EFFECTS OF MEAL FREQUENCY AND BREAKFAST CONSUMPTION ON NUTRITIONAL STATUS OF 9 TO 13 YEAR OLD CHILDREN

By

H.A. THUSHANTHI PERERA

Bachelor of Science in Agricultural Technology
and Management
University of Peradeniya
Peradeniya, Sri Lanka
2009

Master of Science in Food and Nutrition
Postgraduate Institute of Agriculture
University of Peradeniya
Peradeniya, Sri Lanka
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Thesis Approved:

Dr. Gail E. Gates

Thesis Adviser

Dr. Tay S. Kennedy

Dr. Lenka H. Shriver

Name: H.A. THUSHANTHI PERERA

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Abstract: Meal and snacking patterns are thought to influence body weight and nutrient intakes among children and adolescents. Snacking has increased in the United States over the last 25 years and became one of the major dietary behaviors of interest. Therefore, the objective of this study was to investigate the effects of meal and snacking frequency on energy, macronutrient and micronutrient intake, laboratory indicators, waist circumference and body mass index (BMI) z-scores among a cohort of nationally representative children. A sample of 1,261 9 to 13 year olds was selected from 2007-2010 National Health and Nutrition Examination Survey (NHANES). Two-day dietary data were extracted along with demographic data. Multivariate adjusted ANOVA and regression analyses were performed. Data were analyzed using SAS and SUDAAN. On average subjects reported a daily eating frequency of 4.35 with 2.4 snacking occasions. No significant associations were found with respect to BMI z-scores, waist circumference or laboratory indicators except for the breakfast skipping which was associated with higher total blood cholesterol. Daily eating and snacking frequency were significantly associated with consumption of energy, macronutrients, and several vitamins and minerals. More frequent eaters had higher intakes of energy and macronutrients and most of the micronutrients. Compared to the least frequent snackers, children who had three or more snacks consumed the highest amounts of energy, macronutrients, vitamin E, calcium, phosphorous, magnesium, iron, sodium, potassium and moisture. Breakfast skippers had lower intakes of folate, vitamins A and D, phosphorous, iron, potassium and sodium and higher intakes of cholesterol but there was no significant association with macronutrient consumption. Findings from this cross sectional survey suggest that meal and snacking frequency plays an integral role in provision of adequate macronutrients and micronutrients for youth. Breakfast skipping is associated with lower consumption of certain important nutrients.

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CHAPTER I

INTRODUCTION

Dietary behaviors are associated with different diet-related health outcomes. For example, meal and snacking patterns are thought to influence health outcomes. It is generally acknowledged that most food habits and behaviors are established earlier in life starting from early childhood to adolescent life and then continued throughout adulthood implicating development of a number of chronic ailments (Sebastian et al., 2007). Not only the type of food eaten but also the frequency of consumption is believed to affect certain non-communicable diseases including obesity, cardiovascular conditions and glucose intolerance (Kerver et al., 2006).

Snacking has increased in all age groups in the United States over the last 25 years (Sebastian et al., 2007). The number of snacks eaten by children of 2 to 5 years age increased from 1.7 in 1977 to 2.3 in 1996 (Skinner et al., 2004). Nearly 83% of teenagers consumed at least one snack on a given day in 2005-2006 and one fourth of adolescents' total energy was coming from snack foods (Sebastian et al., 2007). Not only the calories but significant amounts of carbohydrates, total sugars, vitamin C and E were also provided by snacking. Snacks therefore are identified as a more substantial source of total daily energy and macronutrients in recent years than they provided in early 1970s (Sebastian et al., 2007).

Meal skipping with most prominently breakfast skipping has become an increasing issue in children in the United States. A nationally representative study conducted in 1965 showed that 5% of children and 11% of adolescents' skipped breakfast. However, in 2000 according to the National Health and Nutrition Examination Survey (NHANES) data these figures increased tremendously as 21% of children and 36% of adolescents were found to be skipping their breakfast. Today much literature has bolstered the importance of consuming all three meals with the special emphasis on breakfast as the most important meal of the day (Chitra & Reddy, 2006). Skipping breakfast is found to be associated with increased adiposity leading to overweight and obesity among cohorts of children and adolescent. Likewise, breakfast skippers are less likely to consume recommended daily amounts of some macronutrients and micronutrients compared to their breakfast eating counterparts (Deshmukh-Taskar et al., 2010).

Along with dietary changes, the prevalence of nutrition-related health concerns among youth has markedly increased. At present, 17% of children and adolescents of age 2 to 19 are obese or overweight (CDC, 2012). Poor diet habits and sedentary life styles have been recognized as the main contributors to the excess weight gain. Obesity and overweight are also associated with occurrence of number of diseases including diabetes, dislipidemia, and hypertension as well as poor self image, distress and deteriorated life quality (Reedy & Krebs-Smith, 2010).

Given such a backdrop, it is of great importance to identify the possible influence of meal frequency on nutritional quality in young populations. The impact of changes in snacking habits and breakfast skipping in children in the United States and their contribution to body weight, energy and other macronutrients and micronutrients intake is important to assess. The effects of meal and snacking frequencies have been researched in nationally representative samples of adults but there is a need to extend the research to children as well. The literature is limited when it comes to a nationally representative sample of children in the US. Likewise, the advisory committee on the 2010 Dietary Guidelines for Americans found insufficient evidence to determine whether the frequency of eating has an effect on body weight and nutrient intake among children (USDA, 2010). Since children are the future backbone of society it is important to study meal and snacking frequencies and their effects on body mass index (BMI) and nutrient intake among children. Therefore, the objective of this study was to investigate the effects of meal/ snacking frequency on energy, macronutrient, micronutrient intake, laboratory indicators (total blood cholesterol, serum and red blood cell (RBC) folate), BMI z-scores and waist circumference among a cohort of nationally representative sample of young children extracted from 2007-2010 NHANES data.

CHAPTER II

LITERATURE REVIEW

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Reviewing and compiling existing literature is important to provide a solid background to a study. This literature review will help in clarifying and bolstering the reasons to justify the importance of this study. First, a descriptive assessment of definitions of meal and snacking patterns will be provided. Then, various factors that could determine the meal and snacking patterns of children will be explained followed by a description on the trends of consumption and influences of an array of the variables including economic, socio-demographic and nutritional factors on meal and snacking patterns. Next, literature related to influences on children's meal/snacking patterns on their BMI will be provided. Finally, meal skipping among youth and its' impact on weight and nutrient intakes will be discussed.

Definition of Snacking

The first section of the literature review is comprised of compiling different definitions available in terms of snacking and how these different definitions being used in studies with different focus.

Eating frequency and snacking frequency are often used as synonyms. The underlying reason for this is the assumption that consumption of snacks is directly proportional to the daily eating occasions. However, there is no universally accepted definition of snacking or a classification of snacking behaviors among different population groups. It has been defined in a number of ways in literature by means of nutrient profiling, time of the consumption, food clusters, hybrid definitions and self designation by consumers or respondents (Johnson & Anderson, 2010).

In the nutritional profiling approach, snacks are classified based on their quality and composition rather than the time of eating or dietary context (Johnson & Anderson, 2010). In the second approach, snacks are classified based on the time of consumption. According to Gregori and Maffeis (2007), food consumed between 10.00 am and 12.00 pm and 2.00 pm to 6.00 pm were considered as snacks. However this concept could be possibly distorted by individual lifestyles and cultural and religious influences. In the third approach, regardless of the nutritional quality and time of consumption, snacking is defined as groups or clusters of foods consumed together. The Food Based Classification of Eating Episodes proposed in 1999, identified six types of eating occasions extending from a complete meal to a low quality snack (Johnson & Anderson, 2010). This fourth approach is hardly used in the field of nutritional sciences. The last approach is to rely on individual reporting based on the individual's perception of a meal or a snack. In this approach the consumer or respondent decides whether a particular food falls into the category of a meal or a snack based on his or her knowledge and opinion. Given such a milieu, the absence of a strict definition of snacking has been detrimental in explaining the findings of current research and for constructing future research as well. Nevertheless, based on a thorough and critical review of available literature, Johnson and Anderson (2010) proposed a rudimentary definition of snack as "composed of solid foods, including those typically eaten with a utensil (with or without a beverage) that occurs between habitual meal occasions for the individual, is not a substitute for a meal, and provides substantially fewer calories than would be consumed in a typical meal" (Johnson & Anderson, 2010, p.851).

After reviewing the literature it is evident that snacking has no universal definition; different studies have adapted different definitions. Therefore it is difficult to compare and contrast results of these studies. It is imperative that researchers determine a consistent definition for snacking, one of the main eating occasions in a day.

Factors Influencing Snacking and Meal Patterns

An individual's food intake is governed by many factors. The objective of this section is to review these factors extensively to identify its' relationship with respect to eating and snacking frequency among youth.

Dietary behavior of an individual is subjected to a myriad of forces. Booth et al. (2001) proposed that one's eating behavior is influenced by concentrically formed layers starting from a psychobiologic core. This psychobiologic core represented the genetically programmed metabolism coupled with behavior of an individual. The psychological state along with behavioral and metabolic phenotype is exerted within a given environment.

This core is covered by another layer called “cultural influences” where an individual’s inherited beliefs and values arising from his or her surroundings, markedly affect that person’s life choices. Then it is coated by another layer representing the roles and relationships created within the environment. This comprises the “societal influences” (Booth et al., 2001, p.s24). The next determinant is the “enablers of choice”, which are the proximal factors affecting the choice made by an individual. These four layers together form the lifestyle of a single person. Further it is surrounded by another three layers namely “behavioral settings”, “proximal leverage points” and “distal leverage points”. Where “behavioral settings” comprised physical and social settings which physical activity and food choices are made, “proximal leverage points” explained controllers of the structure and features of the microenvironment that affect physical activity and food behavior choices, “distal leverage points” were all behavioral settings and macro-environments influenced by additional factors that are direct or indirect. The researchers concluded that restaurant, home, school, employer, family, food markets, city government and food industry acted as proximal leverage points in deciding one’s eating behavior (Booth et al., 2001).

Factors that influence the intake of not only children but also adolescents should be addressed. According to Story et al. (2002) adolescence is a transitional period of life and is characterized by vibrant and complex variables. Countless physical, developmental and social changes arising during the adolescence could tremendously influence the food choices and eating behavior in adulthood. The authors used a conceptual framework including individual, social environmental, physical environmental and macro-system analysis to discuss influences on adolescent eating behaviors. Food preferences, meaning of food, self efficacy, taste and sensory perceptions, health and nutritional values, knowledge, gender, age, lifestyle and cost were found to be associated with adolescent eating patterns. Dieting habits were found to one of the strongest correlates among female adolescents. The social influence of family was a powerful influential factor in determining teen food choices. The researchers cited that more young adolescents eat their meals at home (71%) compared to older ones (66%). Demographic changes such as maternal employment, living in single or two parent households, household income and parental education exerted significant effects on adolescent food choices. Frequent family meals were associated with more healthful adolescent dietary patterns. Food availability at home and peer influences were also in the socio-environmental influences. Physical environmental influences included the school food environment, presence of fast food restaurants, vending machine availability, access to convenience stores and worksites. The macro-system influences were principally the media effects on food advertising. All in all, authors provided a comprehensive ecological model and explained the multiple and complex interacting variables which influence the food choices of adolescents.

Factors that influence an individuals' eating behavior might extend from cultural to societal influences to physical and even macro-level determinants. This makes an individual's eating behavior a very complex phenomenon. Therefore it is also important to look at these factors when studying eating behaviors among young.

Food Consumption in Children in United States

Food consumption patterns are changing rapidly in societies. Snacking and frequency of eating, eating out, increased portion sizes and energy density and even meal skipping have become more prominent among populations in the US (Kant & Graubard, 2006). The following section of the literature review will discuss studies that were provided insights to children's food consumption pattern changes in US.

For the last two decades children's eating patterns have changed markedly. School lunch consumption decreased while eating out increased (Skinner et al., 2004). In the recent years, snacking has become one of the most common dietary habits in the US (Skinner et al., 2004). Children from 2 to 18 years old increased their snacking from 74% in 1970s to 98% in 2003-2006 (Piernas and Popkin, 2010). The prevalence of snacking increased from 61% in 1970s to 84% in 2005-2006 in the adolescent population in the US (Food Surveys Research Group, 2010). In 1996, an average 2 to 5 year old ate about 2 snacks and the average energy contribution from that snacks about 100 calories per day (Skinner et al., 2004). Briefel and Johnson (2004) investigated the patterns of eating among the US population using NHANES data and found that children aged 8 to 18 consumed low nutrient dense foods such as soft drinks, candies, table sweeteners, baked and dairy products, salty snacks and discretionary fats which accounted more than 30% of their daily calories. Food Surveys Research Group of USDA (2010) also found that snacks are often low in essential nutrients but high in energy, solid fats and refined sugars. Therefore, it is worthwhile to understand the nutritional effects of snacking and eating behaviors of young children and adolescents in relation to their body composition and nutrient uptake.

Lin and Guthrie (1996) looked at meal and snacking patterns and the nutritional considerations of food consumed by children and adolescent populations in the US using 1989-1991 Continuing Survey of Food Intakes by Individuals. According to their findings, the average child and adolescent ate 3.8 times a day with 2.7 meals and 1.1 snacks. The results indicated with age meal frequency decreased and older children skipped meals more often than younger children. Fat and sodium consumption was higher in older children while fiber, calcium, fruits and vegetable consumption was lower.

Similar to the previous study, Zizza et al. (2001) investigated young adults snacking patterns from 1977-1978 and 1996-1998. They reported that snacking increased from 77% to 84% between 1977-1978 and 1996-1998. Likewise, the calorie contribution from snacks rose from 20% to 23%. The top contributors of energy in snacks were desserts, sweetened and non-alcoholic beverages, milk and salty snacks.

