Title
Associations Between Diet And Physical Activity And Obesity In Early Adolescence

Author
Fradkin, Chris

Publication Date
2014

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA, MERCED

ASSOCIATIONS BETWEEN DIET AND PHYSICAL ACTIVITY AND OBESITY IN EARLY ADOLESCENCE

A dissertation submitted in partial satisfaction of the requirements
for the degree Doctor of Philosophy

in

Psychological Sciences
(Health Psychology)

by

Chris Fradkin

Committee in charge:
Jan Wallander, Chair
Anna Song
Jack Vevea

2014

The Dissertation of Chris Fradkin is approved and it is acceptable in quality and form for publication on microfilm and electronically:

Anna Song	Date
Jack Vevea	Date
Jan Wallander, Chair	Date

University of California, Merced

2014

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

I would like to express my appreciation to friends, family, and acquaintances, who either by design or accident were instrumental in sparking the fire that grew into my formal education. Thanks to Amanda S. for saying, “A degree would look good on you, too,” as if it were a sweater and we were window shopping. Thanks to my father and my cousin—in education, you believed. And special thanks to Carl K., who urged me, “Check out all the options.”

I would also like to express my gratitude to Professor Carrie Saetermoe, at CSUN for undergraduate advisement. And Professor Michael A. Gardner, who remains the finest instructor I’ve ever studied with. Professor Gardner: You remain an inspiration to this day!

And finally, heartfelt thanks go out to my graduate committee: to advisor Jan L. Wallander for his profound patience, dedication, but most important: kindness; to Anna Song for her instrumental support; and to Jack Vevea for his always open door.

CURRICULUM VITA

Chris Fradkin

Education:

Doctoral Candidate, Psychological Sciences. University of California, Merced. Advisor: Jan L. Wallander. Doctoral degree anticipated 2014, Spring.

M.A. Psychological Sciences, University of California, Merced. (2010, Spring). Advisor: Jan L. Wallander.

B.A. Psychology, cum laude. California State University, Northridge. (2008, Spring). Advisor: Carrie L. Saetermoe.

Publications Since Start of Graduate Studies:

Wallander, J. L., **Fradkin, C.**, Chien, A. T., Mrug, S., Banspach, S. W., Davies, S., et al. (2012). Racial/Ethnic disparities in health-related quality of life and Health in children are largely mediated by family contextual differences. *Academic Pediatrics, 12*(6), 532-538. doi:10.1016/j.acap.2012.04.005

Fradkin, C., Wallander, J. L., Yamakawa, Y., Schwebel, D. C., Chien, A., Le, Y. C. L., et al. (2012). Quality of life among asian american youth. *Asian American Journal of Psychology,* online. doi: 10.1037/a0029822

Wallander, J. L., **Fradkin, C.**, & Scott, S. (2013). Issues in Adolescent Adherence and Health Behavior Change. In R. DiMatteo & L. Martin (Eds.), *Oxford Handbook of Health Communication, Behavior Change, and Treatment Adherence.* New York: Oxford University Press.

Fradkin, C., Wallander, J.L., Elliott, M.N., Tortolero, S., Cuccaro, P. & Schuster, M.A. (in press). Associations Between Socioeconomic Status and Obesity in Diverse, Young Adolescents: Variation Across Race/Ethnicity and Gender. *Health Psychology*.

Invited Lectures and Conference Presentations Since Start of Graduate Studies:

International:

Fradkin, C. & Wallander, J. L. (2013, July). *Physical Activity Provides Protection against Obesity Risk Differentially across Gender and Racial/Ethnic Groups*

during Early Adolescence. Oral presentation at 8th International Conference on Child and Adolescent Psychopathology (ICCAP), London, UK.

Fradkin, C. & Wallander, J. L. (2012, July). *Racial/ethnic disparities in obesity among minority adolescents in the United States may exist independently of socioeconomic factors.* Oral presentation at 7th International Conference on Child and Adolescent Psychopathology (ICCAP), London, UK.

Fradkin, C. & Wallander, J. L. (2012, August). *Racial/ethnic disparities in obesity among minority adolescents in the United States may exist independently of socioeconomic factors.* Poster presentation at 12th International Congress of Behavioral Medicine (ICBM), Budapest, Hungary.

