattern was less prevalent using 'share' method (share ≥25% of total) that requires roughly equal shares for each of the three beverage types. The 'other beverages' (msj) pattern also ranked high using consumption the 'frequency' method, because "under-reporters" would be classified to the 'other beverages' (msj) pattern if they reported drinking all three beverage types <1 time/d. Using the 'share' method, the 'other beverages' (msj) group would have to be drinking 'other beverages' or water most frequently, when neither milk, juice nor sugared-sweetened beverages was consumed with a share ≥25% of total beverage frequency. Defining beverage patterns using the 'share' method (share ≥25% of total) was preferred because each youth was classified by his/her own beverage choices (i.e., the beverages he/she drinks most frequently), and this method was not biased by under- or over-reporting. The 'share' method was used to classify youth by beverage patterns when examining beverage frequencies and nutrient intakes of beverage pattern groups.

Table 5 shows mean beverage frequencies of youth classified to beverage pattern groups using the 'share' method. Mean beverage frequencies tended to be higher in the FFQ than in the 24-hour recall, except consumption of regular soft drinks in the FFQ was less than in the 24-hour recall. As expected, the 'other beverages' groups drank more diet soft drinks and more coffee/tea than the 'caloric beverages' groups, in both the FFQ and 24-hr recall. Mean water (oz) was also high in the 'other beverages' (msj) group, because youth would be classified by the 'other beverages' (msj) pattern if they did not drink any beverage other than water. The 'juice' groups drank juice more frequently than the 'non-juice' groups, the 'milk' groups drank milk more frequently than 'sugar-

Table 5. Mean beverage frequency (# of times/day) in the FFQ and 24-hr recall among groups of adolescents age 12-16 years classified by beverage pattern, i.e., the combination of beverages frequently consumed in the FFQ, based on criteria for frequent consumption using the 'share' method (share ≥25% of total frequency)[1]

Bevg Type & Subtype	All 12-16 yr (n = 1,872)	All Caloric Bevg M S J (n = 109)	Milk & Sug-Swt Bevg M S j (n = 435)	Milk & Juice M s J (n = 248)	Milk M s j (n = 411)	Sugar-Swt Bevg & Juice m S J (n = 184)	Sugar-Swt Bevg m S j (n = 327)	Other Bevg & Juice m s J (n = 103)	Other Bevg m s j (n = 55)
	Beverage Pattern Group[2]								
	Mean (mean ± SE) beverage frequency (# of times/day) in the FFQ and 24-hr recall								
All beverages									
FFQ	4.2 ± 0.1	4.0 ± 0.3	4.0 ± 0.1	4.7 ± 0.2	3.8 ± 0.1	4.0 ± 0.3	4.5 ± 0.2	4.4 ± 0.4	4.6 ± 0.7
24-hr	3.2 ± 0.1	3.1 ± 0.2	3.3 ± 0.1	3.5 ± 0.1	3.2 ± 0.1	3.2 ± 0.2	3.1 ± 0.1	3.0 ± 0.2	3.1 ± 0.3
Milk									
FFQ	1.6 ± 0.1	1.3 ± 0.1 K	1.8 ± 0.1 K	2.0 ± 0.1 M	2.4 ± 0.1 M	0.6 ± 0.1	0.6 ± 0.0	0.7 ± 0.1	0.6 ± 0.2
24-hr	1.0 ± 0.1	1.1 ± 0.1 K	1.1 ± 0.1 K	1.2 ± 0.1 M	1.5 ± 0.1 M	0.6 ± 0.1	0.5 ± 0.1	0.7 ± 0.1	0.6 ± 0.2
Juice									
FFQ	0.9 ± 0.0	1.3 ± 0.1	0.4 ± 0.0	2.0 ± 0.1 J	0.4 ± 0.0	1.5 ± 0.1 J	0.5 ± 0.0	2.4 ± 0.2 O	0.4 ± 0.1 O
24-hr	0.3 ± 0.0	0.4 ± 0.1	0.2 ± 0.1	0.7 ± 0.1 J	0.2 ± 0.0	0.5 ± 0.1 J	0.2 ± 0.1	0.6 ± 0.2	0.0 ± 0.0
Sug-swt bevg									
FFQ	1.2 ± 0.1	1.3 ± 0.1 K	1.6 ± 0.1 K	0.5 ± 0.0	0.5 ± 0.0 N	1.7 ± 0.2 S	2.7 ± 0.1 SN	0.6 ± 0.1	0.7 ± 0.2
24-hr	1.5 ± 0.0	1.6 ± 0.1 K	1.6 ± 0.1 K	1.3 ± 0.1	1.1 ± 0.1	1.9 ± 0.2 S	2.1 ± 0.1 S	1.2 ± 0.2	0.9 ± 0.2
Fruit drinks									
FFQ	0.5 ± 0.0	0.7 ± 0.1 K	0.6 ± 0.0 K	0.3 ± 0.0	0.2 ± 0.0	0.8 ± 0.1 S	1.1 ± 0.1 S	0.3 ± 0.0	0.2 ± 0.1
24-hr	0.4 ± 0.0	0.5 ± 0.1 K	0.4 ± 0.1 K	0.5 ± 0.1 J	0.3 ± 0.0	0.7 ± 0.1 J	0.3 ± 0.0	0.3 ± 0.1	0.2 ± 0.1

Table 5, cont'd.

Bevg Type & Subtype	All 12-16 yr (n = 1,872)	All Caloric Bevg M S J (n = 109)	Milk & Sug-Swt Bevg M S j (n = 435)	Milk & Juice M s J (n = 248)	Milk M s j (n = 411)	Sugar-Swt Bevg & Juice m S J (n = 184)	Sugar-Swt Bevg m S j (n = 327)	Other Bevg & Juice m s J (n = 103)	Other Bevg m s j (n = 55)
		Beverage Pattern Groups							
	Mean (mean ± SE) beverage frequency (# of times/day) in the FFQ and 24-hr recall								
Soft drinks									
FFQ	0.7 ± 0.0	0.6 ± 0.0 K	1.0 ± 0.1 K	0.3 ± 0.0	0.3 ± 0.0 N	0.9 ± 0.2 S	1.5 ± 0.1 SN	0.3 ± 0.0	0.5 ± 0.2
24-hr	1.1 ± 0.0	1.0 ± 0.1	1.3 ± 0.1	0.8 ± 0.1	0.8 ± 0.1	1.3 ± 0.2 S	1.7 ± 0.1 S	0.9 ± 0.2	0.7 ± 0.2
Other bevg									
FFQ	0.5 ± 0.0	0.1 ± 0.0	0.3 ± 0.0	0.2 ± 0.0	0.5 ± 0.1 N	0.3 ± 0.1	0.7 ± 0.1 N	0.8 ± 0.2 O	2.9 ± 0.4 O
24-hr	0.4 ± 0.0	0.1 ± 0.1	0.3 ± 0.0	0.3 ± 0.1	0.4 ± 0.1	0.1 ± 0.1	0.4 ± 0.1	0.5 ± 0.1 O	1.6 ± 0.2 O
Diet drinks									
FFQ	0.2 ± 0.0	0.0 ± 0.0	0.1 ± 0.0	0.1 ± 0.0	0.2 ± 0.0 N	0.1 ± 0.0	0.3 ± 0.1 N	0.5 ± 0.2 O	1.0 ± 0.3 O
24-hr	0.1 ± 0.0	0.0 ± 0.0	0.1 ± 0.0	0.1 ± 0.0	0.1 ± 0.0	0.0 ± 0.0	0.1 ± 0.1	0.3 ± 0.1 O	0.5 ± 0.2 O
Coffee/tea									
FFQ	0.3 ± 0.0	0.1 ± 0.0	0.2 ± 0.0	0.1 ± 0.0	0.3 ± 0.0 N	0.1 ± 0.0	0.4 ± 0.1 N	0.3 ± 0.1 O	1.7 ± 0.3 O
24-hr	0.3 ± 0.0	0.1 ± 0.1	0.2 ± 0.0	0.3 ± 0.1	0.3 ± 0.0	0.1 ± 0.0	0.3 ± 0.1	0.3 ± 0.1 O	0.9 ± 0.2 O
Alcohol									
FFQ	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0 S	0.0 ± 0.0 S	0.0 ± 0.0	0.1 ± 0.1
24-hr	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.1
Water (oz	42 ± 1	49 ± 10	39 ± 3	45 ± 3	46 ± 3	41 ± 5	34 ± 3	39 ± 3	60 ± 8

Table 5, cont'd.

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872)
Mean beverage frequency is sample-weighted and standard error is estimated by linearization method of SUDAAN.

[2] The beverage pattern is the combination of beverages frequently consumed. Capital letters M, S and J refer to milk (milk & mill drinks), sugar-sweetened beverages (fruit drinks & regular soft drinks) and juice (100% fruit juice), respectively, consumed witl share ≥25% of total beverage frequency, and lowercase letters m, s and j refer to consumption of less than the specified amount

K, O, M, S, J, N refer to beverage pattern groups with higher intakes in contrast to other beverage pattern groups ($p<0.05$).
Bonferroni contrasts were K ('caloric beverage' patterns MSJ/MSj) vs. O ('other beverage' patterns msJ/msj), M ('milk' patterns MsJ/Msj) vs. S ('sug-swt bevg' patterns mSJ/mSj) and J ('juice' patterns MsJ/mSJ vs. N ('non-juice' patterns Msj/mSj).

sweetened beverages' groups, and the 'sugar-sweetened beverages' groups drank regular soft drinks more frequently than the 'milk' groups, in both the FFQ and 24-hr recall. The 'sugar-sweetened beverages' groups drank more fruit drinks than the 'milk' groups in the FFQ, but not in the 24-hr recall. The 24-hour recall intakes of fruit drinks were higher for 'juice' groups than 'non-juice' groups. Some misclassification to 'juice' groups might have occurred if youth mistakenly reported fruit drink frequency in response to the 100% fruit juice question in the FFQ.

Table 6 presents the share of total beverage frequency consumed at meal occasions eaten at-home and away-from-home. Milk and juice were most frequently consumed at the breakfast meal occasion, while fruit drinks, regular soft drinks, and other beverages were most frequently consumed at snack/ beverage breaks. Milk and juice were consumed at home ~75% of the time, while for regular soft drinks, the share consumed at home was 52% of the total. The fast food restaurants' share of consumption was greater for regular soft drinks than for any other beverage.

The 24-hr recall nutrient intakes of beverage pattern groups are presented in **Table 7.** It was hypothesized that 'sugar-sweetened beverage' groups might have high energy intakes from both beverages and non-beverages, if regular soft drinks were frequently consumed with high-fat snack foods and fast foods. Comparisons of 'milk' and 'sugar-sweetened beverage' patterns showed that fat intake from beverages was greater for 'milk' groups, and added sugar intake from beverages was greater for the 'sugar-sweetened beverages' groups. Percentage of calories from added sugars was greater for 'sugar-sweetened beverages' groups than for 'milk' groups, but there were no differences in energy or fat intakes from the total diet. Percentage calories from fat and

Table 6. Mean beverage frequency (# of times/day) in the 24-hr recall among beverage consumers aged 12-16 years, and percentage contribution of meal occasions and meal locations to the total beverage frequency[1]

Meal Occasion & Meal Place	Milk & Milk Drinks (n = 1,137)		100% Fruit Juice (n = 467)		Fruit Drinks (n = 604)		Regular Soft Drinks (n = 1,172)		Other Beverages[2] (n = 386)	
	Mean ± SE	%	Mean ± SE	%	Mean ± SE	%	Mean ± SE	%	Mean ± SE	%
All Meal Occasions	1.62 ± 0.05	100.0	1.28 ± 0.05	100.0	1.36 ± 0.05	100.0	1.77 ± 0.05	100.0	1.47 ± 0.05	100.0
Breakfast/Brunch	0.77 ± 0.03	47.3	0.54 ± 0.04	42.6	0.15 ± 0.02	10.9	0.07 ± 0.01	4.2	0.14 ± 0.03	9.6
Lunch	0.30 ± 0.03	18.5	0.23 ± 0.03	17.9	0.31 ± 0.04	22.9	0.34 ± 0.02	19.0	0.31 ± 0.03	21.2
Dinner/Supper	0.26 ± 0.02	15.9	0.15 ± 0.03	11.5	0.33 ± 0.03	24.0	0.51 ± 0.03	28.8	0.42 ± 0.03	28.5
Snack/Bevg Break	0.30 ± 0.03	18.2	0.36 ± 0.04	27.9	0.57 ± 0.04	42.1	0.85 ± 0.04	48.0	0.60 ± 0.05	40.6
All Meal Places	1.62 ± 0.05	100.0	1.28 ± 0.05	100.0	1.36 ± 0.05	100.0	1.77 ± 0.05	100.0	1.47 ± 0.05	100.0
Home	1.26 ± 0.04	77.7	0.95 ± 0.06	74.3	0.87 ± 0.07	64.4	0.91 ± 0.05	51.6	0.96 ± 0.08	65.5
Work	0.01 ± 0.00	0.5	0.01 ± 0.01	1.1	0.00 ± 0.00	0.2	0.05 ± 0.01	3.1	0.02 ± 0.01	1.6
School	0.26 ± 0.03	16.3	0.18 ± 0.03	14.4	0.24 ± 0.04	17.5	0.16 ± 0.02	9.3	0.13 ± 0.03	9.0
Fast Food/Take Out	0.02 ± 0.01	1.3	0.00 ± 0.00	0.4	0.02 ± 0.01	1.6	0.16 ± 0.02	9.1	0.04 ± 0.01	3.0
Restaurant/Cafeteria	0.01 ± 0.00	0.5	0.00 ± 0.00	0.2	0.00 ± 0.00	0.4	0.10 ± 0.02	5.7	0.07 ± 0.01	4.8
Someone's Home	0.04 ± 0.01	2.6	0.09 ± 0.03	6.9	0.13 ± 0.03	9.9	0.15 ± 0.02	8.2	0.16 ± 0.05	11.0
Transit	0.01 ± 0.00	0.4	0.01 ± 0.00	0.6	0.02 ± 0.01	1.3	0.07 ± 0.01	3.8	0.03 ± 0.01	2.0
Other	0.01 ± 0.00	0.7	0.03 ± 0.01	2.1	0.07 ± 0.03	4.8	0.16 ± 0.03	9.2	0.05 ± 0.02	3.2

Table 6, cont'd.

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872) Beverage consumers were identified using the 24-hour recall data and the 'frequency' method (frequency $\geq$1 time/day) . Mean beverage frequency is sample-weighted and standard error is estimated by linearization method of SUDAAN.

[2] Other beverages include diet soft drinks, coffee/ tea and beer/ wine/ liquor.

saturated fat, and caffeine intakes from the total diet and from beverages were lower for 'juice' groups than for 'non-juice' groups.

Energy, fat, carbohydrate and sugars intakes from the total diet and from beverages were higher in 'caloric beverages' groups than in 'other beverages' groups, but caffeine intakes from the total diet and from beverages were higher in 'other beverages' groups than in 'caloric beverages' groups (**Table 7**). Calcium and vitamin D intakes from the total diet and from beverages were lower in 'other beverages' groups than in 'caloric beverages' groups. Calcium, potassium and vitamin D intakes from the total diet and from beverages, and vitamin A intake from beverages were higher in 'milk' groups than in 'sugar-sweetened beverage' groups. Vitamin C intakes from the total diet and from beverages, and folate intake from beverages were higher in 'juice' groups than in 'non-juice' groups. As shown in **Table 8**, teen-age girls, in particular, appeared to be at risk for inadequate intakes of calcium, potassium and vitamin D, and older adolescents appeared to be at risk for inadequate vitamin A intake.

DISCUSSION

Beverage patterns developed in this study provided a simple classification scheme to identify segments of the adolescent population having nutritional risks associated with the types of beverages usually consumed. One other researcher identified similar beverage pattern groups (Bowman et al., 2002), but the current study used FFQ rather than 24-hour recall data to classify youth by the types of beverages most frequently consumed. Others have used 24-hour recall data to identify segments of the adult population eating different types of breakfast foods to examine the association of

Table 7. Mean daily nutrient intake from total diet, beverages and non-beverages among groups of adolescents aged 12-16 years classified by beverage pattern[1,2]

Nutrient	Beverage Pattern Group[2]					
Amount from:	All		Milk & Sugar-		Other	Other
Total Diet	Caloric Bevg		Swt Bevg.		Bevg & Juice	Bevg
Beverages	M S J		M S j		m s J	m s j
Non-beverages	(n = 109)		(n = 435)		(n = 103)	(n = 55)
	Mean (mean ± SE) daily nutrient intake					
Food Energy (Kcal)						
Total Diet	2543 ± 164	K	2470 ± 103	K	1902 ± 119	2099 ± 189
Beverages	494 ± 37	K	542 ± 27	K	410 ± 39	369 ± 58
Non-beverages	2049 ± 135	K	1928 ± 90	K	1492 ± 107	1730 ± 156
Carbohydrate (g)						
Total Diet	348 ± 31	K	321 ± 12	K	257 ± 15	269 ± 22
Beverages	97 ± 7	K	106 ± 5	K	87 ± 8	74 ± 10
Non-beverages	250 ± 27	K	215 ± 9	K	170 ± 11	195 ± 17
Vitamin A (mg RAE)						
Total Diet	650 ± 72		629 ± 48		402 ± 47	623 ± 239
Beverages	153 ± 27		158 ± 13		89 ± 17	123 ± 65
Non-beverages	498 ± 65		472 ± 47		313 ± 35	500 ± 237
Vitamin C (mg)						
Total Diet	134.8 ± 17.4		102.5 ± 7.9		110.4 ± 21.3	61.3 ± 13.4
Beverages	82.4 ± 14.9		40.2 ± 6.0		70.9 ± 19.0	19.6 ± 9.5
Non-beverages	52.2 ± 7.1	K	62.1 ± 6.9	K	39.4 ± 4.0	41.6 ± 7.1
Folate (mg DFE)						
Total Diet	772 ± 99		601 ± 24		432 ± 45	666 ± 164
Beverages	64.2 ± 16.5		35.7 ± 4.1		46.5 ± 11.3	41.6 ± 17.8
Non-beverages	708 ± 97		565 ± 23		386 ± 39	624 ± 164
Calcium (mg)						
Total Diet	1067 ± 91	K	1049 ± 44	K	648 ± 43	722 ± 85
Beverages	415 ± 62	K	435 ± 29	K	251 ± 39	239 ± 58
Non-beverages	651 ± 47	K	614 ± 34	K	397 ± 39	482 ± 64
Potassium (mg)						
Total Diet	2553 ± 219		2579 ± 116		2230 ± 180	2102 ± 244
Beverages	789 ± 121		690 ± 48		658 ± 126	483 ± 98
Non-beverages	1764 ± 121		1889 ± 100		1573 ± 112	1619 ± 196
Vitamin D (mg)						
Total Diet	6.2 ± 0.9	K	6.0 ± 0.3	K	4.2 ± 0.7	2.8 ± 0.4
Beverages	3.2 ± 0.5	K	3.3 ± 0.2	K	1.7 ± 0.3	1.5 ± 0.4
Non-beverages	3.0 ± 0.6		2.7 ± 0.2		2.5 ± 0.5	1.3 ± 0.2

es among

Other Bevg msj n = 55
99 ± 189
69 ± 58
30 ± 156
69 ± 22
74 ± 10
95 ± 17
23 ± 239
23 ± 65
90 ± 237
.3 ± 13.4
.6 ± 9.5
.6 ± 7.1
56 ± 164
.6 ± 17.5
24 ± 164
22 ± 85
59 ± 55
22 ± 64
02 ± 244
53 ± 98
.9 ± 196
.8 ± 0.4
.5 ± 0.4
.3 ± 0.2

Table 7, cont'd.

Nutrient Amount from: Total Diet Beverages Non-beverages	Beverage Pattern Group[2] Milk & Juice M s J (n = 248)		Milk M s j (n = 411)		Sugar-Swt Bevg & Juice m S J (n = 184)		Sugar-Swt Bevg m S j (n = 327)
	Mean (mean ± SE) daily nutrient intake						
Food Energy (Kcal)							
Total Diet	2384 ± 113		2321 ± 77		2488 ± 170		2237 ± 96
Beverages	523 ± 29		485 ± 25		505 ± 47		462 ± 30
Non-beverages	1860 ± 99		1837 ± 67		1984 ± 150		1775 ± 90
Carbohydrate (g)							
Total Diet	328 ± 16		301 ± 11		357 ± 29		298 ± 12
Beverages	103 ± 5		84 ± 5		111 ± 11		106 ± 8
Non-beverages	225 ± 14		218 ± 10		246 ± 24		192 ± 9
Vitamin A (mg RAE)							
Total Diet	684 ± 74		646 ± 38		561 ± 72		472 ± 82
Beverages	188 ± 28	M	212 ± 16	M	81 ± 14		60 ± 8
Non-beverages	496 ± 69		435 ± 32		480 ± 72		412 ± 80
Vitamin C (mg)							
Total Diet	159.4 ± 9.9	J	87.6 ± 6.1		159.1 ± 24.9	J	84.5 ± 9.3
Beverages	103.1 ± 9.3	J	39.2 ± 5.7		101.1 ± 21.6	J	36.0 ± 5.4
Non-beverages	55.9 ± 5.1		48.1 ± 3.1		57.8 ± 6.8		48.2 ± 5.5
Folate (mg DFE)							
Total Diet	720 ± 81		627 ± 29		693 ± 89		468 ± 37
Beverages	73.7 ± 7.5	J	43.3 ± 2.9		65.8 ± 18.5	J	22.1 ± 3.3
Non-beverages	646 ± 80		584 ± 29		627 ± 80		446 ± 35
Calcium (mg)							
Total Diet	1065 ± 68	M	1149 ± 48	M	766 ± 58		752 ± 58
Beverages	486 ± 57	M	574 ± 32	M	249 ± 43		197 ± 21
Non-beverages	579 ± 41		575 ± 30		516 ± 38		555 ± 47
Potassium (mg)							
Total Diet	2899 ± 142	M	2615 ± 74	M	2535 ± 242		2133 ± 155
Beverages	981 ± 84	M	880 ± 41	M	653 ± 114		386 ± 60
Non-beverages	1918 ± 96		1735 ± 58		1883 ± 168		1747 ± 125
Vitamin D (mg)							
Total Diet	6.7 ± 0.8	M	7.2 ± 0.4	M	4.3 ± 0.6		3.4 ± 0.3
Beverages	3.5 ± 0.5	M	4.5 ± 0.3	M	1.6 ± 0.4		1.3 ± 0.2
Non-beverages	3.1 ± 0.3		2.7 ± 0.2		2.6 ± 0.3		2.1 ± 0.2

Table 7, cont'd.

