10-5-2014

Dietary Factors, Body Weight, and Screen Time in U.S. Children with and without Asthma

Joan A. Vaccaro
Department of Dietetics and Nutrition, Florida International University, jvaccaro@fiu.edu

Joanne Niego
Department of Dietetics and Nutrition, Florida International University

Fatma G.. Huffman
Department of Dietetics and Nutrition, Florida International University, huffmanf@fiu.edu

Recommended Citation

Joan A. Vaccaro, Joanne Niego & Fatma G. Huffman (2016) Dietary factors, body weight, and screen time in U.S. children with and without asthma, Children's Health Care, 45:1, 22-38, DOI: 10.1080/02739615.2014.948165

Title: Dietary factors, body weight, and screen time in US children with and without asthma

Authors:

Joan A. Vaccaro Email: jvaccaro@fiu.edu Tel: 305-348-0368 Fax: 305-348-1996

Joanne Niego Email: jnieg001@fiu.edu Tel: 305-348-2879 Fax: 305-348-1996

Fatma G. Huffman* Email: huffmanf@fiu.edu Tel: 305-348-3788 Fax: 305-348-1996

Affiliation: Department of Dietetics and Nutrition; Robert Stempel College of Public Health and Social Work; Florida International University; 11200 SW 8th Street; Miami, FL 33199

*Corresponding author AHC5-306

Email huffmanf@fiu.edu

Tel: 305-348-3788

Fax: 305-348-1996

Acknowledgments: Source of funding: Data collected was publically available by NHANES.

Conflicts of interest: The authors declare that they have no conflicts of interest.

Abstract

Asthma is a chronic disease increasing in prevalence in Western cultures. Sedentary behaviors, such as television viewing, video game and computer use have been associated with poor diet and being overweight. The extent to which these factors were associated with asthma was investigated in a representative sample of US children ages 2-11 years (*N* = 4133). Results showed low dietary fiber, reported being told your child was overweight by a healthcare provider, and race/ethnicity were associated with asthma; whereas, screen time, fat intake and meals out were not associated with asthma. Implications for clinical practice and research were discussed.

Childhood asthma affects 10% to 30% of children worldwide making it the most prevalent chronic disease among this group (Asher et al., 2006; McCloud, & Papoutsakis, 2011). Overall, 14% of US children were diagnosed with asthma (Center for Disease Control and Prevention (CDC), 2014). Aside from genetic factors, the increase in the prevalence of atopic diseases, including asthma, in developed countries may be partially attributed to adaption of the westernized lifestyle (Dowse, Turner, Steward, Alpers & Woolcock, 1985; Seaton, Godden, & Brown, 1994; Stone, 2002, Herbert et al., 2009).

Mechanisms for the effect of diet and metabolic fat on asthma are warranted. Asthma symptoms may be directly related to diet. High fiber foods are high in antioxidants. Consumption of a lower amount of antioxidant-rich foods may be an environmental contributor to asthma and asthma outcomes. Serum antioxidants (beta-carotene, vitamin C, and selenium) were significantly lower in US children (ages 4-16 years) with as compared to without asthma (Rubin, Navon, &. Cassano, 2004). Reducing the adequacy of a diet showed a direct genetic effect for adults with asthma (Baines, Wood, & Gibson, 2009). Inflammatory and immune function genes were up-regulated after 14 days of a low-antioxidant diet administered to adults with asthma (Baines, Wood, & Gibson, 2009). Studies are needed to determine if adipokines directly influence the epithelial cells of the airway (Sideleva et al., 2012). The change in the proportions of fat-type consumed during the latter half of the 20th century, an increase in n-polyunsaturated fatty acid (margarine and vegetable oil) concomitantly with a decrease in n-3 polyunsaturated fatty acid, has been associated with an increase in asthma (Devereux & Seaton, 2005).

The relationship of obesity and asthma may confound diet quality and asthma. Inflammatory markers were higher in obese adults with asthma as compared to their obese controls (Sideleva et al., 2012). The authors suggest the connection between obesity and asthma may be attributed to the relationship among metabolically active fat and lung function (Sideleva et al., 2012). Although the fundamental causes of asthma are not completely understood, certain dietary factors and body weight have been implicated as risk factors. There is overwhelming evidence indicating that obesity is a risk factor for asthma (Dixon et al., 2010; Chen, Rennie, Cormier, & Dosman , 2010; Corbo et al., 2008; Ford, 2005; Wickens et al., 2005a; Sharma, Tailor, Warrington, & Cheang, 2008). The association of childhood asthma with body weight is alarming considering that childhood obesity has more than doubled in children in the past 30 years (Ogden et al., 2014).

Specifically, foods associated with obesity such as high fat and low fiber foods have been studied and juxtaposed to healthy, balanced diets for asthma risk. Studies with children from other societies have shown protective effects of a diet with foods that are high in fiber (unrefined grains, fruits, and vegetables), low in saturated fat and high in monounsaturated fat. Garcia-Marcos et al. (2007) observed asthma prevalence in Spanish children 6-7 years old who were following a Mediterranean diet has a protective effect for severe asthma for girls. This type of diet is typically high in fruits and vegetables, low in dairy products and high in monounsaturated fats. The authors indicated that following a Mediterranean diet has a protective effect on severe asthma in girls and that fast food consumption is associated with severe asthma (Garcia-Marcos et al., 2007). Similarly, Arvaniti et al., (2011a) indicated an inverse association between asthma prevalence and adherence to a Mediterranean diet in Greek children. Wickens et al., (2005b) reported that higher hamburger intake was positively associated with asthma symptoms and higher consumption of takeaway meals correlated positively with bronchial hyper-responsiveness in children from New Zealand. Similarly, fast-food consumption was associated with asthma for Mexican children ages 6-8 and 11-14 years from several randomly chosen elementary schools (Gutiérrez-Delgado et al., 2009). The risk of asthma was more likely with increased intakes of saturated fatty acids, palmitic acid and butter in a cohort of Spanish elementary school children (Rodríguez-Rodríguez et al., 2010). The researchers concluded that the risk of current asthma in the children was elevated with increased intakes of saturated fatty acids, palmitic acid and butter.