Wallander, J. L., **Fradkin, C.**, Elliott, M. N., Banspach, S., Caughy, M., Chien, A. T. , Davis, S., Franzini, L., Mrug, S., & Schuster, M. A. (2010, June). *Quality of life differences among African American, Hispanic, and White boys and girls in a community sample when controlling for socio-demographic status.* Paper presentation (by J. L. Wallander) at 19th World Congress of the International Association and Child and Adolescent Psychiatry and Allied Professions and the 6th Congress of the Asian Society for Child and Adolescent Psychiatry and Allied Professions, Beijing, China.

National:

Fradkin, C. & Wallander, J. L. (2014, April). *Are Diet and Physical Activity Associated With Obesity in Early Adolescence?* Poster presentation at 35th Annual Meeting and Scientific Sessions of Society of Behavioral Medicine (SBM), Philadelphia, PA.

Fradkin, C. & Wallander, J. L. (2014, April). *Are Diet and Physical Activity Associated With Obesity in Early Adolescents?* Poster presentation at UC Global Health Day, UC Davis, Davis, CA.

Fradkin, C. & Wallander, J. L. (2013, March). *Physical Activity Provides Differential Protection Against Obesity Risk Among African American, Hispanic, and White Youth During Early Adolescence.* Poster presentation at 34th Annual Meeting and Scientific Sessions of Society of Behavioral Medicine (SBM), San Francisco, CA.

Fradkin, C. & Wallander, J. L. (2012, April). *Racial/ethnic disparities in obesity among minority adolescents may exist independently of socioeconomic factors.* Poster presentation at 33rd Annual Meeting and Scientific Sessions of Society of Behavioral Medicine (SBM), New Orleans, LA.

Fradkin, C. & Wallander, J. L. (2012, February). *Racial/ethnic disparities in obesity among minority adolescents may be due to factors outside traditional sociodemographic factors* . Poster presentation at UC Global Health Day, UC Berkeley, Berkeley, CA.

Fradkin, C. & Wallander, J. L. (2010, November). *Health disparities among children in racial/ethnic minority groups in the U.S. may be due mainly to family socioeconomic and contextual differences.* Poster presentation at UC Global Health Day, UC Irvine, Irvine, CA.

Fradkin, C. & Wallander, J. L. (2010, August). *Disparities in quality of life and well-being among Hispanic, African-American, and white children are due mainly to sociodemographic differences.* Poster presentation at 11th International Congress of Behavioral Medicine, Washington, DC.

Fradkin, C. & Wallander, J. L. (2010, August). *Quality of life in Hispanic, African American, and white children with and without compromised health status.* Poster presentation at 11th International Congress of Behavioral Medicine, Washington, DC.

Regional:

Fradkin, C. (2010, November). *Childhood Obesity.* Oral presentation at UC Merced's 1st Conference on Community Research and Scholarship, UC Merced, Merced, CA.

Fradkin, C. (2010, October). *Resilience Against Obesity Among Children of Lower SES.* Oral presentation at psychology colloquium at UC Merced, Merced, CA.

Fradkin, C. (2010, September). *Obesity Research.* Oral presentation at Central California Regional Obesity Prevention Program Regional Meeting, Merced, CA.

Fradkin, C. (2009, December). *Self-reported Quality of Life in Children: A Multi-tiered Gradient of Health.* Oral presentation at psychology proseminar at UC Merced, Merced, CA.

Manuscripts in Preparation:

Fradkin, C. & Wallander, J. L. (in preparation). Are Diet and Physical Activity Associated With Obesity in Early Adolescence?

Fradkin, C. & Wallander, J. L. (in preparation). Is Physical Activity Associated With Obesity in Early Adolescence?

Awards Since Start of Graduate Studies:

UC Merced Psychological Sciences Award for Excellence in Research. (2013). $500.

UC Merced 2012-2013 Psychological Sciences Fellowship Award. Summer 2013 funding for continued research and academic development. $7,070.

UC Merced 2012 Summer Fellowship Award. Summer 2012 funding for continued research and academic development. $5,973.

UC Merced Center of Excellence Graduate Research Training Program. 12 months funding (2010, Summer - 2011, Summer) for Research on Health Disparities among Underserved Rural Communities.