Nutrient Amount from: Total Diet Beverages Non-beverages	Beverage Pattern Group[2] All Caloric Bevg M S J (n = 109)	 Milk & Sugar- Swt Bevg. M S j (n = 435)	 Other Bevg & Juice m s J (n = 103)	 Other Bevg m s j (n = 55)
	Mean (mean ± SE) daily nutrient intake			
Caffeine (mg)				
Total Diet	41.3 ± 7.7	68.2 ± 6.8	57.4 ± 12.2 O	138.9 ± 19.6 O
Beverages	36.4 ± 7.5	66.2 ± 6.8	55.1 ± 12.3 O	136.8 ± 20.2 O
Non-beverages	4.9 ± 2.0	1.9 ± 0.2	2.3 ± 0.5	2.1 ± 1.0
Total Sugars (g)				
Total Diet	187.6 ± 20.1 K	170.1 ± 8.1 K	134.0 ± 8.6	124.7 ± 15.9
Beverages	95.1 ± 6.8 K	103.2 ± 5.5 K	82.2 ± 7.7	70.7 ± 10.7
Non-beverages	92.6 ± 16.3	66.9 ± 4.2	51.8 ± 4.8	53.9 ± 13.8
Added Sugars (g)				
Total Diet	138.0 ± 15.7 K	130.2 ± 7.8 K	92.9 ± 8.3	99.6 ± 15.4
Beverages	63.1 ± 6.1	78.5 ± 5.7	57.0 ± 6.9	58.9 ± 9.2
Non-beverages	74.9 ± 14.8	51.7 ± 4.1	36.0 ± 3.8	40.7 ± 13.8
Total Fat (g)				
Total Diet	93.5 ± 5.6 K	96.2 ± 4.9 K	72.3 ± 6.1	83.5 ± 9.0
Beverages	7.6 ± 1.2 K	7.5 ± 0.5 K	4.8 ± 1.0	3.3 ± 1.0
Non-beverages	85.8 ± 5.1	88.7 ± 4.9	67.5 ± 6.0	80.2 ± 8.8
Saturated Fat (g)				
Total Diet	32.7 ± 2.4 K	34.1 ± 1.5 K	23.8 ± 2.2	26.7 ± 2.1
Beverages	4.7 ± 0.8 K	4.6 ± 0.3 K	2.9 ± 0.6	2.0 ± 0.6
Non-beverages	27.9 ± 2.3 K	29.5 ± 1.5 K	20.9 ± 2.1	24.7 ± 2.0
Percent of calories:				
Added sugars	20.6 ± 1.2	21.5 ± 0.9	20.6 ± 2.2	17.4 ± 2.4
Total Fat	32.8 ± 1.5	34.3 ± 0.5	32.8 ± 1.0	35.7 ± 1.2
Saturated Fat	11.5 ± 0.8	12.4 ± 0.3	10.9 ± 0.5	11.7 ± 0.6

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872).

[2] The beverage pattern is the combination of beverages frequently consumed. Capital letters M, S and J refer to milk (milk & milk drinks), sugar-sweetened beverages (fruit drinks), sugar-sweetened beverages (fruit drinks & regular soft drinks) and juice (100% fruit juice), respectively, consumed with a share ³25% of total beverage frequency, and lowercase letters m, s and j refer to consumption of less than the specified amount.

Table 7, cont'd.

Nutrient Amount from: Total Diet Beverages Non-beverages	Beverage Pattern Group[2] Milk & Juice M s J (n = 248)		Milk M s j (n = 411)		Sugar-Swt Bevg & Juice m S J (n = 184)		Sugar-Swt Bevg m S j (n = 327)	
	Mean (mean ± SE) daily nutrient intake							
Caffeine (mg)								
Total Diet	43.4 ± 6.3		52.4 ± 4.2	N	44.6 ± 7.4		76.5 ± 6.7	N
Beverages	40.2 ± 6.3		49.1 ± 4.3	N	43.2 ± 7.3		74.1 ± 6.7	N
Non-beverages	3.3 ± 0.7	M	3.3 ± 0.5	M	1.3 ± 0.3		2.4 ± 0.4	
Total Sugars (g)								
Total Diet	175.4 ± 8.4		152.1 ± 7.5		175.2 ± 13.8		166.1 ± 8.6	
Beverages	99.9 ± 4.7		81.2 ± 4.7		108.6 ± 10.7		104.2 ± 7.7	
Non-beverages	75.5 ± 6.1		70.8 ± 5.5		66.6 ± 6.4		61.9 ± 4.3	
Added Sugars (g)								
Total Diet	113.3 ± 7.2		108.4 ± 6.7		132.7 ± 14.6		133.5 ± 6.6	
Beverages	58.7 ± 4.3		51.9 ± 4.5		81.4 ± 11.0	S	84.5 ± 5.8	S
Non-beverages	54.6 ± 5.4		56.5 ± 4.7		51.3 ± 6.6		49.0 ± 3.9	
Total Fat (g)								
Total Diet	87.1 ± 5.3		91.8 ± 3.6		85.8 ± 5.5		86.3 ± 5.1	
Beverages	7.9 ± 1.0	M	10.5 ± 0.8	M	5.0 ± 1.3		3.1 ± 0.4	
Non-beverages	79.2 ± 5.0		81.3 ± 3.2		80.8 ± 5.5		83.2 ± 5.0	
Saturated Fat (g)								
Total Diet	30.2 ± 1.9		33.4 ± 1.7		28.1 ± 1.8		29.5 ± 1.8	
Beverages	4.7 ± 0.6	M	6.5 ± 0.5	M	3.0 ± 0.8		1.9 ± 0.3	
Non-beverages	25.4 ± 1.7		26.9 ± 1.4		25.1 ± 1.8		27.6 ± 1.8	
Percent of calories:								
Added sugars	19.3 ± 0.8		18.9 ± 0.9		23.5 ± 2.1	S	24.9 ± 1.2	S
Total Fat	31.4 ± 0.7		34.5 ± 0.5	N	31.2 ± 1.1		33.8 ± 1.0	N
Saturated Fat	11.0 ± 0.4		12.4 ± 0.3	N	10.4 ± 0.5		11.5 ± 0.4	N

Means and standard errors are sample-weighted and estimated by linearization method of SUDAAN.

K, O, M, S, J, N refer to beverage pattern groups with higher intakes in contrast to other beverage pattern groups ($p<0.05$). Bonferroni contrasts include K ('caloric beverage' patterns MSJ/MSj) vs. O ('other beverage' patterns msJ/msj), M ('milk' patterns MsJ/Msj) vs. S ('sugar-sweetened beverage' patterns mSJ/mSj) and J ('juice' patterns patterns MsJ/mSJ vs. N ('non-juice' patterns Msj/mSj).

Table 8. Dietary Reference Intakes (DRI) and daily nutrient intake in gender-age groups of adolescents aged 12-16 years[1]

Nutrient		Boys 12-13 yr (n = 109)	Boys 14-16 yr (n = 435)	Girls 12-13 yr (n = 248)	Girls 14-16 yr (n = 411)
Food Energy (Kcal)					
Mean ± SE	**	2583 ± 111	2832 ± 90	1996 ± 68	1927 ± 66
Median ± SE		2344 ± 79	2665 ± 73	1914 ± 82	1798 ± 79
Carbohydrate (g)					
EAR		100	100	100	100
Mean ± SE	**	339 ± 15	378 ± 13	269 ± 9	256 ± 8
Median ± SE		306 ± 11	351 ± 10	255 ± 11	238 ± 7
Vitamin A (mg RAE)					
EAR		445	630	420	485
Mean ± SE	††	723 ± 62	625 ± 28	630 ± 78	475 ± 47
Median ± SE		565 ± 43	522 ± 31	401 ± 32	339 ± 21
Vitamin C (mg)					
EAR		39	63	39	56
Mean ± SE	**	108 ± 6	131 ± 9	104 ± 7	91.1 ± 7.1
Median ± SE		82 ± 9	83 ± 11	85 ± 9	55 ± 6
Folate (mg DFE)					
EAR		250	330	250	330
Mean ± SE	**	682 ± 33	772 ± 51	535 ± 32	452 ± 23
Median ± SE		564 ± 34	596 ± 34	440 ± 23	371 ± 27
Calcium (mg)					
AI		1300	1300	1300	1300
Mean ± SE	**	1142 ± 56	1144 ± 51	866 ± 39	773 ± 34
Median ± SE		1023 ± 71	1017 ± 56	767 ± 48	653 ± 32
Potassium (mg)					
AI		4500	4700	4500	4700
Mean ± SE	**	2677 ± 112	3038 ± 143	2250 ± 72	2097 ± 84
Median ± SE		2387 ± 122	2838 ± 150	2132 ± 102	1868 ± 114
Vitamin D (mg)					
AI		5.0	5.0	5.0	5.0
Mean ± SE	**	6.5 ± 0.4	6.7 ± 0.4	5.3 ± 0.4	4.4 ± 0.3
Median ± SE		5.5 ± 0.4	5.4 ± 0.5	4.0 ± 0.4	3.4 ± 0.3

Table 8, cont'd.

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872). Dietary Reference Intakes (DRI) include Estimated Average Requirements (EAR) and Adequate Intake (AI) levels.
Means, medians and standard errors are sample-weighted and estimated by linearization method of SUDAAN.

** Higher nutrient intakes of boys than girls by Bonferroni contrast ($p < 0.01$)

†† Higher nutrient intakes of youth 12-13 yr than 14-16 yr by Bonferroni contrast ($p < 0.01$)

breakfast patterns with energy/nutrient intakes and the prevalence of overweight (Siega-Riz et al., 2000; Cho et al., 2003).

Estimates of the percentage share of total beverage frequency were used in the current study in the same way that others have used 24-hour recall data to estimate the percentage share of total beverage calories (French et al., 2003). The share of soft drinks obtained at table-service and fast-food restaurants by children and adolescents age 6-17 years was 14.4% in 1977-78 and 22.1% in 1994-98 (French et al., 2003). These data were not comparable to the 14.8% estimate for 1988-94, because only the older subgroup was examined in the current study. The CSFII 1994-98 study indicated that children and adolescents obtained only 4.1% and 3.0% of soft drinks from vending machines and school cafeterias, respectively (French et al., 2003), while 9.0% of soft drinks were consumed at school by adolescents age 12-16 years in NHANES 1988-94. The estimate of school consumption was averaged over the entire year. The share of regular soft drinks consumed at school would be higher if analyses were limited to youth who were attending school and not on summer vacation.

Percentage shares of beverages consumed at eating occasions were calculated from relative frequency data reported for adolescents age 13-18 years in NFCS 1977-78 (Guenther et al., 1986). The percentage share of soft drinks consumed at snacks was 31% (Guenther et al., 1986), compared to 48% for adolescents in the current study. These and other data show a trend toward increased consumption of soft drinks at the snacking occasion (Nielsen et al., 2002; Nielsen & Popkin, 2004). The shares of milk and juice consumed at breakfast in 1977-78 were 38% and 76% (Guenther et al., 1986), while comparable estimates for 1988-94 from the current study were 47% and 43%, respectively. Drinking juice was highly specific to the breakfast occasion (Guenther et al., 2006). Among adolescent girls age 12-19 years, between 36-44% of non-milk drinkers did not eat breakfast, compared to 11-12% of milk drinkers (Bowman et al., 2002). Thus, consumption of both milk and juice is likely a good indicator that the youth ate breakfast. That milk and juice were found in this analysis to be associated with breakfast, and sugared-sweetened beverages were associated with the snacking occasion, suggests that 'milk' and 'juice' groups would have more nutrient-dense diets than 'sugar-sweetened beverages' groups.

Percent calories from added sugars were high for 'sugar-sweetened beverages' groups examined in the current study, as expected from other reports (Bowman et al., 2002; Striegel-Moore et al., 2006), and the expected nutritional benefits of drinking 'milk' and 'juice' patterns were observed in the current study. The methods used here to develop beverage patterns were unique, but the results were consistent with observations from various studies that used the CSFII dataset (Harnack et al., 1999; Ballew et al., 2000; Bowman et al., 2002; Frary et al., 2004). In adolescents age 13-18 years, those drinking ≥13 oz/d soda drank less milk and juice, and had higher vitamin A, calcium, vitamin C and folate intakes than non-soda consumers (Harnack et al., 1999). An association between the amount of soft drinks consumed and calcium adequacy was reported first by Guenther (1986). Others also examined calcium and folate intakes of adolescents and found them to be inadequate in high sugar-sweetened beverage consumption categories (Frary et al., 2004). In adolescent girls, not drinking milk was associated with inadequate vitamin A, calcium and folate intakes (Bowman et al., 2002). By speculation, folate intake of milk consumers was attributed to RTE cereal consumed at breakfast (Bowman et al., 2002). In the current study, folate intakes of the 'milk and juice' group were attributed to juice.

In a study of children and adolescents age 2-17 years, while controlling for intakes of all other beverages in logistic regression models for all age strata, the likelihood that vitamin A and calcium intakes were adequate increased with amounts of milk consumed; the likelihood that vitamin C intake was adequate increased with juice; and the likelihood that folate intake was adequate increased with intakes of both milk and juice (Ballew et al., 2000). Even after Ballew et al. (2000) controlled for milk and all other beverages, soft drinks were inversely associated with decreased vitamin A adequacy in all age strata, but an inverse association between soft drinks and calcium adequacy was observed only for children <12 years old. Among children/adolescents age 9-18 years in another study, controlling for servings of milk and dairy foods, other food group servings, in addition to gram amounts of all other beverages, showed a very weak positive association between soft drinks and calcium (mg) intake (Storey et al., 2004).

Only one study examined the association of calcium with all types of beverages, including diet soft drinks and coffee/tea as well as caloric beverages (Striegel-Moore et al., 2006). In a 10-year followup study of adolescent girls, increased intake of milk and diet soft drinks was associated with increased calcium; regular soft drinks, fruit drinks and coffee/tea decreased calcium; and fruit juice had no association with calcium intake, after controlling for all other beverages (Striegel-Moore et al., 2006). In the current study, the 'other beverages' pattern included coffee/tea in addition to 'diet' soft drinks, and adolescent females in the 'other beverages' group were likely at risk for inadequate calcium and vitamin D intakes. The current study was the first to report potassium and vitamin D intakes of beverage pattern groups.

Beverage patterns may be functional indicators of the risk for overweight when they are associated with lifestyle factors. Drinking milk and juice was associated with the breakfast meal, and other research has suggested that breakfast consumption might be associated with other components of a healthy lifestyle such as high levels of physical activity (Cavadini et al., 2000a; Keski-Rahkonen et al., 2003; Godin et al., 2005). Sugar-sweetened beverages were associated with the snack occasion and meals eaten at fast food restaurants. Youth frequently eat snacks and drink soft drinks while watching TV (Coon et al., 2001; Giammattei et al., 2003; Matheson et al., 2004; Phillips et al., 2004), and as a sedentary behavior TV watching would preclude physical activity (Nelson et al., 2005). Besides drinking diet soft drinks, the 'other beverages' group was drinking coffee, tea and alcoholic beverages. Older female adolescents in this group might also be skipping breakfast and smoking cigarettes to control their weight (Malinauskas et al., 2006). Health-compromising behaviors tend to cluster in high-risk youth (Keski-Rahkonen et al., 2003). Thus, the 'other beverages' group might be at risk for becoming dependent on caffeine, tobacco, alcohol or other drugs in addition to having risks for nutrient inadequacy.

Strengths and Limitations

A major strength of this study was that youth were classified into beverage pattern groups. The association of beverage patterns with energy intakes was investigated by examining mean nutrient intakes of beverage pattern groups, because the mean estimate for a group would not be biased by intraindividual variation in 24-hour recall intakes (Guenther et al., 1997). In the current study, each youth was classified to a beverage pattern group based on his/her usual beverage consumption pattern as reported in the FFQ. Beverage patterns were defined as the combinations of beverages most frequently consumed so that independent effects of individual beverage types could be determined by contrasting nutrient intakes of different beverage pattern groups.

There were several limitations that pertain to the current analyses. An under-reporting bias is a concern, because overweight individuals tend to under-report energy more than those with normal BMI (Bandini et al., 1990; Johnson et al., 1996; Johnson, 2000). Under-reporting occurs not only in the 24-hour recall, but also in the FFQ (Subar et al., 2003). Misclassification to beverage pattern groups due to under-reporting in response to the FFQ was addressed by using the 'share' method (share ≥25% of total beverage frequency). For example, the percentage share was used to reclassify "under-reporters" assigned to the 'other beverages' (msj) group by the 'frequency' method who reported drinking all three beverage types <1 time/d. Youth remaining in the 'other beverages' group who were overweight and trying to lose weight by drinking 'diet' soft drinks might be under-reporting intakes in the 24-hour recall dietary interview.

There were no energy differences between 'milk' and 'sugar-sweetened beverages' groups possibly because of under-reporting of energy intakes. Misclassification due to an under-estimate of sugared-sweetened beverages' percentage share is also a concern. Overall, regular soft drinks were reported less often in the FFQ than in the 24-hour recall, while milk and juice frequencies were higher in the FFQ than in the 24-hour recall. The 'sugar-sweetened beverages' category did not include sugar-sweetened tea or coffee, thus the percentage of calories from added sugars in the 'other beverages' group was relatively high. Youth classified to 'juice' groups might have mistakenly reported fruit drink frequency in response to the 100% fruit juice question, because the fruit juice question was sequenced before the question about fruit drinks in the FFQ. The 'sugar-sweetened beverages' groups drank more fruit drinks than the 'milk' groups in the FFQ, but not in the 24-hr recall, and the 24-hour recall intakes of fruit drinks were higher for 'juice' groups than 'non-juice' groups. Nevertheless, the 'juice' groups drank juice more frequently than the 'non-juice' groups, the 'milk' groups drank milk more frequently than 'sugar-sweetened beverages' groups, and expected nutritional benefits of consuming 'milk' and 'juice patterns were observed.

Implications

Because beverage choice was associated with the meal context, the beverage pattern could be used to indicate how often youth consume different types of meals (e.g., breakfast, snacks, meals eaten at fast food restaurants). Higher added sugar and lower calcium intakes in 'sugar-sweetened beverages' groups than in 'milk' groups suggest that the beverage pattern could potentially be a risk factor for overweight. Consumption of 'other beverages' patterns might put youth at risk for inadequate calcium, potassium or vitamin D intakes.

Chapter 5

RISK FACTORS FOR OVERWEIGHT ASSOCIATED WITH PATTERNS OF BEVERAGE CONSUMPTION AMONG ADOLESCENTS IN THE U.S.

ABSTRACT

Objective To examine the associations of beverage patterns (i.e., the types of beverages most frequently consumed) with sociodemographic and lifestyle characteristics that are risk factors for overweight among adolescents in the U.S.

Design Cross-sectional analysis of data from the Third National Health and Nutrition Examination Survey (NHANES III, 1988-94). Food frequency questionnaire (FFQ) data were used to classify youth by beverage patterns. The prevalence of overweight/risk for overweight and distributions of sociodemographic and lifestyle factors were examined within the beverage pattern groups.

Subjects A U.S. population-based sample of adolescents age 12-16 years (n=1,872).

Statistical analysis Sample-weighted percentage distributions and standard errors were estimated using SUDAAN software. The Chi-square test for association was used to compare the groups' observed and expected distributions ($p<0.05$).

Results Sociodemographic and lifestyle factors associated with the prevalence of overweight/risk for overweight included race-ethnicity, SES, parental overweight/obesity, sports team participation, TV watching, weight loss behavior, smoking, and breakfast consumption. The prevalence of overweight/risk for overweight was lowest (17%) in the 'milk & juice' group, and highest (58%) in a pattern of consuming 'other beverages' such as diet soft drinks, coffee and tea. A greater percentage of the 'other beverages' group than the 'milk & juice' group were smoking cigarettes (19% *vs.* 2%) and trying to lose

weight (60% *vs.* 15%). A greater percentage of the 'milk & juice' group than the 'sugar-sweetened beverages' group ate breakfast every day (57% *vs.* 21%), exercised daily (35% *vs.* 28%), played on ≥3 sports teams (37% *vs.* 16%), and watched TV ≤1 hour/day (39% vs. 20%). TV was watched ≥4 hours/day by 34% of the 'sugar-sweetened beverages' group *vs.* 10% of the 'milk & juice' group. Beverage patterns were also associated with income and other indicators of SES ($p<0.01$).

Implications Beverage patterns might be markers of sociodemographic and lifestyle factors associated with the prevalence of overweight/risk for overweight. This suggests that complex interrelationships between sociodemographic/lifestyle factors, beverage patterns and adolescent obesity exist.

INTRODUCTION

Because the etiology of obesity in youth is complex, not one single associative factor, such as soft drink consumption, has been strongly linked to the high prevalence of overweight in youth. Rather than a single beverage, patterns of beverages consumed together can recognize the interrelationships between a variety of food and beverage choices. A broad view of the sociodemographic and lifestyle context in which beverage patterns are consumed is needed to consider how dietary habits are associated with multiple risk factors for childhood overweight. Insight into the complex interrelationship of beverage patterns with sociodemographic and lifestyle factors might provide new strategies to decrease energy intake and overweight in adolescents.

Over the past 20 years, the prevalence of obesity in African American and Hispanic youth has been increasing at a faster rate than in non-Hispanic whites (Strauss

& Pollack, 2001). Among adolescents age 12-19 years, the prevalence of overweight is currently 19% among non-Hispanic blacks and 21% in Mexican-Americans compared to 15% in non-Hispanic whites (Hedley et al., 2004). In NHANES III, 1988-1994, an inverse relationship between family income and obesity was observed in adolescents of white but not other race-ethnic groups (Troiano & Flegal, 1998; Alaimo et al., 2001; Miech et al., 2006). An increased prevalence of overweight among low-income adolescents may be due in part to the quality of their diets, if only less expensive, energy-dense foods and beverages are consumed (Alaimo et al., 2001; Drewnowski & Specter, 2004; Drewnowski & Darmon, 2005). Additionally, low-income adolescents living in urban environments might watch TV, if they have few opportunities to be physically active. Compounding such sedentary behavior is the fact that soft drinks are frequently consumed while watching TV (Coon et al., 2001; Giammattei et al., 2003; Utter et al., 2003; Matheson et al., 2004; Phillips et al., 2004). Sugar-sweetened beverage consumption has been associated with poverty among adolescents age 12-17 years in NHANES, 1999-2002 (Miech et al., 2006). Still, it is unclear whether disparities in overweight prevalence are driven by income and education of parents *and/or* familial food and physical activity preferences and practices (Gordon-Larsen et al., 2003).

Beverages typically consumed at breakfast are one example of a familial food pattern that could relate to obesity. For example, parental obesity was a risk factor for overweight in adolescents age 12-16 years, but among those having one or two obese parents, eating breakfast some days or every day was associated with normal body weight (Fiore et al., 2006). Breakfast skipping has been associated with poverty, and could potentially be a risk factor for overweight among low-income adolescents (Miech et al., 2006). If youth consumed both milk and orange juice frequently at breakfast, then those youth who regularly eat breakfast might be distinguished from breakfast skippers by identifying those who do or do not consume milk and juice in combination. In developing strategies to prevent overweight in youth, it might be useful to identify beverage patterns that could function as markers of sociodemographic and lifestyle factors associated with the risk for overweight.

The aim of this study was to examine the associations of beverage patterns (i.e., the types of beverages most frequently consumed) with risk factors for overweight in 12-16-year-old adolescents in the U.S. Youth were classified by beverage pattern, and population distributions of sociodemographic and lifestyle factors were examined within these groups. Youth were classified by consumption of milk, 100% fruit juice and/or sugar-sweetened beverages (e.g., regular soft drinks and fruit drinks) to examine the association of beverage patterns with risk factors such as race-ethnicity, household income, parental overweight/obesity, physical activity, TV watching and breakfast consumption. A pattern of drinking milk and juice was expected to be associated with breakfast consumption and other healthful behaviors, while a pattern of drinking sugar-sweetened beverages was expected to be associated with low SES, TV watching and other environmental risk factors for overweight.

METHODS

Dataset

The Third National Health and Nutrition Examination Survey (NHANES III, 1988-1994) data was used for analyses, rather than the more recent 1999-2002 NHANES data, because the dietary food frequency questionnaire used to assess the youth's typical beverage pattern is available only in NHANES III. The National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC) conducts NHANES to obtain nationally representative data on the nutritional and health status of the civilian, non-institutionalized U.S. population. Participants were selected using a complex, stratified, multistage, probability cluster sample design (DHHS, 1994). Interviews were conducted in the household and at a mobile examination center (MEC).

Subjects

Adolescents age 12-16 years who were interviewed and examined in NHANES III comprised the analytic sample for this study. The NHANES III sample included 2,216 adolescents aged 12-16 years selected for examination, and, of those, 2,079 (93.8% of 2,216) were examined in the MEC. Upon examination, 19 respondents (0.9% of 2,216) found to be ineligible (16 teenage girls were pregnant, and three were lactating) were excluded from the current study. Because 24-hour recall data were used in a preliminary analysis necessary to conduct the current study, the analytical sample was limited to adolescents age 12-16 years who completed a 24-hour recall dietary interview as well as all beverage items in the FFQ. There were 1,997 youth (90.1% of 2,216) who had a complete, reliable 24-hour recall dietary interview, and of these, 97 (4.4% of 2,216) were missing beverage frequency data and another 28 (1.3% of 2,216) were missing data on water intake. After excluding those with missing data, the remaining analytic sample of 1,872 youth (84.5% of 2,216) included 871 boys (46.5% of 1,872) and 1,001 girls (53.5% of 1,872) aged 12-16 years.