For children ages 1- 3 years in the United States, total fat should not exceed 40% and for ages 4 and older not more than 35% of daily calories (Institutes of Medicine, 2013). Fat beyond the recommended dietary guidelines may be particularly harmful for children in the US. The poor quality of fat (high saturated fat and trans-fats and too little beneficial polyunsaturated and monounsaturated fats) frequently consumed by individuals on a Western diet has been associated with increased cardiovascular disease risk (Cordain et al, 2005).

Even though the literature indicates a relationship between poor diet and overweight status and asthma in children, the relationships among asthma, diet, sedentary behaviors, overweight/obesity, and race/ethnicity have not been established. Sedentary behaviors, such as television viewing, playing video games, and spending time on the computer have been associated with overweight and obesity (Mitchell et al., 2013). Children spending more screen time (computer, video games, television) were more likely to have respiratory diseases including asthma symptoms (Arvaniti et al., 2011b; Tsai, Tsai, Nriagu, Gosh, Gong, & Sandretto, 2007). Among Hispanics, Puerto Rican children are more likely to have asthma than Mexican children (CDC, 2013). Non-Hispanic Black children were more likely to have asthma than Hispanic or non-Hispanic White children (CDC, 2013). However, the relationship between ethnicity and asthma in children may be moderated by obesity (Black, Smith, Porter, Jacobsen, & Koebnick, 2012).

The aim of this study was to investigate the relationships between overweight status, dietary factors, race/ethnicity, and screen time and asthma in a nationally representative group of children ages 2-11 years from the United States. In particular, few recent studies have investigated dietary factors and asthma in US children. We hypothesized that children ever diagnosed with asthma will be more likely to be overweight, not meet the dietary guidelines for fat and fiber, eat more meals out of the home, and have higher screen time than children without asthma. Moreover, we hypothesized that Hispanics (Mexican Americans and other Hispanics) and African Americans will have the greatest odds of ever having asthma as compared to White non-Hispanics and that race/ethnicity by obesity would not be significantly associated with asthma.

METHOD

Participants and Setting

The participants were children ages 2-11, four race/ethnicity groups – Mexican Americans (MA), Other Hispanics (OH), White non-Hispanics (WNH), and Black non-Hispanics (BNH) from two cycles of the National Health and Nutrition Survey (NHANES) 2007-2008 and 2009-2010. NHANES uses a complex, multistage, probability sample design to obtain a representative sample of the noninstitutionalized, civilian US population (National Center for Health Statistics, 2014). The related documentation, specific survey questions and datasets are available on the Center for Disease Control and Prevention’s website (National Center for Health Statistics (2014). Briefly, the stages of the sampling process are as follows: Primary Sampling Units (PSUs), which are counties or small groups of contiguous counties; 2) segments within PSUs (a block or group of blocks containing a cluster of households; 3) households within segments; and 4) one or more participants within households. A total of 15 PSUs are visited during a 12-month period. After the household interview, all participants are asked to complete the health examination component by scheduling a visit to the Mobile Examination Center (MEC). Specific questions on health conditions are given by interview. Anthropometrics, blood collection, and blood pressure are taken as part of the examination component. The dietary questions for the first 24-hour recall are conducted as part of the individual assessment in a private room of the MEC. Each MEC dietary interview room contains a standard set of measuring guide tools to help the respondent report the volume and dimensions of the food items consumed and estimate portions. Dietary recalls cover intake for any given day, specifically the 24-hour period prior to the dietary Recall interview (midnight to midnight). Upon completion of the in-person first dietary interview, participants are given measuring cups, spoons, a ruler, and a food model booklet, which contain two-dimensional drawings of the various measuring guides available in the MEC, to use for reporting food amounts during the telephone interview. The second dietary recall is collected by exclusively by telephone and is scheduled 3 to 10 days after the first dietary recall-interview. The results of this telephone interview are recorded as the second 24-hour dietary recall. The USDA National Nutrition database was used by NHANES personnel to calculate the nutritional content of reported foods.

This study acquired data for N = 4133: 1218 MA; 523 OH; 1447 WNH; and 945 BNH) who responded yes or no to the question, *ever been told you had asthma* and for whom dietary variables from the first 24-hour recall were available. The fifth racial/ethnic group, “Other Races” was not used since it had an insufficient sample size for multiple comparisons. The data used for this study were publically available. Prior to public release, the study protocols (continuation of *protocol #2005-06* for both datasets) were approved by the *National Center for Health Statistics Research Ethics Review Board* (NCHS-ERB, 2014). Separate assent and informed consent forms were signed by participants/guardians for the interview and health examination, or just the interview. Participants for this study gave assent and guardians read, understood, and signed informed consent forms for the interview and health examination.

Major Variables

Asthma was self-reported by medical diagnosis. Two binary variables were constructed for asthma: a positive response to the variable "ever having a diagnosis of asthma" for asthma (dependent variable 1) and current asthma was considered a positive response to both "ever having a diagnosis of asthma" and "do you still have asthma?" (dependent variable 2). Having asthma is generally considered by a current diagnosis of asthma; however, there may be differences for children who were diagnosed and able to become asthma-free. Sociodemographic comparisons were made for children who ever had asthma to children who never had asthma (model 1) and current asthma versus not current or never having asthma (model 2). Race/ethnicity was measured comparing MA, OH, and BNH against WNH. Dietary variables were calculated from the first 24-hour recall dietary analysis, which was conducted in-person by trained dietary interviewers fluent in English and Spanish. Standard measuring guides were used to help participants estimate portions by this face-to face interview. The second 24-hour dietary recall was conducted by telephone interview on the same participants; however, not all participants agreed to provide the second recall. In addition, the telephone interview process may introduce subject bias since the conditions were not the same for all subjects telephoned. Finally, comparing subjects telephoned to those interviewed introduces and extraneous variable when comparing both 24 –hour recalls for analysis. Due to missing values and the potential bias for combining two methods of dietary recall (in-person and by telephone), the second 24-hour dietary recall was not used for this analysis. Fiber intake was calculated per 1000 Kcal and categorized into quartiles since transformation did not achieve linearity. Fat intake was constructed as a binary variable with high fat considered exceeding the recommended percent of daily calories by age: either > 40 % for children 2-3 years or >35% for children 4-11 years (IOM, 2013).

