January 2016

Associations Between Diet Quality And Adiposity Measures In Us Children And Adolescents Ages 2 To 18 Years

Chasmine Nicole Flax
Yale University, chasmine.flax@yale.edu

Associations between Diet Quality and Adiposity Measures in US Children and Adolescents Ages 2 to 18 Years

Chasmine Flax

Yale School of Public Health
MPH candidate Class of 2016
Chronic Disease Epidemiology

Readers:

Dr. Mayur Desai

Dr. Alicia Landry

Dr. Jessica Thomson

Abstract

Introduction: Childhood obesity is a growing problem in the United States. A good diet quality is essential to the health and well-being of children and adolescents. Little is known about the relationship between diet quality as measured by the 2010 Healthy Eating Index (HEI-2010) and adiposity measures in children and adolescents. The aim of this investigation is to determine if associations between diet quality and adiposity measures exist in United States children and adolescents. This investigation also aims to determine if these potential associations retain significance when accounting for sociodemographic characteristics know to be associated with diet quality.

Methods: A sample of 2,815 children and adolescents ages 2 to 18 years old from the National Health and Nutrition Examination Survey 2011-2012 cycle were used for this study. Food intake was recorded during a 24-hour recall and diet quality was calculated using the HEI-2010. Multivariable linear regression analyses were used to examine associations between diet quality and measures of adiposity, controlling for sociodemographic characteristic.

Results: The mean total HEI-2010 score among the sample was 48.34 ± 0.44**.** Before adjustment of sociodemographic variables, total HEI-2010 score was found not to be associated with body mass index and waist-to-height ratio. After adjustment the association did not change in significance.

Conclusions:

The results of this study suggest that diet quality may not be associated with measures of adiposity in children and adolescents when both are assessed in a cross-sectional manner.

Acknowledgement

I would like to thank my thesis advisors: Dr. Mayur Desai, PhD, MPH associate professor of epidemiology (chronic diseases) at Yale University, Dr. Alicia Landry, PhD, RDN, LDN, SNS assistant professor of nutrition at the University of Central Arkansas, and Dr. Jessica Thomson, PhD epidemiologist at the United States Department of Agriculture. I am truly grateful for their patience and guidance throughout this process.

Table of Contents

CHAPTER PAGE

LIST OF TABLES 1

BODY OF THESIS

I – Introduction 2

II - Methods 3

III – Results 7

IV – Conclusion 10

REFERENCES 12

List of Tables:

Table 1: Demographic Characteristics, Anthropometric Measures, and Diet Quality of NHANES 2011-2012 Child and Adolescent (ages 2-18 years) (n = 2815)

Table 2: Unadjusted Associations between Total HEI-2010 Score and Each Adiposity Measure

Table 3: Multivariate Linear Regression Models for Total HEI – 2010 diet quality score Explained by adiposity measures and adjusted for demographic characteristics

Introduction:

Childhood obesity is a growing problem within the United States [1]. Children who are obese are more likely to have risk factors associated with cardiovascular disease, such as high cholesterol and high blood pressure, and are more likely to remain obese as adults [1].

Good diet quality is essential to the health and well-being of children and adolescents [1, 2]. A diet poor in quality is associated with various negative health outcomes among children and adolescents, including high diastolic blood pressure, early puberty, and obesity [3-5]. Growing evidence suggests that poor diet quality during childhood can contribute to increased risks for heart disease, type 2 diabetes, stroke, several types of cancer, and osteoarthritis in adulthood [1, 5].

The Dietary Guidelines for Americans (DGA) provide recommendations for dietary patterns that promote good health and reduce the risk of chronic disease [6]. The 2010 Healthy Eating Index (HEI-2010) is used to assess diet quality in relation to adherence to the 2010 DGA [7]. The HEI-2010 is the sum of 12 component food groups: 9 adequacy component food groups (e.g. whole fruit) and 3 moderation component food groups (e.g. sodium), with the sum of the scores ranging from 0 to 100. For adequacy components, score increases as density based quantity increases, while for moderation components, scores decrease as density based quantity increases. A higher overall score on the HEI-2010 indicates greater adherence to the 2010 DGA and thus better diet quality [5, 7]. Overall, children and adolescents have poor adherence to the DGA in the US [1, 5].

The diet quality in the US is known to be influenced by several factors including age, socioeconomic status, sex, and race [1, 2, 5, 8, 9]. In children and adolescents, diet quality tends to decrease as age increases while the association is opposite for income with low-income children having better diet quality than higher income children [2]. However, the relationships between diet quality and measures of adiposity in children remain largely untested. A previous study suggests that diet quality is

associated with measures of adiposity [10]. This study, however, differs from the current one in that only children 9-10 years of age were included and the diet quality index used was HEI-2005.