Kant (2003) examined the foods that contribute modest nutritional value in the diets of US children and adolescents. The author used NHANES data from 1988 to 1994 with 4852 children and adolescents aged 8 to 18 years. All the reported foods were divided into five major food groups including dairy, fruit, grain, meal and vegetable. Then all the "other" foods excluding the five major groups were categorized into low nutrient density

(LND) food groups including visible fat, table sweeteners, candy and sweetened beverages, baked and dairy desserts, salty snacks and miscellaneous. Kant concluded that more than 30% of daily energy of US children and adolescents was coming from LND foods; sweeteners and desserts jointly contributed 25% of energy. The percentage of children and adolescents consuming adequate amounts of vitamin B6, vitamin A, folate, magnesium, iron and zinc decreased with increasing consumption of LND food.

In 1997, Munoz et al. investigated the food intakes of US children and adolescents and compared food intakes with the recommendations. Study subjects were 3307 children and adolescents from 2 to 19 years of age, from the USDA 1989-1991 Continuing Survey of Food Intakes by Individuals. The researchers examined the mean serving sizes and percentage of individuals meeting the national recommendation levels. Results indicated mean serving size per day was lower than the recommendation for all food groups except dairy. Percentages of individuals who met the recommendations for each food group were 30% for fruit, grain, meat and dairy and 36% for vegetables. Sixteen percent of children did not meet any recommendation and only 1% met all the recommendations. Total fats and added sugars provided 35% and 15% of energy respectively.

Briefel and Johnson (2004) reviewed the dietary intake and dietary supplement usage among the US population using four NHANES conducted in 1971-1974, 1976-1980, 1988-1994 and 1999-2000. Authors reported that mean energy intakes among all age and ethnic groups increased from 1977 to 2000. Overweight prevalence in pre-school children rose from 7.2% to 10.4%. Significant changes in the macronutrient consumption were identified in which total fat intakes reduced from 36% to 33% while carbohydrate consumption increased up to 50%. The mean sodium intakes increased the past 30 years and authors concluded this was due to the increase in consuming food away home and growth in processed food industries. The calcium intakes showed a drop from 1977 to 2000 period in children (3 to 11 years old) and adolescent boys and girls. Mean iron intake improved in toddlers, young children, pre-schoolers, and children aged 6 to 11 and adolescent boys age 12 to 19 but not for adolescent girls in 2000. Likewise mean intakes of vitamin A and vitamin C increased in 2000 compared to 1977.

Kennedy and Goldberg (1995) also revealed similar findings. The authors examined food consumption data from 1976 to 1988. They reported that the energy consumption of children increased and consumption of carbohydrate strikingly increased after reviewing nationally representative populations of US. Physical inactivity coupled with poor dietary habits had led the US children to be overweight and obese. Intake of saturated fat, total fat and sodium in the form of high fat and salty snacks remarkably increased. On the other hand, consumption of fruits, vegetables and milk and dairy products decreased.

Reedy and Krebs-Smith (2010) conducted a study to identify the main dietary sources of energy, solid fats, and added sugars consumed among children and adolescents in the US. They used NHANES 2005-2006 data to examine food sources of total energy and 2003-2004 data for estimation of total fats and sugars. Children from 2 to 18 consumed grain desserts, pizza, soda, yeast bread and chicken and chicken mixed dishes as their top five energy yielding foods. Children consumed 173 kcal from sweetened beverages alone.

The main sources of fat were pizza, grain desserts, whole milk, regular cheese and fatty meats. Major sugar providers were soda, fruit drinks, grain desserts, dairy desserts and candy. Furthermore, authors concluded that nearly 40% of the total energy consumed by 2 to 18 year old children was empty calories.

In summary, children's food consumption patterns have changed markedly during the last few decades and meal frequencies along with snacking have increased. Consumption of more energy dense food along with food high in sugar, fat and carbohydrates has become more popular while consumption of fruits, vegetables and dairy products decreased.

Influences of Snacking/ Meal Patterns on Body Mass Index and Nutrient Intake in Children

As mentioned in previous sections of the literature review, meal/snacking frequency has increased and it is important to assess what kind of nutritionally related effects that might create for children's anthropometric indicators and nutrient profiles. This section discusses studies that were conducted in terms of meal and snacking frequency and their effects on the nutritional status of children.

Anthropometric measurements play an integral role in the evaluation of nutritional status of a population. These measurements are often used to make inferences on changes which occur during a lifespan of children and adults. Significant trends, changes and deviations from the reference values over the time can be captured through well measured anthropometric data. Body mass index (BMI) and other body composition measurements including skinfold, circumference and fat mass measurements are frequently used in the field of nutritional sciences (NHANES, 2007). Dietary intake of energy and nutrients are measured to understand and identify the amounts of nutrients and energy available for metabolism for an individual or a population group (Rutishauser, 2005).

Bremner et al. (1990) investigated the snacking habits of 194 white South African preschool children, aged 3 to 4 years who were born in 1982 and 1984. Parents were asked to keep three day estimated dietary records. Eating occasions were classified as meals and snacks. Foods were further categorized into non-basic foods and the five basic food groups (milk, meat, fruit and vegetable, cereal and oils and fats). Non-basic foods were sugar, soft drinks, sweetened cookies, cakes, pies and pastries, chips and savory snacks. Results indicated that snacking was as prevalent between breakfast and lunch as between lunch and supper. Soft drinks were consumed more frequently together with fresh fruits, fruit juices, sweets and chocolates and milk. Between meal eating contributed more than one-third of average daily intake and one-quarter of most vitamins and minerals.

Bower and Sandall (2002) investigated the snacking behavior among 84 primary school children in England and Scotland. Children were interviewed followed by a questionnaire. Study subjects were given a definition of snacking that a “snack is any food that is eaten between or instead of breakfast, lunch or teas and snacks are usually a light quick meal” (Bower and Sandall, 2002, p.16). Then they were asked to identify snack foods they were eating. Children were also asked to provide their beliefs and attitudes in snacking. Based on the Pearson chi-square test, results revealed that children showed an overall preference toward sweets, chips, chocolate and less likelihood for consuming fruits and cereal based snacks. Taste was found to be the main reason for snacking choice.

A study was conducted using non-obese pre-menarcheal girls 8 to 12 years old enrolled between 1990 and 1993. The objective of the study was to assess the energy-dense snack food intake and its' association in weight and fatness in adolescent girls. All subjects completed the Willett semi quantitative food frequency questionnaire and a physical activity questionnaire and were measured for BMI. According to the results there was a significant increase in BMI z scores and percentage of body fat between study entry and exit. Their average consumption of energy-dense snacks (EDS) was reported as 2.3 servings at the study entry and reduced to 2 servings at the exit. Subjects consumed nearly 16% of their daily calories from EDS foods. Authors did not find any significant relationship with respect to BMI z scores and EDS food consumption. However soda was the only EDS food that had a significant relationship with BMI z scores, but it was not significantly associated with percentage body fat (Phillips et al., 2004).

Field et al. (2004) assessed the relationship of intake of snacks with weight among children and adolescents. Authors used 8203 girls and 6774 boys aged 9 to 14 years in 1996 recruited from Growing Up Today Study (GUTS). Maternal BMI, childs' dietary intake, physical activity, Tanner stage of development, weight and height were collected.

Authors found that boys consumed more snacks compared to girls and the caloric load from snacks was 420 calories for boys and 365 calories for girls. In both genders the calorie contribution from snacks was about 18% of daily calorie intake. The authors did not find a significant relationship between weight and snack intake in boys. In girls after controlling for confounders (development stage, physical activity, height change), snacking was significantly associated with weight.

In 2004 Huang et al. examined the reported energy intakes and BMI percentiles among US children with respect to their eating occasions. Researchers analyzed data from 4408 children 3 to 19 years of age who participated in the USDA Continuing Survey of Food Intakes by Individuals in 1994-1996. The children and adolescents were asked to complete two non-consecutive 24 hour recalls. The authors found that 15% of the boys and girls were overweight and the highest prevalence was found among young children. Boys in the sample consumed more energy and larger portion sizes compared to girls in meal time as well as in snacks. The regression analysis revealed that for boys the portion size of meals was significantly related to BMI percentile of 3 to 5 year olds, and 6 to 11 year olds. In older groups (12 to 19) BMI was significantly related to eating away from home.

A study done in Germany investigated the relationship between meal frequency and childhood obesity using a sample of 4370 children ranging from 5 to 7 years of age. Parents were administered a questionnaire to indicate children's eating occasions and frequencies. Many children ate four times during the day (43.3%). Children who had five or more meals showed the lowest prevalence of overweight as well as obesity. Frequent daily meals were found to be associated with high educational status of parents, TV watching no more than an hour, no smoking during pregnancy, having siblings and being breast fed more than a month. The authors concluded that increased daily frequency of eating exerted a protective effect against the occurrence of childhood obesity (Toschke et al., 2005).

Stockman et al. (2005) investigated the distribution of energy and nutrient intake of adolescent males with respect to meals and snacks. They further examined the relationship between eating occasion and BMI. The study subjects were 14 to 18 year old healthy boys recruited from Canada. Authors gathered the consumption data using 24 hour dietary recalls. Based on the ANOVA results, authors concluded that dinner was the largest contributor of energy, protein, carbohydrates, total fat, saturated fat, cholesterol, dietary fiber and sodium. On the other hand, breakfast was the smallest contributor of energy, carbohydrates, total and saturated fats. Calcium and iron were mainly provided through breakfast and dinner. Snacks contributed fewer nutrients than meals. BMI was found to be significantly higher and energy intake was significantly lower in subjects who had 3 or less than 3 meals a day compared to 4-6 eating occasions. Breakfast consumption irregularities were found among subjects and 26% reported skipping breakfast. Subjects who reported breakfast irregularities had significantly higher BMI values and lower iron intakes relative to consistent breakfast eaters.

In 2007 Gayle et al. examined the snacking behavior of adolescents and their association with respect to meal skipping. A cross sectional self reported online food habit survey was administered among 3250 students aged 7 and 9 in Australia. The authors defined snacking as “foods and drinks eat in between meals including milk drinks, soft drinks, sport drinks and energy drinks” (Gayle et al., 2007, p.3). Snacking behavior was determined by asking respondents’ past months consumption in following eight contexts: after school, watching television, hanging out with friends, doing homework, on the run, on the way to and from school, all day long and in the middle of night. Meal skipping was assessed by asking the details on past months meal skipping occasions at breakfast, lunch and dinner. Authors found that the highest snacking frequency reported was “snacking after school” and 75% of adolescents admitted that they snacked at this time almost every day or most of the time. Eating snacks while watching television and hanging out with friends were also reported as major snacking events. Regional and gender differences were found to be associated with different snacking behaviors. More students skipped breakfast followed by skipping lunch and dinner. Female students were found to be skipping breakfast and lunch more frequently compared to male students. The logistic regression results indicated that students who were following snacking contexts “on the run, on the way or to school, all day long and eating at night” are at a greater risk of skipping meals.

Sebastian et al. (2007) identified the influence of snacking on nutrient intake and food groups of adolescents in relation to meeting USDA MyPyramid Food Guidance System. The study used 4357 adolescents aged 12 to 19 years from NHANES 2001-2004.

Respondents were asked to complete 24 hour dietary recalls and results were analyzed using linear and logistic regression analysis. Results revealed that with increasing snacking frequency, intake of food energy increased. Most of this energy was derived from carbohydrates. Energy adjusted fat and protein intakes were low in both boys and girls with increasing snacking frequency. Vitamin A, vitamin E, and magnesium intakes were significantly increased for boys with increased consumption of snacks. Vitamin C was significantly increased with snacking for both genders. However, intakes of folate, vitamin B6, calcium, iron and phosphorous were not significantly related to snacking. Authors stated that snacking improved the likelihood of meeting fruit recommendation for both genders and meeting oil and milk recommendations for boys.

Maffeis et al. (2008) conducted a study to examine the consumption of type and number of snacks with respect to body size. Authors used a sample of children from 8 to 10 years of age in Italy 2003. Children's BMI was calculated and simultaneously the number and type of snacks consumed were gathered through a food frequency questionnaire. The authors found that children consumed 4 snacks on an average day. They reported that there was no statistically significant association between number of snacks per day and obesity of children. According to the authors obese children were not consuming more snacks compared to non-obese counterparts but they preferred more energy dense and salty snacks as their snack foods. Each serving per week of salty snack increased the chance of being obese by 2%. The number of snack servings per day, energy and macronutrient content were not different in girls and boys. Researchers' concluded that obese children tend to eat more energy rich snacks than their non-obese counterparts.

A group of researchers from United Kingdom examined the snacking patterns of adolescents between 13 and 16 years who participated in the National Diet and Nutritional Survey (NDNS) in 1997 and compared the changes with respect to a Northern Irish cohort (NIC) recruited in 2005. Respondents (2127 from NDNS and 50 from NIC) were asked to complete 7 day weighed dietary records. The results revealed that adolescents were significantly heavier and taller in 2005 than the adolescents who were surveyed in 1997. Further, the portion sizes of carbonated and soft drinks, milk, beverages, chips, savory snacks and breakfast cereals were significantly higher in 2005. The portion sizes of carbonated and soft drinks were significantly related to overweight or obesity in 2005 (Kerr et al., 2008).

Franko et al. (2008) studied a sample of 1209 black girls and 1166 white girls of 9 to 19 years who were enrolled in a National Heart Study. Their meal frequencies were measured using a 3 day food record. Information on adiposity, physical activity, television viewing and demographic details was also collected. According to the results, girls who ate more than three meals per day showed lower BMI scores for both black and white girls. For black girls eating more meals was associated with reduced incidence of overweight.

MacDiarmid et al. (2009) investigated the meal and snacking patterns of school children in relation to their nutrient intakes. The study recruited 311 children in Scotland, who were asked to complete a 4 day (3 week days and 1 week end) non-weighed diet diary. The help of a guardian was allowed in filling out food diaries. The results revealed that an average child ate 3.3 meals and 2.0 snacks each day. Both girls and boys ate a similar number of snacks but boys consumed more meals compared to girls. Children who came from a low income group ate more meals with fewer snacks. Cookies, cakes and pastries were the most frequently consumed snacks followed by chips, confectionaries and fruits. Fruits and milk were more commonly used as a part of a meal rather than a snack. The proportion of energy and saturated fat was much higher from snacks than meals. Snacks accounted for a fifth of total daily energy and total fat, a quarter of saturated fatty acids, and 40% of Non Milk Extrinsic Sugars (NMES). Girls ate more total fat by consuming snacks compared to boys. Frequent snackers (more than two snacks per day) consumed more NMES but no statistically significant association was found with the total fat or daily energy intake.