Commendations Since Start of Graduate Studies:

UC Merced Chancellor's Letter of Commendation. (2012, August). *"One or more seniors identified you as having made a memorable difference in his/her life as a student at UC Merced."*

Teaching Activities Since Start of Graduate Studies:

Abnormal Psychology / PSY142. (2013, Summer). Instructor for semester. Designed course, wrote lectures, administered exams, graded papers, and held office hours.

Abnormal Psychology / PSY142. (2012, Summer). Instructor for semester. Designed course, wrote lectures, administered exams, graded papers, and held office hours.

Abnormal Psychology / PSY142. (2011, Summer). Instructor for semester. Designed course, wrote lectures, administered exams, graded papers, and held office hours.

Emerging Public Health Threats / BIO125. (2011, Spring). Guest lecturer. *The Relationship Between Health and Social Class, as per Marmot's "Social Gradient."*

Personal Relationships / PSY157. (2010, Spring). Guest lecturer. *Relationship Needs Across Gender as Seen Through Maslow's Hierarchy of Needs.*

Press Coverage Since Start of Graduate Studies:

UC Merced University News. (2013, February). *Psychological Sciences Grad Group Provides Diverse Research Opportunities*. Featured in graduate group web profile. http://www.ucmerced.edu/news/psychological-sciences-grad-group-provides-diverse-research-opportunities

UC Global Health Institute newsletter. (2011, February). Featured in UCGHI web profile. http://www.ucghi.universityofcalifornia.edu/news-events/profiles/fradkin-chris.aspx

Pasadena Weekly (2011, January). *Taking Control.* Quoted in feature on the Community Health Alliance of Pasadena. http://www.pasadenaweekly.com/cms/story/detail/taking_control/9723/

ABSTRACT OF THE DISSERTATION

ASSOCIATIONS BETWEEN DIET AND PHYSICAL ACTIVITY AND OBESITY IN EARLY ADOLESCENCE

by

Chris Fradkin

Doctor of Philosophy in Psychological Sciences
(Health Psychology)

University of California, Merced, 2014

Professor Jan Wallander, Chair

Over the past thirty years, the prevalence of obesity among children in the U.S. has tripled. In response to this epidemic, weight management programs have addressed issues of dietary and activity behaviors, through programs aimed at upgrading children's nutritional intake and increasing their physical activity. While obesity increase among children seems to have plateaued over the last few years, the challenge of reducing obesity remains.

This dissertation examined the associations between diet and physical activity behaviors and obesity risk among a diverse sample of 4,414 children (Hispanic = 38%, African American = 36%, White = 26%), who were assessed longitudinally in both 5th and 7th grade. Direct measurements of height and weight were used to calculate body mass index (BMI) and classify participants into obese vs. non-obese. Four dietary and two physical

activity behaviors were indexed based on self-report. Household education level indexed socioeconomic status (SES).

In the first portion of the dissertation, as the primary aim, I examined whether physical activity is differentially associated with obesity risk in African American, Hispanic, and White youth and whether such associations are moderated by gender. To this end, main effects of obesity risk were calculated within six racial/ethnic, gender subgroups (3 racial/ethnic x 2 gender), and associations were examined while controlling for socioeconomic differences. As the secondary aim, I examined differences in physical activity across racial/ethnic and gender groups.

In light of unexpected findings (see below) in the first portion of the dissertation, I expanded the focus in the second portion to examine the association between four dietary (fruit, vegetable, fast food, sugar-sweetened beverage intake) and two physical activity (exercise and television viewing) behaviors and obesity risk. As the primary aim, I examined the joint and unique contributions of these behaviors to obesity risk by race/ethnicity and gender at 5^{th} and 7^{th} grade assessments, while controlling for socioeconomic differences. As the secondary aim, I examined differences in behavioral prevalences across racial/ethnic and gender groups.

Overall, the findings of both portions of this dissertation suggest that the proximal determinants of children's weight class, namely diet and physical activity, not only have a differential association with obesity risk among the different racial/ethnic, gender groups examined, but also have an unexpected and largely absent (> 50% of subgroups examined) association with obesity risk. With regard to physical activity, the findings indicate an inverse relationship between physical activity and obesity risk, but in less than half the racial/ethnic, gender subgroups that were examined. In lieu of these sparse and unexpected findings, further research should identify moderating influences on adolescent weight status beyond the presumed "proximal" dietary and activity influences.