The relationships between diet quality and adiposity measures in children and adolescents has been identified as a research gap [11]. This investigation aims to fill that research gap, through the use of the HEI-2010 to examine the associations between the diet quality and adiposity measures in US children and adolescents. This investigation also aims to determine if these potential associations retain significance when accounting for sociodemographic characteristics know to be associated with diet quality. These sociodemographic characteristics include age, sex, race, income to poverty ratio (PIR), and parental education level.

Methods:

Population

The National Health and Nutrition Examination Survey (NHANES) combines interviews and physical examinations to assess the health and nutritional status of children and adults in the United States [12]. The survey examines a nationally representative sample every year, selecting participants from 15 counties across the country [12]. The 2011-2012 NHANES data cycle was used in the current study. Out of a sample size of 3,251 children and adolescents between 2 and 18 years of age, those who did not have an HEI-2010 score where excluded (n=287). Children under the ages of 2 years old were ineligible for inclusion in the study population because the DGA does not apply to them. Children above the age of 2 consuming breast milk or infant formula were not eligible for inclusion in the study sample. Children and adolescents who were underweight were also excluded (n=126) due to the relatively small amount of individuals who fell into this category. The final analytic sample size was 2,815, representing an estimated 62.9 million children and adolescents.

Measures

Dietary intake was collected using two 24-hour dietary recalls. The first day 24-hour dietary recall was conducted in person at the Mobile Exam Center (MEC). The second day 24-hour dietary recall was collected by telephone. A standard set of measuring guides are used to help respondents report the proportion size of the food items consumed [13]. Adults served as a proxy and completed the dietary recall for children aged 2 to 5 years [14]. Children aged 6 to 11 years completed the dietary recall with assistance from an adult, and adolescents aged 12 to 18 years completed the dietary recall on their own [14]. For this study, only the first day 24-hour dietary recall due to the higher response rate compared to the second day.

Dietary Quality

Total HEI-2010 score was used as a measure of dietary quality in relation to adherence to the 2010 DGA. The HEI-2010 score is the sum of 12 dietary components [7]. The 12 dietary components are total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, and empty calories [7]. Each component score ranges from 0-5, 0- 10, or 0 -20. The HEI-2010 total score ranges from 0-100, with a higher score indicating greater adherence to the DGA and higher diet quality [7]. The SAS code used to calculate HEI-2010 scores was downloaded from the Center for Nutrition Policy and Promotion website [15].

Sociodemographic Characteristics and Anthropometric Measures

Demographic characteristics were collected during in home interviews included age, sex, race/ethnicity, parental education level and income. Anthropometric measures, including height, weight, and waist circumference, were taken in the MEC.

Race/Ethnicity

Hispanic, non-Hispanic black, non-Hispanic Asian, and low income non-Hispanic white and other persons at or below the 130% of the poverty line were oversampled in the study population. The total sample size in any given year is fixed. Therefore, sample sizes for Hispanic persons, non-low income white and other non- low income persons were decreased in comparison to previous years in order to allow for the increase in sample sizes for other groups [16].

Parental Education Level

Household reference education level was used to represent parental education level. The household reference is defined as the first household member 18 years of age or older listed on the household member roster, who rents or owns the residence where the household members reside. For most households with a child, this will be a parent but it may also be the child's legal guardian. Parental education level was divided into 4 categories: some high school or less (up to 12^{th} grade, but no diploma), graduated high school (diploma or GED), some college (Associate's degree or attended college but did not receive a Bachelor's degree),and graduated college with a Bachelor's degree or higher [17].

Income to Poverty Ratio

Income to Poverty Ratio (PIR) is the ratio of a family's income compared to the federal poverty threshold and is often used to assess eligibility for government food assistance programs [18]. PIR is calculated by dividing annual household income by the poverty threshold corresponding to the household size. PIR below 1 indicates that the household earned less than the poverty threshold. Ratios range from 0.1 to 5.0, although ratios above 5.0 are truncated to 5.0 due to disclosure concerns. Ratios were categorized into three groups: 1.30 or less, 1.31-3.49, and 3.50 or greater.