The variable for overweight/not overweight was based on response to the question, "Has a health care professional ever told your child they were overweight?" Determination of overweight for children requires a healthcare professional's interpretation of percentiles specifically charted by age and gender and this information was not available. Approximately 40% would be classified as obese using conventional body mass index scores which is well-above the expected prevalence of obesity for children (17% of children ages 2-19 years and 8.4% for children 2-5 years in the US) (CDC, 2014). Screen time per day was constructed from combining the categorical variables for hours of television or video viewing with computer time. The original responses were recorded as a continuous variable; however, there were insufficient numbers at the extremes for the variables separate or together. The resulting variable had 6 categories: < 1, 2, 3, 4, ≥ 5 hours per day. The variable "meals out per week" was a categorical variable. Those participants answering "not sure" (<2%) were assigned as missing. Categories were collapse to none, one to 3, and 3 or more times per week due to low response in the higher frequencies.

Adjustment Variables

Covariates used for the models included age, gender, second-hand smoke exposure, and income. Age was categorized in approximate 2-year intervals, by months, to characterize differences among the age groups. The age groups also correspond with preschool, early elementary school, middle elementary school and late elementary school categories. Person(s) smoking in the house was a binary variable (yes/no). Poverty (yes/no) was constructed from the poverty index with less than 1 considered the poverty level.

Statistical Analysis

Adjusted sample weights were used to account for unequal probabilities of selection and non-response in the multi-stage stratified cluster sampling design used by NHANES in order to achieve unbiased national estimates. All analysis took into account differential probabilities of selection and the complex sample design, with SPSS, using the Taylor series linearization and the appropriate sample weights. The choice of sample weight was based on the data file with the smallest sample size as recommended by the NHANES guidelines (National Center for Health Statistics, 2014). The principle need for sample weights in complex designs is to compensate for unequal probabilities of selection, account for non-response, and make sample weights conform to a known population distribution. The base sample weights for interview, dietary interview, and examination are the probability of selection at each stage. In addition to the base sample weight, the design information for the complex sampling plan included mask variances incorporated into strata (sdmvstra) and primary sampling units (sdmvupsu). Together, the design accounted for unequal probability of selection and reduced the chance of type 1 error (National Center for Health Statistics, 2014; Stiller & Tompkins, 2005). A sample plan was constructed with strata and units using the first 24-hour recall dietary weights. The sample weights were computed using the average of the 2-year sample weights for each cycle, as per guidelines set by the National Center for Health Statistics (Johnson et al., 2013). Descriptive statistics were run for the major study variables for the study population as a whole. Cross-tabulations were conducted to compare the variables across race/ethnicity and asthma status. Logistic regression models were used to test the hypotheses for the relationships of race/ethnicity, dietary quality (fiber and fat intake), overweight, screen time, and meals out with odds of asthma including potential confounders (gender, poverty, smoke in the house) with and without the interaction term for race/ethnicity by overweigh. All analysis was conducted with SPSS version 20 with the complex sample analysis module. The Wald *F* was the hypothesis statistical test since it is more conservative and preferred for complex analysis models as compared to χ^2 (Forthoger, Lee & Hernandez, 2007). A *p*-value of <.05 was considered significant.

RESULTS

A greater percent of children having asthma were in the two higher age categories (approximately 30% of cases, ages 6.8-11 years); whereas, 13% of the cases were 2-4 year olds. Black non-Hispanics had the highest prevalence of asthma. Mexican Americans and WNH had the lowest prevalence of asthma, followed by OH. Overall, 14% of the study population (children ages 2-11 years) reported “ever having been diagnosed with asthma” and 8.8% reported “still having asthma”.

General characteristics, “ever having asthma” and no asthma, combined

For the combined population (children with and without asthma) median fiber intake was 6.7 g/1000 Kcal, well-below the recommendation of 14 g/1000 Kcal. Furthermore, three-quarters of the combined population (children 2-11 with and without asthma) consumed less than 9 g/1000 Kcal. Approximately 30% of children with and without asthma exceeded the age-recommended upper limit for percent of calories from total fat. Table 1 presents the general characteristics of children with and without asthma by race/ethnicity. For children with and without asthma, fiber intake was not significantly different by race/ethnicity; albeit, Black non-

Hispanics had a higher prevalence of exceeding recommended fat intake compared to the other groups.

Lifestyle characteristics for "ever having asthma" versus "no asthma"

Differences in lifestyle characteristics by "ever having asthma" versus not having asthma are presented in Table 2. Children with asthma consumed a lower percent of fiber (p = .004) and had higher a percent of overweight (p < .001), screen time (p = .028), poverty (p < .001) and smoke in their house (p < .001). Poverty was measured as the poverty index which was based on a ratio using family income and poverty level; a ratio of below 1 was considered poverty. There were no significant differences for children with and without asthma for fat intake (p = .428) and meals out (p = .127).

Logistic regression analysis was used to test the hypotheses that children 'ever being diagnosed with asthma' are more likely to be overweight, not meet the dietary guidelines for fat and fiber, eat more meals out of the home, and have higher screen time than children without asthma (Table 3). The model was fit (F (21, 9) = 4.93, p = .009) with a Nagelkerke pseudo R^2 explaining 8.3% of the variance of asthma and 85.9% correctly classified. Gender (p = .044), age (p=.003), race/ethnicity (p < .001), fiber intake (p = .034), overweight (p < .001), poverty (p = .039), and smoke in the house (p =.034) were significantly associated with having asthma. Fat intake (p = .211), screen time (p = .863), and meals out (p = .467) were not predictors of having asthma. The odds of having asthma were higher for children who were male, BNH, overweight, at or below the poverty level, had smoke in their house, and were in the lowest quartile of fiber intake. Logistic regression models were run to test the interaction term of race/ethnicity by overweight for asthma. The interaction was not significant, in the reduced model (adjusting for age and gender) (p = .179), (adding poverty and smoke in house) (p = .190) and in the full model (adding fiber, fat, screen time, and meals out) (p = . 243). Similarly, the interaction was tested for current asthma and was not significant (data not shown).