In 2009 Storey et al. examined dietary intake and nutrition patterns among Canadian adolescents. A sample of 2850 respondents was selected using a two stage sampling from schools in Alberta and Ontario. A 24 hour dietary recall was used to collect weekday food and beverage consumption. The results revealed that boys had mean higher energy and lower carbohydrate and fat intakes compared to female students. However, on average all the students met acceptable macronutrient distribution range recommendations. Girls' intake of iron, zinc and calcium was low while fiber intake was a concern of both groups. The sample was divided into superior, average and poor based on the diet quality. A majority of the girls fell into the poor diet category while most boys were in the average diet quality category. Poor quality diets were associated with lower frequency of breakfast and lunch and more frequently eating away from home. According to the MANCOVA analysis boys with a superior diet quality consumed more carbohydrates and less fat compared to their female counterparts for the same group. Likewise, girls with the poor diet quality consumed more carbohydrates that the boys with poor diet quality.

Studies related to children's eating and snacking frequency with respect to anthropometric indicators such as BMI reported inconsistent results. However, results conclusively showed that meals and snacks contributed significantly to nutrient intake among children but in varying degrees.

Meal Skipping and Its' Impact on Body Mass Index and Nutrient Intake in Children

The final section of the literature review is focused on meal skipping, particularly breakfast skipping among children and its' influence on determining their nutritional status and BMI.

Berkey et al. (2003) conducted a study on breakfast skipping and weight changes in an adolescent cohort of 14,000 from the US in 1996. The respondents were 9 to 14 years of age and information on BMI, physical activity, energy intakes, race, breakfast skipping, school work and Tanner stage of development were gathered. The results exhibited that children who never ate breakfast were heavier compared to children who had breakfast almost every day. Children who were reported as physically active were eating more energy as well as children who reported spending more time in front of a television or playing video games. Normal weight children who skipped breakfast on a regular basis were found to be gaining more weight compared to their breakfast eating counterparts. Authors concluded that breakfast eating has a protective role against obesity and overweight in children and adolescents.

Deshmukh-Taskar et al. (2010) assessed the relationship of breakfast skipping and type of breakfast consumed with weight status and nutrient intake among US children and adolescents. Authors used 1999-2006 NHANES data from a sample of 4320 children aged 9 to 13 and 5339 adolescents 14-18 years old. Food intakes were gathered through multipass 24 hour recalls. Intake of total energy and energy from macro and micro nutrients were also evaluated. According to the results, children who were breakfast skippers reported lower energy values compared to those who consumed ready to eat cereal or any other type of breakfast. Percentage of sugar and carbohydrates were higher in breakfast eaters. Dietary fiber content was also higher in ready eat cereal consumers than breakfast skippers and other breakfast eaters. Similar to the children's results, intake of vitamins and minerals were again found to be higher in adolescent breakfast eaters. Children and adolescent breakfast skippers were reported to have higher BMI scores and waist circumference measurements than ready to eat cereal eaters.

Thompson-McCormick et al. (2010) investigated the breakfast skipping and occurrence of overweight and obesity among a sample of 523 school aged ethnic Fijian adolescent girls. The subjects were of 12-15 years of age and their anthropometric, social demographic, breakfast skipping, and eating pathology were assessed. Breakfast skipping was evaluated based on a Likert scale system in which girls were asked how many times they skipped breakfast during a week. Results revealed that breakfast skipping and the prevalence of obesity/overweight was higher in the sample compared to normal weight participants. A bivariate analysis of breakfast skipping and obesity/overweight prevalence indicated that significantly obese/overweight girls were more likely to skip their breakfast compared to their non-obese counterparts.

Kral et al. (2011) conducted a cross sectional study to test the effects of breakfast consumption compared to breakfast omitting on appetite rating and energy intake among 8 to 10 year old children. The children were asked to attend 2 test visits separated by a one week gap but on the same day of the week. On each test day the same food was offered as lunch but children may or may not have had their breakfast. On the other day breakfasts were offered and children were asked to eat breakfast in full. During lunch they ate and drank as much as or as little as they wanted. The test subjects included 15 girls and 6 boys. Children's BMI and energy and nutrient consumption were calculated. Subjects were asked to rate their perceived hunger, thirst and prospective consumption. Results revealed that there was a significant relationship between breakfast consumption and total daily energy intake. Children who did not eat any breakfast ate 362 fewer calories compared to breakfast eaters throughout the day. Likewise, children who did not consume breakfast reported that they were hungrier, less full and wanted to eat more at lunch. Authors discussed that breakfast omitting may positively affect hunger and subsequent intake of larger quantities of other meals.

In 2011, a series of studies conducted by USDA with children and adolescents concluded that individuals who ate breakfast on daily basis had higher intakes of fiber, thiamin, niacin, riboflavin, vitamin B_6 and B_{12}, folate, vitamin A and C, calcium, iron, magnesium, phosphorous, potassium and zinc. However, they were unable to establish a relationship with breakfast eating and intake of total fat, cholesterol, saturated fat and sodium. Children who did not eat breakfast were at increased risk of being obese or overweight and this was more significant among adolescents (USDA, 2011).

In summary, many non-communicable diseases are thought to be triggered by unhealthy dietary behaviors. Snacking along with increased eating frequency and breakfast skipping have become more common among youth in the US. It is evident that these factors significantly influence the nutritional status of children. However, literature related to evaluation of eating/snacking frequency and breakfast consumption with respect to nutritional status of youth in the US were limited to older studies or studies with small sample sizes and provided inconsistent results. Therefore, it is important to study how meal and snacking frequency and breakfast skipping affect children's nutritional status with respect to anthropometry, laboratory indicators and macronutrient and micronutrient intake in a nationally representative sample from the US.

CHAPTER III

METHODOLOGY

The purpose of this study was to determine the effects of meal/snacking frequency on energy, macronutrient, micronutrient intake, laboratory values and body weight in a nationally representative sample of young children in the United States. The study used cross sectional data from 2007 to 2010 NHANES for the analysis. The unit of analysis was an individual. The study was approved as non-human subject research by the Institutional Review Board at Oklahoma State University.

Sample and Subject Characteristics

NHANES data characterize a nationally representative sample of US population. This study was focused on children and adolescents who were of 9 to 13 years age. The sampling unit of NHANES consisted of non-institutionalized US civilians. The sampling procedure is complex multistage sampling. The sampling design has changed from the previous NHANES designs regarding oversampling of certain demographic populations for the 2007-2010 survey years. Oversampling was carried out to minimize the bias in low income, the elderly, Blacks and Hispanics (NHANES, 2011).

Dietary Methods

NHANES staff collected dietary information on the participants through dietary behavior questionnaires, 24 hour dietary recalls and food frequency questionnaires. In the dietary behavior questionnaire, individuals were asked to provide information on dietary modifications due to health outcomes, supplement usage and demographic, socioeconomic and other health related information. Two multiple pass 24 hour dietary recalls were administered in addition to physiological and laboratory tests. Participants who were 12 years and above completed the questionnaires on their own while proxy-assisted interviews were conducted for younger children. Food frequency questionnaires were also distributed following completion of a second 24 hour recall.

All NHANES examinees were asked to complete the dietary interview component. A computer-assisted dietary interview software program was used in the surveys. The dietary interviewer recorded detailed information about the foods and beverages reported by the subjects. Instructions were provided to the respondent orally in English and/or Spanish. Measurement aids and visuals including charts and drawings were used by the respondent to quantify the foods and beverages that were reported. A telephone follow-up dietary interview was also scheduled 3-10 days after their Mobile Examination Center (MEC) exam for all the participants. A set of measuring guides including a USDA food model booklet, a ruler, a set of household spoons, and a set of measuring cups were given to the participants at the end of their MEC dietary interview. The interviewers carried out data recovery by telephone when the information provided by the respondent or a proxy was incomplete. The only circumstances that led to exclusion were instances in which communication or cognitive difficulties made it impossible for the participant to provide the necessary information, and a proxy reporter was not available to complete the interview (NHANES, 2011).

NHANES used the Automated Multiple Pass Method (AMPM), developed by USDA in the process of dietary data retrieval. In the AMPM, intake was reviewed more than once in order to capture forgotten eating occasions and foods. The pass 1 consisted of an initial ‘‘quick list,’’ where the respondent reported all the foods and beverages consumed without interruption from the interviewer for the previous day. Then a forgotten food list of 9 food categories commonly omitted in 24-hour recall reporting; time and occasion, where the respondent reported the time each eating occasion began and names the occasion; a detail pass (pass 2), where probing questions were asked for more detailed information about each food and the portion size, in addition to review of the eating occasions and times between the eating occasions; and final review (pass 3) in which questions were asked about any other item not already reported (Thompson and Subar, 2001). Due to the large number and the variety of foods consumed in the US, different types of questions, along with a very large number of possible responses, were included in the AMPM. Foods reported by respondents were selected from a file called the Main Food List (MFL) and recorded in a table called the Respondent Food List. The MFL contained about 2600 foods. Frequency data from earlier surveys were used to identify commonly eaten foods to place on the MFL. Each food on the MFL was assigned to one of the 132 food categories. A category code attached to each food on the list provided information to the program the appropriate set of questions to ask for a food. One of the main advantages of an automated interview was the consistency maintained across all interviews. Questions and the potential responses were identified and were the same for all interviews. The interviewer read a question as presented on the screen and the program automatically skipped to the next appropriate question based on the answer received. While information about a food may be incomplete because a respondent did not know the answer to a question, it was never incomplete because an interviewer failed to ask the right questions. Throughout the AMPM various types of edit checks were included to improve the quality and consistency of the data (Raper et al., 2004). Once the dietary records were collected total energy and nutrient intakes from foods on recall day were analyzed by the USDA (NHANES, 2011).

Anthropometry and Laboratory Examinations

All the respondents were subjected to a series of anthropometrical measurements. Standing height was collected on all participants aged 2 years and older who were able to stand unassisted. Standing height was measured using a stadiometer with a fixed vertical backboard and an adjustable head piece. In obtaining weight measurements participants were weighed in kilograms using a digital weight scale. Participants wore the standard MEC examination gown, which consisted of a disposable shirt, pants, and slippers. Subjects wore only underpants beneath the gown. Waist circumference was also measured on participants who are of age 2 and above. Participants were instructed gather his/her gown above waist and cross the arms and place the hands on opposite shoulder. Then a non stretchable measuring tape was used across the waist ensuring the horizontal alignment of the tape. Measurements were taken to the nearest 0.1 cm (NHANES Anthropometry Manual, 2007).

The laboratory component included the collection and processing of various biological and environmental specimens including blood for subjects 1 year and older, and urine for subjects 6 years and older. Total cholesterol, complete blood count and Folate (RBC and serum) were measured in all subjects who were at least 3 years old.

Variables

Snacking/meal frequency were considered as the main independent variable. Meal frequency and snacking frequency were calculated from dietary records and classified according to the eating occasions of breakfast, lunch, dinner and snacks. During the 24 hour dietary recall respondents were asked to identify the time and name of each eating occasion from a list of possible names (breakfast, brunch, lunch, dinner and snack). One eating episode comprised all foods and beverages consumed at one clock time, regardless of the type or the amount of food reported. The number of times at which "snack" was mentioned during four segments of time (morning, afternoon, evening and night) was considered as a different snack event.

Body mass index z-scores and waist circumference, selected macronutrients and micronutrients consumed and selected laboratory indicators were the major dependent variables while demographic and socioeconomic variables including gender, age, race, ethnicity, and income, as well as physical activity and whether or not the child consumed a supplement were included as potentially confounding variables in the analysis. The specific type of supplement consumed was not included in the analysis.

Two-day averages for energy, carbohydrate, protein and fat intakes from food intake were evaluated along with micronutrients including calcium, iron, folic acid, sodium, potassium, magnesium, prosperous, and vitamins A, C, D, E and K. Moisture (mg) and caffeine (mg) intakes were also included in the analysis. Moisture values included food moisture combined with liquids consumed by the individual. Nutrient intakes were presented along with Recommended Daily Intake (RDA), Estimated Average Requirement (EAR) and Adequate Intake (AI). An RDA is the average daily dietary intake level that is sufficient to meet the nutrient requirements of 97 to 98% of healthy individuals in a group. It is calculated from an EAR. An EAR is the average daily nutrient intake level estimated to meet the requirements of half of the healthy individuals in a group. If sufficient scientific evidence was not available to establish an EAR, an AI was developed. The AI is believed to cover the needs of all healthy individuals in the group (Food and Nutrition Board, 2012).

Heights and weights extracted from the NHANES were used to calculate BMI. These BMI values were fed into Epi Info software (CDC, 2012) that produced z-scores which adjusted for gender and age of the children. BMI alone is not considered to be a comprehensive adiposity evaluator, as children's anthropometric measures change more quickly with the changes in body fat accumulation and growth spurts with sexual maturation. A BMI z-score of plus or minus one standard deviation is considered as the normal BMI range while a BMI z-score less than -2 SD is considered thin and above +1 is considered overweight (National Obesity Observatory, 2011). Laboratory values including serum folate, RBC folate and total cholesterol were also analyzed.

Statistical Analysis

Data analysis was performed using SAS software (version 9.3). Because NHANES was conducted in a multistage stratified sampling, traditional methods of analysis based on random sampling will not be accurate so SUDAAN software was used to estimate descriptive and inferential statistics. NHANES data were weighted to adjust the unequal probability of selection because of oversampling of certain population groups and for non-response rates. Preliminary analysis was conducted by performing descriptive data analysis. Percentages and standard errors of means were calculated. A series of regression analyses and multivariate adjusted ANOVA were carried out to identify the relations between snacking and meal frequency and dietary intake, laboratory indicators of nutritional status and body mass index in children and adolescents.