Adiposity Measures

Body Mass Index

Body mass index (BMI) is calculated as weight (kg) divided by height (m) squared. The Centers for Disease Control and Prevention (CDC) recommend the use of the their growth charts to measure the body mass index (BMI) for children and adolescents from ages 2 to 19 years [19]. The growth charts are a series of percentile curves that show the distribution of body measurements in US children [19]. Children who fall below the 5th percentile for BMI for are classified as underweight. Children at or above the 5th and less than the 85th percentile for BMI are classified as normal weight. Children in the 85th to less than the 95th percentile for BMI are classified as overweight, and children in 95th or greater percentile for BMI are classified as overweight [20]. The SAS code used to calculated BMI percentiles was downloaded from the Centers for Disease Control and Prevention [21].

Waist- to -Height Ratio

Waist -to -height ratio (WHtR) is calculated as waist circumference (cm) divided by height (cm)[22].

Analysis

The analysis for this study proceeded in four parts. First, frequencies and percentages for all categorical variables, were calculated to describe the sample. Mean and standard error was calculated for total HEI-2010 score and waist-to-height ratio. Next, unadjusted associations between total HEI-2010 and measures of adiposity were calculated using linear regression. Finally, adjusted associations between total HEI-2010 and measures of adiposity were examined using multivariable linear regression. The linear regression was adjusted for age, sex, race/ethnicity, PIR, and parental education level. All

analysis accounted for the complex survey design of NHANES. Data was analyzed using SAS® software, version 9.4 (SAS Institute Inc., Cary, NC). The statistical significance of the tests was set at the 0.05 level.

Results

Sociodemographic characteristics, anthropometric measures, and diet quality of the NHANES sample of children and adolescents are presented in Table 1. The largest age group was 12-18 years (42.3%) and the smallest age group was 2-5 years (23.3%). Approximately half the sample was male (50.3%) and non – Hispanic white (54.1%). Approximately a fourth (23.1%) of the sample was Hispanic. Approximately equal (40%) proportions of the sample fell into the two lower PIR categories, while over half (55.8%) the sample's parental education level fell into the two higher education categories. Approximately two-thirds of the children and adolescents had a BMI in the normal range with 15.8% and 17.3% classified as overweight and obese, respectively. The mean WHtR was 0.49. The mean HEI total score was 48.34 ± 0.44.

Table 1: Demographic Characteristics, Anthropometric Measures, and Diet Quality of NHANES 2011-2012 Child and Adolescent (ages 2-18 years) (n = 2815)

Characteristic	N[a]	Weighted %
Age		
2 – 5 years old	753	23.3%
6 – 11 years old	1107	34.3%
12 – 18 years old	955	42.3%
Sex		
Male	1419	50.3%
Female	1396	49.7%
Race/Ethnicity		
Non – Hispanic White	624	54.1%
Non – Hispanic Black	827	14.5%
Asian	328	4.4%
Hispanic	884	23.1%
Other/Multiracial	152	3.9%
Income to Poverty Ratio (PIR)		
≤ 1.3	1246	42.6%
> 1.3 - ≤ 3.5	848	43.1%
> 3.5	266	14.3%
Parental Education Level		
Some High School	757	23.6%
Graduated High School	612	20.6%
Some College	723	27.6%
Graduated College	622	28.2%
BMI		
Normal	1881	66.9%
Overweight	424	15.8%
Obese	510	17.3%
Waist to Height Ratio	2734	0.49 ± 0.00
Mean HEI Total Score	2815	48.34 ± 0.44

[a] Totals may not sum to 2,815 due to missing data [unweighted sample size]

For all continuous variables : mean ± standard error (SE) were calculated; for categorical variables, percentages were calculated

Table 2 represents the linear regression results for HEI-2010 scores regressed onto BMI z score and WHtR separately without adjustment for any other variables. Without adjustment for other variables, total HEI-2010 scores were not significantly associated with BMI z scores. Similarly, total HEI-2010 scores were not significantly associated with WHtR.

Table 2: Unadjusted Associations between Total HEI-2010 Score and Each Adiposity Measure

	UNADJUSTED LINEAR REGRESSION	
Outcome	**ESTIMATE ± SE[a]**	**P VALUE**
BMI Z SCORE	-0.46 ± 0.32	0.174
WHtR	-0.95 ± 3.32	0.778

[a] Survey weighted Linear Regression

Table 3 presents the multivariable linear regression results for HEI-2010 scores regressed onto BMI z scores and WHtR separately while controlling for demographic characteristics. After adjusting for age, sex, race/ethnicity, PIR, and parental education level, BMI z score was not significantly associated with total HEI-2010. Similarly, WHtR did not gain significance when adjusting for the demographic covariates in the model. However, age, race/ethnicity, and parental education level were significant explanatory variables in the models. For every one year increase in age, total HEI-2010 decreased by approximately one-half point. Asian and Hispanic children and adolescents scored approximately 4 and 2 points higher on total HEI-2010 as compared to non-Hispanic white children and adolescents ($p < 0.001$ and $p = 0.003$, respectively). Similarly, children and adolescents living with a parent who graduated college scored approximately 3 points higher on total HEI-2010 as compared to children and adolescents living with a parent that did not have a high school education ($p = 0.003$).