Definition of beverage patterns

Youth were classified by the combination of beverage types most frequently consumed, as reported in the FFQ. Four main categories of the 12 FFQ beverage items listed in **Table 1** were (1) milk, including milk on cereal as well as milk drinks, (2) 100% fruit juice, (3) sugar-sweetened beverages (e.g., fruit drinks and regular soft drinks) and (4) other beverages (e.g., diet soft drinks, coffee/tea and beer/wine/liquor).

Beverage pattern classifications were based on 'usual' intake in the FFQ of a combination of up to three beverage types: milk, sugar-sweetened beverages (e.g., regular soft drinks and fruit drinks) and/or 100% fruit juice. To classify youth into beverage pattern groups, the FFQ beverage frequencies were used to identify the combination of beverages that characterized a youth by his/her 'typical' beverage pattern. The combination of beverages having shares that were at least 25% of the total were identified by expressing each beverage's frequency as a percentage of the summed frequency for all beverages. Notations for the eight beverage patterns were combinations of the capital letters M, S and J to refer to milk, sugar-sweetened beverages and juice, respectively, having shares $\geq$ 25% total frequency, and lowercase letters m, s and j represented consumption of less than the specified amount. The beverage patterns were named according to the eight beverage combinations: 'all caloric beverages' (MSJ), 'milk & sugar-sweetened beverages' (MSj), 'milk & juice' (MsJ), 'milk' (Msj), 'sugar- sweetened beverages & juice' (mSJ), 'sugar-sweetened beverages' (mSj), 'other beverages & juice' (msJ) and 'other beverages' (msj).

Table 1. Beverage categories and beverage subcategories corresponding to beverage items in the NHANES III food frequency questionnaire (FFQ)

Beverage categories & beverage subcategories	FFQ beverage items
1. Milk and milk drinks, chocolate & regular	1a. How often did you have chocolate milk and hot cocoa?
	1b. How often did you have milk to drink or on cereal? Do not count small amounts of milk added to coffee or tea.
2. 100% fruit juice, citrus & non-citrus	2a. How often did you have orange juice, grapefruit juice and tangerine juice?
	2b. Other fruit juices such as grape juice, apple juice, cranberry juice, and fruit nectars?
3. Sugar-sweetened bevg.	
3a. Fruit drinks	3a. How often did you have Hi-C, Tang, Hawaiian Punch, Koolaid, and other drinks with added vitamin C?
3b. Regular soft drinks	3b. Regular colas and sodas, not diet?
4. Other beverages	
4a. Diet soft drinks	4a. Diet colas, diet sodas, and diet drinks such as Crystal Light?
4b. Coffee/ tea	4b (1). Regular coffee with caffeine?
	4b (2). Regular tea with caffeine?
4c. Alcoholic beverages	4c (1). Beer and lite beer?
	4c (2). Wine, wine coolers, Sangria, and champagne?
	4c (3). Hard liquor such as tequila, gin, vodka, scotch, rum, whiskey and liqueurs, either alone or mixed?

BMI and criteria for overweight in youth

Weight and height were measured at the MEC to assess Body Mass Index (BMI=kg/m^2), and youth were classified by weight status based on their BMI. The SAS program available from NCHS was run to calculate the youth's BMI percentile using the gender-specific BMI-for-age CDC Growth Charts reference data (NCHS; Kuczmarski et al., 2000). The BMI percentile was used to classify youth by weight status (i.e., underweight: BMI <5th percentile, normal body weight: BMI ≥5th percentile and BMI <85th percentile, at risk for overweight: BMI ≥85th percentile and <95th percentile, and overweight: BMI ≥95th percentile).

Potential risk factors for overweight

Sociodemographic factors examined were gender, age, race-ethnicity, region, urbanization, parental overweight/obesity, household income and other indicators of social economic status (SES). Lifestyle factors included smoking, alcohol use, weight loss behavior, physical activity, TV watching, frequency of breakfast consumption, and type of milk (e.g., whole, 2%, 1%, skim) usually consumed.

Categories for race-ethnicity included non-Hispanic white, non-Hispanic black, Hispanic and other race-ethnic groups. Four broad regions of the U.S. included the Northeast, Midwest, South and West. The urban/rural classification was a metropolitan area having a population ≥1 million *vs.* all other areas. The poverty income ratio was the ratio of household income to the poverty level for household size in an urban or rural area. Other indicators of SES included the family size and characteristics of the household head or family reference person (FRP), such as their gender, age group, marital status, education and employment status. BMI was calculated from reported weight and height of the youth's mother and father to determine whether both or one of two parents were overweight (BMI $\geq$25 kg/m^2) or obese (BMI $\geq$30 kg/m^2).

The survey included lifestyle questions, such as those asking youth whether they currently smoked cigarettes or drank alcohol in the past year. Youth were also asked whether they were currently trying to lose weight and how often they ate breakfast (e.g., every day, some days, rarely, never, weekends only). The FFQ included a question asking whether whole, 2%, 1% or skim/nonfat milk was usually consumed. Physical activity was assessed using the following questionnaire items asking youth about their exercise habits and participation in team sports:

1. How many times per week do you play or exercise enough to make you sweat or breathe hard?
2. In the past year, how many sports teams or organized exercise programs have you been involved in (not including physical education or gym classes)?

Youth were asked twice, once in the household and again at the MEC, about time spent watching TV the previous day, and the average hours/day in two days was used in the current study.

Statistical analysis

The Statistical Package for the Social Sciences, SPSS for Windows, Version 12.0 (SPSS Inc. Chicago, IL, USA) was used to prepare the dataset for analysis, while all statistical analyses were performed using SUDAAN version 8 (Research Triangle Institute, Research Triangle Park, NC), to account for the effect of the complex sampling design while conducting statistical tests.

The prevalence of overweight risk and overweight (BMI $\geq 85^{th}$ percentile) was estimated for youth classified by categories of each sociodemographic/lifestyle factor, and the percentage distribution of each sociodemographic/lifestyle factor was estimated for all youth and for each beverage pattern group. The percentage of each beverage pattern group classified by weight status (e.g., underweight, normal, at risk for overweight, overweight) was estimated as well. The Chi-square test for the association of categorical variables was performed to determine whether the observed and expected distributions were different ($p<0.05$).

The six-year MEC-examined sample weights were applied to the calculation of all population parameters, such as the percentage of youth who were overweight. The sample weights account for unequal probability of selection, non-coverage and non-response and adjust the data to the 1990 U.S. Census figures, therefore the estimates were representative of adolescents in the 1990 U.S. population. The linearization (Taylor series) method was used in SUDAAN to account for effects of the clustered sample design in estimating the variance of population parameters (Shah et al., 1997).

RESULTS

Risk factors for overweight

Table 2 shows the distribution of individual/household sociodemographic and lifestyle characteristics among all adolescents age 12-16 years, and the association of these characteristics with the prevalence of overweight risk and overweight. Sociodemographic

Table 2. Distribution (% of adolescents aged 12-16 years in categories) of sociodemographic and lifestyle characteristics, and the prevalence of overweight/ risk for overweight among adolescents classified by these characteristics[2]

Characteristic Category	Sample Size (n)	Distribution of Characteristic Percent ± SE	Prevalence of Overwt/ Risk for Overwt Percent ± SE
All adolescents age 12-16 years	1,872	100.0 ± 0.0	27.3 ± 2.1
** Weight status			
<5 pctl	45	2.4 ± 0.5	0.0 ± 0.0
5-84 pctl	1,236	70.4 ± 2.0	0.0 ± 0.0
85-94 pctl	298	16.5 ± 1.4	100.0 ± 0.0
≥95 pctl	258	10.7 ± 1.4	100.0 ± 0.0
Missing	35		
Gender			
Male	871	50.5 ± 2.1	26.5 ± 2.6
Female	1,001	49.5 ± 2.1	28.0 ± 2.4
Missing	0		
Age (yr)			
12-13	773	39.4 ± 1.6	28.2 ± 1.8
14	369	22.4 ± 1.9	32.0 ± 3.8
15-16	730	38.2 ± 1.7	23.6 ± 3.3
Missing	0		
** Race-ethnicity			
Non-Hisp. White	492	67.1 ± 2.4	26.9 ± 2.9
Non-Hisp. Black	671	14.9 ± 1.4	29.8 ± 1.7
Hispanic	670	12.6 ± 1.7	35.1 ± 4.8
Other	39	5.4 ± 1.0	6.0 ± 3.2
Missing	0		
Region of the U.S.			
Northeast	212	19.5 ± 2.1	24.1 ± 2.7
Midwest	339	21.8 ± 2.0	26.7 ± 4.7
South	834	34.7 ± 3.2	27.0 ± 3.9
West	487	23.9 ± 3.8	30.8 ± 4.1
Missing	0		
Rural/urban code			
Metro areas	873	46.6 ± 5.3	25.9 ± 2.6
All other areas	999	53.4 ± 5.3	28.5 ± 2.7
Missing	0		

Table 2, cont'd.

Characteristic Category	Sample Size (n)	Distribution of Characteristic Percent ± SE	Prevalence of Overwt/ Risk for Overwt Percent ± SE
** Parent's weight status			
2 overwt/obese	759	33.6 ± 1.9	39.7 ± 3.3
1 overwt/obese	621	40.9 ± 2.2	22.8 ± 2.9
Both normal	386	25.4 ± 1.7	17.6 ± 2.8
Missing	106		
Family ref. person (FRP) gender			
Male	1,149	69.4 ± 1.9	26.4 ± 2.4
Female	707	30.6 ± 1.9	28.2 ± 3.2
Missing	16		
FRP age (yr)			
15-29	72	2.9 ± 0.9	33.7 ± 9.1
30-39	834	45.6 ± 2.2	28.4 ± 2.8
40-49	695	41.2 ± 2.3	22.7 ± 2.4
^{3}50	250	10.3 ± 1.2	33.9 ± 7.3
Missing	21		
FRP marital status			
Married	1,162	69.0 ± 1.9	26.1 ± 2.4
Not married	706	31.0 ± 1.9	29.8 ± 3.2
Missing	4		
** FRP education			
<9th grade	406	11.0 ± 1.4	32.9 ± 5.3
9-11th grades	341	12.8 ± 1.3	35.3 ± 4.8
HS grad	618	35.5 ± 2.0	29.5 ± 3.8
Some college	502	40.7 ± 2.4	21.3 ± 3.5
Missing	5		
FRP employed			
Yes	1,352	83.2 ± 1.5	27.1 ± 2.5
No	424	16.8 ± 1.5	29.8 ± 4.1
Missing	96		
** Poverty Income Ratio (PIR)			
0-130%	808	29.1 ± 2.2	34.9 ± 2.9
131-185%	239	14.4 ± 1.6	28.6 ± 5.5
186-350%	473	35.0 ± 2.6	26.5 ± 3.8
>350%	197	21.5 ± 2.7	15.3 ± 4.2
Missing	155		

Table 2, cont'd.

Characteristic Category	Sample Size (n)	Distribution of Characteristic Percent ± SE	Prevalence of Overwt/ Risk for Overwt Percent ± SE
Family size (# persons)			
1-3	360	20.7 ± 1.7	32.2 ± 3.9
4-5	926	57.8 ± 2.4	27.6 ± 2.8
≥6	586	21.6 ± 2.5	21.5 ± 3.1
Missing	0		
** Trying to lose weight			
Yes	351	18.5 ± 1.6	57.7 ± 4.7
No	1,457	81.5 ± 1.6	20.2 ± 1.8
Missing	64		
Exercise (times/wk)			
≤2	428	20.7 ± 1.5	30.4 ± 3.6
3-4	421	21.9 ± 1.8	30.1 ± 3.6
5-6	528	27.6 ± 2.2	21.7 ± 2.6
≥7	434	29.9 ± 2.4	27.1 ± 3.9
Missing	61		
** # sports teams past yr			
None	775	38.2 ± 1.9	37.0 ± 3.3
1-2	735	40.8 ± 1.9	23.6 ± 2.8
≥3	301	21.0 ± 2.1	15.3 ± 2.8
Missing	61		
** TV watched (hr/d)			
≤1	394	26.7 ± 1.8	24.8 ± 3.6
2-3	891	49.0 ± 2.1	22.5 ± 2.5
≥4	587	24.3 ± 1.4	39.7 ± 3.4
Missing	0		
** Smoke cigarettes			
Yes	81	6.8 ± 1.0	40.3 ± 7.3
No	1,730	93.2 ± 1.0	26.0 ± 2.3
Missing	61		
Alcohol past yr			
Yes	191	11.9 ± 1.1	25.5 ± 5.4
No	1,608	88.1 ± 1.1	27.3 ± 2.4
Missing	73		

Table 2, cont'd.

Characteristic Category	Sample Size (n)	Distribution of Characteristic Percent ± SE	Prevalence of Overwt/ Risk for Overwt Percent ± SE
** How often eat breakfast			
Every day	681	41.5 ± 2.2	22.9 ± 2.9
Some days	617	33.0 ± 1.8	24.4 ± 3.0
Rarely	246	13.9 ± 1.3	35.7 ± 5.4
Never	46	2.5 ± 0.8	26.7 ± 10.4
Weekends only	221	9.1 ± 0.9	42.6 ± 6.5
Missing	61		
Type of milk used			
Whole/regular	879	36.8 ± 2.2	26.0 ± 2.6
2%	568	43.4 ± 2.0	30.1 ± 2.7
1%	63	6.0 ± 1.2	17.2 ± 7.7
Skim/nonfat	155	11.5 ± 1.6	24.9 ± 6.4
Never drink milk	63	2.4 ± 0.6	42.2 ± 12.2
Missing	144		

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872) Percentages and standard errors are sample-weighted and estimated by linearization method of SUDAAN.

[2] Overweight/risk for overweight defined by BMI ≥85th percentile of BMI-for-age

** $p<0.01$, * $p<0.05$, by Chi-square test for association between characteristic and prevalence of overweight/risk for overweight groups more likely to have a BMI ≥85th percentile included Hispanics and adolescents of low SES. Education level of the household head and income were both inversely associated with the prevalence of overweight risk and overweight. Adolescents whose parents' were both overweight/obese were more likely to be at risk/overweight themselves.

Lifestyle factors potentially associated with lower BMI included physical activity and breakfast consumption. Sports team participation was inversely associated, and TV watching, positively to BMI. Exercise did not have a linear relationship with overweight; 22% of those exercising 5-6 times/week were at risk/overweight, and the prevalence was higher among those exercising both <5 and >6 times/week. A positive association between overweight and weight loss behavior was highly significant. The prevalence of overweight risk and overweight was 60% among those trying to lose weight. Smoking was associated with overweight risk and overweight. Those who ate breakfast every day or some days were less likely to be at risk or overweight than those who ate breakfast rarely or on weekends only.

Risk factors associated with beverage patterns

Profiles describing characteristics of beverage pattern groups were based on the distributions of sociodemographic and lifestyle factors shown in **Table 3**. The percentage of a beverage pattern group having a characteristic was highlighted in this table using arrows pointing upwards or downwards when the distribution within that group was disproportionate relative to distributions in other beverage pattern groups.

Table 3. Distribution of sociodemographic and lifestyle characteristics within beverage pattern groups of adolescents age 12-16 years[1]

Characteristic / Category	All Caloric Bevg M S J (n = 109)	Milk & Sugar-Swt Bevg. M S j (n = 435)	Milk & Juice M s J (n = 248)	Milk M s j (n = 411)	Sugar-Swt Bevg & Juice m S J (n = 184)	Sugar-Swt Bevg m S j (n = 327)	Other Bevg & Juice m s J (n = 103)	Other Bevg m s j (n = 55)
	Beverage Pattern Group[2]							
	Percentage (percent ± SE) of adolescents in category of sociodemographic/lifestyle characteristic							
** Weight status								
<5 pctl	3.5 ± 2.3	2.0 ± 0.9	2.1 ± 1.5	2.9 ± 1.1	2.8 ± 2.2	3.2 ± 1.4	0.0 ± 0.0	0.0 ± 0.0
5-84 pctl	69.3 ± 6.9	70.3 ± 4.1	↑ 80.5 ± 3.1	69.3 ± 4.4	71.5 ± 6.0	69.1 ± 3.8	68.4 ± 8.4	↓ 41.8 ± 9.4
85-94 pctl	↓ 11.4 ± 4.3	15.9 ± 2.9	↓ 11.0 ± 2.8	↑ 18.6 ± 3.7	13.7 ± 4.6	↑ 17.6 ± 2.5	↑ 19.5 ± 6.8	↑ 33.8 ± 10.4
≥95 pctl	↑ 15.9 ± 6.7	↑ 11.8 ± 2.3	↓ 6.4 ± 2.2	9.2 ± 2.7	↑ 12.0 ± 3.6	10.1 ± 2.5	↑ 12.1 ± 3.7	↑ 24.5 ± 8.5
** Gender								
Male	↑ 59.7 ± 8.5	↑ 61.2 ± 3.3	49.9 ± 4.7	52.2 ± 2.8	40.5 ± 6.7	46.2 ± 5.6	21.3 ± 5.9	36.9 ± 7.1
Female	40.3 ± 8.5	38.8 ± 3.3	50.1 ± 4.7	47.8 ± 2.8	↑ 59.5 ± 6.7	53.8 ± 5.6	↑ 78.7 ± 5.9	↑ 63.1 ± 7.1
* Age (yr)								
12-13	44.0 ± 8.7	↑ 43.7 ± 3.2	↑ 55.0 ± 3.7	↑ 39.7 ± 3.0	26.0 ± 5.1	27.7 ± 4.6	28.1 ± 6.0	30.3 ± 7.8
14	9.1 ± 3.6	17.7 ± 2.9	15.3 ± 3.2	↑ 28.3 ± 3.9	↑ 32.5 ± 7.5	26.3 ± 5.6	26.8 ± 7.5	20.6 ± 7.1
15-16	↑ 46.9 ± 8.3	38.6 ± 3.0	29.7 ± 3.8	32.0 ± 3.2	41.6 ± 6.3	↑ 46.1 ± 4.7	↑ 45.2 ± 6.3	↑ 49.2 ± 8.3
** Race-ethnicity								
NonHisp White	49.2 ± 7.6	↑ 72.9 ± 3.4	↑ 65.7 ± 5.0	↑ 72.0 ± 3.8	43.7 ± 7.5	↑ 69.6 ± 3.7	55.0 ± 8.3	↑ 73.3 ± 8.2
NonHisp Black	↑ 23.2 ± 4.9	14.0 ± 1.9	13.8 ± 2.5	11.7 ± 1.8	↑ 24.0 ± 3.9	17.1 ± 2.9	13.5 ± 3.8	11.0 ± 3.5
Hispanic	↑ 18.0 ± 5.6	9.4 ± 1.7	14.1 ± 3.1	10.8 ± 2.0	↑ 22.6 ± 5.7	10.6 ± 2.0	↑ 19.2 ± 7.7	15.8 ± 7.9
Other	9.5 ± 3.8	3.8 ± 1.8	6.5 ± 3.1	5.5 ± 2.5	9.7 ± 5.1	2.7 ± 1.4	↑ 12.2 ± 6.0	0.0 ± 0.0

Table 3, cont'd.

Characteristic / Category	Beverage Pattern Group[2]							
	All Caloric Bevg M S J (n = 109)	Milk & Sugar-Swt Bevg. M S j (n = 435)	Milk & Juice M s J (n = 248)	Milk M s j (n = 411)	Sugar-Swt Bevg & Juice m S J (n = 184)	Sugar-Swt Bevg m S j (n = 327)	Other Bevg & Juice m s J (n = 103)	Other Bevg m s j (n = 55)
	Percentage (percent ± SE) of adolescents in category of sociodemographic/lifestyle characteristic							
** Region of the U.S.								
Northeast	↑ 28.2 ± 7.5	13.9 ± 2.2	↑ 28.8 ± 7.6	20.3 ± 5.0	12.3 ± 4.3	↑ 25.7 ± 5.7	7.9 ± 3.2	5.9 ± 3.4
Midwest	22.7 ± 6.5	↑ 28.3 ± 3.7	16.0 ± 3.3	19.7 ± 3.0	22.7 ± 6.4	22.6 ± 6.0	18.1 ± 6.5	15.5 ± 7.6
South	25.0 ± 6.8	35.7 ± 3.8	30.4 ± 6.1	32.7 ± 4.5	32.3 ± 7.3	↑ 40.1 ± 5.9	34.3 ± 8.0	↑ 55.3 ± 9.6
West	24.1 ± 8.8	22.1 ± 4.1	24.9 ± 5.8	27.3 ± 5.1	↑ 32.7 ± 7.3	11.6 ± 3.4	↑ 39.7 ± 9.5	23.3 ± 8.2
Rural/urban code								
Metro areas	39.9 ± 8.8	42.6 ± 6.6	↑ 57.0 ± 7.5	50.0 ± 6.5	↑ 56.2 ± 8.3	35.0 ± 6.7	55.0 ± 9.6	37.3 ± 11.0
All other areas	↑ 60.1 ± 8.8	57.4 ± 6.6	43.0 ± 7.5	50.1 ± 6.5	43.8 ± 8.3	↑ 65.0 ± 6.7	45.0 ± 9.6	62.7 ± 11.0
** Parent's weight status								
2 overwt/obese	↑ 47.8 ± 9.7	23.5 ± 2.6	33.2 ± 5.8	↑ 36.8 ± 4.7	31.9 ± 6.4	↑ 40.6 ± 5.4	35.1 ± 8.5	34.9 ± 10.7
1 overwt/obese	26.6 ± 6.9	↑ 48.5 ± 4.3	41.6 ± 5.0	39.1 ± 4.4	40.5 ± 7.2	35.4 ± 4.2	39.2 ± 8.6	↑ 46.6 ± 10.3
Both normal	25.6 ± 8.9	28.0 ± 3.6	25.2 ± 5.1	24.1 ± 3.6	27.6 ± 6.0	24.0 ± 4.4	25.7 ± 7.9	18.5 ± 6.5
FRP[3] gender								
Male	51.0 ± 6.7	69.9 ± 3.0	69.5 ± 4.1	70.6 ± 3.5	70.3 ± 5.4	69.9 ± 4.3	↑ 78.5 ± 6.1	60.5 ± 10.2
Female	↑ 49.0 ± 6.7	30.1 ± 3.0	30.5 ± 4.1	29.4 ± 3.5	29.7 ± 5.4	30.1 ± 4.3	21.5 ± 6.1	39.6 ± 10.2

Table 3, cont'd.