Research Questions and Hypotheses

1. What is the relationship between meal/snacking frequency and BMI z-scores of 9 to 13 year old children?

   1HO: There will be no relation between meal/snacking frequency and BMI z-scores of 9 to 13 year old children

   1HA: There will be a relationship between meal/snacking frequency and BMI z scores of 9 to 13 year old children

2. What is the relationship between meal/snacking frequency and waist circumference of 9 to 13 year old children?

   2HO: There will be no relation between meal/snacking frequency and waist circumference of 9 to 13 year old children

   2HA: There will be a relationship between meal/snacking frequency and waist circumference of 9 to 13 year old children

3. What is the relationship between meal/snacking frequency and energy intake of 9 to 13 year old children?

   3HO: There will be no relation between meal/snacking frequency and energy intake of 9 to 13 year old children

   3HA: There will be a positive relationship between meal/snacking frequency and energy intake of 9 to 13 year old children

4. What is the relationship between meal/snacking frequency and carbohydrate intake in 9 to 13 year old children?

   4HO: There will be no relation between meal/snacking frequency and carbohydrate intake in 9 to 13 year old children

   4HA: There will be a positive relationship between meal/snacking frequency and carbohydrate intake in 9 to 13 year old children

5. What is the relationship between meal/snacking frequency and protein intake in 9 to 13 year old children?

5HO: There will be no relation between meal/snacking frequency and protein intake in 9 to 13 year old children

5HA: There will be a relationship between meal/snacking frequency and protein intake in 9 to 13 year old children

6. What is the relationship between meal/snacking frequency and total fat intake in 9 to 13 year old children?

   6HO: There will be no relation between meal/snacking frequency and total fat intake in 9 to 13 year old children

   6HA: There will be a relationship between meal/snacking frequency and total fat intake in 9 to 13 year old children

7. What is the relationship between meal/snacking frequency and total sugar intake in 9 to 13 year old children?

   7HO: There will be no relation between meal/snacking frequency and total sugar intake in 9 to 13 year old children

   7HA: There will be a positive relationship between meal/snacking frequency and total sugar intake in 9 to 13 year old children

8. What is the relationship between meal/snacking frequency and cholesterol intake in 9 to 13 year old children?

   8HO: There will be no relation between meal/snacking frequency and cholesterol intake in 9 to 13 year old children

8HA: There will be a relationship between meal/snacking frequency and cholesterol intake in 9 to 13 year old children

9. What is the relationship between meal/snacking frequency and saturated fat intake in 9 to 13 year old children?

   9HO: There will be no relation between meal/snacking frequency and saturated fat intake in 9 to 13 year old children

   9HA: There will be a relationship between meal/snacking frequency and saturated fat intake in 9 to 13 year old children

10. What is the relationship between meal/snacking frequency and monounsaturated fat intake in 9 to 13 year old children?

    10HO: There will be no relation between meal/snacking frequency and monounsaturated fat intake in 9 to 13 year old children

    10HA: There will be a relationship between meal/snacking frequency and monounsaturated fat intake in 9 to 13 year old children

11. What is the relationship between meal/snacking frequency and polyunsaturated fat intake in 9 to 13 year old children?

    11HO: There will be no relation between meal/snacking frequency and polyunsaturated fat intake in 9 to 13 year old children

    11HA: There will be a relationship between meal/snacking frequency and polyunsaturated fat intake in 9 to 13 year old children

12. What is the relationship between meal/snacking frequency and calcium intake of 9 to 13 year old children?

    12HO: There will be no relation between meal/snacking frequency and calcium intake of 9 to 13 year old children

    12HA: There will be a negative relationship between meal/snacking frequency and calcium intake of 9 to 13 year old children

13. What is the relationship between meal/snacking frequency and iron intake of 9 to 13 year old children?

    13HO: There will be no relation between meal/snacking frequency and iron intake of 9 to 13 year old children

    13HA: There will be a relationship between meal/snacking frequency and iron intake of 9 to 13 year old children

14. What is the relationship between meal/snacking frequency and folate intake of 9 to 13 year old children?

    14HO: There will be no relation between meal/snacking frequency and folate intake of 9 to 13 year old children

    14HA: There will be a relationship between meal/snacking frequency and folate intake of 9 to 13 year old children

15. What is the relationship between meal/snacking frequency and sodium intake of 9 to 13 year old children?

15HO: There will be no relation between meal/snacking frequency and sodium intake of 9 to 13 year old children

15HA: There will be a positive relationship between meal/snacking frequency and sodium intake of 9 to 13 year old children

16. What is the relationship between meal/snacking frequency and potassium intake of 9 to 13 year old children?

    16HO: There will be no relation between meal/snacking frequency and potassium intake of 9 to 13 year old children

    16HA: There will be a positive relationship between meal/snacking frequency and potassium intake of 9 to 13 year old children

17. What is the relationship between meal/snacking frequency and magnesium intake of 9 to 13 year old children?

    17HO: There will be no relation between meal/snacking frequency and magnesium intake of 9 to 13 year old children

    17HA: There will be a positive relationship between meal/snacking frequency and magnesium intake of 9 to 13 year old children

18. What is the relationship between meal/snacking frequency and vitamin C intake of 9 to 13 year old children?

    18HO: There will be no relation between meal/snacking frequency and vitamin C intake of 9 to 13 year old children

18HA: There will be a positive relationship between meal/snacking frequency and vitamin C intake of 9 to 13 year old children

19. What is the relationship between meal/snacking frequency and vitamin D intake of 9 to 13 year old children?

    19HO: There will be no relation between meal/snacking frequency and vitamin D intake of 9 to 13 year old children

    19HA: There will be a negative relationship between meal/snacking frequency and vitamin D intake of 9 to 13 year old children

20. What is the relationship between meal/snacking frequency and vitamin A intake of 9 to 13 year old children?

    20HO: There will be no relation between meal/snacking frequency and vitamin A intake of 9 to 13 year old children

    20HA: There will be a relationship between meal/snacking frequency and vitamin A intake of 9 to 13 year old children

21. What is the relationship between meal/snacking frequency and caffeine intake of 9 to 13 year old children?

    21HO: There will be no relation between meal/snacking frequency and caffeine intake of 9 to 13 year old children

    21HA: There will be a positive relationship between meal/snacking frequency and caffeine intake of 9 to 13 year old children

22. What is the relationship between meal/snacking frequency and moisture intake of 9 to 13 year old children?

    22HO: There will be no relation between meal/snacking frequency and moisture intake of 9 to 13 year old children

    22HA: There will be a positive relationship between meal/snacking frequency and moisture intake of 9 to 13 year old children

23. What is the relationship between meal/snacking frequency and total blood cholesterol of 9 to 13 year old children?

    23HO: There will be no relation between meal/snacking frequency and total cholesterol of 9 to 13 year old children

    23HA: There will be a positive relationship between meal/snacking frequency and total cholesterol of 9 to 13 year old children

24. What is the relationship between meal/snacking frequency and folate (serum and RBC) level of 9 to 13 year old children?

    24HO: There will be no relation between meal/snacking frequency and folate (serum and RBC) level of 9 to 13 year old children

    24HA: There will be a relationship between meal/snacking frequency and folate (serum and RBC) level of 9 to 13 year old children.

CHAPTER IV

INFLUENCE OF MEAL FREQUENCY AND BREAKFAST CONSUMPTION ON NUTRITIONAL STATUS OF 9 TO 13 YEAR OLD CHILDREN

Meal and snacking patterns are thought to influence health outcomes and to affect non-communicable diseases including obesity, cardiovascular conditions and glucose intolerance (Kerver et al., 2006). Snacking has increased in all age groups in the United States over the last 25 years (Sebastian et al., 2007). The number of snacks eaten by children 2 to 5 years old increased from 1.7 in 1977 to 2.3 in 1996 (Skinner et al., 2004). Nearly 83% of teenagers in the US consumed at least one snack per day in 2005-2006 and one fourth of adolescents' total energy came from snack foods (Skinner et al., 2004). Also significant amounts of carbohydrates, total sugars, vitamin C and E were provided by snacking (NHANES, 2011). Snacks are identified as a more substantial source of total daily energy and macronutrients in recent years compared to early 1970s (Sebastian et al., 2007).

Another meal pattern that has become an increasing issue in youth in the United States is breakfast skipping. According to Deshmukh-Taskar (2010) in 1965, 5% and 12% of children and adolescents aged 11 to 14 years and 15 to 18 years, respectively, skipped breakfast. In 2009 Rampersaud reported that 10 to 30% of children and adolescents skipped breakfast depending on age group, gender and race. The effects of meal and snacking frequencies have been researched in adults but there is a need to extend the research to a younger generation, since there is a scarcity of literature. The advisory committee on the 2010 Dietary Guidelines for Americans found insufficient evidence to determine whether the frequency of eating has an effect on body weight and nutrient intake among children (USDA, 2010). Therefore, the impact of changes in snacking habits and breakfast skipping in children in the United States and their contribution to nutritional status is important to assess. The purpose of this study was to investigate the effects of meal/snacking frequency on energy, macronutrient, micronutrient intake, laboratory indicators and body mass index (BMI) among a cohort of nationally representative children.

Subjects and Methods

Subjects were 9 to 13 year old children selected from 2007 to 2010 National Health and Nutrition Examination Survey (NHANES). NHANES collects a nationally representative sample of non-institutionalized US civilians with a complex multistage sampling. The sampling design included oversampling of low income, elderly, Blacks and Hispanics respondents to minimize bias (NHANES, 2011). NHANES 2007-2008 included data from 10,148 respondents with 902 participants between 9 to 13 years old. There were

10,537 participants in NHANES 2009-2010 with 955 respondents in the age category of 9 to 13 years. After removing respondents with missing data and unreliable or incomplete dietary information, the final sample consisted of 1261 children of 9 to 13 years old and who had complete demographic, dietary data, anthropometric and laboratory data.

Anthropometry and Laboratory Examinations

NHANES subjected all the respondents to a series of anthropometrical measurements. Standing heights were collected on all participants aged 2 years and older who were able to stand unassisted. They were measured using a stadiometer with a fixed vertical backboard and an adjustable head piece. In obtaining weight measurements participants were weighed in kilograms using a digital weight scale (NHANES Anthropometry Manual, 2007). Waist circumference was also measured in children above two years of age. The laboratory component included the collection and processing of various biological and environmental specimens including blood for subjects one year and older, and urine for subjects 6 years and older. Total cholesterol, complete blood counts and Folate (Red Blood Cell and serum) were measured in all subjects who were at least 3 years old.

Dietary Data

NHANES used the Automated Multiple Pass Method (AMPM), developed by USDA to collect two days of dietary data. In the AMPM, intake was reviewed more than once in order to capture forgotten eating occasions and foods. Throughout the AMPM various types of edit checks were included to improve the quality and consistency of the data

(Raper et al., 2004). Once the dietary records were collected total energy and nutrient intakes from foods on recall day were analyzed by the USDA (NHANES, 2011).

Variables

Meal and snacking frequency, and breakfast consumption were considered as the main independent variables. Meal and snacking frequencies and breakfast consumption data were extracted from dietary records and classified according to the eating occasions reported by respondents. During the 24 hour dietary recall respondents were asked to identify the time and name of each eating occasion from a list of possible names. The dietary questionnaires were administered in English and Spanish. Eating occasions were divided into breakfast, brunch, lunch, dinner, supper, comida and snacks as identified by the respondent. One eating episode comprised all foods and beverages consumed at one clock time, regardless of the type or the amount of food reported. The number of different clock times at which "snack" was mentioned was considered as a different snack event. Snacks were separated into four snacking occasions based on the time reported by respondent (Morning snack from 6 am to 12 pm, afternoon snack from 12 pm to 6 pm, evening snack from 6 pm to 12 am and night snack from 12 am to 6 am). The sum of all eating occasions including the four snacking occasions were considered as an individual's total eating occasions per a day. The average number of snacks eaten during both days was divided into four groups, subjects in category one had the lowest frequency of snacking (0 to 0.5 snacks) and category four had the highest frequency of snacking (3 or more snacks). Subjects were also categorized into four groups based on total self reported eating occasions (breakfast, lunch, dinner, snacks and etc.). Subjects in category one had the lowest consumption frequency (1-2.5 eating occasions) while those in category four had the highest consumption frequency (5 or more eating occasions). Breakfast consumption was coded into three categories based on eating a breakfast on two days, one day or none of the days.

Anthropometric measures (BMI z-scores and waist circumference), intake of selected macronutrients and micronutrients from food and laboratory indicators of the nutritional status of children were identified as the major dependent variables while demographic and socioeconomic variables including gender, age, ethnicity, and income, and supplement usage and physical activity were used in the analysis to control for possible confounding variables. Heights and weights extracted from NHANES were used to calculate BMI, and subsequently they were converted into z-scores using Epi-Info (CDC, 2012a). The two day averages for energy, carbohydrates, protein, total fats, saturated fats, monounsaturated fats, polyunsaturated fats, cholesterol and total sugars were evaluated. Micronutrients including calcium, phosphorus, iron, total folate, sodium, potassium, magnesium, vitamin C, vitamin D, vitamin K and vitamin A and caffeine and moisture intakes were collected. Laboratory values including serum folate, RBC folate and total blood cholesterol were also included in the analysis.

Statistical Analysis

Data analysis was performed using SAS software (9.3 version). Data were analyzed with SUDAAN software as NHANES data were weighted to adjust the unequal probability of selection because of oversampling of certain population groups and for non-response rates. Appropriate sample weights were applied in order to maintain the generalizability to the US children and adolescent populations. Preliminary analysis was conducted by performing descriptive data analysis. Percentages and standard errors of means were calculated by Taylor series linearization variance estimation method using SUDAAN. Chi-square tests were conducted to capture the association between categorical variables and meal and snacking consumption and breakfast consumption behavior. Variances of anthropometric measures, laboratory values and nutrient intakes with respect to meal and snacking and breakfast consumption were analyzed using multivariate adjusted ANOVA. A series of regression analyses with eating and snacking consumption frequency as continuous variables was carried out to identify the relations between snacking, eating frequency and breakfast consumption in relation to nutrient intake, laboratory indicators of nutritional status and anthropometric indicators in children and adolescents. A level of significance $p<0.05$ was used. Values are presented in means ± standard errors.