Table 3: Multivariate Linear Regression Models for Total HEI – 2010 diet quality score Explained by adiposity measures and adjusted for demographic characteristics

	Coefficients for Model including BMI z Score		Coefficients for Model including WtHR	
	ADJUSTED LINEAR REGRESSION[a]		ADJUSTED LINEAR REGRESSION[a]	
Characteristic	**ESTIMATE ± SE**	**P VALUE[b]**	**ESTIMATE ± SE**	**P VALUE[b]**
Total HEI-2010 Score	-0.07 ± 0.25	0.793	0.38 ± 3.53	0.915
Age (Year)	-0.49 ± 0.10	**<0.001**	-0.45 ± 0.10	**<0.001**
Sex				
Male	REFERENCE	--	REFERENCE	--
Female	0.33 ± 0.72	0.646	0.31 ± 0.77	0.695
Race/Ethnicity				
White	REFERENCE	--	REFERENCE	--
Black	-0.96 ± 0.92	0.314	-0.80 ± 0.95	0.411
Asian	3.65 ± 0.76	**<0.001**	3.85 ± 0.86	**<0.001**
Hispanic	2.18 ± 0.64	**0.003**	2.42 ± 0.71	**0.003**
Other/Multiracial	-1.24 ± 1.21	0.320	-0.96 ± 1.27	0.458
Income to Poverty Ratio				
≤ 1.3	REFERENCE	--	REFERENCE	--
> 1.3 - ≤ 3.5	-0.10 ± 0.47	0.841	-0.06 ± 0.47	0.900
> 3.5	-1.05 ± 1.16	0.378	-0.77 ± 1.14	0.506
Parental Education Level				
Some HS	REFERENCE	--	REFERENCE	--
Graduated HS	-0.43 ± 1.20	0.722	-0.64 ± 1.13	0.576
Some College	0.75 ± 0.89	0.411	0.85 ± 0.90	0.354
Graduated College	3.28 ± 0.95	**0.003**	3.41 ± 0.97	**0.003**

[a] Survey weighted Linear Regression

[b] Significant p-values are bolded

Conclusion

While the poor adherence of US children and adolescents to the DGA, coupled with the significant proportion who are overweight or obese [1, 5] suggests a link between diet quality and adiposity in children and adolescents, we did not find one in the present study. Using a nationally representative sample of children and adolescents from NHANES, we found that diet quality score assessed using the HEI- 2010 is not associated with either BMI z score or WHtR.

While this study had several strengths, including the use of a nationally representative sample of US children and adolescents as well as the use of multiple adiposity measures, some limitations bear

mentioning. The data was cross-sectional in nature and hence temporal associations could not be taken into account. It may be that past diet quality is more highly associated with adiposity than current diet quality. The two measures, BMI and WHtR, may not have been optimal for determining body fatness or abdominal fat. Further, the use of WHtR is controversial. There is no solid evidence to support whether or not it is effective in assessing body fat due to a lack of standardization of anatomical site used for measurement in addition to the suggestion for cut off points vary among studies [23]. The self-report nature of the dietary data could have introduced bias into the study results. The 24-hour recall used by NHANES has been established as valid, however, it is unknown whether over-or under-reported can have an influence on diet quality score [24].

In conclusion, results from this study suggest that diet quality is not associated with measures of adiposity in child and adolescents when measured in a cross-sectional manner. Future research might consider other measures of adiposity such as body fat percentage or abdominal fat, as well as exploring associations among adiposity and individual components of the HEI in children and adolescents. Further longitudinal studies are likely needed to more fully understand the link between diet and adiposity in children and adolescents.