Characteristic Category	All Caloric Bevg M S J (n = 109)	Milk & Sugar-Swt Bevg. M S j (n = 435)	Milk & Juice M s J (n = 248)	Milk M s j (n = 411)	Sugar-Swt Bevg & Juice m S J (n = 184)	Sugar-Swt Bevg m S j (n = 327)	Other Bevg & Juice m s J (n = 103)	Other Bevg m s j (n = 55)
	Beverage Pattern Group[2]							
	Percentage (percent ± SE) of adolescents in category of sociodemographic/lifestyle characteristic							
* FRP[3] age (yr)								
15-29	0.8 ± 0.5	↑ 4.9 ± 1.8	2.5 ± 1.4	2.4 ± 1.1	5.4 ± 4.2	1.4 ± 0.7	0.3 ± 0.3	2.8 ± 1.1
30-39	↑ 58.5 ± 7.0	47.9 ± 3.4	43.9 ± 5.4	43.6 ± 5.0	40.9 ± 6.0	46.2 ± 4.2	44.5 ± 9.0	41.9 ± 11.3
40-49	35.2 ± 6.8	36.6 ± 3.8	46.4 ± 6.1	42.6 ± 5.1	39.2 ± 7.7	43.6 ± 4.3	47.0 ± 8.7	31.3 ± 9.1
≥50	5.4 ± 2.5	10.6 ± 2.4	7.2 ± 2.4	11.4 ± 2.6	↑ 14.4 ± 3.5	8.8 ± 1.9	8.2 ± 4.1	↑ 24.0 ± 9.6
FRP[3] marital status								
Married	56.0 ± 8.7	67.8 ± 2.8	71.3 ± 5.0	71.6 ± 3.1	70.8 ± 5.5	64.8 ± 4.8	↑ 77.4 ± 6.1	69.3 ± 9.2
Not married	↑ 44.0 ± 8.7	32.2 ± 2.8	28.8 ± 5.0	28.4 ± 3.1	29.2 ± 5.5	35.3 ± 4.8	22.6 ± 6.1	30.7 ± 9.2
** FRP[3] education								
<9th grade	13.3 ± 5.4	11.1 ± 2.2	7.5 ± 1.9	11.6 ± 2.9	13.3 ± 4.3	11.9 ± 2.3	8.7 ± 2.6	13.8 ± 8.1
9-11th grades	17.7 ± 6.8	↑ 15.8 ± 3.1	8.7 ± 1.9	9.6 ± 1.8	12.2 ± 3.0	13.9 ± 2.4	14.8 ± 7.5	18.2 ± 5.2
HS grad	45.0 ± 9.9	38.5 ± 4.0	26.6 ± 4.4	35.7 ± 3.4	24.7 ± 4.7	↑ 40.4 ± 5.9	32.8 ± 8.0	39.2 ± 11.4
Some college	↓ 23.9 ± 5.5	34.7 ± 3.7	↑ 57.1 ± 5.9	43.2 ± 4.7	↑ 49.8 ± 6.7	33.8 ± 4.9	43.7 ± 8.5	↓ 28.8 ± 8.6
FRP[3] employed								
Yes	69.6 ± 8.2	82.7 ± 2.8	85.6 ± 3.1	82.1 ± 3.4	81.3 ± 4.8	83.5 ± 2.9	↑ 90.5 ± 4.0	↑ 93.2 ± 4.0
No	↑ 30.5 ± 8.2	17.3 ± 2.8	14.4 ± 3.1	17.9 ± 3.4	18.7 ± 4.8	16.5 ± 2.9	9.5 ± 4.0	6.8 ± 4.0

Table 3, cont'd.

Characteristic Category	Beverage Pattern Group[2] All Caloric Bevg M S J (n = 109)	 Milk & Sugar-Swt Bevg. M S j (n = 435)	 Milk & Juice M s J (n = 248)	 Milk M s j (n = 411)	 Sugar-Swt Bevg & Juice m S J (n = 184)	 Sugar-Swt Bevg m S j (n = 327)	 Other Bevg & Juice m s J (n = 103)	 Other Bevg m s j (n = 55)
	Percentage (percent ± SE) of adolescents in category of sociodemographic/lifestyle characteristic							
** Poverty Income Ratio (PIR)								
0-130%	↑ 44.5 ± 7.8	26.5 ± 2.7	23.6 ± 4.8	28.3 ± 3.8	↑ 34.2 ± 6.1	31.8 ± 5.1	32.6 ± 8.5	27.0 ± 9.7
131-185%	6.3 ± 3.4	12.7 ± 2.7	14.8 ± 3.3	↑ 17.0 ± 2.7	↑ 17.5 ± 5.7	11.4 ± 2.5	16.2 ± 6.1	23.8 ± 8.3
186-350%	29.3 ± 7.0	↑ 44.9 ± 3.4	34.5 ± 6.2	28.9 ± 4.0	28.0 ± 5.9	36.0 ± 4.4	↓ 23.6 ± 7.5	↑ 45.2 ± 10.5
>350%	20.0 ± 7.3	↓ 15.9 ± 3.6	↑ 27.1 ± 5.2	↑ 25.8 ± 3.4	20.4 ± 6.0	20.8 ± 5.8	↑ 27.5 ± 8.3	↓ 4.1 ± 3.0
** Family size (# persons)								
1-3	21.3 ± 7.3	↑ 25.5 ± 4.0	15.5 ± 3.4	14.1 ± 2.2	13.7 ± 2.9	↑ 26.5 ± 3.7	26.3 ± 7.1	↑ 31.0 ± 10.5
4-5	62.4 ± 7.7	55.8 ± 4.4	56.0 ± 5.7	61.1 ± 3.8	63.3 ± 6.5	56.3 ± 5.0	50.8 ± 7.8	57.4 ± 10.6
≥6	16.3 ± 4.7	18.7 ± 3.0	↑ 28.5 ± 6.1	↑ 24.8 ± 3.7	↑ 23.1 ± 6.2	17.2 ± 3.2	22.9 ± 6.9	11.6 ± 4.0
Trying to lose weight								
Yes	11.5 ± 5.3	15.5 ± 2.5	15.0 ± 3.0	15.2 ± 3.0	↑ 24.6 ± 6.1	19.7 ± 3.4	↑ 27.9 ± 8.1	↑ 59.7 ± 10.5
No	↑ 88.5 ± 5.3	84.5 ± 2.5	85.0 ± 3.0	84.8 ± 3.0	75.4 ± 6.1	80.3 ± 3.4	72.1 ± 8.1	40.3 ± 10.5

Table 3, cont'd.

Characteristic / Category	All Caloric Bevg M S J (n = 109)	Milk & Sugar-Swt Bevg. M S j (n = 435)	Milk & Juice M s J (n = 248)	Milk M s j (n = 411)	Sugar-Swt Bevg & Juice m S J (n = 184)	Sugar-Swt Bevg m S j (n = 327)	Other Bevg & Juice m s J (n = 103)	Other Bevg m s j (n = 55)
	Beverage Pattern Group[2]							
	Percentage (percent ± SE) of adolescents in category of sociodemographic/lifestyle characteristic							
** Exercise (times/wk)								
≤2	21.2 ± 5.7	19.3 ± 3.0	↓ 11.6 ± 2.8	19.6 ± 2.8	↑ 28.2 ± 6.8	↑ 26.3 ± 3.0	↑ 28.6 ± 6.0	21.6 ± 7.8
3-4	25.5 ± 9.5	19.6 ± 2.2	20.6 ± 3.8	23.6 ± 3.7	↓ 6.4 ± 2.3	22.3 ± 4.0	↑ 32.9 ± 7.0	↑ 37.1 ± 9.3
5-6	24.8 ± 6.3	33.5 ± 4.4	32.4 ± 5.4	24.2 ± 3.3	29.8 ± 6.1	23.2 ± 4.2	20.1 ± 5.3	21.4 ± 7.4
≥7	28.4 ± 7.4	27.6 ± 3.6	↑ 35.4 ± 5.0	32.6 ± 3.8	35.6 ± 7.2	28.3 ± 5.2	18.4 ± 6.0	19.9 ± 6.6
** # sports teams past yr								
None	39.8 ± 9.5	39.2 ± 3.1	↓ 18.9 ± 3.8	↑ 46.5 ± 4.0	32.7 ± 6.7	38.7 ± 4.9	38.2 ± 7.3	↑ 65.1 ± 8.7
1-2	32.2 ± 8.1	41.4 ± 3.0	↑ 44.1 ± 5.3	39.8 ± 3.5	38.8 ± 6.3	↑ 45.7 ± 5.3	39.5 ± 7.3	↓ 22.8 ± 6.3
≥3	↑ 28.0 ± 7.7	19.4 ± 3.3	↑ 37.0 ± 6.4	↓ 13.6 ± 2.5	↑ 28.6 ± 7.0	15.7 ± 2.6	22.4 ± 6.6	↓ 12.1 ± 6.7
** TV watched (hr/d)								
≤1	25.2 ± 7.3	↓ 20.4 ± 3.5	↑ 38.7 ± 5.3	28.0 ± 3.6	28.2 ± 7.7	↓ 20.4 ± 4.4	↑ 37.1 ± 8.2	22.5 ± 7.4
2-3	48.5 ± 6.7	↑ 53.5 ± 3.9	51.3 ± 5.6	↑ 53.9 ± 3.5	38.8 ± 7.1	45.7 ± 5.1	29.6 ± 6.3	39.2 ± 7.9
≥4	26.3 ± 5.3	26.1 ± 3.1	↓ 10.0 ± 2.3	↓ 18.1 ± 2.8	↑ 33.0 ± 6.9	↑ 33.9 ± 4.8	↑ 33.3 ± 8.4	↑ 38.4 ± 7.5
* Smoke cigarettes								
Yes	7.3 ± 2.4	7.6 ± 2.2	2.0 ± 1.2	6.6 ± 1.9	1.6 ± 0.9	↑ 11.1 ± 2.9	3.7 ± 2.4	↑ 18.7 ± 8.5
No	92.7 ± 2.4	92.4 ± 2.2	↑ 98.0 ± 1.2	93.4 ± 1.9	↑ 98.4 ± 0.9	88.9 ± 2.9	96.3 ± 2.4	81.3 ± 8.5

Table 3, cont'd.

	Beverage Pattern Group[2]							
Characteristic	All Caloric Bevg M S J	Milk & Sugar-Swt Bevg. M S j	Milk & Juice M s J	Milk M s j	Sugar-Swt Bevg & Juice m S J	Sugar-Swt Bevg m S j	Other Bevg & Juice m s J	Other Bevg m s j
Category	(n = 109)	(n = 435)	(n = 248)	(n = 411)	(n = 184)	(n = 327)	(n = 103)	(n = 55)
	Percentage (percent ± SE) of adolescents in category of sociodemographic/lifestyle characteristic							
* Alcohol past yr								
Yes	13.3 ± 5.4	14.2 ± 2.9	4.1 ± 1.7	11.5 ± 2.2	16.0 ± 5.4	13.9 ± 2.3	5.9 ± 3.1	↑ 24.3 ± 8.2
No	86.7 ± 5.4	85.8 ± 2.9	↑ 95.9 ± 1.7	88.5 ± 2.2	84.0 ± 5.4	86.1 ± 2.3	↑ 94.1 ± 3.1	75.7 ± 8.2
** How often eat breakfast								
Every day	44.7 ± 7.7	44.9 ± 3.5	↑ 57.1 ± 4.5	46.9 ± 4.8	30.3 ± 6.7	↓ 21.1 ± 4.3	25.7 ± 6.4	↑ 51.6 ± 11.7
Some days	↑ 38.3 ± 5.9	32.0 ± 3.3	31.7 ± 4.2	34.9 ± 5.1	↑ 36.0 ± 6.4	↑ 35.1 ± 5.7	28.5 ± 7.4	14.9 ± 5.9
Rarely	6.1 ± 2.2	13.3 ± 2.3	7.0 ± 2.2	11.4 ± 3.1	17.3 ± 4.2	↑ 19.7 ± 2.7	↑ 22.7 ± 5.7	↑ 27.7 ± 10.6
Never	2.7 ± 2.6	2.1 ± 0.9	0.1 ± 0.1	0.7 ± 0.3	1.5 ± 0.6	↑ 9.5 ± 4.6	0.3 ± 0.2	1.0 ± 0.9
Weekends only	8.3 ± 5.3	7.7 ± 1.3	4.1 ± 1.6	6.0 ± 1.4	14.9 ± 4.8	14.5 ± 3.3	↑ 22.8 ± 5.7	4.8 ± 3.0
** Type of milk used								
Whole/regular	42.7 ± 11	38.5 ± 3.9	27.4 ± 5.6	33.2 ± 4.9	↑ 45.3 ± 6.9	↑ 50.0 ± 3.7	28.2 ± 5.8	21.0 ± 6.5
2%	48.0 ± 12	43.2 ± 4.2	↑ 48.1 ± 5.3	↑ 47.9 ± 3.9	35.3 ± 6.6	32.3 ± 5.0	45.4 ± 8.3	47.1 ± 9.9
1%	4.4 ± 3.7	5.7 ± 2.0	↑ 10.0 ± 3.4	↑ 7.5 ± 2.7	3.5 ± 3.0	1.7 ± 1.4	5.8 ± 4.1	5.6 ± 4.7
Skim/nonfat	↓ 4.9 ± 2.2	12.7 ± 3.2	14.6 ± 4.8	11.4 ± 3.3	6.6 ± 2.9	6.9 ± 2.1	↑ 18.1 ± 7.8	↑ 17.6 ± 6.8
Never drink milk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	9.3 ± 4.7	9.0 ± 3.1	2.5 ± 1.5	8.7 ± 4.3

Table 3, cont'd.

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872)
Means and percentages are sample-weighted and standard errors are estimated by linearization method of SUDAAN.

[2] The beverage pattern is the combination of beverages most frequently reported in the FFQ. Capital letters M, S and J refer to intakes of milk, sugar-sweetened beverages and juice, respectively, each having a share ≥25% of total beverage frequency, and lowercase letters m, s and j represent intakes less than the specified amount

[3] The family reference person (FRP) was usually the household head.

** $p<0.01$, * $p<0.05$, by Chi-square test for association between characteristic and beverage pattern

'All caloric beverages' (MSJ)

The 'all caloric beverage' (MSJ) pattern was associated with overweight; 16% of youth classified by this beverage pattern had a BMI ≥95th percentile of BMI-for-age. Those consuming a combination of all three caloric beverages (milk, sugar-sweetened beverages and juice) were more likely to be older, non-Hispanic black or Hispanic, male adolescents living in rural areas or in the Northeast region of the U.S. The 'all caloric beverage' (MSJ) pattern was associated with low SES; household heads were more likely young, unmarried or female, less likely to have a college education, less likely to be employed in the past 2 weeks or more likely to have income ≤130% poverty. For many youth in this group, both parents were overweight or obese. Although this beverage pattern was not associated with exercise or TV watching, it was associated with sports team participation; many youth in this group played ≥3 sports (28%). The 'all caloric beverage' (MSJ) group tended to consume breakfast only some days. The group was less likely to use skim/nonfat milk.

'Milk & sugar-sweetened beverages' (MSj)

The 'milk & sugar-sweetened beverages' (MSj) pattern was moderately associated with overweight; although the majority of youth classified by this beverage pattern had normal BMI (70%), 12% had a BMI ≥95th percentile of BMI-for-age. Although it was less likely that both parents' were overweight or obese, one was. Those consuming both milk & sugar-sweetened beverages were more likely to be younger, male, Midwestern, non-Hispanic white adolescents of moderately high-income households (186-350% poverty). Because a disproportionate number of household heads were age 15-29 years and not graduated from High School, it seems that some youth were independent from their parents and living with other young adults. The youth in the 'milk & sugar-sweetened beverages' (MSj) group tended to watch TV 2-3 hours/day, but otherwise physical activity and breakfast consumption levels were normally distributed.

'Milk & juice' (MsJ)

The 'milk & juice' (MsJ) pattern was associated with a low prevalence of overweight risk and overweight (17%); more than 80% had normal body weight. An even number of boys and girls were classified by this beverage pattern. Those consuming both milk and juice tended to be younger, non-Hispanic white adolescents living in the Northeast or in urban areas of the U.S. SES was high; 57% of household heads were college-educated and 27% were wealthy (>350% poverty). The majority of youth in this group ate breakfast every day (57%). The group usually drank 1-2% milk. Other healthy characteristics of the 'milk & juice' (MsJ) group included a very high level of physical activity; many exercised ≥7 times/week (35%). Most adolescents in the 'milk & juice' (MsJ) group participated in team sports (81%) and many played ≥3 sports (37%). Few watched TV ≥4 hours/day (10%) and a high proportion watched TV ≤1 hour/day (39%). In addition, these youth were less likely to smoke cigarettes (2%) or drink alcohol (4%).

'Milk' (MSj)

Some youth in the 'milk' (Msj) group were at risk for overweight (19%), but the group tended to have an average distribution of many risk factors for overweight. Few characteristics distinguished this beverage pattern from others. Gender groups were close to having equal numbers. Like the 'milk & sugar-sweetened beverages' (MSj) and 'milk & juice' (MsJ) groups, the youth in this group tended to be younger and non-Hispanic white. The ‘milk’ (Msj) pattern represented both low- and high-income groups. There was a tendency for some youth to have two overweight/obese parents (37%). Like the ‘milk & juice’ (MsJ) group, the ‘milk’ group also tended to use 1-2% milk, but team sports participation was low (54%) and many watched TV 2-3 hours/day (54%).

‘Sugar-sweetened beverages & juice’ (mSJ)

Like the ‘milk & sugar-sweetened beverages’ (MSj) pattern, the ‘sugar-sweetened beverages & juice’ (MSj) pattern was moderately associated with overweight; 12% had a BMI ≥ 95th percentile of BMI-for-age, and many were trying to lose weight. This beverage pattern represented non-Hispanic black or Hispanic, 14-year-old, females living in urban areas or in the West. SES was moderate; half of the household heads had a college education (50%). Nevertheless, for 52% of the group, income was low (≤185% poverty). Some adolescents might have been living in multi-generational family units; household heads age 50 or older were over-represented in this group and family size tended to be large. Youth in this group tended to exercise either a lot (≥5 times/week) or very little (≤2 times/week), perhaps because this beverage pattern was associated with both sports team participation and TV watching. Large proportions of youth in this group played ≥3 sports (29%) or watched TV ≥4 hours/day (33%). The group tended to consume breakfast only some days, and many youth in the group drank whole milk.

‘Sugar-sweetened beverages’ (mSj)

The prevalence of overweight risk/risk was 30% in the ‘sugar-sweetened beverages’ (mSj) group. This beverage pattern represented older non-Hispanic white adolescents living in the Northeastern, Southern or rural areas of the U.S. SES indicators were normally distributed within this group. Many youth in the ‘sugar-sweetened beverages' (mSj) group (27%) exercised infrequently (≤2 times/week), although 46% of the group played 1-2 sports per year. Most youth watched TV for ≥2 hours/day (80%). There was a very low rate of regular breakfast consumption in this group (21%). A high percentage of youth in the group drank whole milk (50%).

'Other beverages & juice' (msJ)

The 'other beverages & juice' (msJ) pattern was associated with overweight/risk and weight loss behavior; 32% had BMI ≥85th percentile and 28% were trying to lose weight. The group consisted mostly of 15-16-year-old girls representing Hispanics and other race-ethnic groups living in the Western region of the U.S. SES was high; household heads were mostly male (79%), married (77%), employed (91%) and 28% were wealthy (>350% poverty). A low rate of alcohol use (6%) distinguished this group from the 'other beverages' (msj) pattern discussed below. Most youth watched TV either ≤1 hour/day (37%) or ≥4 hours/day (33%). There was a low rate of regular breakfast consumption in this group (26%); many ate breakfast rarely (23%) or on weekends only (23%). Many youth in the group drank skim milk (18%).

'Other beverages' (msj)

The 'other beverages' (msj) pattern was highly associated with overweight/risk for overweight and weight loss behavior. Of all the beverage pattern groups, the 'other beverages' (msj) group had the highest prevalence of overweight/risk for overweight. Those with BMI ≥85th percentile were 58%, and 60% were trying to lose weight. The majority had parents that were overweight or obese (65%). Most were non-Hispanic white girls age 15-16 years. SES was moderate; household heads tended to be age ≥50 years, most were employed (93%) and incomes were high (186-350% poverty), although few were college-educated (29%). Many lived in the South (55%), so the 'other beverages' consumed might have been sweet tea. There were high rates of smoking (19%) and alcohol use 924%). Coffee and other caffeineated beverages were might have been consumed as well. Those who drank diet soft drinks might have been also exercising 3-4 times/week in their efforts to lose weight. Few were involved with team sports (65%) and TV was watched ≥4 hours/day (38%). Although the majority ate breakfast every day (52%), another large proportion ate breakfast rarely (28%). Many youth in the group drank skim milk (18%).

Summary

Sociodemographic and lifestyle factors associated with the prevalence of overweight/risk for overweight included race-ethnicity, SES, parental overweight/obesity, sports team participation, TV watching, weight loss behavior, smoking and breakfast consumption. Two caloric/sugar-sweetened beverage patterns associated with a high prevalence of overweight, the 'caloric beverages' (MSJ) pattern consumed more often by black/Hispanic boys and the 'sugar-sweetened beverages & juice' (mSJ) pattern consumed more often by black/Hispanic girls, were also associated with low income and other indicators of low SES. Two different sugar-sweetened beverage patterns consumed more often by non-Hispanic whites, the 'milk & sugar-sweetened beverages' (MSj) and 'sugar-sweetened beverages' (mSj) patterns, were associated with parental overweight/obesity and TV watching. The 'milk & juice' pattern was positively associated with SES, breakfast consumption, exercise and sports team participation; and inversely associated with TV watching and overweight/risk for overweight. The 'other beverages' group had the highest prevalence of overweight/risk for overweight, and this pattern was positively associated with weight loss behavior, smoking, TV watching and inversely with sports team participation.

DISCUSSION

Beverage patterns defined in this study were based on a simple classification scheme (Bowman, 2002) and used to identify segments of the adolescent population that had distinct sociodemographic and lifestyle characteristics. Because these sociodemographic and lifestyle factors were associated with the prevalence of overweight/risk for overweight, understanding their association with beverage patterns gave insight into the complex inter-relationship between these risk factors, beverage consumption and the prevalence of overweight/risk for overweight. For example, the discriminating characteristic of the 'milk & juice' group was regular breakfast consumption, and the 'milk & juice' group had the lowest prevalence of overweight. Other sociodemographic and lifestyle factors associated with the 'milk & juice' pattern included high SES, frequent exercise, sports team participation and not watching TV. In contrast, the 'sugared-sweetened beverage' patterns were associated with low SES and TV watching, and overweight was more prevalent in the 'sugared-sweetened beverage' groups than in the 'milk & juice' groups. Perhaps SES was the common denominator behind breakfast habits, TV watching and physical activity levels (Miech et al., 2006). Nevertheless, beverage patterns functioned effectively as a marker of these risk factors for overweight, because the beverage patterns were associated with these sociodemographic/lifestyle factors, and both the beverage patterns and sociodemographic/lifestyle factors were associated with the prevalence of overweight/risk for overweight.

Beverage patterns were defined *a priori* to classify youth into mutually exclusive groups according to the combination of beverages he/she most frequently consumed. One other researcher classified youth by consumption of milk and/or soda (Bowman et al., 2002), but the current study used FFQ rather than 24-hour recall data, and also controlled for juice consumption while contrasting beverage pattern groups to determine effects of the various types of beverages. Cluster analysis could have been used to empirically derive beverage patterns and classify youth into mutually exclusive groups (Kant, 2004), but each individual would not have necessarily consumed all beverages that characterized his/her cluster. A cluster analysis of water, beverages and selected foods consumed by adults showed that higher-educated, older adults (>60 years) were more likely to be grouped with a ''water/fruit & vegetable/low fat milk'' cluster, while young adults (18-35 years) were more likely to be grouped with a "fast food/snack/soft drink" cluster (Popkin et al., 2005).

Youth were classified into the various beverage pattern groups according to their beverage preferences. Others have found that beverage choices differed by age, gender, race-ethnicity or region (Guenther, 1986; Harnack et al., 1999; Bowman, 2002; Forshee & Storey, 2003). For example, age was associated with decreased intakes of milk and increased intakes of soft drinks, both regular and diet, especially in girls (Forshee & Storey, 2003). Boys tended to drink greater quantities of milk (Guenther, 1986) and soft drinks (Guenther, 1986; Harnack et al., 1999) than girls. African Americans drank less milk (Guenther, 1986; Forshee & Storey, 2003), coffee/tea (Guenther, 1986) and soft drinks (Harnack et al., 1999; Bowman, 2002; Forshee & Storey, 2003) but more fruit drinks (Guenther, 1986; Forshee & Storey, 2003) than whites. Hispanic girls drank more citrus juice than non-Hispanic girls (Forshee & Storey, 2003). Adolescent girls living in the Midwest tended to drink soft drinks, while those living in the Northeast were more likely to drink milk (Bowman, 2002). Adolescents in the South tended to drink sweetened iced tea (Guenther et al., 1986). The age, gender, race-ethnic and regional distributions of beverage patterns defined by the present study reflected the different beverage choices of population subgroups that others have found (Guenther, 1986; Harnack et al., 1999; Bowman, 2002; Forshee & Storey, 2003).