Results

The mean age of the children was 11.5+0.02 years and about half of the sample was girls (50.6%). White children accounted for 57.5% of the sample followed by 14.8% Mexican Americans, 13.8% Blacks 7.0% other Hispanic children. The majority of the children did not report using supplements (79.2%). The mean income to poverty ratio was 2.5±0.01. The mean BMI Z-score and waist circumferences were respectively 0.57±0.04 and 72.2±0.41 cm.

On average children consumed 1935 calories per day (Table 1). The average protein; vitamins A, D and C; iron and folate consumption were higher than the Recommended Daily Allowance (RDA) (Food & Nutrition Board, 2012). Sodium intake was higher but cholesterol intake was lower than the RDA. Vitamin K exceeded but potassium intake fell below the AI. Calcium, vitamin D and vitamin E consumption were below the EAR. Magnesium intake was less than the RDA but greater than the EAR.

The mean total blood cholesterol was 160.52± 1.29 mg/dl. RBC folate and serum folate were 475.34±8.58 ng/dl and 24.14±0.31 ng/dl, respectively.

Daily Eating Frequency in Relation to Anthropometric, Biochemical and Dietary Measures

On average subjects reported a daily eating frequency of 4.35±0.04 with a range from one eating occasion to maximum of six. Subjects were categorized into four groups based on their self reported eating occasions (breakfast, lunch, dinner, snacks and etc.). Category one includes the lowest consumption frequency (1-2.5 meals/snacks) while category four represents the highest consumption frequency (>5 meals/snacks). Gender was not significantly associated with eating frequency. Many in the population consumed three meals/snacks per day (43.14%), 4.82% ate only once per day and 34.21% consumed more than four meals/snacks per day. Whites and supplement users were significantly more likely to be frequent eaters. Blacks were more likely to eat 3.5 or fewer meals/snacks (Table 2).

Table 3 summarizes the unadjusted means and standard errors for anthropometric, biochemical and dietary measures by daily eating frequency in US children. Unadjusted BMI z-scores were not significantly related to eating frequency, however unadjusted waist circumference was lowest among the most frequent eaters. The highest values for RBC folate were reported among least frequent eaters. The most frequent eaters showed the highest values for energy, carbohydrates, proteins, total fats, saturated fats, unsaturated fats, cholesterol, total sugars, vitamins C and D, calcium, phosphorous, magnesium, iron, sodium, potassium and moisture in the unadjusted ANOVA. However, none of the anthropometric measures or the laboratory measures were significantly related to eating frequency when adjusted for age, gender, physical activity, ethnicity and income to poverty ratio in the multivariate adjusted ANOVA (Table 4). When controlled for the confounding variables, the more frequent eaters had higher intakes of energy and most of the nutrients except for vitamins C, K and E. The highest intakes of vitamins C, K and E were reported among the least frequent eaters. When evaluated using regression analysis, daily eating frequency was significantly associated with consumption of energy, macronutrients, micronutrients as well as serum and RBC folate values and total cholesterol (Table 5). Eating frequency was not significantly related to BMI z-scores or waist circumference in the regression analysis.

Table 1. Nutrient Consumption by 9-13 Year Old Children and Recommended Intakes

Nutrient	Population Means (Standard Errors)	Recommended Intakes[a]		
		EAR[b]	RDA[c]	AI[d]
Energy (Kcal)	1935 (27.9)			
Protein (gm)	70.9 (1.12)		34	
Carbohydrates (gm)	258 (4.07)	100	130	
Total Sugars (gm)	123 (1.91)			
Total Fats (gm)	70.9 (1.44)			
Saturated Fats (gm)	24.8 (0.53)			
Monounsaturated Fats (gm)	25.4 (0.55)			
Polyunsaturated Fats (gm)	14.5 (0.34)			
Cholesterol (mg)	220 (4.10)		<300	
Vitamin E (mg)	6.25 (0.22)	9	11	
Vitamin A RAE (mcg)	617 (21.08)	445	600	
Folate (mcg)	394 (10.09)	250	300	
Vitamin C (mg)	73.9 (4.62)	39	45	
Vitamin D (mcg)	5.80 (0.19)	10	15	
Vitamin K (mcg)	57.9 (2.48)			30
Calcium (mg)	1046 (29.7)	1100	1300	
Phosphorous (mg)	1283 (22.9)	1055	1250	
Magnesium (mg)	234 (4.92)	200	240	
Iron (mg)	14.78 (0.28)	5.9	8	
Sodium (mg)	3114 (54.8)		<2200	1500
Potassium (mg)	2201 (40.0)			4500
Caffeine (mg)	26.2 (1.68)			
Moisture (mg)	1673 (34.2)			

[a]Recommended intakes are based on the Dietary Reference Intakes (Food and Nutrition Board, 2012). Empty cells indicate recommended intakes have not been established.
[b]An RDA is the average daily dietary intake level that is sufficient enough to meet the nutrient requirements of nearly 97 to 98 % of healthy individuals in a group
[c]An EAR is the average daily nutrient intake level estimated to meet the requirements of half of the healthy individuals in a group.
[d]The AI for other life stage and gender groups except for infants is believed to cover the needs of all healthy individuals in the groups.

Table 2. Differences in Socio-Demographic and Lifestyle Characteristics by Daily Eating Frequency in US Children

	Daily Eating Frequency[a]				
	1	**2**	**3**	**≥4**	**P value (Wald F)**
Gender%					
Male	4.91	16.99	38.79	39.33	0.1626
Female	4.74	18.66	47.38	29.22	
Ethnicity%					
White	3.17	13.63	42.69	40.51	<0.0001
Mexican American	5.97	23.39	44.73	25.91	
Black	11.69	35.13	36.83	16.36	
Other Hispanic	1.91	13.34	52.06	32.69	
Other	5.31	10.77	47.10	36.82	
Supplement Usage%					
Yes	4.50	10.17	38.17	47.16	0.0316
No	4.90	19.83	44.43	30.83	

[a] Two day average eating frequency: 1= 1 to 2.5, 2= 3 to 3.5, 3= 4 to 4.5, 4= 5 to 6.5 meals and snacks.

Table 3. Differences in Anthropometric, Biochemical and Dietary Measures by Daily Eating Frequency in US Children

	Daily Eating Frequency[a]				P value (Wald F)
	1	2	3	≥4	
	Mean (Standard Error)				
BMI z-score	0.65 (0.19)	0.68 (0.08)	0.58 (0.07)	0.48 (0.07)	0.2995
Waist Circumference (cm)	76.0 (2.15)	74.4 (1.07)	72.1 (0.82)	70.6 (0.58)	**0.0101**
Total Cholesterol (mg/dl)	161 (4.88)	161 (1.96)	161 (2.04)	158 (2.33)	0.7848
Total Cholesterol (mmol/l)	4.18 (0.13)	4.16 (0.05)	4.18 (0.05)	4.11 (0.06)	0.7874
RBC Folate (ng/ml)	503 (28.86)	458 (12.55)	463 (12.32)	495 (10.15)	**0.0159**
RBC Folate (nmol/l)	1139 (65.36)	1039 (28.42)	1050 (27.91)	1120 (22.99)	**0.0159**
Serum Folate (ng/ml)	25.4 (1.81)	23.7 (0.88)	23.2 (0.57)	25.2 (0.66)	0.1256
Serum Folate (nmol/l)	57.5 (4.11)	53.8 (1.98)	52.6 (1.29)	57.2 (1.50)	0.1236
Energy (Kcal)	1725 (89.66)	1699 (57.12)	1906 (35.77)	2123 (47.91)	**0.0001**
Protein (gm)	66.3 (5.17)	60.8 (2.13)	70.1 (1.65)	78.0 (2.23)	**0.0001**
Carbohydrates (gm)	240 (16.57)	228 (8.70)	251 (5.55)	286 (6.65)	**0.0001**
Total Sugars (gm)	120 (12.66)	108 (4.53)	121 (3.43)	135 (3.37)	**0.0011**
Total Fats (gm)	57.9 (3.96)	62.2 (2.57)	71.3 (1.74)	76.9 (2.29)	**0.0001**
Saturated Fats (gm)	19.7 (1.27)	21.2 (0.88)	24.8 (0.61)	27.4 (0.93)	**<0.0001**
Monounsaturated Fats (gm)	20.9 (1.63)	22.4 (0.99)	25.6 (0.66)	27.3 (0.85)	**0.0009**
Polyunsaturated Fats (gm)	12.0 (1.11)	13.0 (0.73)	14.7 (0.52)	15.3 (0.45)	**0.0056**
Cholesterol (mg)	206 (31.02)	186 (11.15)	220 (8.59)	240 (7.98)	**0.0136**
Vitamin E (mg)	6.87 (1.11)	5.02 (0.34)	6.51 (0.39)	6.48 (0.21)	**0.0006**
Vitamin A RAE (mcg)	662 (103.13)	488 (22.86)	601 (21.48)	698 (31.92)	**<0.0001**
Folate (mcg)	74.0 (365.57)	258 (328.02)	534 (387.43)	395 (442.99)	**0.0012**
Vitamin C (mg)	365 (30.52)	328 (19.46)	387 (11.65)	442 (15.71)	**0.0002**
Vitamin D (mcg)	5.41 (0.91)	4.87 (0.31)	5.58 (0.19)	6.62 (0.38)	**0.0016**
Vitamin K (mcg)	93.7 (28.49)	47.8 (4.30)	53.1 (3.31)	64.3 (4.26)	**0.0246**
Calcium (mg)	1068 (169.58)	839 (32.06)	1020 (37.55)	1183 (43.09)	**<0.0001**
Phosphorous (mg)	1196 (81.28)	1085 (54.22)	1271 (26.80)	1415 (42.03)	**0.0015**
Magnesium (mg)	242 (17.44)	201 (15.01)	227 (5.46)	260 (6.42)	**0.0002**
Iron (mg)	13.7 (1.15)	12.8 (0.76)	14.3 (0.35)	16.5 (0.48)	**0.0021**
Sodium (mg)	2859 (288.46)	2725 (109.11)	3047 (67.87)	3436 (92.48)	**0.0001**
Potassium (mg)	2229 (187.69)	1877 (87.21)	2130 (51.34)	2456 (66.26)	**0.0005**
Caffeine (mg)	23.6 (9.71)	23.9 (6.89)	28.4 (2.38)	25.0 (2.34)	0.7616
Moisture (mg)	1712 (121.94)	1348 (51.46)	1591 (34.15)	1942 (67.10)	**<0.0001**

[a] Two day average eating frequency: 1= 1 to 2.5, 2= 3 to 3.5, 3= 4 to 4.5, 4= 5 to 6.5 meals and snacks

Table 4. Differences in Multivariate Adjusted[a] Anthropometric, Biochemical and Dietary Measures by Mean Daily Eating Frequency in US Children

	Daily Eating Frequency[b]				P value (Wald F)[c]
	1	**2**	**3**	**≥4**	
	LS Mean (Standard Error)				
BMI z-score	0.57 (0.21)	0.60 (0.09)	0.59 (0.06)	0.53 (0.06)	0.8796
Waist Circumference (cm)	74.0 (2.17)	72.5 (1.08)	72.3 (0.75)	71.7 (0.48)	0.5806
Total Cholesterol (mg/dl)	164 (4.92)	162 (2.09)	161 (2.05)	157 (2.12)	0.3468
Total Cholesterol (mmol/l)	4.25 (0.13)	4.21 (0.05)	4.17 (0.05)	4.08 (0.05)	0.3511
RBC Folate (ng/ml)	521 (26.25)	474 (12.66)	464 (12.06)	483 (8.37)	0.1449
RBC Folate (nmol/l)	1180 (59.46)	1074 (28.67)	1052 (27.32)	1094 (18.95)	0.1449
Serum Folate (ng/ml)	26.7 (1.67)	25.1 (0.76)	23.2 (0.50)	24.3 (0.67)	0.0799
Serum Folate (nmol/l)	60.5 (3.78)	56.9 (1.72)	52.7 (1.14)	55.1 (1.51)	0.0794
Energy (Kcal)	1706 (88.16)	1684 (53.81)	1917 (30.83)	2119 (48.78)	**0.0001**
Protein (gm)	65.7 (5.15)	60.6 (2.08)	70.6 (1.49)	77.6 (2.30)	**0.0001**
Carbohydrates (gm)	238 (16.83)	227 (8.20)	252 (5.06)	285 (6.55)	**0.0001**
Total Sugars (gm)	122 (13.09)	108 (3.87)	121 (3.01)	133 (3.30)	**0.0010**
Total Fats (gm)	56.9 (3.95)	61.2 (2.58)	71.7 (1.63)	77.0 (2.28)	**0.0001**
Saturated Fats (gm)	19.6 (1.27)	21.0 (0.85)	24.9 (0.60)	27.4 (0.89)	**<0.0001**
Monounsaturated Fats (gm)	20.5 (1.65)	22.1 (1.03)	25.7 (0.62)	27.3 (0.85)	**0.0010**
Polyunsaturated Fats (gm)	11.6 (1.11)	12.7 (0.78)	14.8 (0.50)	15.4 (0.48)	**0.0067**
Cholesterol (mg)	203 (31.64)	183 (11.08)	221 (8.99)	242 (8.89)	**0.0117**
Vitamin E (mg)	6.77 (1.10)	4.95 (0.36)	6.56 (0.41)	6.46 (0.21)	**0.0017**
Vitamin A RAE (mcg)	672 (104.75)	498 (25.02)	604 (21.14)	688 (31.31)	**<0.0001**
Folate (mcg)	363 (31.45)	329 (20.16)	390 (11.95)	439 (15.42)	**0.0035**
Vitamin C (mg)	103 (28.78)	52.8 (2.90)	69.7 (6.49)	86.0 (5.52)	**<0.0001**
Vitamin D (mcg)	5.81 (0.94)	5.14 (0.35)	5.59 (0.18)	6.41 (0.36)	**<0.0001**
Vitamin K (mcg)	89.4 (27.54)	46.0 (4.55)	53.5 (3.07)	65.3 (4.04)	**0.0118**
Calcium (mg)	1102 (167.89)	861.1 (32.04)	1024 (34.47)	1164 (43.21)	**<0.0001**
Phosphorous (mg)	1217 (80.08)	1100 (54.01)	1276 (22.97)	1398 (43.69)	**0.0072**
Magnesium (mg)	242 (17.36)	202 (15.48)	228 (5.49)	258 (6.64)	**0.0006**
Iron (mg)	13.3 (1.15)	12.7 (0.79)	14.4 (0.34)	16.4 (0.48)	**0.0030**
Sodium (mg)	2827 (281.82)	2719 (113.20)	3071 (64.85)	3414 (92.20)	**0.0003**
Potassium (mg)	2237 (183.66)	1885 (79.19)	2138 (45.95)	2442 (66.15)	**0.0007**
Caffeine (mg)	26.2 (9.90)	25.0 (6.31)	28.8 (2.16)	23.6 (2.13)	0.3280
Moisture (mg)	1694 (123.11)	1344 (44.93)	1606 (32.27)	1927 (65.13)	**<0.0001**