Lifestyle characteristics for "current asthma" versus "no asthma"

The final logistic regression model for "current asthma" is shown in Table 4. The model was fit (F (19, 11) = 10.8, p < .001) with a Nagelkerke pseudo R^2 explaining 8.1% of the variance of asthma and 91.3% correctly classified. Race/ethnicity (p <.001), fiber (p = .027), overweight (p = .002), and smoke in house (p = .013) were significantly associated with currently having asthma.

DISCUSSION

The hypothesized models were partially supported. Children with asthma were more likely to be overweight, consume lower fiber and be of minority status as compared to children without asthma. However, there were no significant differences in fat intake, meals out, and screen time by asthma status (regardless of classification: "ever having asthma" or "current asthma"). This study provides useful findings that indicate the relationships among sociodemographics, diet quality, sedentary activity and asthma status in young children (ages 2-11 years) in the United States. There was little difference when classifying asthma as 'ever diagnosed' (model 1) or 'current asthma' (model 2) with the exception of age, gender, and poverty which were significant only for 'ever diagnosed'. Race/ethnicity, overweight, fiber, and smoke in house were significant for both models. Overall, 14% of the study population reported ever having been diagnosed with asthma and 8.8% reported still having asthma. By comparison, self-reported asthma for children ages 5-9 years in the United States from the *Behavior Risk Factor Surveillance Survey* was 10.0% (CDC, 2013). Current asthma for children 2-19 years was reported as 10.7% for 2005-2006 (Visness et al., 2012).

Race/ethnicity and overweight were both found to be associated with the odds of ever having asthma and odds of current asthma. Conversely, Black et al., (2012) reported an effect of increasing body mass index for WNH and Asian/Pacific Islanders on odds of having current asthma; while weight class for Hispanics and BNH did not significantly affect odds of asthma. Studies are needed to determine whether genetic variants influence both obesity and asthma in specific populations (Dixon et al., 2010). Asthma may be affected differently in obese individuals since higher oxidative stress which combined with diet may alter immune response (Dixon et al., 2010). Asthma control and response to medication may be altered by obesity and the role of race/ethnicity together with body fat induced inflammation in asthma prevalence and severity has not been established (Dixon et al., 2010).

This study found low dietary fiber intake to be associated with asthma. However, the majority of children were not meeting their recommended fiber intake of 14 g/1000 Kcal. Adequate fiber is essential its role as producer of short-chained fatty acids such as acetate, propionate, and butyrate, which have anti-inflammatory properties (Maslowski & Mackay, 2011). Although the exact cause of asthma is not known, it is thought to be an autoimmune response triggered by inflammation. The incidence of atopic dermatitis, also thought to be prompted by inflammation, was reduced in the first year of life by the addition of fiber (in the form of oligosaccharides) to formula compared to controls (formula, only) (Gruber et al., 2010). The investigators speculate that the effect persists beyond the first year and may even result in a reduced incidence of respiratory allergy later in life. Fiber in the form of oligosaccharides given to infants showed a protective effect against allergies for the first five years of life (Arslanoglu et al., 2012). The researchers suggest performing long-term follow-up studies in larger populations to evaluate the potential preventive effect of this prebiotic on asthma (Arslanoglu et al., 2012).

Although we found a significantly higher proportion of children with asthma spent 5 or more hours engaged in sedentary activities by the unadjusted Chi-Square test (21 as opposed to 13 percent); the difference was no longer significant in the adjusted, logistic regression model. Results of this study concerning sedentary behavior and asthma were not in line with several studies that found children spending more screen time were more likely to have respiratory diseases (Arvaniti et al., 2011b; Tsai, Tsai, Nriagu, Gosh, Gong, & Sandretto, 2007). This may be attributed to the younger age included in this study (2-11 years) as compared to Alvaniti et al., (2011a), (2011b) and Tsai et al., (2007) who assessed 10-12 year old children. Sedentary behaviors differ by age from child to adolescent (Must & Tybor, 2005). Children from 2-9 years may have more vigorous, bouts of physical activity that may take place while performing sedentary activities as compared to 10-12 year olds. The context of sedentary behavior is changing; for example, cellular phone use may take place while walking or sitting (Must & Tybor, 2005). The development of valid tools for assessing sedentary behavior is needed (Leung Agaronov, Grytsenko, & Yeh, 2012).

It was interesting to note that children ever having asthma differed by age, gender, and poverty; whereas these differences were no longer significant for children currently with asthma. It is possible that a change in environmental factors corresponded with lessening of asthma for some children; while children with a strong genetic component remained affected by asthma. Once diagnosed with asthma, health care professionals may have provided suggestions to reduce toxins in the environment contributing to asthmatic conditions. Since children are more likely to have ever had asthma then to currently have asthma when comparing across age-group, age is a possible confounder. The relationship between asthma and gender also changes with age. Other possible confounders include patient-provider communication, as well as the motivation and efficacy to make changes on the part of the parents and the child.

Limitations

There are several limitations to this study that must be considered. All variables, including sociodemographics, diagnosis of asthma and overweight were self-reported which may have potential issues related to validity. Children's screen time was reported by parents and may be inaccurate or bias for age, gender, or race/ethnicity. Overweight was considered if the parent/guardian remembered a health care professional telling them that their child was overweight. Although categorization of weight by chart is a standard procedure for pediatric assessment, the patient-provider relationship may influence the parent's recollection of being told. Parents not remembering would have lowered the percent of children classified as overweight and may have affected the results. The variance of asthma was explained by less than 10% of the covariates. This implies that factors beyond fiber intake, overweight status, and the measured sociodemographics influence asthma in children. Genetics and other environmental factors such as perceived psychological stress, neighborhood conditions, and outdoor pollution should be considered in subsequent studies. The risk for asthma may be related to a number of factors beyond the scope of this investigation, including genetic differences in adipocyte inflammatory molecules and hormones that may differentially affect the airways or immune system (Dixon et al., 2010). Future studies should investigate genetic variants that influence obesity and asthma and their prevalence in race/ethnicity. Moreover, investigations of other factors such as perceived stress, family and emotional problems, environmental toxin exposure would be informative in assessing asthma risk for children.