As indicated by preliminary analyses of beverage frequency (Chapter 4, Table 5), the 'other beverages' groups included many adolescents who were drinking diet soft drinks in addition to those who drank coffee and tea. A high percentage of youth in this group reported trying to lose weight. Therefore, the association of the high prevalence of overweight with the 'other beverages' pattern should be interpreted with caution. Because cross-sectional data lack temporality, reverse causality should be considered when interpreting these observations. Rather than causing overweight, drinking "diet" soft drinks, exercising, smoking cigarettes and breakfast skipping were possibly related to the weight loss efforts of the 'other beverages' group. Drinking "diet" beverages or bottled water instead of sugared-sweetened beverages decreased BMI among those in the upper BMI tertile at baseline in a 25-week intervention study of non-dieting youth age 13-18 years (Ebbeling et al., 2006). Dieting in adolescents was associated with unhealthy weight loss practices rather than exercise in a prospective study (French et al., 1995).

Among school-aged children in Ireland, dieters reported drinking more coffee, higher levels of tobacco use, and lower exercise levels than non-dieters (Gabhainn et al., 2002).

Reverse causality, i.e., that overweight adolescents were exercising to lose weight, provides an alternative explanation for the high prevalence of overweight/risk found among infrequent exercisers in the present study compared to those exercising 5-6 times per week. However, as observed in a previous investigation using NHANES III data (Crespo et al., 2001), in the current study, overall, no association was found between exercise and the prevalence of overweight/risk, because the prevalence was also high among those exercising 7 or more times per week. Others omitted a discussion of the exercise variable and used only the measurement of team sports participation to examine the relationship between physical activity and BMI in NHANES III (Storey et al., 2003; Forshee et al., 2004). A positive association between exercise and the prevalence of normal BMI was found in CSFII (Boumtje et al., 2005). The high prevalence of overweight observed in the current study among daily exercisers compared to those exercising 5-6 times per week might be due to increased lean body mass, not fat. BMI does not accurately assess body composition, e.g., overweight youth with a high proportion of lean body mass are not overfat (Forbes, 1987).

The association between smoking and overweight might also be due to reverse causality. College women have reported they smoke cigarettes to control body weight (Malinauskas et al., 2006). That smoking might be used as a weight loss strategy even among teenagers is a disturbing trend. Youth who reported they were trying to lose weight were more likely to initiate smoking in two prospective studies (French et al., 1994; Austin et al., 2001). Smoking was associated with trying to lose weight (Lowry et al., 2002) and also with other unhealthy weight loss practices in the 1999 Youth Risk Behavior Survey (YRBS) (Delnevo et al., 2003). Daily smokers were 2-4 times more likely to fast, use pills and purge to control weight than nonsmokers (Delnevo et al., 2003), and smoking was associated with vomiting or laxative use in another study (Krowchuk et al., 1998).

College women reported that they used breakfast skipping as a weight loss strategy even more often than smoking (Malinauskas et al., 2006), and breakfast skipping was also associated with unhealthy weight loss practices, as breakfast skippers were more likely to report fasting to lose weight in the YRBS (Zullig et al., 2006). The inverse association between overweight prevalence and breakfast consumption observed in the current study could then be due to overweight youth skipping breakfast to lose weight, although it's possible that breakfast skipping might lead to weight gain over time. Breakfast skippers in a longitudinal study tended to gain more weight (measured as BMI) than regular breakfast eaters, but only among normal-weight subjects; BMI decreased in overweight adolescents who skipped breakfast (Berkey et al., 2003). Potential confounding provides another explanation for the association of breakfast skipping with overweight. The 'milk and juice' pattern was associated not only with regular breakfast consumption, but also with high SES and other healthy behaviors like exercise and not watching TV, and these other factors could account for the association between breakfast consumption and the low prevalence of overweight. Drinking milk and juice was associated with breakfast consumption, and breakfast consumption might be associated with other components of a healthy lifestyle such as high levels of physical activity (Cavadini et al., 2000b; Keski-Rahkonen et al., 2003; Godin et al., 2005).

Cross-sectional analyses cannot be used to make causal inferences, but the model in Figure 1 presumes that factors like breakfast consumption and TV watching are downstream from beverage patterns in the causal pathway leading from beverage patterns to overweight (causal pathway A). Numerous studies have shown that regular soft drinks and snack foods are consumed while watching TV (Coon et al., 2001; Giammattei et al., 2003; Utter et al., 2003; Matheson et al., 2004; Phillips et al., 2004). Preliminary analyses of the frequency with which adolescents consumed beverages at the various meal occasions (shown in Table 6 of Chapter 4) demonstrated that sugared-sweetened beverages were most frequently consumed at snack/ beverage breaks, while milk and juice were most frequently consumed at the breakfast meal occasion. The model shown in Figure 1 suggests that TV watching and the frequency of breakfast consumption determine the meal situation and beverage patterns that accompany the snack or breakfast occasion. Because of their proximity, beverage patterns might have a stronger relationship to the mediating and outcome variables (energy intake and adolescent obesity) than those downstream. However, as shown in Figure 1, the effects of TV watching would be larger than beverage patterns (causal pathway A), because TV watching would be associated with physical activity levels (causal pathway B) as well (Robinson et al., 1993; Nelson et al., 2005).

Recent research showing the effects of SES on adolescent overweight suggested that poverty was associated with breakfast skipping, physical inactivity, and sugar-sweetened beverage consumption (Miech et al., 2006). Therefore, SES might be shown downstream from breakfast, TV watching and exercise habits in the model of Figure 1. The current analyses of the association between beverage patterns and overweight were

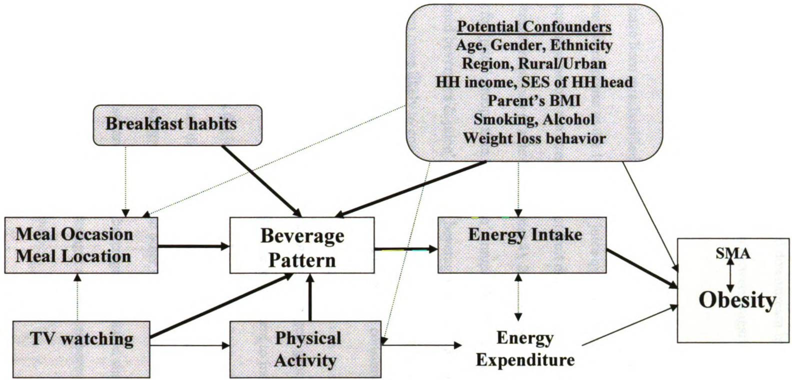

Figure 1. Conceptual model for the association of beverage patterns with obesity

not adjusted for covariates. Adjusting for SES, TV watching and other sociodemographic/lifestyle factors depicted downstream in the model might lead to 'over-control' in examining the association between sugar-sweetened beverages and overweight.

There were several limitations that pertain to the current analyses. Some youth might have been misclassified to a 'juice' group, if they mistakenly reported fruit drink frequency in response to the 100% fruit juice question, because the fruit juice question was sequenced before the question about fruit drinks in the FFQ. In preliminary analyses of beverage frequency (Table 5 of Chapter 4), 24-hour recall intakes of fruit drinks were higher for 'juice' groups than 'non-juice' groups. Youth of low SES among the 'sugared-sweetened beverages & juice' or 'other beverages & juice' groups, for example, might have been more likely to confuse fruit drinks with fruit juice than those with high SES in the 'milk & juice' group. Small variances indicated that consumers of the 'milk & juice' pattern were a homogeneous group.

Large variances indicated that the 'other beverages' groups were comprised of subgroups. Because the FFQ did not allow the respondent to indicate whether sugar was added to coffee or tea, the 'other beverages' group included both sugar-sweetened coffee/tea consumers and diet soft drink consumers, and risk factors might have varied widely between these subgroups. On the other hand, because there were four separate patterns that included sugar-sweetened beverages and shared similar risk factors, it might be necessary to collapse them to see a stronger association between sugar-sweetened beverage consumption and obesity in youth.

The major strength of this study was that youth were classified into beverage pattern groups according to their 'usual' beverage intakes reported using the FFQ. Assessing each youth's 'typical' beverage pattern using 'usual' intakes in the FFQ should strengthen the relationship of beverage consumption with sociodemographic and lifestyle factors. Because of intra-individual variation in dietary intake, youth might have been misclassified to beverage patterns if a single 24-hour recall were used instead. In addition, misclassification to beverage pattern groups due to under-reporting in response to the FFQ was addressed by identifying most frequently consumed beverage types based on their percentage share of total beverage frequency. Rather than using the beverage frequency to identify youth who reported consumption ≥1 time/day, for example, youth were classified by the combination of beverages consumed with shares ≥25% of total beverage frequency. If frequency-based criteria were used, youth who reported drinking all caloric beverage types <1 time/d would have been classified to the 'other beverages' (msj) pattern, and these "under-reporters" were removed from this group by using consumption criteria based on the percentage share. Avoiding potential bias due to under-reporting was important to the design of this study; overweight youth might be more likely to under-report beverage consumption (Bandini et al., 1990; Johnson et al., 1996; Johnson, 2000).

Implications

Beverage patterns might be markers of sociodemographic and lifestyle factors that are risk factors for overweight. This suggests that complex interrelationships between sociodemographic/lifestyle factors, beverage patterns and adolescent obesity exist.

Chapter 6

PATTERNS OF BEVERAGE CONSUMPTION ASSOCIATED WITH ADOLESCENT OBESITY IN THE U.S.

ABSTRACT

Objective To examine associations of beverage patterns (i.e., the types of beverages most frequently consumed) with BMI percentile, percentage body fat and overweight/risk for overweight among adolescents in the U.S.

Design Cross-sectional analysis of data from the Third National Health and Nutrition Examination Survey (NHANES III, 1988-94). Food frequency questionnaire (FFQ) data were used to classify youth into beverage pattern groups. BMI percentile and overweight/risk for overweight were determined from measured BMI using CDC Growth Charts, and percentage body fat from two skinfold measurements.

Subjects A U.S. population-based sample of adolescents age 12-16 years (n=1,872).

Statistical analysis SUDAAN software was used to run linear and logistic regression analyses. The crude and adjusted associations of each beverage pattern group with body weight and with body fat, least-square (LS) mean BMI percentile and percentage body fat, as well as the odds ratios for overweight/risk for overweight were examined. Covariates examined were gender, age, race-ethnicity, region, urbanization, parental overweight/obesity, SES indicators, smoking, alcohol use, weight loss behavior, exercise, team sports participation and TV watching.

Results The LS means of both BMI percentile and percentage body fat were lower in the 'milk & juice' group than in the 'other beverages' group, and LS mean BMI percentile was higher in the 'sugar-sweetened beverages' than in the 'milk & juice'

group, in the unadjusted model that included only the beverage pattern, amount of water and type of milk usually consumed. The crude odds ratio for overweight/risk for overweight was low in the 'milk & juice' group (OR=0.52, 95% CI = 0.28-0.96), and high in the 'other beverages' group (OR=2.74, 95% CI = 1.12-6.68), compared to the 'milk' group. The adjusted associations of 'milk & juice' with BMI percentile, percentage body fat and overweight/risk for overweight were significant in most models, except those adjusted for SES, physical activity or TV watching. The adjusted association of the 'sugar-sweetened beverages' pattern with BMI percentile was significant while controlling for physical activity, but it was not significant while controlling for SES or TV watching. The associations of the 'other beverages' pattern with obesity outcomes were not significant with adjustments for youth who were trying to lose weight.

Implications This study suggests that several sociodemographic/lifestyle factors examined are highly correlated with beverage patterns, and together these sociodemographic/lifestyle factors and beverage patterns are associated with adolescent obesity. The interrelationships between sociodemographic/lifestyle factors and beverage patterns must be carefully considered to elucidate the potential role each specific etiologic factor has in increasing the prevalence of adolescent overweight.

INTRODUCTION

The prevalence of overweight among adolescents has been steadily increasing over the past three decades in the U.S. Among adolescents age 12-19 years, the current prevalence rate of 17.4% is more than three times higher than the rate of 5.0% observed

30 years ago (Ogden et al., 2002; Hedley et al., 2004; Ogden et al., 2006). At the same time, intakes of soft drinks and other sugar-sweetened beverages have increased, for example, soft drink intakes of adolescents age 14-17 years doubled (from 7 to 14 oz/day) for girls, and more than tripled (from 7 to 22 oz/day) for boys between 1977-78 and 1994-98 (French et al., 2003), and other researchers have observed similar trends (Cavadini et al., 2000a; Nielsen & Popkin, 2004). Some researchers have suggested that consumption of sugar-sweetened beverages is related to the high prevalence of overweight in youth (Harnack et al., 2000; Bray et al., 2004).

Consumption of milk has declined, for example, 77% of girls age 12-19 years drank milk at least once per day in 1977-78 compared to 53% in 1994-96, while soft drink consumption increased from 41% to 56% of girls at the same time (Bowman et al., 2002). Other researchers have corroborated these trends in milk and soft drink intakes among children and adolescents of various age and gender groups (Morton & Guthrie, 1998; Moshfegh et al., 2000; Enns et al., 2002; Enns et al., 2003). An inverse relationship between calcium and adiposity has been hypothesized (Zemel et al., 2000), which suggests that low fat milk intakes of youth might be inversely correlated with body fat. Age was associated with decreased intakes of milk and increased intakes of soft drinks, especially in girls (Lytle et al., 2000; Bowman et al., 2002; Forshee & Storey, 2003). If intakes of milk are low and soft drink intakes are high in adolescents compared to children of younger age groups, then the low calcium intakes combined with excess calories from intakes of sugar-sweetened beverages might be associated with the prevalence of overweight in adolescents.

Several prospective studies (Ludwig et al., 2001; Berkey et al., 2004) and intervention studies (James et al., 2004; Ebbeling et al., 2006) have shown an association between soft drinks and weight gain in youth, although cross-sectional studies examining sugar-sweetened beverage consumption in relation to Body Mass Index (BMI) or overweight status have had inconsistent results (Forshee & Storey, 2003; Forshee et al., 2004; Boumtje et al., 2005). Those studies that used the Continuous Survey of Food Intake by Individuals (CSFII) data to examine the association of beverage intakes with BMI or overweight in adolescents (Forshee & Storey, 2003; Boumtje et al., 2005) were limited in that self-reported information rather than measured height and weight were used to compute BMI (Kuczmarski et al., 2001; Brener et al., 2003). In addition, analyses of children or adolescents using National Health and Nutrition Examination Survey (NHANES) data that examined BMI in relation to beverage intakes (Forshee & Storey, 2003; Forshee et al., 2004) were limited, because BMI was not adjusted for gender and age using the CDC Growth Charts reference data (Kuczmarski et al., 2000; Bachman et al., 2006). In the current study, BMI percentile was calculated from measured height and weight using the gender-specific BMI-for-age percentile reference data provided by the CDC Growth Charts, because criteria based on the BMI-for-age percentiles were recommended to assess overweight/risk for overweight in children and adolescents (Kuczmarski et al., 2000). In addition, percentage body fat was determined from summed triceps and subscapular skinfold measurements (Slaughter et al., 1988), because BMI does not accurately assess body composition, e.g., overweight youth with a high proportion of lean body mass are not overfat (Forbes, 1987).

Cross-sectional studies using the CSFII or NHANES data (Forshee & Storey, 2003; Forshee et al., 2004; Boumtje et al., 2005) might have been limited by inaccurate assessment of beverage consumption due to intra-individual variation in intake (Beaton et al., 1979; Sempos et al., 1985) or under-reporting of intake (Bandini et al., 1990; Johnson et al., 1996; Johnson, 2000; Subar et al., 2003). In the current study, beverage intakes were assessed using a food frequency questionnaire (FFQ) rather than the 24-hour recall to address intra-individual variation. Instead of focusing on individual beverages, the current study examined beverage intake by defining patterns that reflected multiple beverages consumed in combination. Youth were classified into mutually exclusive groups according to the combinations of beverage types most frequently reported as 'usual' intake. A method for classifying youth by his/her 'typical' beverage pattern was developed to address under-reporting of intakes.

The aim of this study was to examine the associations of beverage patterns (i.e., the types of beverages most frequently consumed) with obesity (i.e., overweight and adiposity) in 12-16-year-old adolescents in the U.S. Indicators of overweight and adiposity examined separately included the BMI percentile, percentage body fat as assessed by skinfold measurements, and overweight/risk for overweight (i.e., BMI $\geq 85^{th}$ percentile of BMI-for-age). Youth were classified into beverage pattern groups according to the combination of beverage types reported most frequently in the FFQ. In addition to beverage pattern groups, other beverage variables considered in analyses were fluid ounces of water and type of milk (e.g., whole, 2%, 1%, skim) usually consumed. Potential covariates examined were gender, age, race-ethnicity, region, urbanization, parental overweight/obesity, SES indicators, smoking, alcohol use, weight loss behavior, exercise, team sports participation and TV watching. Covariates were examined separately one at a time to investigate whether each one might potentially confound the relationship between beverage patterns and overweight/ adiposity.

METHODS

Dataset

The Third National Health and Nutrition Examination Survey (NHANES III, 1988-1994) dataset was used for analyses, rather than the more recent 1999-2002 NHANES dataset, because the dietary food frequency questionnaire used to assess the youth's usual beverage pattern is available only in NHANES III. The National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC) conducts NHANES to obtain nationally representative data on the nutritional and health status of the civilian, non-institutionalized U.S. population. Participants were selected using a complex, stratified, multistage, probability cluster sample design (NCHS, 1994). The survey included interviews conducted in the household and at a mobile examination center (MEC). The examination included an anthropometric component and sexual maturation staging. A food frequency questionnaire and a 24-hour recall dietary interview were also administered at the MEC.

Subjects

Adolescents age 12-16 years who were interviewed and examined in NHANES III comprised the analytic sample for this study. The NHANES III sample included 2,216 adolescents aged 12-16 years selected for examination, and, of those, 2,079 (93.8% of 2,216) were examined at the MEC. Upon examination, 19 respondents (0.9% of 2,216) found to be ineligible (16 teenage girls were pregnant, and three were lactating) were excluded from the current study. Because 24-hour recall data were used in a preliminary analysis necessary to conduct the current study, the analytical sample was limited to adolescents age 12-16 years who completed a 24-hour recall dietary interview as well as all beverage items in the FFQ. There were 1,997 youth (90.1% of 2,216) who had a complete, reliable 24-hour recall dietary interview, and of these, 97 (4.4% of 2,216) were missing beverage frequency data and another 28 (1.3% of 2,216) were missing data on water intake. After excluding those with missing data, the remaining analytic sample of 1,872 youth (84.5% of 2,216) included 871 boys (46.5% of 1,872) and 1,001 girls (53.5% of 1,872) aged 12-16 years.

Definition of beverage patterns

Youth were classified by the combination of beverage types most frequently consumed, as reported in the FFQ. Four main categories of the 12 FFQ beverage items listed in **Table 1** were (1) milk, including milk on cereal as well as milk drinks, (2) 100% fruit juice, (3) sugar-sweetened beverages (e.g., fruit drinks and regular soft drinks) and (4) other beverages (e.g., diet soft drinks, coffee/tea and beer/wine/liquor). An additional item in the FFQ asked what type of milk was usually consumed: whole, 2%, 1%, or skim/nonfat milk. The dietary interview included a question to respondents about how many glasses/cups or fluid ounces of plain water they usually drank in a 24-hour period. If the response was in terms of glasses or cups, participants specified the fluid ounces per glass or cup, and numbers of glasses/cups were converted to fluid ounces. The beverage

Table 1. Beverage categories and beverage subcategories corresponding to beverage items in the NHANES III food frequency questionnaire (FFQ)

Beverage categories & beverage subcategories	FFQ beverage items
1. Milk and milk drinks, chocolate & regular	1a. How often did you have chocolate milk and hot cocoa?
	1b. How often did you have milk to drink or on cereal? Do not count small amounts of milk added to coffee or tea.
2. 100% fruit juice, citrus & non-citrus	2a. How often did you have orange juice, grapefruit juice and tangerine juice?
	2b. Other fruit juices such as grape juice, apple juice, cranberry juice, and fruit nectars?
3. Sugar-sweetened bevg.	
3a. Fruit drinks	3a. How often did you have Hi-C, Tang, Hawaiian Punch, Koolaid, and other drinks with added vitamin C?
3b. Regular soft drinks	3b. Regular colas and sodas, not diet?
4. Other beverages	
4a. Diet soft drinks	4a. Diet colas, diet sodas, and diet drinks such as Crystal Light?
4b. Coffee/ tea	4b (1). Regular coffee with caffeine?
	4b (2). Regular tea with caffeine?
4c. Alcoholic beverages	4c (1). Beer and lite beer?
	4c (2). Wine, wine coolers, Sangria, and champagne?
	4c (3). Hard liquor such as tequila, gin, vodka, scotch, rum, whiskey and liqueurs, either alone or mixed?

pattern, type of milk and fluid ounces of water usually consumed were all included in the current analyses.

Beverage pattern classifications were based on 'usual' intake in the FFQ of a combination of up to three beverage types: milk, sugar-sweetened beverages and/or 100% fruit juice. To classify youth into beverage pattern groups, the FFQ beverage frequencies were used to identify the combination of beverages that characterized a youth by his/her 'typical' beverage pattern. Each beverage's frequency was expressed as a percentage of the summed frequency for all beverages to identify the combination of beverages each having a share that was at least 25% of the total beverage frequency. Notations for the eight beverage patterns were combinations of capital letters M, S and J to refer to milk, sugar-sweetened beverages and juice, respectively, having shares ≥25% total beverage frequency, and lowercase letters m, s and j represented consumption of less than the specified amount. Beverage patterns were named according to the eight beverage combinations: 'all caloric beverages' (MSJ), 'milk & sugar-sweetened beverages' (MSj), 'milk & juice' (MsJ), 'milk' (Msj), 'sugar-sweetened beverages & juice' (mSJ), 'sugar-sweetened beverages' (mSj), 'other beverages & juice' (msJ) and 'other beverages' (msj).

Assessment of overweight and adiposity

Weight and height measured at the MEC (DHHS, 1998) were used to assess Body Mass Index (BMI=kg/m^2), and skinfold thickness measures (DHHS, 1998) were used to assess percentage body fat. The SAS program available from NCHS was run to calculate the youth's BMI percentile using the gender-specific BMI-for-age CDC Growth Charts reference data (NCHS; Kuczmarski et al., 2000). The BMI percentile and percentage body fat were dependent variables in two separate linear regression analyses. The BMI percentile was used to classify youth by weight status (i.e., underweight: BMI <5th percentile, normal body weight: BMI ≥5th percentile and BMI <85th percentile, at risk for overweight: BMI ≥85th percentile and <95th percentile, and overweight: BMI ≥95th percentile). The presence of overweight/risk for overweight (i.e., BMI ≥85th percentile) was the dependent variable for logistic regression analyses. Underweight youth were excluded from logistic regression analyses.

Percentage body fat was determined from summed triceps and subscapular skinfold thickness (mm) measurements using prediction equations for adolescents developed by Slaughter et al. (1988). There were 35 youth whose triceps or subscapular skinfold thickness was too large for the calipers. Rather than excluding these obese adolescents from analyses, percentage body fat was calculated using the group's maximum skinfold thickness (mm) measurements in place of the missing values. Slaughter et al. (1988) included separate skinfold equations for prepubescent, pubescent, and postpubescent white and black male adolescents and all female adolescents whose summed tricep and subscapular skinfolds were 35 mm or less, and male and female adolescents whose summed tricep and subscapular skinfolds were greater than 35 mm. Adolescent boys were classified by race and sexual maturation (SMA) stage to use the Slaughter equations. White and black male adolescents were classified by the composite pubic hair and genitalia rating as follows: prepubescent (SMA stages 1.0 - 2.0), pubescent (SMA stages 2.5-3.5) and postpubescent (SMA stages 4.0-5.0) (Boileau et al., 1984; Slaughter et al., 1984).