References:

1. Hiza, H., P. Guenther, and C. Rihane, *Diet Quality of Children Age 2 - 17 Years as Measured by the Healthy Eating Index - 2010.* USDA Center for Nutrition Policy and Promotion, 2013.
2. Hiza, H., et al., *Diet Quality of Americans Differs by Age, Sex, Race/Ethnicity, Income,and Education Level.* Journal of the Academy of Nutrition and Dietetics, 2013. **113**(2): p. 297 - 306.
3. Biro, F. and M. Wien, *Childhood obesity and adult morbidities.* Am J Clin Nutr, 2010. **91**(5): p. 1499S-1505S.
4. Cheng, G., et al., *Diet quality in childhood is prospectively associated with the timing of puberty but not with body composition at puberty onset.* Journal of Nutrition, 2010. **140**(1): p. 95 - 102.
5. Banfield, E.C., et al., *Poor Adherence to US Dietary Guidelines for Children and Adolescents in the National Health and Nutrition Examination Survey Population.* J Acad Nutr Diet, 2015.
6. Wilson, M., et al., *American Diet Quality: Where It is, Where It Is Heading, and What It Could Be.* Journal of the Academy of Nutrition and Dietetics, 2015.
7. Guenther, P.M., et al., *Update of the Healthy Eating Index: HEI-2010.* Journal of the Academy of Nutriton and Dietetics, 2013. **113**(4): p. 569-80.
8. Raffensperger, S., et al., *The effects of race and predictors of socioeconomic status on diet quality in the healthy aging neighborhoods of diversity across the life span (HANDLS) study sample.* Journal of National Medicine Association, 2010. **102**(10): p. 923 - 930.
9. Wang, D., et al., *Trends in Dietary Quality Among Adults in the United States, 1999 Through 2010.* JAMA, 2014. **174**(10): p. 1587-1595.
10. Jennings, A., et al., *Diet qualilty is independently associated with weight status in chldren aged 9 - 10 years.* Journal of Nutrition, 2011. **141**(3): p. 453 - 459.
11. Myers, E.F., et al., *A critical assessment of research needs identified by the dietary guidelines committees from 1980 to 2010.* J Acad Nutr Diet, 2013. **113**(7): p. 957-971 e1.
12. Centers for Disease Control and Prevention. *About the National Health and Nutrition Examination Survey*. 2015 [cited 2016 March 22]; Available from: http://www.cdc.gov/nchs/nhanes/about_nhanes.htm.
13. Center for Diease Control and Prevention. *Measuring Guides for the Dietary Recall Interview*. 2010 2015 [cited 2016 March 22]; Available from: http://www.cdc.gov/nchs/nhanes/measuring_guides_dri/measuringguides.htm.
14. Centers for Disease Control and Prevention, *MEC In- Person Dietary Interviewers Procedures Manuel*. 2011. p. 17 -18.
15. Center for Nutrition Policy and Promotion. *Healthy Eating Index-2010 SAS Program*. [cited 2016 March 23]; Available from: http://www.cnpp.usda.gov/healthy-eating-index-support-files-07-08
16. Centers for Disease Control and Prevention, *National Health and Nutrition Examination Survey: Analytic Guidelines, 2011 - 2012*. 2013.
17. Centers for Disease Control and Prevention, *Demographic Varaibles and Sample Weights (DEMO_G)*, in *National Health and Nutrition Examination Survey : 2011 - 2012 Data Documentation, Codebook, and Frequencies*. 2013, Center for Disease Control and Prevention.
18. U.S Census Bureau. *How the Census Bureau Measures Poverty*. [cited 2016 04/13].
19. Grummer - Strawn, L., C. Reinold, and N. Krebs, *Use of World Health Organization and CDC Growth Charts for Children Aged 0 -- 59 Months in the United States.* Morbidity and Mortality Weekly Report 2010. **59**(RR09): p. 1 - 15.
20. National Center for Chronic Disease Prevention and Health Promotion, *Use and Interpretation of the WHO and CDC Growth Charts for Children from Birth to 20 Years in the United States*, C.f.D.C.a. Prevention, Editor. 2013.

21. Centers for Disease Control and Prevention. *A SAS Program for the 2000 CDC Growth Charts (ages 0 to <20 years)*. 2015 [cited 2016 04/01].
22. Zhou, D., et al., *Waist - to - Height Ratio: A Simple, effective and practical screening tool for childhood obesity and metabolic syndrome.* Preventive Medicine, 2014. **67**: p. 35 - 40.
23. Magalhães, E., Sant'Ana, L., Priore, S., Franceschini, S., *Waist circumference, waist/height ratio, and neck circumference as parameters of central obesity assessment in children* Revista Paulista de Pediatria, 2014. **32**(3): p. 273 - 281.
24. Moshfegh, A., et al., *The US Deparement of Agriculture Automated Multiple - Pass Method reduces bias in the collection of energy intakes.* American Journal of Clinical Nutrition, 2008. **88**(2): p. 324 - 332.