Implications for Practice

The results of this study have important implications for health care professionals working with children who are at risk for or have asthma. In particular, these findings suggest that children's diet, body weight, and sociodemographic background are associated with for asthma. These findings, together with the increasing rate of childhood obesity, suggest the need for interventions to prevent chronic diseases in children which include active parental involvement (Flynn et al., 2006; Koulouglioti et al., 2013). Despite the fact that dietary factors have been associated with asthma in children, specific dietary guidelines for US children are missing from asthma management provided by the National Institutes of Health (National Asthma Education and Prevention Program, 2007). Protocol for a randomized control, lifestyle intervention to be conducted in Dutch children ages 6-16 years with asthma will include counselling to improve dietary behavior, reduce sedentary behaviors, and increase physical activity (Willeboordse et al., 2013). The investigators will apply the Health Belief Model with psychologists and dietitians (Willeboordse et al., 2013). Their results should show that lifestyle change decreased obesity and improved lung function. Sedentary behavior and measures of obesity were significantly reduced for children in school and community settings according to a systematic review of obesity interventions; however, these interventions were not designed specifically for children with asthma (Leung, Agaronov, Grytsenko, & Yeh, 2012). Physical activity levels did not vary at baseline for children with and without asthma and improved after a 7-day walking intervention for both groups receiving the intervention as compared to controls (Walders-Abramson, Wamboldt, Curran- Everett, & Zhang, 2009). Although lifestyle intervention studies for children with asthma are limited, the findings suggest encouragement of healthy lifestyle behaviors may reduce asthma symptoms.

In conclusion, the results of this study emphasized important aspects related to asthma risk. Of particular interest are the modifiable risk factors such as diet, body weight, and sedentary behavior that can be the focus of future assessment and intervention to address the needs of children at risk for or having asthma.

REFERENCES

Allan, K., & Devereux, G. (2011). Diet and asthma: nutrition implications from prevention to treatment. *Journal of the American Dietary Association*, *111*, 258–268. doi: 10.1016/j.jada.2010.10.048.

Arslanoglu, S., Moro, G. E., Boehm, G., Wienz, F., Stahl, B., & Bertino, E. (2012). Early neutral prebiotic oligosaccharide supplementation reduces the incidence of some allergic manifestations in the first 5 years of life. *Journal of Biological Regulators and Homeostatic Agents, 26* (3 Suppl), 49–59. PMID: 23158515.

Arvaniti, F., Priftis, K. N., Papadimitriou, A., Papadopoulos, M., Roma, E, Kapsokefalou, M. . . . Panagiotakos, D. B. (2011a) Adherence to the Mediterranean type of diet is associated with lower prevalence of asthma symptoms, among 10–12 years old children: the PANACEA study. *Pediatric Allergy Immunology, 22*, 283–289. doi: 10.1111/j.1399-3038.2010.01113.x.

Arvaniti, F., Priftis, K. Papadimitriou, A., Yiallouros, P., Kapsokefalou, M., Anthracopoulos, M. B., & Panagiotakos, D. B. (2011b) Salty-Snack Eating, Television or Video-Game Viewing, and Asthma Symptoms among 10- to 12-Year-Old Children: The PANACEA Study. *Journal of the American Dietetic Association*, *111*, 251–257. doi: 10.1016/j.jada.2010.10.051

Asher, M. I., Montefor,t S., Bjorksten, B., Lai, C. K. W., Strachan, D. P., Weiland, S. K., & Williams, H. (2006). Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC phases one and three repeat multicountry cross-sectional surveys. *Lancet*, *368*(9537), 733–743. PMID:16935684.

Baines, K. J., Wood, L. G., & Gibson, P. G. (2009). The nutrigenomics of asthma: molecular mechanisms of airway neutrophilia following dietary antioxidant withdrawal. *Omics: a Journal of Integrative Biology*, *13* (5). doi: 10.1089/omi.2009.0042.

Black, M. H., Smith, N., Porter, A. H., Jacobsen, S. J.,& Koebnick, C. (2012). Higher prevalence of obesity among children with asthma. *Obesity*, *20*, 1041–1047.

Centers for Disease Control and Prevention (2013). Asthma Facts. CDC's National Asthma Control Program Grantees. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 1–15.

Centers for Disease Control and Prevention (2014). Childhood obesity facts: prevalence of childhood obesity in the United States, 2011-2012. Retrieved from: http://www.cdc.gov/obesity/data/childhood.html

Center for Disease Control and Prevention (CDC) (2014). 2012 National Health Interview Survey (NHIS) Data. Table 2-1, Lifetime asthma prevalence percent by age, United States. Retrieved from: http://www.cdc.gov/asthma/nhis/2012/table2-1.htm

Chen, Y., Rennie, D., Cormier, Y., & Dosman, J. (2010). Association between obesity and atopy in adults. *International Archives of Allergy and Immunology*, *153*(4), 372–377. doi:10.1159/000316348.

Corbo, G. M., Forastiere, F., De Sario, M., Brunetti, L., Bonci, E., Bugiani, M., . . . Sidria-2 Collaborative Group (2008). Wheeze and asthma in children: associations with body mass index, sports, television viewing, and diet. *Epidemiology*, *19*,747–755. doi: 10.1097/EDE.0b013e3181776213.

Cordain, L. Boyd-Eaton, S. Sebastian, A. Mann, N. Lindeberg, S., Watkins, B.A., . . . Brand-Miller, J. (2005). Origins and evolution of the Western diet: health implications for the 21st century. *American Journal of Clinical Nutrition, 81*, 341–354.

Devereux, G. & Seaton, A. (2005). Diet as a risk factor for atopy and asthma. *Journal of Allergy and Clinical Immunology, 225*, 1109 –1117.

Dixon, A. E., Holguin, F., Sood, A., Salome, D.M., Pratley, R. E., Beuther, D. A. . . . Shore, S. A. (2010). An official American Thoracic Society workshop report: obesity and asthma. *Proceedings of the American Thoracic Society*, *7*(5), 325–335. doi: 10.1513/pats.200903-013ST.