Assessment of sexual maturation stage

The physician's examination included an assessment of SMA according to the 5-stages of developing pubic hair (male and female), male genitalia, and female breasts (Tanner, 1962; DHHS, 1991). A composite score was calculated by averaging the pubic hair rating with the genitalia rating for boys and with the breast rating for girls (Tanner, 1962). The composite score was used to classify both males and females by pubertal status: prepubescent (SMA stages 1.0 - 2.0), pubescent (SMA stages 2.5-3.5) and postpubescent (SMA stages 4.0-5.0) (Boileau et al., 1984; Slaughter et al., 1984). Pubertal status of those missing both SMA ratings was determined by age (years). The regression models included pubertal status in addition to the beverage variables and potential covariates described next.

Covariates in regression analyses

Potential covariates considered in regression analyses included sociodemographic factors such as gender, age, race-ethnicity, region, urbanization, parental overweight/obesity, household income and other indicators of social economic status (SES). Lifestyle factors examined were smoking, alcohol use, weight loss behavior, physical activity and TV watching. Categories for race-ethnicity included non-Hispanic white, non-Hispanic black, Hispanic and other race-ethnic groups. Four broad regions of the U.S. included the Northeast, Midwest, South and West. The urban/rural classification was a metropolitan area having a population ≥1 million *vs.* all other areas. The poverty income ratio was the ratio of household income to the poverty level for household size in an urban or rural area. Other indicators of SES included the family size and characteristics of the household head or family reference person (FRP), such as their gender, age group, marital status, education and employment status. BMI was calculated from reported weight and height of the youth's mother and father to determine whether both or one of two parents were overweight (BMI $\geq$25 kg/m^2) or obese (BMI $\geq$30 kg/m^2).

The survey included lifestyle questions, such as those asking youth whether they currently smoked cigarettes or drank alcohol in the past year. Youth were also asked whether they were currently trying to lose weight. Physical activity was assessed using the following questionnaire items asking youth about their exercise habits and participation in team sports:

1. How many times per week do you play or exercise enough to make you sweat or breathe hard?
2. In the past year, how many sports teams or organized exercise programs have you been involved in (not including physical education or gym classes)?

Youth were asked twice, once in the household and again at the MEC, about time spent watching TV the previous day, and the average hours/day in two days was used in the current study.

Statistical analysis

The Statistical Package for the Social Sciences, SPSS for Windows, Version 12.0 (SPSS Inc. Chicago, IL, USA) was used to prepare the dataset for analysis. All statistical analyses were performed using SUDAAN version 8 (Research Triangle Institute, Research Triangle Park, NC), to account for the effect of the clustered sample design in estimating the variance of population parameters while conducting statistical tests (Shah et al., 1997). The six-year MEC-examined sample weights were applied to the calculation of all statistics. The sample weights adjust the data to the 1990 U.S. Census figures, therefore the data are representative of adolescents in the 1990 U.S. population.

The association of obesity outcomes with beverage pattern groups was examined after controlling for covariates using regression analysis. Multiple regression analysis was used to implement a multiple analysis of variance (MANOVA) with categorical variables (i.e., dummy variables) in a general linear model. The p-value of the Wald F test for the treatment effect was interpreted to test for a significant association between any one of the beverage pattern groups and obesity. Because the p-value to test the significance of an effect of a particular beverage pattern group indicates only whether the beta coefficient was different from zero, Bonferroni contrasts of least square (LS) means were performed to indicate whether the 'milk & juice' beverage pattern group was significantly different from each of the other seven beverage pattern groups (i.e., LS mean BMI percentile and LS mean body fat (%) were adjusted for effects of covariates). The 95% confidence intervals for odds ratios were calculated and interpreted to indicate whether a beverage pattern group's risks were significantly different from 1.0. Odds ratios for overweight/risk for overweight were adjusted for effects of covariates as well.

Each covariate was added individually to the model that included only the beverage pattern, amount of water and type of milk usually consumed (Model 1). Covariates were examined separately one at a time to investigate whether each one might potentially confound the relationship between beverage patterns and overweight/ adiposity. If the effect of beverage patterns was no longer significant with the inclusion of the potential confounder in the model then it was concluded that this covariate was indeed confounding the relationship between beverage patterns and overweight/adiposity. Covariates not found to be confounders were added to Model 1 together to form an adjusted model (Model 2), and the remaining covariates were each added individually one at a time to the adjusted model (Model 2).

RESULTS

Table 2 presents mean values of overweight and adiposity measurements in beverage pattern groups. Bonferroni contrasts indicated that BMI percentile, percentage body fat and overweight prevalence were highest in the 'other beverage' (msj) group compared to the 'milk' (Msj) group.

Percentile of BMI-for-age

The associations of beverage patterns with the BMI percentile are shown in **Table 3**. The R-square for the unadjusted model (Model 1) indicated that the beverage pattern, water and milk type explained 3% of the variance in the percentile of BMI-for-age. The association between BMI percentile and beverage patterns (Wald F $p<0.05$) was such that the least square (LS) mean BMI percentile of the 'sugar-sweetened beverage' (mSj) and 'other beverage' (msj) pattern groups were higher than the 'milk & juice' (MsJ) group ($p<0.05$).

Adding parent's weight status individually to Model 1 increased R-square to ~10% of the variance explained, and the overall beverage pattern effect was significant at the $p=0.01$ level. The overall beverage pattern effect was no longer significant (Wald F $p=0.11$) when indicators of social economic status (SES), such as income and education

Table 2. Mean body weight and body fat measurement used to assess overweight and adiposity among adolescents age 12-16 years classified by beverage pattern[1]

Body weight & body fat measurement	All 12-16 yr (n = 1,872)	Beverage Pattern Group[2] All Caloric Bevg M S J (n = 109)	Milk & Sug-Swt Bevg M S j (n = 435)	Milk & Juice M s J (n = 248)	Milk M s j (n = 411)	Sug-Swt Bevg & Juice m S J (n = 184)	Sug-Swt Bevg m S j (n = 327)	Other Bevg & Juice m s J (n = 103)	Other Bevg m s j (n = 55)
Mean (mean ± SE) body weight measurement used to assess overweight									
Weight (kg)	58.8 ± 0.8 (n = 1,837)	60.6 ± 3.2 (n = 109)	58.1 ± 1.0 (n = 429)	54.7 ± 1.0 (n = 238)	59.5 ± 2.1 (n = 405)	57.3 ± 1.5 (n = 181)	60.5 ± 1.0 (n = 320)	60.7 ± 2.5 (n = 101)	66.7 ± 3.0 (n = 54)
BMI (kg/m^2)	21.7 ± 0.3 (n = 1,837)	22.0 ± 0.8 (n = 109)	21.4 ± 0.3 (n = 429)	20.6 ± 0.3 (n = 238)	21.8 ± 0.7 (n = 405)	21.6 ± 0.5 (n = 181)	21.9 ± 0.3 (n = 320)	22.6 ± 0.8 (n = 101)	24.7 ± 0.9 (n = 54)
BMI z-score	0.36 ± 0.05 (n = 1,837)	0.46 ± 0.16 (n = 109)	0.35 ± 0.08 (n = 429)	0.19 ± 0.09 (n = 238)	0.34 ± 0.11 (n = 405)	0.29 ± 0.13 (n = 181)	0.39 ± 0.08 (n = 320)	0.45 ± 0.14 (n = 101)	0.98 ± 0.18** (n = 54)
BMI percentile	60.1 ± 1.2 (n = 1,837)	62.9 ± 4.6 (n = 109)	59.5 ± 2.5 (n = 429)	55.5 ± 2.6 (n = 238)	59.7 ± 2.8 (n = 405)	57.2 ± 3.9 (n = 181)	62.3 ± 2.0 (n = 320)	62.0 ± 4.3 (n = 101)	76.5 ± 4.9* (n = 54)
Prevalence (percent ± SE) of overwt (BMI ≥95th percentile) and overwt/risk for overwt (BMI ≥85th percentile)									
BMI ≥95th percentile	10.7 ± 1.4 (n = 1,837)	15.9 ± 6.7 (n = 109)	11.8 ± 2.3 (n = 429)	6.4 ± 2.2 (n = 238)	9.2 ± 2.7 (n = 405)	12.0 ± 3.5 (n = 181)	10.1 ± 2.5 (n = 320)	12.1 ± 3.7 (n = 101)	24.5 ± 8.5 (n = 54)
BMI ≥85th percentile	27.3 ± 2.1 (n = 1,837)	27.2 ± 7.4 (n = 109)	27.7 ± 4.2 (n = 429)	17.4 ± 3.3 (n = 238)	27.8 ± 4.5 (n = 405)	25.7 ± 5.6 (n = 181)	27.7 ± 3.6 (n = 320)	31.6 ± 8.4 (n = 101)	58.2 ± 9.4* (n = 54)

Table 2, cont'd.

Body weight & body fat measurement	All 12-16 yr (n = 1,872)	Beverage Pattern Group[2] All Caloric Bevg M S J (n = 109)	Milk & Sug-Swt Bevg M S j (n = 435)	Milk & Juice M s J (n = 248)	Milk M s j (n = 411)	Sug-Swt Bevg & Juice m S J (n = 184)	Sug-Swt Bevg m S j (n = 327)	Other Bevg & Juice m s J (n = 103)	Other Bevg m s j (n = 55)
	Mean (mean ± SE) body fat measurement used to assess adiposity								
Triceps skinfold (mm)	15.0 ± 0.4 (n = 1,819)	14.5 ± 1.1 (n = 109)	14.5 ± 0.7 (n = 423)	13.6 ± 0.6 (n = 238)	14.8 ± 0.9 (n = 400)	14.9 ± 1.0 (n = 182)	15.6 ± 0.6 (n = 314)	17.9 ± 1.0 (n = 99)	21.9 ± 2.0* (n = 54)
Subscapular skinfold (mm)	12.8 ± 0.4 (n = 1,804)	12.9 ± 1.3 (n = 109)	12.5 ± 0.7 (n = 415)	11.2 ± 0.6 (n = 237)	12.4 ± 0.7 (n = 402)	12.7 ± 0.9 (n = 181)	12.9 ± 0.5 (n = 309)	15.9 ± 1.1 (n = 99)	19.7 ± 1.7** (n = 52)
Summed skinfold (mm)	27.8 ± 0.8 (n = 1,801)	27.5 ± 2.3 (n = 109)	26.8 ± 1.4 (n = 415)	24.8 ± 1.2 (n = 237)	27.2 ± 1.5 (n = 400)	27.6 ± 1.8 (n = 181)	28.4 ± 1.1 (n = 308)	33.8 ± 2.1 (n = 99)	41.5 ± 3.7** (n = 52)
Body fat (%)	22.5 ± 0.6 (n = 1,801)	22.2 ± 1.9 (n = 109)	21.6 ± 1.0 (n = 415)	20.4 ± 0.9 (n = 237)	22.1 ± 1.2 (n = 400)	22.1 ± 1.4 (n = 181)	22.8 ± 0.8 (n = 308)	27.1 ± 1.3 (n = 99)	32.4 ± 2.6** (n = 52)

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872)
Means and percentages are sample-weighted and standard errors are estimated by linearization method of SUDAAN.
[2] The beverage pattern is the combination of beverages most frequently reported in the FFQ. Capital letters M, S and J refer to intakes of milk, sugar-sweetened beverages and juice, respectively, each having a share ≥25% of total beverage frequency, and lowercase letters m, s and j represent intakes less than the specified amount
* $p < 0.05$, ** $p < 0.01$ for comparison of beverage pattern group to 'milk' (Msj) group

Table 3. Building the linear regression model of the effects of beverage pattern on BMI percentile in adolescents age 12-16 years[1]

Model / Beverage Pattern[2]	BMI Percentile Least Square Mean ± SE		Beta Coeff.	SE Beta	P-value T-test H_0: B=0	Wald F[3]	P-value Wald F[3]	Model R-Square
MODEL 1: beverage pattern, water & milk type						2.50	0.028	0.030
MSJ	62.8 ± 4.4		2.98	4.87	0.543			
MSj	59.6 ± 2.6		-0.15	3.91	0.970			
MsJ	54.9 ± 2.6		-4.86	3.44	0.164			
Msj	59.8 ± 2.9		0.00	0.00	.			
mSJ	57.5 ± 4.0		-2.26	5.48	0.681			
mSj	64.9 ± 2.2	**	5.14	3.31	0.127			
msJ	60.4 ± 3.9		0.61	5.03	0.904			
msj	74.1 ± 5.5	**	14.33	5.73	0.016			
MODEL 1 + A (gender, age, ethnicity & sexual maturation)						2.42	0.033	0.085
MODEL 1 + B (region & rural/urban area)						2.50	0.028	0.034
MODEL 1 + C (parent's weight status)						3.03	0.010	0.098
MODEL 1 + D (smoking, alcohol & drug use)						2.80	0.016	0.044
MODEL 1 + E (SES[4])						1.79	0.111	0.062
MODEL 1 + F (trying to lose weight)						2.14	0.056	0.169
MODEL 1 + G (physical activity)						2.13	0.058	0.039
MODEL 1 + H (TV watching)						1.93	0.085	0.050
MODEL 2: model 1 + A, B, C & D						3.35	0.005	0.155
MSJ	61.4 ± 5.5		0.56	5.63	0.921			
MSj	61.4 ± 2.5	*	0.58	3.55	0.872			
MsJ	54.4 ± 2.4		-6.39	3.13	0.046			
Msj	60.8 ± 2.5		0.00	0.00	.			
mSJ	57.4 ± 3.5		-3.35	4.16	0.424			
mSj	63.1 ± 2.1	**	2.30	2.83	0.422			
msJ	60.4 ± 3.8		-0.38	4.83	0.938			
msj	72.3 ± 5.4	**	11.55	5.31	0.035			

Table 3, cont'd.

Model Beverage Pattern[2]	BMI Percentile Least Square Mean ± SE		Beta Coeff.	SE Beta	P-value T-test H_0: B=0	Wald F^3	P-value Wald F^3	Model R-Square
MODEL 2 + E (SES[4])						2.00	0.075	0.176
MSJ	61.8 ± 5.6		1.44	5.78	0.804			
MSj	60.3 ± 2.6		-0.03	3.87	0.993			
MsJ	55.2 ± 2.1		-5.15	3.11	0.104			
Msj	60.4 ± 2.7		0.00	0.00	.			
mSJ	57.5 ± 3.7		-2.86	4.20	0.499			
mSj	62.3 ± 2.3		1.91	3.19	0.553			
msJ	61.5 ± 4.3		1.18	5.10	0.818			
msj	69.8 ± 5.4	*	9.42	5.51	0.094			
MODEL 1 + F (trying to lose weight)						2.16	0.055	0.260
MSJ	62.7 ± 4.7		1.24	4.87	0.800			
MSj	61.8 ± 2.2	*	0.32	3.23	0.921			
MsJ	55.2 ± 2.4		-6.28	3.28	0.061			
Msj	61.5 ± 2.3		0.00	0.00	.			
mSJ	56.0 ± 3.6		-5.47	4.25	0.205			
mSj	62.5 ± 1.8	*	1.03	2.64	0.697			
msJ	60.7 ± 3.7		-0.80	4.49	0.859			
msj	63.3 ± 5.7		1.85	5.81	0.752			
MODEL 2 + G (physical activity)						2.45	0.031	0.167
MSJ	61.3 ± 5.5		1.23	5.60	0.827			
MSj	61.5 ± 2.5		1.49	3.56	0.679			
MsJ	54.9 ± 2.5		-5.08	3.23	0.122			
Msj	60.0 ± 2.5		0.00	0.00	.			
mSJ	58.3 ± 3.6		-1.70	4.19	0.686			
mSj	63.3 ± 2.1	*	3.23	2.90	0.270			
msJ	60.7 ± 3.7		0.65	4.78	0.893			
msj	71.5 ± 5.4	*	11.48	5.42	0.039			

Table 3, cont'd.

Model	BMI Percentile			P-value			
Beverage Pattern[2]	Least Square Mean ± SE	Beta Coeff.	SE Beta	T-test H_0: B=0	Wald F[3]	P-value Wald F[3]	Model R-Square
MODEL 2 + H (TV watching)					2.08	0.064	0.166
MSJ	61.7 ± 5.6	0.63	5.74	0.914			
MSj	60.9 ± 2.5	-0.19	3.52	0.957			
MsJ	55.5 ± 2.4	-5.63	3.15	0.080			
Msj	61.1 ± 2.6	0.00	0.00	.			
mSJ	57.3 ± 3.5	-3.80	4.12	0.361			
mSj	62.5 ± 2.1	1.41	3.01	0.641			
msJ	60.0 ± 4.0	-1.08	4.98	0.829			
msj	71.2 ± 5.5 *	10.08	5.43	0.070			
OVERALL MODEL: model 2 + E, F, G & H					1.09	0.385	0.284
MSJ	63.7 ± 5.1	2.37	5.38	0.661			
MSj	60.5 ± 2.3	-0.83	3.57	0.816			
MsJ	56.2 ± 2.4	-5.07	3.27	0.128			
Msj	61.3 ± 2.5	0.00	0.00	.			
mSJ	56.4 ± 3.6	-4.87	4.18	0.249			
mSj	61.6 ± 1.9	0.25	2.88	0.931			
msJ	61.7 ± 4.2	0.40	5.02	0.936			
msj	59.6 ± 6.1	-1.70	6.24	0.786			

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872).

[2] The beverage pattern is the combination of beverages most frequently reported in the FFQ. Capital letters M, S and J refer to intakes of milk, sugar-sweetened beverages and juice, respectively, each having a share ≥25% of total beverage frequency, and lowercase letters m, s and j represent intakes less than the specified amount

*** p< 0.01, **p<0.05, *p<0.10 for contrast of beverage pattern to 'milk & juice' (MsJ)

[3] Wald F and p-value for the overeall beverage pattern effect

[4] Characteristics pertaining to social economic status (SES) include household size, income, and gender, age, marital status, education and employment of the household head

of the household head, were added to Model 1. Weight loss behavior increased the R-square to ~17%, compared to ~4-5% of the variance explained with physical activity or TV watching each added individually to Model 1.

To examine the effects of adding SES, weight loss behavior, physical activity and TV watching individually and incrementally to an adjusted model, Model 2 was formed from Model 1 plus parents' weight status and other model components. Model 2 explained >15% of the variance in the BMI percentile, and the overall beverage pattern effect was significant at the p=0.005 level.

When SES was added to Model 2, the association between the BMI percentile and beverage patterns became significant at the p<0.1 level only (Wald F p=0.075), and the effects of the 'sugar-sweetened beverage' (mSj) pattern disappeared. On the other hand, effects of the 'other beverage' (msj) pattern disappeared, while the BMI percentile of 'sugar-sweetened beverage' (mSj) pattern was still higher than the 'milk & juice' (MsJ) pattern (p<0.1) when weight loss behavior was added to Model 2. Adding weight loss behavior increased the R-square by more than 10% from 15.5% for Model 2 to 26% of the variance explained. The additional variance explained was less than 1% when physical activity and TV watching were each added individually to Model 2. Physical activity and TV watching were similar to SES in the way that these covariates changed the association between beverage patterns and the BMI percentile. No association between beverage patterns and BMI percentile was observed in the overall model formed by adding SES, weight loss behavior, physical activity and TV watching together to Model 2.

Percentage Body Fat

Linear regression models of beverage pattern effects on percentage body fat are shown in **Table 4**. In these analyses, beverage pattern effects were mainly due to an association of percentage body fat with the 'other beverages' patterns (msJ and msj). Effects of 'sugar-sweetened beverage' patterns were not significant in either the unadjusted or adjusted models.

In the unadjusted model (Model 1), beverage variables explained 3.7% of the variance in percentage body fat, and in the adjusted model (Model 2), the R-square increased to 21.4% of the variance explained. Adding weight loss behavior to Model 2 increased the R-square by more than 15% to almost 37% variance explained. With this adjustment, the percentage body fat in the 'other beverages' groups (msJ and msj) was lower than in Model 2, and no longer significantly different from the 'milk & juice' (MsJ) pattern.

SES, physical activity and TV watching were similar in the way that these covariates made adjustments to Model 2. The percentage body fat of the 'milk & juice' (MsJ) group was slightly higher than in Model 2 with adjustments for SES, physical activity or TV watching. The Wald F was still significant with physical activity added to Model 2, but there was no effect of beverage patterns in the overall model when SES, weight loss behavior and TV watching were added as well.

Table 4. Building the linear regression model of the effects of beverage pattern on percentage body fat in adolescents age 12-16 years[1]

Model Beverage Pattern[2]	Body Fat (%) Least Square Mean ± SE		Beta Coeff.	SE Beta	P-value T-test H_0: B=0	Wald F[3]	P-value Wald F[3]	Model R-Square
MODEL 1: beverage pattern, water & milk type						4.57	0.001	0.037
MSJ	22.5 ± 1.9		0.03	2.19	0.989			
MSj	21.7 ± 1.0		-0.74	1.59	0.644			
MsJ	20.5 ± 0.9		-1.95	1.38	0.163			
Msj	22.4 ± 1.3		0.00	0.00	.			
mSJ	22.0 ± 1.6		-0.43	2.13	0.842			
mSj	23.0 ± 1.0		0.54	1.46	0.713			
msJ	26.8 ± 1.2	***	4.34	1.91	0.027			
msj	31.9 ± 2.9	***	9.43	3.27	0.006			
MODEL 1 + A (gender, age, ethnicity & sexual maturation)						3.19	0.007	0.176
MODEL 1 + B (region & rural/urban area)						3.96	0.002	0.041
MODEL 1 + C (parent's weight status)						4.27	0.001	0.063
MODEL 1 + D (smoking, alcohol & drug use)						5.30	0.000	0.054
MODEL 1 + E (SES[3])						4.46	0.001	0.078
MODEL 1 + F (trying to lose weight)						2.55	0.025	0.267
MODEL 1 + G (physical activity)						2.70	0.019	0.039
MODEL 1 + H (TV watching)						4.49	0.001	0.045
MODEL 2: model 1 + A, B, C & D						2.85	0.014	0.214
MSJ	22.9 ± 2.1		0.53	2.24	0.815			
MSj	22.7 ± 1.0		0.33	1.50	0.826			
MsJ	20.6 ± 0.8		-1.79	1.31	0.178			
Msj	22.4 ± 1.2		0.00	0.00	.			
mSJ	21.4 ± 1.0		-0.96	1.43	0.504			
mSj	22.6 ± 0.9		0.16	1.31	0.906			
msJ	24.5 ± 1.1	**	2.15	1.66	0.202			
msj	30.5 ± 3.1	**	8.11	3.43	0.022			

Table 4, cont'd.

Model Beverage Pattern[2]	Body Fat (%) Least Square Mean ± SE		Beta Coeff.	SE Beta	P-value T-test H_0: B=0	Wald F[3]	P-value Wald F[3]	Model R-Square
MODEL 2 + E (SES[3])						2.88	0.013	0.286
MSJ	23.1 ± 2.1		1.75	2.07	0.401			
MSj	22.4 ± 0.9		1.03	1.23	0.406			
MsJ	21.2 ± 0.7		-0.14	0.94	0.881			
Msj	21.4 ± 0.7		0.00	0.00	.			
mSJ	21.5 ± 1.0		0.14	1.14	0.901			
mSj	22.1 ± 0.9		0.77	1.10	0.488			
msJ	25.8 ± 1.3	**	4.47	1.39	0.002			
msj	29.5 ± 2.8	**	8.19	2.90	0.007			
MODEL 1 + F (trying to lose weight)						2.27	0.044	0.370
MSJ	23.6 ± 1.8		0.97	1.78	0.588			
MSj	23.0 ± 0.9		0.36	1.13	0.752			
MsJ	21.0 ± 0.9		-1.65	1.03	0.117			
Msj	22.7 ± 0.8		0.00	0.00	.			
mSJ	20.9 ± 1.0		-1.76	1.20	0.148			
mSj	22.1 ± 0.9		-0.59	1.11	0.601			
msJ	24.3 ± 1.4		1.63	1.71	0.346			
msj	26.7 ± 2.3		4.04	2.58	0.124			
MODEL 2 + G (physical activity)						1.78	0.113	0.246
MSJ	22.9 ± 2.1		1.03	2.17	0.636			
MSj	22.7 ± 0.9		0.85	1.41	0.551			
MsJ	21.3 ± 0.9		-0.53	1.31	0.689			
Msj	21.8 ± 1.1		0.00	0.00	.			
mSJ	22.1 ± 1.0		0.21	1.40	0.882			
mSj	22.6 ± 0.9		0.72	1.29	0.579			
msJ	24.6 ± 1.1		2.78	1.58	0.085			
msj	29.8 ± 2.9	**	7.95	3.21	0.017			

Table 4, cont'd.