INTRODUCTION

According to a recent report (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010), almost 17% of all children and adolescents in the United States are obese (BMI ≥ 95th%ile) and almost 32% are overweight (BMI ≥ 85th%ile). This figure represents a tripling in the obesity rate of children over the last three decades. Physically, obesity affects almost every organ system in the child: orthopedic, neurological, pulmonary, gastroenterological, and endocrine (Must & Strauss, 1999). Children with obesity have higher rates of hyperinsulinaemia, glucose intolerance, hypertension, sleep apnea and dyslipidemia (Deckelbaum & Williams, 2001), as well as more frequent reports of asthma, early menarche, and non-alcoholic fatty liver disease (NAFLD) (Lobstein, Baur, & Uauy, 2004). These complications present heightened risk for type 2 diabetes, coronary heart disease (CHD), and other lifetime, chronic health conditions that often manifest in early adulthood.

In addition to physical impairment, children with obesity also deal with psychosocial hardships, many stemming from the stigma of obesity. Wallander and colleagues (2009) found children of obese weight reporting significantly lower psychosocial quality of life (QL) than their peers of healthy weight. In examining self-worth and body dissatisfaction, the authors theorized that excess body weight may negatively impact the child's sense of who they are. In a study of 7 and 10 year olds, Klaczynski (2008) found healthy children holding strong and significant biases against children of obese weight. In a study of preschool children (N = 4,718), Boneberger and colleagues (2009) found a strong association between peer relationship problems and overweight/obesity among 5 and 6 year old girls, suggesting that the stigma of obesity is present from a very young age.

The presence of obesity also affects children's education. In a study of attendance records for 4th to 6th graders (N = 1,069), Geier, Foster, Womble, McLaughlin, Borradaile, Nachmani, et al. (2007) found that children of obese weight class had higher school absenteeism than their peers of healthy weight for the academic school year. And for one of two children of obesity weight class, this trend of absenteeism continues in adulthood where, as adults of obese weight class, they take more sick days and have lower productivity than their peers of healthy weight (Gates, Succop, Brehm, Gillespie, & Sommers, 2008).

Along with the increase in obesity comes the increased burden on the nation's health care system. Wang and Dietz (2002) report that obesity-related annual hospital costs have tripled for children (6-17 years) between the early 1980s and the late 1990s (from $35 million/year in 1979-1981 to $127 million in 1997-1999), an increase directly related to the 3-fold rise in childhood obesity that occurred in the same period. Payment for these increased hospital costs are passed on to the public in the form of increased health insurance premiums (Le Masurier & Corbin, 2006). These increases are borne by families of children at high risk for obesity-related health care as well as families of children at low risk.

In response to the present epidemic, weight management programs have addressed issues of dietary and activity behaviors, through programs (e.g., Let's Move!, 2011) aimed at upgrading children's nutritional intake and increasing their physical activity. These programs have addressed the current crisis focusing on the presumed proximal determinants of weight class, namely dietary and activity behavior, through a platform built on behavioral change. There are some experts, however, that challenge this approach. Kelly Brownell, for one, of the Rudd Center for Food Policy and Obesity at Yale University, is especially critical of the present behavioral approach, and insists that the obesity epidemic can be more reasonably be contained through policy-based change (e.g., sugar-sweetened beverage taxes) than behavioral change (Schwartz & Brownell, 2010). Other factions oppose the encroachment of government on individual choice (Creighton, 2010). But independent of these arguments is a fundamental question: Are diet and physical activity associated with obesity in children?

The relationship between diet and physical activity and obesity in children is a holistic one—it involves a constellation of dietary and activity behaviors that influences the weight class of the child. The relationship of these presumed proximal determinants of weight class with obesity risk in children has been studied, but infrequently in constellation form, and no study to my knowledge has examined the relationship between multiple dietary and activity behaviors and obesity risk in children through an integrated analysis among a diverse youth population, over multiple assessment points in time.