Dowse, G. K., Turner, K. J., Steward, G. A., Alpers, M. P., & Woolcock, A. J. (1985) The association between Dermatophagoides mites and the increasing prevalence of asthma in village communities within the Papua New Guinea highlands. *Journal of Allergy and Clinical Immunology*, *75*, 75–83. PMID: 2578494.

Flynn, M. A. T., McNeil, D. A., Maloff, B., Mutasingwa, D.,Wu, M., Ford, C., & Tough, S. C. (2006). Reducing obesity and related chronic disease risk in children and youth: a synthesis of evidence with "best practice" recommendations. *Obesity Reviews*, *7* (Suppl. 1), 7–66. PMID: 16371076.

Ford, E. S. (2005). The epidemiology of obesity and asthma. *Journal of Allergy and Clinical Immunology, 115*, 897–909. doi:10.1016/j.jaci.2004.11.05.

Forthoger, R. N., Lee, E. S., & Hernandez, M. (2007). Contingency table analysis. *Biostatistics: A guide to design, analysis and discovery*. (2nd Ed). Burlington, MA: Academic Press, Elsevier, Inc. pp. 421–444.

Garcia-Marcos, L., Canflanca, I. M., Garrido, J. B., Varela, A., Garcia-Hernandez, G., Grima, F.G. . . . Blanco-Quiros, A. (2007). Relationship of asthma and rhinoconjunctivitis with obesity, exercise and Mediterranean diet in Spanish schoolchildren. *Thorax. 62*, 503–508. PMID:17251311.

Gutiérrez-Delgado, R. I., Barraza-Villarreal, A., Escamilla-Núñez, M. C. Solano-González, M., Moreno-Macías, H, & Romieu, I. (2009). Food consumption and asthma in school children in Cuernavaca, Morelos, Mexico. *Salud Pública de México*, *51*(3), 202–211. PMID:19967305.

Gruber, C., van Stuijvenberg, M., Mosca, F., Moro, G., Chirico, G., Braegger, C. P., . . . Boehm, G., Wahn, U. (2010). Reduced occurrence of early atopic dermatitis because of immunoactive prebiotics among low-atopy-risk infants. *Journal of Allergy and Clinical Immunology* , *126*, 791-797. doi: 10.1016/j.jaci.2010.07.022.

Herbert, O. C., Ross, Barnetson, W., Weninger, W, Krämer, U, Behrendt, H., & Ring, J. (2009). Western Lifestyle and Increased Prevalence of Atopic Diseases: An Example from a Small Papua New Guinean Island. *World Allergy Organization Journal*, *2*, 130–137. doi: 10.1097/WOX.0b013e3181accf27.

Institutes of Medicine (2013). Dietary Reference Intakes for Energy, Carbohydrate. Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002/2005). Retrieved from: http://www.iom.edu/Activities/Nutrition/SummaryDRIs/DRI-Tables.aspx.

Johnson, C. L., Paulose-Ram, R., Ogden, C. L., Carroll, M. D., Kruszon-Moran, D., Dohrmann, S. M., & Curtin, L. R. (2013) National Health and Nutrition Examination Survey: Analytical and Reporting Guidelines 1999-2010. National Center for Health Statistics, *Vital Health Statistics*, *2* (161). DHHS publication no. 2013-1361. Hyattsville MD, USA.

Kouloulglioti , C., Cole, R. , McQuillan, B. , Moskow, M. Kueppers, J., & Pigeon, W. (2013) Feasibility of an Individualized, Home-Based Obesity Prevention Program for Preschool-Age Children, *Children's Health Care*, *42*(2), 134–152, doi: 10.1080/02739615.2013.766099.

Leung, M. M., Agaronov, A. Kateryna Grytsenko, K. & Yeh, M-C. (2012). Intervening to reduce sedentary behaviors and childhood obesity among school-age youth: a systematic review of randomized trials. *Journal of Obesity, volume 2012,* Article ID 685430, 14 pages. doi:10.1155/2012/685430. Retrieved from: http://www.hindawi.com/journals/jobe/2012/685430/

Maslowski, K. M. & Mackay, C. R. (2011). Diet, gut microbiota and immune responses. *Nature Immunology*, *12*(1), 5–9. doi:10.1038/ni0111-5.

McCloud, E. & Papoutsakis, C. (2011). A medical nutrition therapy primer for childhood asthma: current and emerging perspectives. *Journal of the American Dietetic Association, 111*, 1052–1064. doi: 10.1016/j.jada.2011.04.005.

Mitchell, E. A., Beasley, R., Bjorksten, B., Crane, J., Garcia-Marcos, L., Keil, U, & the ISAAC Phase Three Study Group (2013). The association between BMI, vigorous physical activity and television viewing and the risk of symptoms of asthma, rhinoconjunctivitis and eczema in children and adolescents: ISAAC Phase Three. *Clinical & Experimental Allergy, 43*, 73–84. doi: 10.1111/cea.12024.

National Asthma Education and Prevention Program (2007): Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma. NIH publication 08-4051. National Institutes of Health, National Heart, Lung, and Blood Institute.

National Center for Health Statistics (2014): National Health and Nutrition Examination Survey, questionnaires, datasets and related documentation. Retrieved from: http://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm

NCHS Research Ethics Review Board (ERB): Approval National Health and Nutrition Examination, National Center of Health Statistics (NHANES-NCHS). Retrieved from: http://www.cdc.gov/nchs/nhanes/irba98.htm

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2014) Prevalence of childhood and adult obesity in the United States, 2011-2012. *Journal of the American Medical Association*. *311*(8), 806–814. doi:10.1001/jama.2014.732.

Rodríguez-Rodríguez, E., Perea, J. M., Jiménez , A. I., Rodríguez-Rodríguez , P., López-Sobaler, A. M., & Ortega, R. M. (2010). Fat intake and asthma in Spanish schoolchildren. *European Journal of Clinical Nutrition*, *64*, 1065–1071. doi:10.1038/ejcn.2010.127.

Rubin, R. N., Navon, L. &. Cassano, P. A. (2004). Relationship of Serum Antioxidants to Asthma Prevalence in Youth, *American Journal of Respiratory and Critical Care Medicine*, *169*(3), 393–398. doi: 10.1164/rccm.200301-055OC

Seaton, A., Godden, D. J., & Brown, K. (1994). Increase in asthma: a more toxic environment or a more susceptible population? *Thorax*, *49*, 171–174.