[a]Adjusted for age, gender, physical activity, income to poverty ratio and ethnicity
[b]Two day average eating frequency: 1= 1 to 2.5, 2= 3 to 3.5, 3= 4 to 4.5, 4= 5 to 6.5 meals and snacks
[c]Reference: Compared to 3 eating occasions/day (2)

Table 5. Relations Between Daily Eating Frequency and Anthropometric, Biochemical and Dietary Measures in US Children

Variables	R square[a]	Model Significance	P value (Wald F) for Eating Frequency
BMI z-score	0.051	<0.0001	0.1063
Waist Circumference (cm)	0.166	<0.0001	0.2873
Total Cholesterol (mg/dl)	0.034	<0.0001	**0.0052**
Total Cholesterol (mmol/l)	0.033	<0.0001	**0.0052**
RBC Folate (ng/ml)	0.100	<0.0001	**<0.0001**
RBC Folate (nmol/l)	0.100	<0.0001	**<0.0001**
Serum Folate (ng/ml)	0.149	<0.0001	**0.0007**
Serum Folate (nmol/l)	0.149	<0.0001	**0.0006**
Energy (Kcal)	0.145	<0.0001	**<0.0001**
Protein (gm)	0.145	<0.0001	**<0.0001**
Carbohydrates (gm)	0.141	<0.0001	**<0.0001**
Total Sugars (gm)	0.131	<0.0001	**<0.0001**
Total Fats (gm)	0.102	<0.0001	**<0.0001**
Saturated Fats (gm)	0.108	<0.0001	**<0.0001**
Monounsaturated Fats (gm)	0.088	<0.0001	**<0.0001**
Polyunsaturated Fats (gm)	0.054	<0.0001	**<0.0001**
Cholesterol (mg)	0.061	<0.0001	**<0.0001**
Vitamin E (mg)	0.048	<0.0001	**0.0001**
Vitamin A RAE (mcg)	0.113	<0.0001	**<0.0001**
Folate (mcg)	0.092	<0.0001	**<0.0001**
Vitamin C (mg)	0.277	<0.0001	**<0.0001**
Vitamin D (mcg)	0.126	<0.0001	**0.0003**
Vitamin K (mcg)	0.119	<0.0001	**0.0002**
Calcium (mg)	0.219	<0.0001	**<0.0001**
Phosphorous (mg)	0.144	<0.0001	**<0.0001**
Magnesium (mg)	0.121	<0.0001	**<0.0001**
Iron (mg)	0.094	<0.0001	**<0.0001**
Sodium (mg)	0.120	<0.0001	**<0.0001**
Potassium (mg)	0.164	<0.0001	**<0.0001**
Caffeine (mg)	0.123	<0.0001	**<0.0001**
Moisture (mg)	0.209	<0.0001	**<0.0001**

[a]Adjusted for age, gender, physical activity, income to poverty ratio and ethnicity.

Daily Snacking Frequency in Relation to Anthropometric, Biochemical and Dietary Measures

On average children ate 2.4±0.03 snacks per day. The children were categorized according to the average snacking frequency. Category one includes the lowest snacking frequency (less than one snack per day) while category four represents the highest snack consumption frequency (3 or more snacks per day). There were no gender differences in terms of snacking frequency. Many children (44.9%) reported having one snacking occasion while 43.0% ate two snacks per day. Only 4.5% reported consuming three or more snacks per day. A majority of Mexican Americans and Blacks reported having a one snack or no snacks while the most of White children reported having two or more snacks per day (Table 6).

Unadjusted mean anthropometric, biochemical and dietary measures with respect to daily snacking are provided in Table 7. The most frequent snackers had the lowest waist circumference values in the unadjusted ANOVA. The highest intakes of energy, carbohydrates, proteins, total fats, saturated fats, polyunsaturated fats, cholesterol and total sugars were also reported among the most frequent snackers in the unadjusted ANOVA. Similar to daily eating frequency, snacking frequency was not significantly related to BMI z-scores, waist circumference or laboratory measures in multivariate adjusted ANOVA (Table 8). Compared to the least frequent snackers, children who had three or more snacks consumed the highest amounts of energy, macronutrients, vitamin E, calcium, phosphorous, magnesium, iron, sodium, potassium and moisture. When snacking was treated as a continuous variable in the regression analysis, energy, carbohydrates, proteins, fats, total sugars, monounsaturated fats, polyunsaturated fats, cholesterol, saturated fat, vitamin E, calcium, phosphorous, magnesium, iron, sodium, potassium and moisture intake were significantly related to daily snacking frequency (Table 9).

Table 6. Differences in Socio-Demographic and Lifestyle Characteristics by Daily Snacking Frequency in US Children

	Daily Snacking Frequency[a]				
	1	**2**	**3**	**4**	**P value (Wald F)**
Gender%					
Male	8.96	37.70	48.04	5.29	0.0772
Female	6.21	52.00	38.08	3.70	
Ethnicity%					
White	4.81	41.76	47.66	5.77	0.0001
Mexican American	10.44	47.12	39.93	2.51	
Black	16.85	56.26	25.98	0.90	
Other Hispanic	8.00	45.55	43.61	2.83	
Other	5.42	43.37	44.24	6.98	
Supplement Usage%					
Yes	5.29	44.26	47.57	2.88	0.6680
No	8.17	45.11	41.81	4.91	

[a] Two day average snacking frequency: 1= 0 to 0.5 snacks, 2= 1 to 1.5 snacks, 3= 2 to 2.5 snacks, 4= 3 or more snacks.

Table 7. Differences in Anthropometric, Biochemical and Dietary Measures by Daily Snacking Frequency in US Children

	Daily Snacking Frequency[a]				P value (Wald F)
	1	2	3	4	
	Mean (Standard Error)				
BMI z-score	0.80 (0.16)	0.58 (0.06)	0.54 (0.06)	0.38 (0.16)	0.1613
Waist Circumference (cm)	77.2 (2.48)	72.6 (0.76)	71.2 (0.65)	69.7 (1.93)	**0.0291**
Total Cholesterol (mg/dl)	163 (2.80)	159 (1.53)	160 (2.33)	160 (4.14)	0.6903
Total Cholesterol (mmol/l)	4.23 (0.07)	4.13 (0.04)	4.16 (0.06)	4.16 (0.11)	0.6899
RBC Folate (ng/ml)	457 (18.24)	468 (11.54)	482 (9.02)	504 (24.28)	0.1229
RBC Folate (nmol/l)	1036 (41.31)	1061 (26.13)	1093 (20.42)	1142 (54.99)	0.1229
Serum Folate (ng/ml)	23.7 (0.85)	23.4 (0.59)	24.7 (0.64)	25.5 (0.98)	0.3094
Serum Folate (nmol/l)	53.7 (1.92)	53.2 (1.33)	56.0 (1.45)	57.8 (2.22)	0.3093
Energy (Kcal)	1592 (84.36)	1834 (35.77)	2070 (36.55)	2222 (144.86)	**<0.0001**
Protein (gm)	61.5 (3.12)	67.3 (1.55)	75.3 (1.58)	81.6 (6.71)	**0.0008**
Carbohydrates (gm)	209 (12.58)	247 (4.93)	275 (5.63)	298 (20.49)	**0.0001**
Total Sugars (gm)	96.6 (8.38)	118 (3.05)	131 (3.38)	135 (5.86)	**0.0019**
Total Fats (gm)	58.2 (3.68)	66.2 (1.83)	77.0 (1.98)	81.5 (5.46)	**0.0002**
Saturated Fats (gm)	20.8 (1.55)	22.6 (0.62)	27.3 (0.86)	29.4 (2.23)	**0.0003**
Monounsaturated Fats (gm)	21.0 (1.31)	23.8 (0.67)	27.3 (0.78)	28.8 (1.81)	**0.0009**
Polyunsaturated Fats (gm)	11.1 (0.73)	14.0 (0.51)	15.5 (0.45)	15.7 (0.95)	**0.0001**
Cholesterol (mg)	213 (22.38)	199 (5.53)	241 (6.50)	235 (30.58)	**0.0003**
Vitamin E (mg)	4.25 (0.25)	6.19 (0.24)	6.56 (0.41)	7.25 (0.57)	**<0.0001**
Vitamin A RAE (mcg)	531 (53.69)	595 (28.91)	643 (25.05)	737 (91.99)	0.2080
Folate (mcg)	332 (24.82)	389 (12.91)	406 (11.51)	447 (46.62)	**0.0357**
Vitamin C (mg)	71.8 (19.29)	73.1 (5.52)	72.9 (4.80)	95.3 (13.60)	0.4041
Vitamin D (mcg)	5.09 (0.56)	5.52 (0.22)	6.18 (0.23)	6.20 (0.89)	0.0902
Vitamin K (mcg)	54.9 (14.25)	56.5 (3.12)	60.2 (3.50)	55.6 (5.27)	0.7622
Calcium (mg)	915 (113.17)	963 (32.36)	1132 (34.47)	1273 (102.39)	**0.0004**
Phosphorous (mg)	1041 (62.06)	1218 (32.74)	1374 (30.36)	1470 (99.00)	**0.0002**
Magnesium (mg)	194 (10.14)	223 (7.69)	249 (5.84)	277 (16.13)	**0.0001**
Iron (mg)	12.3 (0.91)	14.5 (0.47)	15.3 (0.33)	16.0 (1.34)	**0.0159**
Sodium (mg)	2633 (147.68)	2982 (68.77)	3283 (64.84)	3622 (329.60)	**0.0007**
Potassium (mg)	1872 (140.65)	2116 (51.81)	2315 (55.34)	2523 (143.70)	**0.0132**
Caffeine (mg)	19.8 (6.54)	24.3 (2.39)	29.7 (2.68)	22.0 (6.96)	0.3395
Moisture (mg)	1399 (100.03)	1525 (39.80)	1832 (51.44)	2096 (180.95)	**0.0001**

[a] Two day average snacking frequency: 1= 0 to 0.5 snacks, 2= 1 to 1.5 snacks, 3= 2 to 2.5 snacks, 4= 3 or more snacks.

Table 8. Differences in Multivariate Adjusted[a] Anthropometric, Biochemical and Dietary Measures by Daily Snacking Frequency in US Children

	Daily Snacking Frequency[b]				P value (Wald F)[c]
	1	2	3	4	
	LS Mean (Standard Error)				
BMI z-score	0.69 (0.15)	0.58 (0.06)	0.56 (0.06)	0.41 (0.16)	0.5504
Waist Circumference (cm)	75.0 (2.29)	72.2 (0.62)	71.9 (0.65)	70.2 (1.16)	0.2080
Total Cholesterol (mg/dl)	166 (2.56)	160 (1.65)	160 (2.12)	159 (4.03)	0.1634
Total Cholesterol (mmol/l)	4.30 (0.07)	4.14 (0.04)	4.14 (0.05)	4.13 (0.10)	0.1640
RBC Folate (ng/ml)	475 (17.71)	472 (11.78)	476 (7.50)	499 (19.32)	0.5316
RBC Folate (nmol/l)	1076 (40.11)	1069 (26.67)	1078 (16.98)	1130 (43.77)	0.5316
Serum Folate (ng/ml)	25.2 (0.81)	23.6 (0.53)	24.2 (0.58)	25.4 (0.99)	0.1804
Serum Folate (nmol/l)	57.2 (1.83)	53.6 (1.20)	54.9 (1.31)	57.6 (2.24)	0.1812
Energy (Kcal)	1553 (93.27)	1850 (34.59)	2063 (34.37)	2194 (134.29)	**<0.0001**
Protein (gm)	60.2 (3.36)	68.0 (1.40)	74.9 (1.45)	80.7 (6.31)	**0.0005**
Carbohydrates (gm)	204 (13.83)	249 (4.80)	273 (5.40)	294 (18.56)	**0.0001**
Total Sugars (gm)	95.8 (8.97)	120 (2.85)	130 (3.28)	133 (6.37)	**0.0055**
Total Fats (gm)	56.6 (4.05)	66.7 (1.87)	76.9 (1.90)	80.4 (5.48)	**0.0002**
Saturated Fats (gm)	20.4 (1.63)	22.8 (0.62)	27.2 (0.78)	29.0 (2.28)	**0.0001**
Monounsaturated Fats (gm)	20.5 (1.44)	24.0 (0.69)	27.3 (0.78)	28.4 (1.83)	**0.0011**
Polyunsaturated Fats (gm)	10.6 (0.85)	14.1 (0.53)	15.5 (0.47)	15.5 (0.98)	**0.0003**
Cholesterol (mg)	208 (23.94)	200 (5.66)	241 (6.57)	235 (30.18)	**0.0002**
Vitamin E (mg)	4.06 (0.39)	6.24 (0.25)	6.57 (0.42)	7.08 (0.54)	**0.0005**
Vitamin A RAE (mcg)	544 (58.20)	600 (28.65)	636 (23.90)	725 (92.42)	0.3680
Folate (mcg)	329 (27.18)	392 (13.43)	403 (10.52)	446 (44.21)	0.0543
Vitamin C (mg)	68.3 (19.06)	72.8 (5.67)	73.4 (4.03)	99.7 (13.22)	0.2274
Vitamin D (mcg)	5.38 (0.56)	5.64 (0.25)	6.02 (0.21)	6.05 (0.82)	0.4551
Vitamin K (mcg)	51.9 (15.26)	56.0 (2.95)	61.3 (3.51)	55.2 (5.55)	0.3787
Calcium (mg)	934 (115.18)	978 (33.97)	1116 (31.00)	1249 (93.02)	**0.0015**
Phosphorous (mg)	1045 (68.63)	1235 (30.92)	1361 (27.61)	1438 (91.56)	**0.0008**
Magnesium (mg)	192 (11.00)	225 (7.44)	248 (5.88)	275 (15.29)	**0.0005**
Iron (mg)	12.0 (0.98)	14.5 (0.48)	15.3 (0.32)	16.1 (1.34)	**0.0091**
Sodium (mg)	2588 (157.06)	3010 (71.22)	3267 (60.18)	3567 (316.99)	**0.0006**
Potassium (mg)	1862 (143.35)	2133 (50.51)	2301 (51.39)	2506 (130.89)	**0.0121**
Caffeine (mg)	20.4 (6.43)	25.2 (2.57)	29.0 (2.39)	19.8 (6.66)	0.3296
Moisture (mg)	1373 (109.91)	1539 (37.36)	1825 (48.05)	2075 (177.82)	**0.0001**