The goal of this dissertation, therefore, was to examine the association between dietary and physical activity behaviors and obesity risk among a diverse sample of early adolescents. I focused on this developmental period (ages 10-13) because children frequently adopt weight-related behaviors in this period that sustain into adulthood (WHO, 2004; Windle et al., 2004). Of interest were the potential differential relationships dietary and physical activity behaviors may have with obesity risk, within and between different racial/ethnic and gender subgroups. Of secondary interest were potential differences in dietary and activity prevalences that may exist across racial/ethnic and gender subgroups.

The above research needs were addressed in two manuscripts, which contribute to a deeper understanding of the differential relationships diet and physical activity have with obesity risk among diverse early adolescents. The first manuscript, "Is Physical Activity Associated With Obesity in Early Adolescence?" examined the sometimes termed "controversial" (Thibault, Contrand, Saubusse, Baine, & Maurice-Tison, 2010) relationship that exists between physical activity and obesity risk; while the second, "Are Diet and Physical Activity Associated With Obesity in Early Adolescence?" expanded the focus to the holistic or "constellational" relationship that exists between multiple dietary and activity behaviors (four and two, respectively) and obesity risk.

In this dissertation, I (a) examined the relationship between physical activity and obesity risk, and whether that relationship is moderated by race/ethnicity or gender, (b) examined the relationship between multiple dietary and physical activity behaviors and obesity risk, and whether those relationships are moderated by race/ethnicity or gender, and (c) examined between-groups differences in obesity risk, dietary and physical activity behavior prevalences, and socioeconomic status. Analyses were conducted on data from

4,414 children (Hispanic = 38%, African American = 36%, White = 26%) from the Healthy Passages™ study, who were assessed longitudinally in both 5th and 7th grade.

This dissertation presented a framework for a more nuanced understanding of the differential associations that dietary and physical activity behaviors have with obesity risk, among a diverse sample of early adolescents, across two assessment points, race/ethnicity and gender. Using a within- and between-groups approach, this framework revealed unexpected findings about the associations between the presumed proximal determinants of children's weight class (diet, physical activity) and their actual, BMI-based weight risk. Based on these findings, implications for clinical care, policy, and research were discussed, as well as the utility of current decision-based weight management programs.

Reference (Unique to Introduction)

Creighton, R. (2010). Fat Taxes: The Newest Manifestation of the Age-Old Excise Tax. *Journal of Legal Medicine, 31,* 123-136.

Is Physical Activity Associated With Obesity in Early Adolescence?

Chris Fradkin, MA

Psychological Sciences, University of California, Merced.

Acknowledgments: The Healthy Passages™ study is funded by the Centers for Disease Control and Prevention, Prevention Research Centers (Cooperative Agreements CCU409679, CCU609653, CCU915773, U48DP000046, U48DP000057, U48DP000056, U19DP002663, U19DP002664, and U19DP002665). The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the CDC. The authors have no conflict of interest to disclose. No author received any form of payment to produce this paper. The contributions made to this research by study participants in the Birmingham, Houston, and Los Angeles areas, other Healthy Passages™ investigators, field teams at each site, and the CDC Division of Adolescent and School Health are gratefully acknowledged.

Address correspondence to: Chris Fradkin, MA, SSHA, UC Merced, 5200 N. Lake Rd, Merced, CA 95343, cfradkin@ucmerced.edu.

Abstract

Objective: This study examined whether physical activity is differentially associated with obesity in African American, Hispanic, and White youth and whether relationships are moderated by gender.
Methods: Data are from 4,824 5th graders (ages 10-11) in the Healthy Passages™ study, a population-based, longitudinal study conducted in three U.S. metropolitan areas, who were re-assessed 2 years later with 93% retention. Obesity was classified from measured BMI (27% in 5th grade). Physical activity was classified from child-report using guideline criteria into Optimal (≥ 5 days/week 60+ minutes/day moderate-vigorous physical activity) and Sub-Optimal (76% in 5th grade).
Results: Racial/ethnic-gender subgroup analyses showed that optimal physical activity was associated with reduced obesity risk only among Hispanic and White males in 7th grade. There was no relationship between physical activity and obesity risk among youth in 5th grade, females, or African American males or females.
Conclusions: Physical activity is associated with obesity risk differentially across gender, racial/ethnic groups, and different ages during early adolescence. The reduced weight risk generally attributed to physical activity does not appear to apply universally for all youth. Further research should identify influences on weight status beyond physical activity, especially among Hispanic and White females and African American youth of either gender.