Sharma, S., Tailor, A., Warrington, R., & Cheang, M. (2008). Is obesity associated with an increased risk for airway hyperresponsiveness and development of asthma? *Allergy, Asthma & Clinical Immunology*, *4*, 51–58. doi:10.1186/1710-1492-4-2-51.

Sideleva, O. Suratt, B.T., Black, K. E., Tharp, W. G., Pratley, R.E., Forgione, P., . . . Dixon, A. E. (2012). Obesity and asthma: an inflammatory disease of adipose tissue not the airway. *American Journal of Respiratory and Critical Care Medicine*, *186*, 598–605.

Stiller, A. B. & Tompkins, L. (2005). The big four: Analyzing complex sample survey data using SAS®, SPSS®, STATA® and SUDAAN®. Proceedings from the Northeastern Users Group, Inc. Presenters are from the Centers of Disease Control, Division of the National Center for Health Statistics. Retrieved from: www.nesug.org/proceedings/nesug05/pos/pos3.pdf

Stone, K. D. (2002). Atopic diseases of childhood. *Current Opinions in Pediatrics*, *14*, 634–646. PMID: 12352260.

Tsai, H. J., Tsai, A. C., Nriagu, J., Gosh, D., Gong, M., & Sandretto, A. (2007). Associations of BMI, TV-watching time, and physical activity on respiratory symptoms and asthma in 5th grade schoolchildren in Taipei, Taiwan. *Journal of Asthma*, *44*(5), 397–401. PMID: 17613637.

Visness, C. M., London, S. J., Daniels, J. L., Kaufman, J. S., Yeatts, K. B. , Siega-Riz AM. . . Zeldin, D. C. (2010). Association of childhood obesity with atopic and nonatopic asthma: results from the National Health and Nutrition Examination Survey 1999-2006. *Journal of Asthma*, *47*, 822–829. doi: 10.3109/02770903.2010.489388.

Walders-Abramson, N., Wamboldt, F. S., Curran- Everett, D, & Zhang, L. (2009). Encouraging physical activity in pediatric asthma: a case–control study of the Wonders of Walking (WOW) Program. *Pediatric Pulmonology*, *44*(9): 909–916. doi:10.1002/ppul.21077.

Wickens, K., Barry, D., Friezema, A., Rhodius, R., Bone, N., Purdie, G., & Crane, J. (2005a). Obesity and asthma in 11–12 year old New Zealand children in 1989 and 2000. *Thorax*, *60*, 7–12.

Wickens, K., Barry, D., Friezema, A., Rhodius, R., Bone, N., Purdie, G., & Crane, J. (2005b). Fast foods-are they a risk factor for asthma? *Allergy*, 60:1537–1541. PMID: 15618575.

Willeboordse, M., van de Kant, K. D. G, de Laat, Onno, M. N., van Schayck, O. C. P., Mulkens, S. & Dompeling, E. (2013). Multifactorial intervention for children with asthma and overweight (Mikado): study design of a randomised controlled trial. BMC Public Health, 13:494. Retrieved from: http://www.biomedcentral.com/1471-2458/13/494

Table 1. Characteristics by race/ethnicity

Variable	**Mexican American**	**Other Hispanics**	**Black non-Hispanic**	**White non-Hispanic**	***p***
Asthma (yes)	11.3[a] (9.3, 13.7)	15.8[b] (11.8, 20.8)	24.4[c] (20.7, 28.6)	11.7[a] (9.7, 14.1)	<.001
Fiber intake /1000 Kcal (4th Q)	32.8 (28.6, 37.4)	26.9 (21.2, 33.6)	21.2 (18.4, 24.3)	24.4 (20.0, 29.4)	.062
Total fat (higher than recommended)	27.8[a] (23.4, 32.6)	23.7[a] (18.7, 29.6)	36.8[b] (33.1, 40.6)	29.9[a] (25.8, 34.5)	.013
Told overweight	11.1[a] (8.8, 13.8)	11.7[a] (8.9, 15.2)	11.8[a] (9.4, 14.8)	5.5[b] (4.3, 7.0)	<.001
Screen time (≥ 5 hr/d)	10.4[a] (8.1, 13.3)	10.2[a] (6.9, 14.9)	13.0[b] (10.8, 15.7)	9.6[a] (8.0, 11.4)	<.001
Meals out (≥ 3/wk)	24.4[a] (20.2, 29.3)	23.4[a] (18.9, 28.6)	34.8[b] (31.2, 38.6)	35.3[b](30.3, 40.7)	<.001
Poverty	45.4[a] (40.0, 50.8)	40.2[a] (32.0, 49.0)	42.2[a] (36.1, 48.4)	15.3[b] (11.0, 20.9)	<.001
Smoke in house	5.3[a] (3.2, 8.6)	6.5[a] (3.0, 13.7)	23.8[b] (18.3, 30.3)	16.3[c] (11.9, 22.0)	<.001

Notes: Asthma (yes) was children reporting ever having asthma; fiber intake per 1000 Kcal was reported at the 4th quartile; total fat was considered higher than recommended at >40% Kcal for children 2-3 years and >35% Kcal for children 4-11 years; told overweight indicated classification by a health professional; screen time included total hour engaged in television, video games and computer; poverty was measured as the poverty index which was based on a ratio using family income and poverty level; a ratio of below 1 was considered poverty. Data are expressed as percent (95th confidence intervals). Significance was calculated by the adjusted F (a variant of the second-order Rao-Scott adjusted Chi-Square test). Age categories (*p* = .664) and gender (*p* = .479) were not significantly different by race/ethnicity. Columns with the same letter are not significantly different from each other. No letters are indicated for when the overall hypothesis test failed.