[a]Adjusted for age, gender, physical activity, income to poverty ratio and ethnicity
[b]Two day average snacking frequency: 1= 0 to 0.5 snacks, 2= 1 to 1.5 snacks, 3= 2 to 2.5 snacks, 4= 3 or more snacks.
[c]Reference: Compared to lowest snacking frequency (1)

Table 9. Relation Between Daily Snacking Frequency and Anthropometric, Biochemical and Dietary Measures in US Children

Variables	R square[a]	Model Significance	P value (Wald F) for Snacking Frequency
BMI z-score	0.0443	<0.0001	0.5504
Waist Circumference (cm)	0.1577	<0.0001	0.2080
Total Cholesterol (mg/dl)	0.0233	<0.0001	0.1634
Total Cholesterol (mmol/l)	0.0232	<0.0001	0.1640
RBC Folate (ng/ml)	0.0802	<0.0001	0.5316
RBC Folate (nmol/l)	0.0802	<0.0001	0.5316
Serum Folate (ng/ml)	0.1358	<0.0001	0.1804
Serum Folate (nmol/l)	0.1358	<0.0001	0.1812
Energy (Kcal)	0.1181	<0.0001	**<0.0001**
Protein (gm)	0.0984	<0.0001	**0.0005**
Carbohydrates (gm)	0.0950	<0.0001	**0.0001**
Total Sugars (gm)	0.0796	<0.0001	**0.0055**
Total Fats (gm)	0.0892	<0.0001	**0.0002**
Saturated Fats (gm)	0.0917	<0.0001	**0.0001**
Monounsaturated Fats (gm)	0.0743	<0.0001	**0.0011**
Polyunsaturated Fats (gm)	0.0529	<0.0001	**0.0003**
Cholesterol (mg)	0.0486	<0.0001	**0.0002**
Vitamin E (mg)	0.0439	<0.0001	**0.0005**
Vitamin A RAE (mcg)	0.0450	<0.0001	0.3680
Folate (mcg)	0.0452	<0.0001	0.0543
Vitamin C (mg)	0.0284	<0.0001	0.2274
Vitamin D (mcg)	0.0562	<0.0001	0.4551
Vitamin K (mcg)	0.0326	<0.0001	0.3787
Calcium (mg)	0.0690	<0.0001	**0.0015**
Phosphorous (mg)	0.1059	<0.0001	**0.0008**
Magnesium (mg)	0.0722	<0.0001	**0.0005**
Iron (mg)	0.0432	<0.0001	**0.0091**
Sodium (mg)	0.0844	<0.0001	**0.0006**
Potassium (mg)	0.0618	<0.0001	**0.0121**
Caffeine (mg)	0.0864	<0.0001	0.3296
Moisture (mg)	0.1376	<0.0001	**0.0001**

[a]Adjusted for age, gender, physical activity, income to poverty ratio and ethnicity.

Breakfast Consumption in Relation to Anthropometric, Biochemical and Dietary Measures

The majority of the children consumed breakfast on both days (73.3%) while 21.9% skipped breakfast on one day and 4.8% did not consumed any breakfast during the two days under consideration. Black children were more likely to skip breakfast on both days.

Children who did not take supplements were more likely to skip breakfast on a one day. Breakfast consumption did not show any gender diffrences (Table 10).

In the unadjusted ANOVA the breakfast skippers had the highest BMI z-scores, waist circumference values and total blood cholesterol values (Table 11). Breakfast skippers reported lower consumption of vitamins A and D, folate, iron, sodium, potassium and phosphorous. Caffeine intake was significantly related to breakfast skipping in the unadjusted ANOVA. Children who consumed breakfast on both days consumed less caffeine. Neither of the anthropometric indicators was significantly related to breakfast consumption in the multivariate adjusted ANOVA (Table 12). Total blood cholesterol was significantly higher among breakfast skippers than in children who consumed breakfast at least one day. Macronutrient consumption was not found to be significantly related to breakfast consumption in the multivariate adjusted ANOVA (Table 12). Breakfast skippers had lower intakes of nutrients including folate, vitamins A and D, phosphorous, iron, potassium and sodium compared to children who had breakfast on both days. Except for potassium these relations were significant when adjusted for other confounding variables in the regression model. Breakfast skippers reported significant higher intakes of caffeine than children who ate breakfast on both days.

Table 10. Differences in Socio-Demographic and Lifestyle Characteristics by Frequency of Breakfast Consumption in US Children

	Breakfast Consumption			
	Consumed Both days	**Skipped One Day**	**Skipped Both days**	**P value (Wald F)**
Gender%				
Male	72.32	21.47	6.21	0.1279
Female	74.30	22.29	3.41	
Ethnicity%				
White	76.85	19.79	3.39	0.0194
Mexican American	63.15	31.18	5.67	
Black	63.67	25.13	11.20	
Other Hispanic	77.32	18.05	4.63	
Other	81.12	16.97	1.92	
Supplement Usage%				
Yes	87.74	10.05	4.80	<0.0001
No	69.56	24.97	2.21	

Table 11. Differences in Mean Anthropometric, Biochemical and Dietary Measures by Breakfast Consumption Frequency in US Children

	Breakfast Consumption			P value (Wald F)
	Consumed Both days	**Skipped One Day**	**Skipped Both days**	
	Mean (Standard Error)			
BMI z-score	0.50 (0.05)	0.74 (0.09)	0.87 (0.17)	**0.0218**
Waist Circumference (cm)	71.3 (0.45)	74.6 (1.00)	74.5 (2.15)	**0.0079**
Total Cholesterol (mg/dl)	160 (1.75)	159 (1.66)	173 (4.97)	**0.0280**
Total Cholesterol (mmol/l)	4.14 (0.05)	4.12 (0.04)	4.49 (0.13)	**0.0280**
RBC Folate (ng/ml)	478 (9.82)	462 (8.28)	488 (30.63)	0.2612
RBC Folate (nmol/l)	1083 (22.25)	1046 (18.76)	1107 (69.39)	0.2612
Serum Folate (ng/ml)	24.3 (0.37)	23.6 (0.65)	22.7 (2.04)	0.6244
Serum Folate (nmol/l)	55.2 (0.85)	53.5 (1.48)	51.4 (4.63)	0.6210
Energy (Kcal)	1944 (35.12)	1944 (59.32)	1747 (81.87)	0.1219
Protein (gm)	71.7 (1.14)	70.1 (2.69)	63.0 (3.43)	0.0654
Carbohydrates (gm)	260 (5.41)	259 (8.17)	231 (13.44)	0.1352
Total Sugars (gm)	123 (2.66)	125 (5.48)	111 (7.78)	0.2956
Total Fats (gm)	71.0 (1.63)	72.1 (3.18)	64.9 (3.72)	0.2886
Saturated Fats (gm)	25.1 (0.57)	24.6 (1.25)	21.6 (1.30)	0.0703
Monounsaturated Fats (gm)	25.3 (0.63)	25.9 (1.22)	23.4 (1.42)	0.4281
Polyunsaturated Fats (gm)	14.3 (0.40)	15.3 (0.79)	14.1 (1.04)	0.5358
Cholesterol (mg)	224 (4.71)	215 (9.15)	185 (15.11)	0.0817
Vitamin E (mg)	6.16 (0.29)	6.56 (0.42)	6.26 (0.79)	0.7400
Vitamin A RAE (mcg)	650 (18.88)	554 (32.43)	399 (55.04)	**<0.0001**
Folate (mcg)	412 (10.61)	366 (15.97)	257 (15.07)	**<0.0001**
Vitamin C (mg)	74.6 (4.44)	71.7 (9.01)	72.9 (19.33)	0.9438
Vitamin D (mcg)	6.13 (0.20)	5.16 (0.29)	3.72 (0.57)	**<0.0001**
Vitamin K (mcg)	55.8 (2.75)	59.4 (5.23)	84.7 (24.67)	**0.4769**
Calcium (mg)	1069 (27.41)	1014 (61.70)	842 (106.01)	0.0783
Phosphorous (mg)	1303 (23.44)	1268 (55.80)	1061 (59.99)	**0.0068**
Magnesium (mg)	236 (5.20)	235 (13.67)	202 (16.23)	0.1022
Iron (mg)	15.4 (0.30)	13.6 (0.56)	9.9 (0.62)	**<0.0001**
Sodium (mg)	3141 (53.45)	3125 (125.58)	2642 (150.20)	**0.0137**
Potassium (mg)	2232 (42.56)	2162 (84.30)	1907 (180.81)	**0.0360**
Caffeine (mg)	22.4 (1.41)	36.8 (7.03)	36.8 (10.79)	**0.0015**
Moisture (mg)	1687 (36.81)	1653 (68.54)	1548 (108.59)	0.2589

Table 12. Differences in Multivariate Adjusted[a] Anthropometric, Biochemical and Dietary Measures by Breakfast Consumption Frequency in US Children

	Breakfast Consumption			R square[a]	P value[b] (Wald F) for Breakfast Consump-tion
	Consumed Both days	Skipped One Day	Skipped Both days		
	LS Mean (Standard Error)				
BMI z-score	0.52 (0.05)	0.68 (0.10)	0.78 (0.16)	0.0471	0.1684
Waist Circumference (cm)	71.8 (0.50)	73.0 (1.06)	74.3 (1.85)	0.1557	0.3193
Total Cholesterol (mg/dl)	159 (1.62)	160 (1.66)	174 (4.85)	0.0320	**0.0126**
Total Cholesterol (mmol/l)	4.13 (0.04)	4.15 (0.04)	4.51 (0.13)	0.0318	**0.0128**
RBC Folate (ng/ml)	474 (8.95)	470 (8.83)	505 (24.39)	0.0811	0.3739
RBC Folate (nmol/l)	1075 (20.28)	1066 (20.01)	1144 (55.26)	0.0811	0.3739
Serum Folate (ng/ml)	23.9 (0.33)	24.7 (0.55)	23.8 (1.60)	0.1333	0.4365
Serum Folate (nmol/l)	54.3 (0.75)	55.9 (1.25)	53.9 (3.62)	0.1333	0.4383
Energy (Kcal)	1946 (34.27)	1941 (56.76)	1730 (78.82)	0.0611	0.0654
Protein (gm)	71.7 (1.10)	70.2 (2.63)	62.9 (3.55)	0.0673	0.0808
Carbohydrates (gm)	260 (5.25)	259 (7.77)	229 (12.78)	0.0489	0.0776
Total Sugars (gm)	123 (2.48)	125 (5.12)	109 (7.88)	0.0538	0.2219
Total Fats (gm)	71.1 (1.56)	71.8 (3.03)	64.0 (3.83)	0.0412	0.2031
Saturated Fats (gm)	25.1 (0.55)	24.6 (1.18)	21.4 (1.44)	0.0457	0.0742
Monounsaturated Fats (gm)	25.4 (0.60)	25.8 (1.18)	23.1 (1.42)	0.0361	0.2962
Polyunsaturated Fats (gm)	14.3 (0.40)	15.2 (0.77)	13.8 (1.05)	0.0236	0.5571
Cholesterol (mg)	224 (4.75)	213 (8.82)	183 (14.43)	0.0303	0.0536
Vitamin E (mg)	6.16 (0.31)	6.54 (0.41)	6.29 (0.77)	0.0231	0.7872
Vitamin A RAE (mcg)	647 (17.79)	561 (34.03)	412 (59.07)	0.0645	**<0.0001**
Folate (mcg)	411 (10.58)	368 (16.23)	258 (15.50)	0.0666	**<0.0001**
Vitamin C (mg)	74.6 (4.01)	71.7 (8.55)	72.8 (21.07)	0.0231	0.9358
Vitamin D (mcg)	6.09 (0.20)	5.28 (0.30)	3.87 (0.54)	0.0740	**0.0001**
Vitamin K (mcg)	55.7 (2.53)	59.8 (5.29)	84.1 (23.47)	0.0405	0.3583
Calcium (mg)	1065 (26.08)	1023 (59.56)	864 (101.74)	0.0525	**0.0074**
Phosphorous (mg)	1300 (22.47)	1272 (54.63)	1078 (51.45)	0.0772	**0.0031**
Magnesium (mg)	236 (5.34)	237 (13.72)	205 (16.24)	0.0404	0.1477
Iron (mg)	15.4 (0.29)	13.6 (0.59)	9.9 (0.69)	0.0650	**<0.0001**
Sodium (mg)	3137 (50.92)	3142 (125.24)	2632 (148.82)	0.0594	**0.0081**
Potassium (mg)	2229 (41.00)	2169 (82.38)	1927 (183.01)	0.0407	0.0672
Caffeine (mg)	22.1 (1.40)	36.8 (6.34)	40.3 (10.77)	0.1092	**0.0005**
Moisture (mg)	1683 (37.38)	1659 (65.25)	1589 (109.03)	0.0734	0.6040

[a]Adjusted for age, gender, physical activity, income to poverty ratio and ethnicity
[b]Reference: Compared to breakfast consumption on both days

Discussion

Results of this study provided information on eating, snacking and breakfast consumption frequency and their associations with certain anthropometric, laboratory measures and macronutrient and micronutrient consumption of children 9 to 13 years of age in the US. On average subjects in this study reported a daily eating frequency of 4.35 including 2.4 snacking occasions. This is similar to the findings of Huang et al. (2004) who reported a daily meal frequency and snacking frequency of 4.7 and 2.0 respectively for a group of 6 to 11 year old children from the 1994-98 Continuing Survey of Food Intakes by Individuals (CSFII). However, Lin and Guthrie (1996) analyzed the 1989-91 CSFII using children and adolescents and found fewer total eating occasions (3.8) including 1.1 snacking occasions. The USDA Food Survey Research Group (2010) reported that average snacking was about 1.7 snacks per day using 2006 NHANES data but they used a different definition of snacks than the present study. Depending on the definition of eating occasions and snacks used, the number of eating occasions will vary.