Model Beverage Pattern[2]	Body Fat (%) Least Square Mean ± SE		Beta Coeff.	SE Beta	P-value T-test H_0: B=0	Wald F[3]	P-value Wald F[3]	Model R-Square
MODEL 2 + H (TV watching)						2.13	0.058	0.231
MSJ	23.1 ± 2.2		0.53	2.31	0.819			
MSj	22.5 ± 1.0		-0.10	1.43	0.946			
MsJ	21.2 ± 0.8		-1.41	1.26	0.267			
Msj	22.6 ± 1.2		0.00	0.00	.			
mSJ	21.4 ± 1.0		-1.22	1.43	0.397			
mSj	22.3 ± 0.9		-0.30	1.30	0.818			
msJ	24.3 ± 1.2		1.74	1.73	0.320			
msj	29.9 ± 3.0	**	7.33	3.33	0.032			
OVERALL MODEL: model 2 + E, F, G & H						1.78	0.114	0.416
MSJ	24.1 ± 1.9		2.46	1.86	0.193			
MSj	22.4 ± 0.8		0.73	1.11	0.513			
MsJ	22.1 ± 0.8		0.48	1.01	0.635			
Msj	21.6 ± 0.6		0.00	0.00	.			
mSJ	21.3 ± 0.9		-0.35	1.05	0.738			
mSj	21.7 ± 0.8		0.04	0.93	0.965			
msJ	25.6 ± 1.3		3.97	1.45	0.009			
msj	25.1 ± 1.9		3.52	2.07	0.095			

[1] Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872).

[2] The beverage pattern is the combination of beverages most frequently reported in the FFQ. Capital letters M, S and J refer to intakes of milk, sugar-sweetened beverages and juice, respectively, each having a share ≥25% of total beverage frequency, and lowercase letters m, s and j represent intakes less than the specified amount

*** p< 0.01, **p<0.05, *p<0.10 for contrast of beverage pattern to 'milk & juice' (MsJ)

[3] Wald F and p-value for the overeall beverage pattern effect

[4] Characteristics pertaining to social economic status (SES) include household size, income, and gender, age, marital status, education and employment of the household head

Overweight/Risk for Overweight

Table 5 shows the odds ratios for overweight/risk for overweight (≥85th percentile) in each beverage pattern group. Compared to the 'milk' (Msj) group (reference category), the odds ratio for overweight/risk for overweight was low in the 'milk & juice' (MsJ) group (OR=0.52, 95% CI = 0.28-0.96), while the 'other beverage' (msj) group was more likely to be at risk for overweight or overweight (OR=2.74, 95% CI = 1.12-6.68). Although the linear regression analyses of BMI percentile showed effects of 'sugar-sweetened' beverage patterns, none were observed in these logistic regression models.

When SES was added to Model 2, the odds ratio for the 'other beverage' pattern (OR=2.47, 95% CI = 1.03-5.87), but not the 'milk & juice' pattern (OR=0.52, 95% CI = 0.25-1.11), was significant, while the Wald F for the overall beverage pattern effect became significant at the p<0.01 level. The opposite was true of weight loss behavior. When weight loss behavior was added to Model 2, the odds ratio for the 'milk & juice' pattern (OR=0.47, 95% CI = 0.23-0.97), but not the 'other beverage' pattern (OR=1.62, 95% CI = 0.65-4.02), was significant, even though the Wald F for the overall beverage pattern effect was no longer significant (p>0.2).

Physical activity and TV watching were similar to SES in their effects. When either of these covariates were added to Model 2, the odds ratio for the 'other beverage' pattern, but not the 'milk & juice' pattern, was significant. The Wald F was no longer significant with TV watching added to Model 2. There were no further associations of beverage patterns with overweight/risk in the overall model formed by adding SES, weight loss behavior, physical activity, and TV watching together to Model 2.

Table 5. Building the logistic regression model of the effects of beverage pattern on the likelihood of overweight/risk for overweight in adolescents age 12-16 years[1,2]

Model component Beverage pattern[3]	Odds Ratio[4]	Lower Limit[4]	Upper Limit[4]	Wald F[5]	P-value Wald F[5]
MODEL 1: beverage pattern, water & milk type				2.85	0.0142
MSJ	0.95	0.39	2.30		
MSj	0.94	0.50	1.78		
MsJ	0.52	0.28	0.96		
Msj	1.00	1.00	1.00		
mSJ	0.89	0.43	1.81		
mSj	1.14	0.67	1.92		
msJ	0.97	0.42	2.20		
msj	2.74	1.12	6.68		
MODEL 1 + A (gender, age, ethnicity & sexual maturation)				2.33	0.0393
MODEL 1 + B (region & rural/urban area)				2.63	0.0216
MODEL 1 + C (parent's weight status)				3.12	0.0084
MODEL 1 + D (smoking, alcohol & drug use)				3.24	0.0066
MODEL 1 + E (SES[5])				3.13	0.0083
MODEL 1 + F (trying to lose weight)				1.80	0.1082
MODEL 1 + G (physical activity)				1.88	0.0929
MODEL 1 + H (TV watching)				2.13	0.0581
MODEL 2: model 1 + A, B, C & D				2.55	0.0256
MSJ	0.88	0.31	2.52		
MSj	0.99	0.47	2.06		
MsJ	0.50	0.26	0.99		
Msj	1.00	1.00	1.00		
mSJ	0.87	0.44	1.73		
mSj	1.13	0.66	1.93		
msJ	1.02	0.45	2.32		
msj	2.91	1.21	6.96		

Table 5, cont'd.

Model component Beverage pattern[3]	Odds Ratio	Lower Limit	Upper Limit	Wald F[4]	P-value Wald F[4]
MODEL 2 + E (SES[6])				3.65	0.0030
MSJ	1.19	0.42	3.34		
MSj	1.00	0.46	2.18		
MsJ	0.52	0.25	1.11		
Msj	1.00	1.00	1.00		
mSJ	0.87	0.46	1.65		
mSj	1.18	0.64	2.20		
msJ	1.28	0.51	3.22		
msj	2.47	1.03	5.87		
MODEL 1 + F (trying to lose weight)				1.42	0.2193
MSJ	0.93	0.35	2.51		
MSj	0.97	0.46	2.01		
MsJ	0.47	0.23	0.97		
Msj	1.00	1.00	1.00		
mSJ	0.77	0.38	1.55		
mSj	1.02	0.59	1.75		
msJ	0.98	0.40	2.44		
msj	1.62	0.65	4.02		
MODEL 2 + G (physical activity)				1.96	0.0799
MSJ	0.97	0.33	2.89		
MSj	1.09	0.51	2.30		
MsJ	0.64	0.33	1.25		
Msj	1.00	1.00	1.00		
mSJ	1.15	0.58	2.28		
mSj	1.29	0.75	2.22		
msJ	1.15	0.49	2.72		
msj	2.80	1.12	6.96		

Table 5, cont'd.

Model component Beverage pattern[3]	Odds Ratio	Lower Limit	Upper Limit	Wald F[4]	P-value Wald F[4]
MODEL 2 + H (TV watching)				1.64	0.1465
MSJ	0.88	0.30	2.60		
MSj	0.92	0.44	1.92		
MsJ	0.54	0.28	1.06		
Msj	1.00	1.00	1.00		
mSJ	0.84	0.44	1.60		
mSj	1.04	0.60	1.82		
msJ	0.95	0.39	2.34		
msj	2.56	1.04	6.34		
OVERALL MODEL: model 2 + E, F, G & H				1.35	0.2471
MSJ	1.46	0.53	3.99		
MSj	0.94	0.42	2.12		
MsJ	0.58	0.24	1.38		
Msj	1.00	1.00	1.00		
mSJ	0.94	0.48	1.84		
mSj	1.09	0.58	2.04		
msJ	1.32	0.43	4.05		
msj	1.09	0.38	3.07		

1 Source: NHANES III, 1988-1994, adolescents aged 12-16 years, with complete, reliable 24-hr recall dietary interview, and no missing or unknown responses to beverage items on FFQ, excluding pregnant or lactating females (n=1,872).

2 The beverage pattern is the combination of beverages most frequently reported in the FFQ. Capital letters M, S and J refer to intakes of milk, sugar-sweetened beverages and juice, respectively, each having a share ≥25% of total beverage frequency, and lowercase letters m, s and j represent intakes less than the specified amount

3 Overweight/risk for overweight defined by BMI ≥85th percentile of BMI-for-age

4 Shaded odds ratio (95% confidence interval) is significantly different from 1.0 ($p<0.05$)

5 Wald F and p-value for the overall beverage pattern effect

6 Characteristics pertaining to social economic status (SES) include household size, income, and gender, age, marital status, education and employment of the household head

DISCUSSION

This study provides much needed data regarding interrelationships between sociodemographic/lifestyle factors, beverage patterns and adolescent obesity in the U.S. That low least square (LS) mean BMI percentile, percentage body fat, and the odds ratio for overweight/risk for overweight in the 'milk & juice' group were adjusted upwards when covariates were added to the models indicated that the 'milk & juice' pattern was associated with high levels of SES and physical activity, and with low levels of TV watching. Adjustments for the effects of covariates that reduced the high LS mean BMI percentile of the 'sugar-sweetened beverage' group indicated that the 'sugar-sweetened beverage' pattern was associated with low levels of SES and physical activity, and with high levels of TV watching. These results were consistent with other analyses of soft drinks and BMI controlled for income, sports team participation and watching TV (Forshee & Storey, 2003; Forshee et al., 2004).

An increased prevalence of overweight among low-income adolescents may be due in part to the quality of their diets, when primarily less expensive, energy-dense foods and beverages are consumed (Alaimo et al., 2001; Drewnowski & Specter, 2004; Drewnowski & Darmon, 2005). Additionally, low-income adolescents living in urban environments might watch TV, if they have few opportunities to be physically active (Elkins et al., 2004). Compounding such sedentary behavior is the fact that soft drinks are frequently consumed while watching TV (Coon et al., 2001; Giammattei et al., 2003; Utter et al., 2003; Matheson et al., 2004; Phillips et al., 2004). Sugar-sweetened beverage consumption and physical inactivity have been associated with poverty among adolescents age 12-17 years in NHANES, 1999-2002 (Miech et al., 2006). Still, it is unclear whether disparities across poverty groups in overweight prevalence are driven by the social environment, built environment, income and education of parents *and/or* familial food and physical activity preferences and practices (Link & Phelan, 1995; Diez Roux, 2005; Sallis & Glanz, 2006; Gordon-Larsen et al., 2003).

Research showing the effects of SES on adolescent overweight suggested that poverty was associated not only with sugar-sweetened beverage consumption and physical inactivity, but with breakfast skipping as well (Miech et al., 2006). In analyses of NHANES III data, eating breakfast some days or every day was associated with normal body weight only among adolescents having one or two obese parents (Fiore et al., 2006). Parental overweight/obesity was a potential covariate considered in the current analyses as well.

The current analyses of beverage patterns and adolescent obesity were not adjusted for the effects of breakfast consumption habits. There were several reasons for excluding this potential covariate from analyses. First, the association between breakfast skipping and overweight has not been firmly established (Berkey et al., 2003; Rampersaud et al., 2005), and other NHANES III analyses of the association of beverages and overweight have also omitted breakfast habits from their models (Forshee & Storey, 2003; Forshee et al., 2004). Second, preliminary research (Chapter 4, Table 6) and other analyses of beverages consumed by adolescents (Guenther et al., 1986; Bowman et al., 2002) suggested that the 'milk & juice' pattern would be a good indicator of breakfast consumption, and breakfast habits might then 'over-control' the potential association of the 'milk & juice' pattern with overweight.

Preliminary analyses of the frequency with which adolescents consumed beverages at the various meal occasions demonstrated that milk and juice were most frequently consumed at the breakfast meal occasion (Chapter 4, Table 6). In 1977-78, the shares of milk and juice consumed at breakfast were 38% and 76%, respectively (Guenther et al., 1986). Drinking juice was highly specific to the breakfast occasion (Guenther et al., 1986). Among adolescent girls age 12-19 years, between 36-44% of non-milk drinkers did not eat breakfast, compared to 11-12% of milk drinkers (Bowman et al., 2002). Thus, consumption of both milk and juice is likely a good indicator that the youth ate breakfast.

The model shown in **Figure 1** depicts how the beverage pattern assignment can be a marker for meal situation variables, such as the meal occasion (e.g., breakfast, lunch, dinner, snack) and meal location (e.g., home or places away from home such as school or a fast food restaurant) that hypothetically determine which beverages are frequently consumed by youth. Because milk and 100% fruit juice were frequently consumed at breakfast (Chapter 4, Table 6), breakfast-eating habits might determine whether youth were classified as milk and 100% fruit juice consumers.

Beverage patterns were defined *a priori* to classify youth into mutually exclusive groups according to the combination of beverages he/she most frequently consumed. Only one other researcher has classified youth by consumption of milk and/or soft drinks (Bowman et al., 2002), but the current study differed by using FFQ rather than 24-hour recall data, and also controlled for juice consumption while contrasting beverage pattern groups to determine effects of the various types of beverages. Cluster analysis could have been used to empirically derive beverage patterns and classify youth into mutually

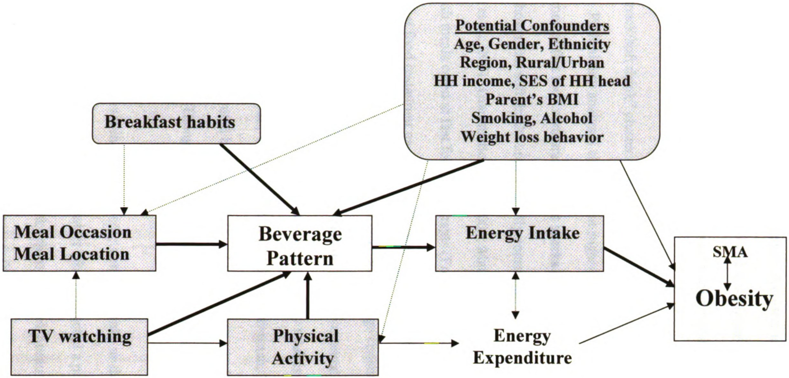

Figure 1. Conceptual model for the association of beverage patterns with obesity

exclusive groups (Kant, 2004), but each individual would not have necessarily consumed all beverages that characterized his/her cluster. A cluster analysis of water, beverages and selected foods consumed by adults showed that higher-educated, older adults (>60 years) were more likely to be grouped with a ''water/fruit & vegetable/low fat milk'' cluster, while young adults (18-35 years) were more likely to be grouped with a "fast food/snack/soft drink" cluster (Popkin et al., 2005).

Preliminary analyses showed that sugar-sweetened beverages were frequently consumed at fast food restaurants and at snacks (Chapter 4, Table 6). Other researchers have shown that soft drinks are frequently consumed while snacking and watching TV (Coon et al., 2001; Giammattei et al., 2003; Matheson et al., 2004; Phillips et al., 2004), and with meals eaten at fast food restaurants (French et al., 2001b; Bowman et al., 2004). Thus, fast food restaurant use, TV watching and snack-eating habits might determine whether youth are classified as sugar-sweetened beverage consumers. Youth who are characterized by beverage patterns that include sugar-sweetened beverages might be more overweight than other youth because of the energy intakes contributed by these beverages (Harnack et al., 1999; Troiano et al., 2000; Bowman, 2002), or because of the energy intakes contributed by snack foods and fast foods typically consumed with sugar-sweetened beverages (Hampl et al., 2003; Utter et al., 2003; Bowman et al., 2004; Phillips et al., 2004).

The model shown in **Figure 1** depicts energy intake as the mediator between beverage patterns and obesity. Investigators who conducted a prospective study of preschool children excluded energy intake from analyses, because it was the mediating variable in the pathway between the exposure (beverage consumption) and the outcome (changes in weight or BMI) (Newby et al., 2004). For this reason, energy intake was excluded from the current analyses. Instead, the mean energy intake of beverage pattern groups was examined in a separate study (Chapter 4, Table 7). In the current study, youth classified by beverage patterns associated with fast food restaurant use or snacking behavior might be more overweight than youth classified by beverage patterns associated with breakfast consumption, due to potential energy intake differences between the beverage pattern groups.

Inverse associations of the 'milk & juice' pattern with BMI percentile, percentage body fat, and overweight/risk for overweight were observed in the current study. Weight loss behavior was included in the current study to examine whether the correlation between overweight and 'milk & juice' was due to overweight youth skipping breakfast to lose weight. College women have reported that they skipped breakfast as a weight loss strategy (Malinauskas et al., 2006), even though breakfast skipping might lead to weight gain over time (Berkey et al., 2003). Breakfast skippers in a longitudinal study tended to gain more weight (measured as BMI) than regular breakfast eaters, but only among normal-weight subjects; BMI decreased in overweight adolescents who skipped breakfast (Berkey et al., 2003).

Potential confounding provides another explanation for the inverse association of the 'milk & juice' pattern with overweight. Other research suggested that breakfast consumption might be associated with components of a healthy lifestyle such as high levels of physical activity (Cavadini et al., 2000b; Keski-Rahkonen et al., 2003; Godin et al., 2005). In preliminary analyses, the 'milk and juice' pattern was associated not only with regular breakfast consumption, but also with high SES and other healthy behaviors like exercise and not watching TV (Chapter 5, Table 2), and these other factors could account for the association between the 'milk & juice' pattern and the low prevalence of overweight. In the current analyses, effects of the 'milk & juice' pattern were no longer significant when indicators of SES, physical activity and TV watching were added to the models.

In this study, sports team participation was associated with obesity outcomes, but exercise was not (data not shown), similar to another study using NHANES III data (Crespo et al., 2001). Others have omitted the exercise variable and used only the measurement of team sports participation to examine the relationship between physical activity and BMI (Forshee et al., 2004). Exercise has been positively associated with the prevalence of normal BMI in analyses of CSFII data (Boumtje et al., 2005).

In cross-sectional analyses, the associations of obesity outcomes with lifestyle factors like exercise, smoking and dietary patterns should be interpreted with caution. Because cross-sectional data lack temporality, reverse causality must be considered when interpreting these observations, i.e., overweight youth might be exercising to lose weight. The association of smoking with overweight might also be due to reverse causality. Youth who reported they were trying to lose weight were more likely to smoke (French et al., 1994; Austin et al., 2001; Lowry et al., 2002; Delnevo et al., 2003).

The association of the 'other beverages' pattern with obesity outcomes was another example of reverse causality. As indicated by preliminary analyses of beverage frequency, the 'other beverages' groups drank 'diet' soft drinks, coffee and tea more frequently than the 'caloric beverages' groups (Chapter 4, Table 5), and a high percentage of youth in the 'other beverages' group reported trying to lose weight

(Chapter 5, Table 2). Rather than causing overweight, drinking 'diet' soft drinks was possibly related to the weight loss efforts of the 'other beverages' group. In the current study, the association of the 'other beverages' group with obesity outcomes was no longer statistically significant when analyses controlled for youth who were trying to lose weight. Drinking "diet" beverages or bottled water instead of sugar-sweetened beverages decreased BMI among those in the upper BMI tertile at baseline in a 25-week intervention study of non-dieting youth age 13-18 years (Ebbeling et al., 2006).

Strengths and Limitations

The anthropometric and dietary assessment methods were the major strengths of this study. The youth's BMI percentile was calculated from measured height and weight using the gender-specific BMI-for-age percentile reference data provided by the CDC Growth Charts. In addition, a measure of percentage body fat was used to assess body composition. Youth were classified into beverage pattern groups according to their 'usual' beverage intakes reported using the FFQ. Because of intra-individual variation in dietary intake, youth might have been misclassified to beverage patterns if a single 24-hour recall were used instead of the FFQ. Therefore, an assessment of 'typical' beverage patterns (i.e., 'usual' intake) should strengthen the relationship of beverage consumption with obesity outcomes. In addition, misclassification to beverage pattern groups due to under-reporting in response to the FFQ was addressed by identifying most frequently consumed beverage types based on their percentage share of total beverage frequency. Rather than using the beverage frequency to identify youth who reported consumption ≥1 time/day, for example, youth were classified by the combination of beverages consumed with shares ≥25% of total beverage frequency. If frequency-based criteria were used, youth who reported drinking all caloric beverage types <1 time/d would have been classified to the 'other beverages' (msj) pattern, and these "under-reporters" were removed from this group by using consumption criteria based on the percentage share. Avoiding potential bias due to under-reporting was important to the design of this study, because overweight youth might be more likely to under-report beverage consumption (Bandini et al., 1990; Johnson et al., 1996; Johnson, 2000).

There were several limitations that pertain to the current analyses. Some youth might have been misclassified to a 'juice' group, if they mistakenly reported fruit drink frequency in response to the 100% fruit juice question, because the fruit juice question was sequenced before the question about fruit drinks in the FFQ. Beverage items in the FFQ did not distinguish sugar-sweetened coffee/tea from coffee/tea consumed without added sugar. Therefore, the 'other beverages' group might have included both sugar-sweetened coffee/tea consumers and diet soft drink consumers. Effects of sugar-sweetened beverages on overweight might have been diluted by misclassification. In addition, there were four separate patterns that included sugar-sweetened beverages compared to the 'milk & juice' pattern, and it might be necessary to collapse these four patterns to identify a potential association between sugar-sweetened beverages intake and obesity in youth.

Implications

This study suggests that several sociodemographic/lifestyle factors examined are highly correlated with beverage patterns, and together these sociodemographic/lifestyle factors and beverage patterns are associated with adolescent obesity. The interrelationships between sociodemographic/lifestyle factors and beverage patterns must be carefully considered to elucidate the potential role each specific etiologic factor has in increasing the prevalence of adolescent overweight.

Chapter 7

CONCLUSION

The concluding chapter provides a summary of key findings, and an assessment of the overall strengths and limitations of this research. The chapter concludes with implications for future research suggested by findings from this dissertation.

A. Summary of Findings

The aims of this research were to examine the associations of beverages with the meal context; to examine the associations of beverage patterns (i.e., types of beverages most frequently consumed) with dietary intake and sociodemographic/lifestyle risk factors for overweight; and to examine associations of beverage patterns with BMI percentile, percentage body fat and overweight/risk for overweight, adjusted for potential covariates of interest. Youth were classified by their 'typical' beverage pattern using the 'share' method to identify the combination of beverage types (i.e., milk, juice and/or sugar-sweetened fruit drinks/soft drinks) that were each reported frequently (i.e., beverage frequency 'share' ≥25% of the total beverage frequency) in a food frequency questionnaire.

A key, and somewhat unexpected, finding of this study was that the 'milk & juice' pattern, not the 'milk' pattern, was inversely associated with the BMI percentile and percentage body fat in most adjusted regression models. In addition, the odds ratio for overweight/risk for overweight was low in the 'milk & juice' group, compared to the 'milk' group, but these effects disappeared when the models were adjusted for SES, physical activity (i.e., exercise and sports team participation) or TV watching.

Another key finding pertaining to 'milk & juice' was that this pattern was associated with breakfast consumption. Milk and juice were consumed frequently at the breakfast meal, and a high percentage of the 'milk & juice' group reported eating breakfast daily. The 'milk & juice' pattern was also positively associated with exercise and sports team participation, and inversely with TV watching. In addition, the 'milk & juice' pattern was positively associated with income, suggesting that income might also be associated with breakfast consumption and other lifestyle factors correlated with the 'milk & juice' pattern.