Keywords: obesity, children, adolescents, physical activity

Introduction

Programs in the U.S. that address childhood obesity typically target caloric expenditure, through the increase of physical activity. The targeting of physical activity is the hallmark of both large-scale programs with a national commitment (Let's Move!, 2011), as well as smaller-scale lifestyle interventions (e.g., Janicke et al., 2008; Sweat et al., 2011). However, the empirical support for these strategies may be less consistent than one would expect given their ubiquitousness. In fact, there is increasingly inconsistent evidence supporting the notion that physical activity is inversely associated with obesity risk for children. This study will examine the association between physical activity and obesity risk for diverse groups of young adolescents.

Some studies on children and adolescents indeed have reported the expected inverse relationship between physical activity and obesity risk (Janssen & LeBlanc, 2010; Jiménez-Pavón, Kelly, & Reilly, 2010; Norman et al., 2010). However, others have reported no relationship at all (Goran, Hunter, Nagy, & Johnson, 1997; Sallis, Prochaska, & Taylor, 2000; Treuth et al., 1998), and one study we are aware of has reported a positive relationship between physical activity and obesity risk (Gazzaniga & Burns, 1993). Whereas differences in methodology may explain these inconsistencies, the relationship between physical activity and healthier weight has nonetheless been described as controversial (Goran, Reynolds, & Lindquist, 1999; McMurray, Harrell, Deng, Bradley, Cox, & Bangdiwala, 2000; Thibault, Contrand, Saubusse, Baine, & Maurice-Tison, 2010).

The conflicting findings on the relationship between physical activity and obesity risk in children are further complicated by the variability that occurs in both physical activity and obesity risk across race/ethnicity and gender. Physical activity is higher among male than female youth (Belcher et al., 2010; Gortmaker et al., 2012; McMurray et al., 2000), and precipitously declines in adolescence for both genders (Kimm et al., 2002). In addition to the lower prevalence of physical activity among teenage girls, within-gender research also suggests that African American girls are less physically active than White girls (Kimm et al., 2002).

Obesity is more than twice as frequent among African American and Hispanic children than among White children (Singh, Siahpush, & Kogan, 2010). Research suggests that much of this disproportionate risk in obesity can be explained by the marked differences in socioeconomic resources that on average disfavor African American and Hispanic youth (Goodman, Slap, & Huang, 2003; Goodman, 1999). Studies indicate, however, that within specific racial/ethnic groups, higher SES is differentially associated with obesity risk. In fact, in a study of close to 4,000 African American, Hispanic, and White youth, higher SES was reported to be a risk factor among African Americans, with overweight increasing as family income rose (Alaimo, Olson, & Frongillo, 2001).

Although studies have been informative as to differences in physical activity and obesity risk specific to race/ethnicity and gender, no studies we are aware of have examined the relationship between physical activity and obesity risk in childhood with an integrated analysis taking into account both race/ethnicity and gender. Furthermore, there

are no studies that we know of that have examined this relationship in Hispanic youth, now the second largest racial/ethnic group in the U.S. Consequently, this study aims to examine the association between physical activity behavior and obesity risk in a diverse sample including the three largest racial/ethnic groups in the U.S. (African American, Hispanic, White) and both genders during early adolescence (age 10-13). We choose this early adolescent period because children commonly adopt weight-related behaviors around this time that sustain through adolescence into adulthood (WHO, 2004; Windle et al., 2004).

The primary aim for this research was to examine whether physical activity is differentially associated with obesity risk across racial/ethnic groups, gender, and different ages in early adolescent development. Because the most recent prior studies support that physical activity is inversely associated with obesity, we will test the hypothesis that physical activity is inversely associated with obesity universally regardless of race/ethnicity, gender, and age in early adolescence. A secondary aim will be to examine whether there are differences in physical activity and obesity related to race/ethnicity and gender in early adolescence. As this is a secondary aim, we will refrain from hypothesizing potential main effects differences.

Method

We used data from Healthy Passages™, a multi-site longitudinal community cohort study of adolescent health and health behaviors and their correlates initiated in 2004 (Schuster et al., 2012; Windle et al., 2004). Data were collected from the same cohort of youth while in 5th grade and then two years later when they generally were in 7th grade. Institutional review boards at each research site approved the Healthy Passages™ study.