Table 2. Characteristics by asthma status: Ever having asthma or no asthma

Variable	Asthma (yes)	Asthma (no)	*p*
Age (months)	-	-	<.001
24-49	13.3^{a} (9.9, 17.6)	24.6^{b} (22.1, 27.2)	-
50-81	24.9^{a} (20.8, 9.5)	25.4^{a} (23.4, 27.6)	-
82-112	31.9^{a} (26.3, 38.1)	25.6^{b} (23.8, 27.6)	-
113-132	29.9^{a} (24.6, 35.9)	24.4^{b} (22.2, 26.7)	-
Gender	-	-	.082
Male	57.0 (49.9, 63.8)	50.6 (47.6, 53.7)	-
Female	43.0 (36.2, 50.1)	49.4 (46.3, 52.4)	-
Fiber intake /1000 Kcal (4^{th} Q)	18.1^{a} (13.8, 23.5)	26.7^{b} (23.9, 29.7)	.004
Total fat (higher than recommended)	32.3 (27.0, 38.1)	29.8 (26.7, 33.0)	.428
Told overweight	13.0^{a} (10.3, 16.3)	7.0^{b} (5.9, 8.3)	<.001
Screen time (≥ 5 hr/d)	21.3^{a} (16.3, 27.4)	13.0^{b} (10.9, 15.4)	.028
Meals out (≥ 3/wk)	35.1 (28.6, 42.2)	32.1 (28.8, 35.7)	.127
Poverty	34.3^{a} (28.3, 40.9)	24.5^{b} (21.7, 27.5)	<.001
Smoke in house	22.5^{a} (16.1, 30.5)	13.6^{b} (10.8, 17.1)	<.001

Notes: Fiber intake per 1000 Kcal was reported at the 4^{th} quartile; total fat was considered higher than recommended at >40% Kcal for children 2-3 years and >35% Kcal for children 4-11 years; told overweight indicated classification by a health professional; screen time included total hour engaged in television, video games and computer; poverty was measured as the poverty index which was based on a ratio using family income and poverty level; ratio of below 1 was considered poverty. Data are expressed as percent (95^{th} confidence intervals). Significance was calculated by the adjusted F (a variant of the second-order Rao-Scott adjusted Chi-Square test). Columns with the same letter are not significantly different from each other.

Table 3. Model 1: Odds of ever having asthma considering socio-demographic, dietary and lifestyle factors

Variable	**OR**	**Lower**	**Upper**	***p***
Male	1.379	1.004	1.920	.048*
Female (reference)	1.000	-	-	-
Age (months)				.003*
24-49	0.424	0.281	0.641	<.001*
50-81	0.784	0.553	1.112	.165
82-112	0.868	0.600	1.257	.441
113-132 (reference)	1.000	-	-	-
MA	0.874	0.633	1.206	.339
OH	1.315	0.933	1.851	.113
BNH	1.984	1.469	2.679	<.001*
WNH (reference)	1.000			
High fat (yes)	0.922	0.687	1.238	.579
High fat (no, reference)	1.000	-	-	-
Q1 fiber/1000 Kcal	1.311	0.876	1.961	.180
Q2 fiber/1000 Kcal	1.710	1.144	2.555	.011*
Q3 fiber/1000 Kcal	1.742	1.150	2.641	.011*
Q4 fiber/1000 Kcal (reference)	1.000	.	.	.
Overweight (yes)	1.890	1.416	2.522	<.001*

Overweight (no, reference)	1.000	-	-	-
Screen time (hrs/day)	-	-	-	.857
Meals out per week	-	-	-	.452
Poverty (yes)	1.276	1.014	1.605	.039*
Poverty (no, reference)	1.000	-	-	-
Smoke in house (yes)	1.527	1.038	2.246	.033*
Smoke in house (no, reference)	1.000	-	-	-

Abbreviations: MA=Mexican American; OH=Other Hispanic; BNH=Black non-Hispanic; WNH=White non-Hispanic. *Notes*: Fiber intake per 1000 Kcal was reported at the 4^{th} quartile; total fat was considered higher than recommended at >40% Kcal for children 2-3 years and >35% Kcal for children 4-11 years; told overweight indicated classification by a health professional; screen time included total hour engaged in television, video games and computer; poverty was measured as the poverty index which was based on a ratio using family income and poverty level; ratio of below 1 was considered poverty. Data are expressed as percent (95^{th} confidence intervals). Significance was calculated by the adjusted F (a variant of the second-order Rao-Scott adjusted Chi-Square test. *Represents significant findings ($p < .05$).

Table 4. Model 2: Odds of current asthma considering socio-demographic, dietary and lifestyle factors

Variable	OR	Lower	Upper	*p*
Male	1.327	0.896	1.963	.115
Female (reference)	1.000	-	-	-
Age (yrs)	1.047	0.988	1.111	.115
MA	0.919	0.562	1.503	.727
OH	1.490	0.930	2.388	.095
BNH	2.336	1.644	3.319	<.001*
WNH (reference)	1.000			
High fat (yes)	0.851	0.570	1.271	.418
High fat (no, reference)	1.000	-	-	-
Q1 fiber/1000 Kcal	1.378	0.865	2.195	.169
Q2 fiber/1000 Kcal	1.941	1.283	2.936	.003*
Q3 fiber/1000 Kcal	1.812	1.081	3.037	.026*
Q4 fiber/1000 Kcal (reference)	1.000	-	-	-
Overweight (yes)	1.983	1.314	2.992	.002*
Overweight (no, reference)	1.000	-	-	-
Screen time (hrs/day)	-	-	-	.807
Meals out per week	-	-	-	.789
Poverty (yes)	1.404	0.933	2.114	.100
Poverty (no, reference)	1.000	-	-	-
Smoke in house (yes)	1.602	1.111	2.311	.013*
Smoke in house (no, reference)	1.000	-	-	-

Abbreviations: MA=Mexican American; OH=Other Hispanic; BNH=Black non-Hispanic; WNH=White non-Hispanic. *Notes*: Fiber intake per 1000 Kcal was reported at the 4th quartile; total fat was considered higher than recommended at >40% Kcal for children 2-3 years and >35% Kcal for children 4-11 years; told overweight indicated classification by a health professional; screen time included total hour engaged in television, video games and computer; poverty was measured as the poverty index which was based on a ratio using family income and poverty level; ratio of below 1 was considered poverty. Data are expressed as percent (95th confidence intervals). Significance was calculated by the adjusted F (a variant of the second-order Rao-Scott adjusted Chi-Square test. *****Represents significant findings ($p < .05$).