Sugar-sweetened beverages were consumed more frequently at the snack occasion than at meals. In addition, soft drinks were consumed more frequently than other beverages at fast food restaurants. Energy intakes did not differ between beverage pattern groups, but 'sugar-sweetened beverages' groups had higher added sugars and lower calcium intakes than 'milk' groups. The 'sugar-sweetened beverages' pattern was positively associated with BMI percentile after adjusting for physical activity, but not after adjusting for TV watching, suggesting that watching TV was strongly associated with intakes of soft drinks for overweight youth in this study. That sugar-sweetened beverage patterns were associated inversely with income, and positively with watching TV, suggests that income might be inversely associated with watching TV as well.

The 'other beverages (diet soft drinks, coffee and tea)' pattern was positively associated with both BMI percentile and percentage body fat. In addition, the odds ratio for overweight/risk for overweight was high in the 'other beverages' group, compared to the 'milk' group. However, a high percentage of youth in the 'other beverages' group reported that they were trying to lose weight. Together, these findings indicate that overweight youth were drinking diet sodas to lose weight. Cigarette smoking was also prevalent among those youth in the 'other beverages' group. In addition, energy and calcium intakes were lower, and caffeine intakes were higher in 'other beverages' groups than in 'caloric beverages' groups. However, mean intakes of the 'other beverages' group should be interpreted with caution, because the sample size of this group, in particular, was relatively small (n=55).

B. Strengths and Limitations

Strengths of this study include the methods used to assess overweight and adiposity in adolescents. Cross-sectional studies using the Continuous Survey of Food Intake by Individuals (CSFII) data to examine the association of beverage intakes with BMI or overweight in adolescents (Forshee & Storey, 2003; Boumtje et al., 2005) were limited in that self-reported information rather than measured height and weight were used to compute BMI (Kuczmarski et al., 2001; Brener et al., 2003). In addition, analyses of children or adolescents using National Health and Nutrition Examination Survey (NHANES) data that examined BMI in relation to beverage intakes (Forshee & Storey, 2003; Forshee et al., 2004) were limited, because BMI was not adjusted for gender and age using the CDC Growth Charts reference data (Kuczmarski et al., 2000; Bachman et al., 2006). In the current study, BMI percentile was calculated from measured height and weight using the gender-specific BMI-for-age percentile reference data provided by the CDC Growth Charts, because criteria based on the BMI-for-age percentiles were recommended to assess overweight/risk for overweight in children and adolescents (Kuczmarski et al., 2000). In addition, percentage body fat was determined from summed triceps and subscapular skinfold measurements (Slaughter et al., 1988), because BMI does not accurately assess body composition, e.g., overweight youth with a high proportion of lean body mass are not overfat (Forbes, 1987).

Cross-sectional studies using 24-hour recall data available from CSFII or NHANES (Forshee and Storey, 2003; Forshee et al., 2004; Boumtje et al., 2005) might have been limited by inaccurate assessment of beverage consumption due to intra-individual variation in intake (Beaton et al., 1979; Sempos et al., 1985). When intake of an individual is assessed, intra-individual variation can be addressed by averaging repeated measurements obtained from multiple 24-hour recall interviews or by asking the individual to average his/her intake over multiple days in response to a FFQ.

When the mean nutrient intake of a group is estimated using a random sample of the population like that found in the national surveys, intra-individual variation is addressed through the use of a random process, according to the stochastic model (Parzen, 1962). In the stochastic model, because of the random process, theoretically, each sample person in a group represents a repeated measurement obtained from the average individual characterized by that group (Parzen, 1962). The mean nutrient intake of a group is not biased by intra-individual variation, because it represents the mean of repeated measurements obtained from the average individual in the group.

Although the mean intake of the group is an unbiased estimate of the average individual's true mean intake (Guenther et al., 1997), intra-individual variation affects the precision of the mean estimate, and two groups are not significantly different if the within-group (or within-person) variation is larger than the between-group (or between-person) variation (Sempos et al., 1985). Increasing the sample size increases the precision of the estimate. Therefore, the variance in the estimate of the mean intake of a group is reduced when the sample size is large, as in the national surveys like NHANES.

In the current study, youth were classified into mutually exclusive groups according to the combinations of beverage types most frequently reported as 'usual' intake using a FFQ. The FFQ was comprehensive (i.e., all beverage items were included), but it had not been quantified or 'validated' to estimate nutrient intakes (Briefel, et al., 1992; Briefel, 1994). Youth were classified by beverage patterns to allow for the use of 24-hour recall data to estimate mean nutrient intake of beverage pattern groups, because the mean estimate for a group would not be biased by intra-individual variation (Guenther et al., 1997).

Beverage patterns were defined as combinations of beverage types so that independent effects of individual beverage types on energy intake or obesity outcomes could be determined through comparisons of various beverage pattern groups. In addition, using dummy variables to represent the beverage pattern groups instead of continuous measures of beverage intakes in the regression models addressed the potential for multicollinearity interfering with the investigation of obesity outcomes.

Youth were classified into beverage pattern groups according to their 'usual' beverage intakes reported using the FFQ. Because each individual was classified by his/her own beverage intakes, due to intra-individual variation in dietary intake, youth might have been classified incorrectly into beverage pattern groups if a single 24-hour recall were used instead. Therefore, assessing each youth's 'typical' beverage pattern using 'usual' intakes in the FFQ should strengthen the relationship of beverage consumption with sociodemographic/ lifestyle factors or obesity outcomes.

Under-reporting of intake was still a concern, however, as the Observing Protein and Energy Nutrition (OPEN) study has shown that it occurs when either the 24-hour recall or FFQ methods are used to assess intake (Subar et al., 2003). Avoiding potential bias due to under-reporting was important to the design of this study, because overweight youth might be more likely to under-report intake (Bandini et al., 1990; Johnson et al., 1996; Johnson, 2000). This study was limited by the potential bias due to under-reporting in estimating mean energy intakes of beverage pattern groups that were associated with overweight. Low energy intakes in the 'other beverages' group might be due to overweight youth trying to lose weight or under-reporting of intakes in the 24-hour recall dietary interview. In addition, if 'sugar-sweetened beverage' groups tended to be more overweight than 'milk' groups, then under-reporting among the 'sugar-sweetened beverage' groups could explain why there were no energy intake differences between these groups.

Misclassification to beverage pattern groups due to under-reporting in response to the FFQ was addressed by identifying most frequently consumed beverage types based on their percentage share of total beverage frequency. Rather than using the beverage frequency to identify youth who reported consumption ≥1 time/day, for example, youth were classified by the combination of beverages consumed with shares ≥25% of total beverage frequency. If frequency-based criteria were used, youth who reported drinking all caloric beverage types <1 time/d would have been classified to the 'other beverages' pattern, and these "under-reporters" were removed from this group by using consumption criteria based on the percentage share.

However, misclassification due to under-reporting may still be a concern if sugar-sweetened beverages were under-reported more often than milk or juice, for example. In the current study, overall, regular soft drinks were reported less often in the FFQ than in the 24-hour recall, while milk and juice frequencies were higher in the FFQ than in the 24-hour recall. If the percentage share of 'sugar-sweetened beverages' were under-reported in the FFQ, then youth might have been incorrectly classified to beverage pattern groups. Effects of drinking sugar-sweetened beverages on overweight might have been diluted, if youth were not classified correctly to 'sugar-sweetened beverages' groups.

Some sugar-sweetened beverage consumers might have been misclassified to a 'juice' group, if they mistakenly reported fruit drink frequency in response to the 100% fruit juice question, because the fruit juice question was sequenced before the question about fruit drinks in the FFQ. The 'sugar-sweetened beverage' category was limited to soft drinks and fruit drinks that contained added sugar. Sugar-sweetened coffee and tea were not included in the 'sugar-sweetened beverage' category, because the FFQ did not distinguish these beverage items from coffee and tea consumed without added sugar.

The FFQ instrument available in NHANES III was also limited because it had not been quantified or 'validated' to estimate energy intakes (Briefel, et al., 1992; Briefel, 1994). Although it was tested in the National Center for Health Statistics Cognitive Laboratory and pretested, the NHANES III FFQ was not 'validated' for nutrient intake estimates against another dietary method, because it was not intended for quantifying nutrient intakes (Briefel, personal communication). Further, the validity of the FFQ nutrient intake estimates, and the ability of respondents to appropriately respond to a FFQ in order to estimate quantities of foods consumed (e.g., "How often did you eat a ½ cup serving of broccoli over the past year?") has been called into question (Kristal et al., 2005). In addition, results of the OPEN study indicated that the low attenuation factor (0.04-0.16) observed with a single administration of a FFQ is not improved by repeat administration, but the attenuation factor for a single 24-hour recall (0.10-0.20) increases to 0.35-0.50 with four repeats (Schatzkin et al., 2003). These results from the OPEN study (Schatzkin et al., 2003) suggest that the 24-hour recall nutrient intake estimates would be more accurate than those obtained from a FFQ, if multiple days of 24-hour recall intake were available, unless the test-retest reliability of the FFQ can be improved (perhaps by reordering or clarifying the wording of the questionnaire items, for example). Results from a food-based validation study that examined frequency of food and beverage consumption from repeated FFQ and repeated 7-day records indicated intra-individual week-to-week variation in intake was lower for beverages than meat or vegetables (Salvini et al., 1989). Therefore, beverages may require fewer repeated measures than does food to reliably assess frequency of consumption (Salvini et al., 1989) using the 24-hour recall method. Results of this study also suggested that response to the FFQ tended to over-represent "socially desirable" foods (Salvini et al., 1989).

Because the FFQ instrument in NHANES III was not intended for quantifying nutrient intakes (Briefel, et al., 1992; Briefel, 1994), reference amounts customarily consumed (RACC) per eating occasion (Food and Drug Administration, 2002) were not given with instructions for the respondent to adjust his/her frequency response for intake amounts that were more or less than the RACC. Even if the caloric intake from beverages were estimated using the frequency response and the RACC, the analysis plan in the current study was to classify youth by the percentage of total beverage frequency rather than by the percentage of total calories in order to account for intakes of non-caloric beverages containing caffeine like coffee, tea, and diet soft drinks that might be associated with overweight. Classifying youth by beverage frequency or weighting the frequency by the RACC would have the same result, because the RACC, the serving size used for labeling purposes, is the same, 240 mL (8 fl oz), for carbonated beverages, noncarbonated beverages, milk and juice (Food and Drug Administration, 2002). If actual serving sizes that are larger than the RACC were more likely for carbonated soft drinks than for milk and juice, then the 'sugar-sweetened beverage' group would be more likely to have higher energy intakes from beverages than 'milk and juice' group. Because of intra-individual variation in the actual amounts consumed per eating occasion, it may be difficult for an individual to weight his/her frequency response by the number of recommended portions he actually consumed. Therefore, in the current study, energy intake from beverages was estimated using the 24-hour recall rather than the FFQ data. The mean intake of the beverage pattern group accounts for intra-individual variation, because it represents the mean of repeated measurements obtained from the average individual in the group.

The FFQ was limited in that it did not include a question about water intake. Water intake was also not assessed in the 24-hour recall dietary interview. Instead, youth were asked a separate question to estimate the amount (fluid ounces) of water they usually drink per day. Because water intake was not reported in terms of frequency (times/day), water intake could not be added to the total beverage frequency to adjust the beverage's percentage share for the amount of water consumed. If the 'milk and juice' group tended to drink more water, then presumably they would need to obtain less water for hydration from beverages and the total beverage frequency would be lower than the 'sugar-sweetened beverage' group. However, the FFQ had not been validated to estimate the amount of water obtained from beverages, and the question about water intake had not been validated either. Further, there was a concern that overweight youth might be biased toward under-reporting intake in the FFQ and over-reporting water intake at the same time. Therefore, youth were classified into beverage pattern groups according to the beverage's percentage share without adjusting for the total beverage frequency or amount of water consumed. Instead, the mean water intake and total beverage frequency of beverage pattern groups were examined separately, and the measure of association between beverage patterns and overweight/risk for overweight was adjusted for the amount of water consumed. Although there may have been a reporting bias, the estimates of the groups' mean water and beverage intakes were not biased by intra-individual variation.

Because the FFQ did not allow the respondent to indicate whether sugar was added to coffee or tea, the 'other beverages' group included both sugar-sweetened coffee/tea consumers and diet soft drink consumers, and risk factors might have varied widely between these subgroups. In addition, the 'juice' groups included both orange juice and apple juice consumers. Because the association between 100% fruit juice consumption and overweight/risk for overweight might depend on the type of juice usually consumed, it might be important to indicate whether it was citrus juice (e.g., orange juice and grapefruit juice) or non-citrus juice (e.g., grape juice, apple juice, cranberry juice and fruit nectars). On the other hand, because there were four separate patterns that included sugar-sweetened beverages and shared similar risk factors, it might be necessary to collapse them to identify a potential association between sugar-sweetened beverage consumption and obesity in youth.

The most important limitation of this study is that cross-sectional data lack temporality, and cannot be used to make causal inferences. Interpretation of results of this study was difficult when an unexpected finding could be explained by reverse causality. For example, when low calorie "diet" soft drinks were positively associated with body weight, there were two possible explanations to consider, i.e., "diet" soft drinks promote weight gain (which is contradictory to what was expected), or overweight youth drink "diet' beverages because they are trying to lose weight. Although these cross-sectional data cannot be used to establish which explanation for the positive association between "diet' soft drinks and body weight was correct, a theoretical model was proposed and the statistical analysis adjusted the measures of association for the body weight of youth who were trying to lose weight.

C. Implications

The frequency with which beverages were consumed in various meal settings was examined in this study, and youth were classified into beverage pattern groups according to the types of beverages he/she consumed most frequently. Because beverage choice was associated with the meal context, the beverage pattern could be used to indicate how often youth consume different types of meals (e.g., breakfast, snacks, meals eaten at fast food restaurants). Because milk and juice were both consumed more frequently with the breakfast meal than any other type of meal occasion, when an adolescent was classified by the 'milk & juice' pattern (by determining that he/she most frequently consumed milk and juice from 'usual' intakes reported in the FFQ) it was a good indication that he/she usually ate breakfast. A high percentage of the 'milk & juice' group (57%) reported that they ate breakfast every day.

The 'milk & juice' pattern and breakfast eating were both inversely associated with overweight/risk for overweight. These results provide additional support for health professionals to recommend that parents encourage youth to eat breakfast daily to reduce the risk for overweight in adolescence (Ritchie et al., 2005). The inverse associations of the 'milk & juice' pattern with indicators of adolescent obesity remained after controlling for youth who were trying to lose weight, which suggests that it's unlikely these results were due to reverse causality, i.e. overweight youth skipping breakfast to lose weight. Analyses of various sociodemographic/lifestyle risk factors for overweight that were associated with the 'milk & juice' pattern suggested that eating breakfast regularly was associated with other components of a healthy lifestyle like drinking reduced fat (2%) or low fat (1%) milk, exercising daily, and watching TV less than one hour per day. Thus, the 'milk & juice' pattern was effectively a marker for breakfast consumption and other components of a healthy lifestyle, and these lifestyle characteristics together with the 'milk & juice' pattern were inversely associated with adolescent obesity. The results of regression analyses that were adjusted for income suggested that youth in low-income households might be especially at risk for overweight if they skip breakfast and have low levels of physical activity.

Analyses of the meal context in which sugar-sweetened beverages were consumed indicated that fruit drinks and soft drinks were more frequently consumed at the snack/beverage occasion than with meals like breakfast, lunch or dinner, and soft drinks frequently accompanied meals eaten at fast food restaurants. Because youth were classified by beverage patterns according to the types of beverages he/she consumed most frequently, that sugar-sweetened beverages were associated with the snack occasion and meals eaten at fast food restaurants suggests that classification into the 'sugar-sweetened beverage' group was determined by how often youth eat snack foods and fast foods. Other researchers have shown that soft drinks are often consumed with pizza, chips, and fast food while viewing television (Coon et al., 2001; Matheson et al., 2004), and in the current study, the 'sugar-sweetened beverages' pattern was associated with TV watching. These results then suggest that snacks consumed while watching TV were likely to include soft drinks, consumed either alone as a snack/beverage or with other snack foods.

A pattern of consuming 'sugar-sweetened beverages' could potentially be a risk factor for overweight, because of the higher added sugar and lower calcium intakes in 'sugar-sweetened beverages' groups than in 'milk' groups, even though energy intakes did not differ. Because the 'sugar-sweetened beverages' pattern was associated with TV watching, regression analyses indicated that the 'sugar-sweetened beverages' pattern and TV watching were both positively associated with the BMI percentile. Results of regression analyses adjusted for income suggested that youth in low-income households might be especially at risk for overweight if they drink sugar-sweetened beverages and watch TV for 4 hours/day or more. These results provide additional support for health professionals to recommend that parents limit television-viewing time to reduce the risk for overweight in adolescence (Ritchie et al., 2005).

Because beverage choice was associated with the meal context, theses findings support that parents should establish regular meal times and encourage youth to limit the number of snacks consumed between meals. Family meals should be eaten while seated at a table rather than in front of a TV. Rather than serving foods and beverages typically consumed while watching TV, like fast foods, pizza and soft drinks (Coon et al., 2001; Matheson et al., 2004), the meal preparer should plan to serve foods and beverages that help youth meet the recommendations of the MyPyramid Plan (USDA, 2005). Because the typical adolescent should be consuming 3 cups of milk per day (USDA, 2005), it is important that milk is consumed at meal times. Because beverage choice might be limited in some settings, for example, only soft drinks might be available in fast food restaurants, a suggestion to intervene outside the home environment would be for policy-makers to develop and implement a marketing plan to offer alternative beverages with meals consumed away-from-home.

Although the 'other beverages (diet soft drinks, coffee and tea)' pattern was associated with adolescent obesity, results of this study suggested that this association was likely due to reverse causality, i.e., overweight youth were drinking 'diet' soda to lose weight. An intervention study has shown that replacing regular soft drinks with low-calorie soft drinks could potentially prevent weight gain in youth (Ebbeling et al., 2006). Health practitioners should note, however, that youth who diet to lose weight might be potentially at risk for developing unhealthy weight loss practices, like breakfast skipping, smoking cigarettes, using substances containing caffeine, fasting or purging (French et al., 1995; Krowchuk et al., 1998; French et al., 2001; Austin et al., 2001; Lowry et al., 2002; Delnevo et al., 2003, Malinauskas et al., 2006). Results of the current study suggested that consumption of 'other beverages' patterns might put youth at risk for inadequate calcium, potassium or vitamin D intakes.

D. Recommendations for Future Research

Analyses of beverage frequency reported in the FFQ and 24-hour recall suggested that youth should be educated to distinguish 100% fruit juice from fruit drinks that contain added sugars. It may also be necessary to distinguish citrus juice (e.g., orange juice) from non-citrus juice (e.g., apple juice, grape juice) when educating youth about the nutritional benefits of drinking 100% fruit juice. It may be important to know that orange juice is consumed more frequently than apple juice at the breakfast occasion, for example, to recommend that youth drink juice with breakfast. Therefore, future research recommendations are to separate the different types of juice in examining beverages consumed at the various meal occasions.

Future research should also examine the amounts of beverages consumed at the various meal occasions. In the current study, energy intakes from beverages in the total diet were examined. However, it may be useful to know that greater amounts of beverages are consumed at the snack occasion than at breakfast, for example. It's possible that drinking 'milk & juice' was inversely associated with overweight, because youth in the 'milk & juice' group drank the recommended ½ cup serving (USDA, 2005) of orange juice at breakfast. If large portions of apple juice are frequently consumed as snack/beverages throughout the day, consumption of excessive amounts of apple juice might be associated with a risk for overweight (Dennison et al., 1997; Dennison et al., 1999). Likewise, if large portions of sugar-sweetened beverages were consumed per occasion, increased energy intakes from beverages in the 'sugar-sweetened beverages' group could explain why this pattern was positively associated with the BMI percentile. Researchers should note the potential for bias in under-reporting intake in the 24-hour recall could still lead to null results.

The type of milk (e.g., whole, 2%, 1%, skim) usually consumed by beverage pattern groups was examined, and regression analyses adjusted for the type of milk when examining the associations of beverage patterns with obesity outcomes. If analyses were not adjusted for the type of milk, those beverage pattern groups that tended to consume whole milk might be associated with obesity. If these unadjusted analyses were replicated with the latest NHANES data, perhaps there would be significant differences in the risk for overweight between 'milk' and 'sugar-sweetened beverages' patterns, because the milk fat content is lower today than it was in NHANES III, 1988-94. In addition, replication of analyses of the association of beverages with away-from-home meal locations (e.g., school, fast food restaurants) might show that the school's share of the sugar-sweetened beverage consumption would be greater in NHANES, 1999-2004 than in NHANES III, 1988-94. These changes in the beverage market may affect the percentage of youth who are distributed among beverage pattern groups. Therefore, it is important to replicate this research using the most recent survey data.

The most recent NHANES data might have improved the assessment of physical activity by obtaining a complete inventory of activities, instead of including only the two items to assess exercise-induced sweating and sports team participation in youth. The assessment of 'screen' time might also be improved by including the use of video games and the computer in addition to television-viewing time. The dietary assessment methodology has also been improved in the most recent NHANES. If the second day of intake that was collected from respondents were available in the public-use dataset, then the 'usual' intake of the group could be assessed using the method developed at Iowa State University to adjust the intake distribution for intra-individual variation (Carriquiry, 1999; Carriquiry, 2003). It is necessary to estimate the 'usual' intake of the beverage pattern groups to assess the prevalence of inadequate nutrient intake using the Estimated Average Requirement and DRI-based methods (Suitor & Gleason, 2002). The NHANES, 2003-04, dataset will also include responses to a Food Propensity Questionnaire that was developed for use with two 24-hour recalls to improve the estimation of the 'usual' intake of food (Freedman et al., 2004; Subar et al., 2004; Tooze et al., 2005). Because the second day of intake was available for only 10% of the sample, it was not possible to estimate 'usual' intake in the current study. Therefore, it will be important to replicate this research using a dataset that has two days of 24-hour recall days for all respondents.

In the current study, the 'milk & juice' pattern was positively associated with physical activity and inversely associated with TV watching, while the 'sugar-sweetened beverages' pattern was positively associated with TV watching. In addition, the 'milk & juice' pattern was effectively a marker for breakfast consumption, and other researchers have shown that both breakfast skipping and TV watching are inversely associated with income (Miech et al., 2006). Therefore, further examination of TV watching and income is warranted in reanalyses of these data. The analyses of the current study included a test for an interaction between gender and beverage patterns, and because the interaction term was not significant, analyses were not stratified by gender. Future reanalyses of these data should test for an interaction and possibly stratify by levels of TV watching or by income. Because income and the household head's SES were significant in this study, it might be useful to separate the youth's race-ethnicity from other individual characteristics like age and gender when potential covariates are reexamined. Because there were four separate patterns that included sugar-sweetened beverages and shared similar risk factors, it might be necessary to collapse them to identify a potential association between sugar-sweetened beverage consumption and obesity in youth.

It was not clear from this study whether the low prevalence of overweight/risk for overweight in those who ate breakfast every day was due to beverage patterns (e.g., milk and juice consumption), other dietary patterns (e.g., food patterns or meal patterns), nutrient intakes (e.g., calcium intakes), sociodemographic/lifestyle factors (e.g., income and education of parents, exercise habits, sports team participation, TV watching), or more fundamental causes (e.g., neighborhood effects associated with SES). Therefore, further research in this area is recommended to clarify the inter-relationships between beverage patterns and other risk factors for overweight.

That 'milk & juice' was associated with breakfast and 'sugar-sweetened beverages' was associated with watching TV suggests beverage patterns, meal patterns, diet patterns and physical activity patterns are all inter-related, and the context in which beverages are consumed require further investigation. Because cross-sectional data cannot be used to make causal inferences, a prospective study is recommended for further research in this area. The FFQ is limited and could not be used to investigate meal patterns, while the potential for bias due to under-reporting of intake in the 24-hour recall remains. Therefore, continued improvement in dietary assessment methodology is essential to progress in this area of study.

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