The results of this study indicated that daily eating frequency was significantly and positively associated with consumption of energy, protein, carbohydrates, total sugars, total fats, saturated fats, monounsaturated and polyunsaturated fats, cholesterol and micronutrients including vitamin A and D, folate, iron, potassium, magnesium, phosphorous, sodium and calcium and also moisture. Daily snacking frequency was positively and significantly associated with increased consumption of energy, protein, carbohydrates, total sugars, total fats, saturated fats, monounsaturated and polyunsaturated fats, cholesterol, iron, potassium, magnesium, phosphorous, sodium, calcium and moisture. Breakfast skippers had lower intakes total folate, vitamins A and D, phosphorous, iron, potassium and sodium and higher intakes of cholesterol but there was no significant association with macronutrient consumption.

Results of this study indicated a positive relationship with respect to daily eating and snacking frequency and energy, protein, carbohydrates, total sugars, total fats, total saturated fats, cholesterol among children and adolescents. It is evident that children who eat more often are consuming more carbohydrates, protein, fats and sugar. This evidence it bolstered not only by the results of this study but also other studies which looked at eating and snacking among children and reported similar results. According to Sebastian et al. (2007) increasing snacking frequency was related to increased food energy along with carbohydrates and total sugars. Keast et al. (2010) also reported higher energy intake with increased snacking among 12-18 old adolescents. Ruxton et al. (1996) reported that snacking was associated with increased consumption of energy and macronutrients, however energy adjusted protein and fat intakes were significantly lower in the diets of children as snacking frequency increased. The USDA Food Survey Research Group (2010) also suggested that children who ate more snacks reported more daily calories, carbohydrates and total sugars, but a lower proportion of calories from proteins. These results raise questions about the potential negative consequences increased snacking frequency might create for children's future health and nutritional status.

Except for vitamins C, K and E, all the other micronutrients studied had a positive association with daily eating frequency. Likewise, daily snacking frequency was also associated with increased consumption of vitamin E, calcium, phosphorous, magnesium, iron, sodium and potassium. In a study conducted with adolescents by McCoy et al. (1986) snacks provided the 15-20% of the mineral intakes and 13-17% of the vitamin intakes. Snacks contributed greatly to the intake of riboflavin, vitamin C and thiamin providing 52, 43 and 39% of the RDA respectively. Ruxton et al. (1996) assessed snacking habits of 7 to 8 year old children and concluded that snacks made an important contribution to daily intakes of vitamin C; for children who consumed low volumes of milk, snacking was an important source of vitamin A and calcium; and for children with a low consumption of breakfast cereal, snacks were an important source of iron and folate. Sebastian et al. (2007) suggested that vitamin C intake was positively associated with snacking among adolescents. The Food Survey Research Group of USDA (2010) concluded that snacks provided more Vitamin C and E but lower proportions of other micronutrients including iron, folate and vitamin A of their daily caloric requirements compared to their total overall daily caloric intake. The findings of increased vitamin and mineral intake with increased eating and snacking frequency indicate that children are eating foods that provide these important nutrients.

Macronutrient consumption was not significantly related to breakfast consumption, but breakfast skippers had significantly lower intakes of folate, vitamins A and D, phosphorous, iron, potassium and sodium compared to children who had breakfast on both days in our study. Barton et al. (2005) evaluated breakfast consumption and its effect on nutritional status of a group of girls and found that breakfast consumption was associated with higher intakes of calcium, fiber, cholesterol, iron, folic acid, vitamin C, and zinc. Williams (2007) concluded that the typical breakfast consumed by young Australians was low in fat, high in carbohydrate and a good source of thiamin, riboflavin, niacin, calcium and magnesium. Those who did not eat breakfast cereal were much more likely to have inadequate nutrient intakes, especially of thiamin, riboflavin, calcium, magnesium and iron. Sampson et al. (1995) found that a significantly greater proportion of low income African-American children who skipped breakfast failed to achieve dietary adequacy in most of the nutrients studied compared to those who ate breakfast. More than one third of breakfast skippers consumed less than 50% of the recommended amounts of vitamins A, E, B6, and folate, and one fourth consumed less than 50% of the recommended dietary allowance for vitamin C, calcium, and iron. Williams et al. (2008) concluded that children and adolescents who had breakfast of ready to eat cereals had the highest mean intakes of vitamins A, B6 and B12, thiamine, riboflavin, niacin, folate, calcium, iron and zinc compared to breakfast skippers. Most studies related to breakfast skipping looked at the quantity as well as quality of food eaten at the breakfast. However, in the present study the researchers did not evaluate the type or quantity of foods children ate at breakfast such as fortified cereals, but it is likely that children who skipped breakfast were less likely to consume these nutrient-dense foods.

In this study, no significant associations were found with respect to BMI z-scores, waist circumference or laboratory indicators of nutritional status except for the relation between breakfast skipping and total blood cholesterol. Other studies also reported a lack of association between eating and snacking frequency and body weight. In 1996, Ruxton et al. reported that snacking was not associated with BMI or skinfold thickness among a sample of 7 to 8 years old children in Scotland. An analysis of 2005-2006 NHANES data showed that snacking frequency was not associated with BMI among adolescents (USDA, 2010). Field et al. (2004) revealed that snacking had no independent effect on 9 to 14 years old children's BMI after controlling for Tanner stages of development, gender, physical activity and height change. However, Toschke et al. (2005) reported that increased daily meal frequency in young children had a protective effect against weight gain. Franko et al. (2008) reported that 9 to 19 year old children who ate more than 3 meals per day had lower BMI values compared to children who ate less than that. A study using a sample of 12 to 18 year olds from NHANES 1999-2004 concluded that snackers were less likely to be overweight or obese compared to non-snackers (Keast et al., 2010). Differences in age groups studied might have impacted the results as children's food habits and food choices change significantly with age.

This study did not find a significant association between frequency of breakfast consumption and BMI z-scores when adjusted for potentially confounding variables. A study conducted in Australia with children and adolescents 2 to 18 years also reported no difference in BMI of regular breakfast eaters compared with breakfast skippers (Williams, 2007). However, several other studies reported a significant association between breakfast consumption and body weight. Siega-Riz et al. (1998) concluded that less frequent breakfast eating was associated with increased incidence of obesity among the sample of 1 to 18 year olds. Timlin et al. (2007) conducted a prospective study and concluded that breakfast consumption was inversely associated with BMI in a dose-response manner when adjusted for age, race, physical activity and socioeconomic status. Likewise, Barton et al. (2005) revealed that breakfast consumption was associated with a healthful BMI among a group of girls 9 to 19 years old after adjusting for confounding variables. Deshmukh-Taskar et al. (2010) also reported that the children who had breakfast showed favorable BMI and waist circumference measures among a group of 9 to 18 year olds. These different conclusions may be attributed to different methods of evaluating body weight. Some studies looked at BMI rather than BMI z-scores while others looked at percentage of fatness among children. Some studies also looked at the changes over time while other studies such as the present study evaluated body weight at a single point in time.

The overall mean total blood cholesterol and RBC folate levels were within normal ranges (American Heart Association, 2012 & WHO, 2012). Serum folate values were slightly above the normal limit of 6-20 ng/ml (WHO, 2012). Serum folate levels indicate the most recent folate consumption. According to 2005-2006 NHANES the median serum folate level of the US population 4 years of age and older was 12.2 ng/ml and the median RBC folate level was 266 ng/ml. In 1998, with the folate supplementation for all enriched breads, cereals, flours, corn meal, pasta products, rice, and other cereal grain products sold in the US began and this has increased blood folate among US citizens (CDC, 2012).

This study did not find any significant associations of laboratory indicators including total blood cholesterol, total serum and RBC folate with daily eating and snacking frequency. However, breakfast skippers had significantly higher amounts of total blood cholesterol compared to children and adolescents who ate breakfast. Resnicow (1991) reported similar findings; breakfast skippers had the highest total blood cholesterol levels after controlling for age, gender and BMI compared to regular breakfast consumers. Preziosi et al (2003) concluded that RTE breakfast cereal consumption was associated with lower serum cholesterol. Smith et al (2010) showed that even after adjusting for age, gender, socio-demographic and lifestyle characteristics, participants who skipped breakfast in childhood had higher serum cholesterol.

A major strength of this study is that it used a nationally representative sample of children and adolescents so the results are generalizable to the US population. The study used a unique cohort of youth in the investigation; past literature on meal/snacking frequency and its relationship to nutritional status in this age group in the US is scanty. Finally, this study used eating occasions identified by the respondent based on their knowledge and time of eating rather than researcher-defined meals and snacks.

However, the study was limited because secondary data were used. The anthropometric, laboratory and dietary intake data were assumed to be accurately collected and reliable. The two days of food intake considered for the analysis might not be representative of a typical daily consumption of the group of the 9 to 13 year old child. Only the number of eating and snacking occasions was considered, rather than the type of food or the amounts of food consumed at each meal or snack. Therefore, the researchers cannot comment on differences in nutrient intake data with respect to consumption of specific foods by the participants.

Conclusions and Implications

This study marked an important first step in analyzing the effects of eating and snacking frequency and breakfast skipping on body weight and nutritional status among a nationally representative group of children and adolescents in the US. It is evident that meals and snacks contributed significantly to macronutrient and micronutrient consumption and skipping breakfast is associated with reduced consumption of important micronutrients. Daily eating frequency was associated with consumption of energy, protein, carbohydrates, total sugars, total fats, saturated fats, monounsaturated and polyunsaturated fats, cholesterol, vitamin A and D, folate, iron, potassium, magnesium, phosphorous, sodium, calcium and moisture. Daily snacking frequency was positively and significantly associated with increased consumption of energy, protein, carbohydrates, total sugars, total fats, saturated fats, monounsaturated and polyunsaturated fats, cholesterol, iron, potassium, magnesium, phosphorous, sodium, calcium and moisture. Breakfast consumption was not associated with macronutrient intake, but breakfast skippers had lower intakes of total folate, vitamins A and D, phosphorous, iron, potassium and sodium and higher intakes of cholesterol. This study also showed that there was no significant association between eating or snacking frequency and weight status among children. None of the laboratory indicators were significant except for the higher blood cholesterol levels among breakfast skippers. In general children lacked some of the important micronutrients such as vitamin K and D and calcium as their intakes were less than the RDA and even the EAR. It is evident that less frequent eaters were more likely to consume less of important nutrients. However, children who ate more frequently also had higher intakes of less desirable nutrients such as sodium, sugar and cholesterol.

The results of this study provide a better insight into children and adolescents' eating patterns and nutrient profiles. According to the present study, children who ate more snacks had greater macronutrient and micronutrient intake. Therefore, it is important to encourage children and adolescents to have snacks but it is also important to encourage them to choose healthier and more nutritious options rather than opting for high calorie, sugar, fat and sodium snacks. Children should be encouraged to eat more fruits and vegetables, nuts and daily products as snacks. Results of this study also highlight the importance of consuming breakfast every day.

Meals and snacks provide important nutrients for children. Snacks are a good source of macronutrients and can provide some of the most important micronutrients. Children should be encouraged to eat at least 2 snacks per day but it is also important to watch out for excess sugar, sodium, saturated fat and cholesterol. Nutritionists, dietitians and public health workers should encourage children to choose healthy snacking. Professionals should pay special attention to the least frequent eaters and encourage them to consume foods that are nutrient dense such as fortified products or supplements to address missing nutrients.

As for future research, nutrient intake analysis across food groups should be investigated in terms of meal patterns and health outcomes. Also investigations related to different population segments such as gender, age, income, and racial or ethnic groups might provide better insight into different socio-demographic consumption groups. Also future research should evaluate whether snacks provided by after school programs influence children's body weight and nutrient intake.

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VITA

H.A. Thushanthi Perera

Candidate for the Degree of

Master of Science

Thesis: EFFECTS OF MEAL FREQUENCY AND BREAKFAST CONSUMPTION ON NUTRITIONAL STATUS OF 9 TO 13 YEAR OLD CHILDREN

Major Field: Nutritional Sciences

Biographical:

Education:

Completed the requirements for the Master of Science in Nutritional Sciences at Oklahoma State University, Stillwater, Oklahoma in December, 2012.

Completed the requirements for a Master of Science in Food and Nutrition at the Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka in 2011.

Completed the requirements for the Bachelor of Science in Agricultural Technology and Management at the University of Peradeniya, Sri Lanka in 2009.

Experience:

Employed by University of Peradeniya, faculty of Agriculture as a graduate research and teaching assistant from 2009-2010.

Employed by Oklahoma State University as an research assistant at the Nutritional Sciences Department from 2011 to 2012

Professional Memberships:

Phi Kappa Phi Honor Society