Participants

Participants were recruited from public schools in: (1) 10 contiguous public school districts in and around Birmingham, Alabama, (2) 25 contiguous public school districts in Los Angeles County, California, and (3) the largest public school district in Houston, Texas. Eligible schools had an enrollment of at least 25 5th-graders, representing over 99% of students enrolled in regular classrooms in the three areas. To ensure adequate sample sizes of non-Hispanic African-American, Hispanic, and non-Hispanic white youth, we took a random sample of schools using probabilities that were a function of how closely a school's racial/ethnic mix corresponded to the site's racial/ethnic target, as detailed elsewhere (Windle et al., 2004). Information was disseminated to the 5th graders in 118 selected schools, with 11,532 students, to bring to their parents (or caregivers). Permission to be contacted was returned by 6,663, of which 5,147 (77%) completed both a parent and a youth interview. Exclusion criteria included not attending a regular academic classroom or having a parent who could not complete interviews in English or Spanish. The 6% who were not identified by their parents as being African-American, Hispanic, or white (details below) were omitted from analysis, resulting in 4,824 with the unweighted (weighted) distribution of 36% (30%) African-

American, 38% (47%) Hispanic, and 26% (23%) White, 51% (51%) females, and youth age $M = 11.11$ ($SD = .56$) at the 5th grade assessment. Additional detailed demographic information appears elsewhere (Schuster et al., 2012). The retention at the 7th grade assessment, at age $M = 13.06$ ($SD = .59$), was 93%, resulting in 4,491 participants with an essentially identical distribution across race/ethnicity and gender as at 5th grade.

Procedures

The full Healthy Passages™ assessment protocol was completed with a child and parent separated in private spaces at their home or another setting by two trained interviewers using both computer-assisted personal interview and computer-administered self interview methods (Windle et al., 2004). The parent could choose whether material would be presented in English or Spanish (prepared using standard back-translation methods). The same procedures were used for the 7th grade assessment.

Measures

Obesity. Body Mass Index (BMI) calculations were based on weight and standing height obtained according to standard anthropometric protocols (Centers for Disease Control and Prevention, 1998) by trained and certified interviewers. Height was measured, with the participant in bare feet or socks, to the nearest millimeter using a portable stadiometer. Weight was measured to the nearest 0.1 kg using a Tanita electronic digital scale. Sex-specific ratios of children's weight for height by age (months) were calculated according to CDC guidelines (Kuczmarski et al., 2000), with obese defined as BMI ≥ 95th percentile.

Physical activity. One item adapted from the PACE+ Adolescent Physical Activity Measure was used to measure frequency of moderate-to-vigorous physical activity (Prochaska, Zabinski, Calfas, Sallis, & Patrick, 2000): "On how many of the past 7 days did you exercise or take part in any kind of exercise or physical activity in which you were moving for at least 60 or more minutes?" This item has shown strong test-retest reliability (ICC = 0.72) as well as moderate correlation with accelerometer ($r = 0.37$, $p < .001$) (Prochaska, Sallis, & Long, 2001). Responses ranged from 0 to 7 days, which were dichotomized into optimal (*5-7 days/week*) and sub-optima" (*< 5 days/week*) physical activity categories, as per guidelines for this age group (Butcher, Sallis, Mayer, & Woodruff, 2008).

Race/ethnicity. The parent was asked which one or more of seven racial/ethnic categories describe the child. The child was classified as Hispanic if so indicated regardless of other racial/ethnic indication. Children not categorized as Hispanic were classified as non-Hispanic African American, non-Hispanic White, or other (6%, which was excluded from analysis).

Socioeconomic Status (SES). Parent report of highest year of education completed in the household was used to index SES. Experts consider this the most salient and stable indicator of SES (Williams & Collins, 1995) for members of racial/ethnic minority groups, who do not receive the same financial gains for equivalent years of education as do whites (Kaufman, Cooper, & McGee, 1997; Williams, 1999). Response was made among seven categories (*≤ 8th grade, some high school, high school graduate,*

GED, some college, 4-year college degree, > 4-year college degree). These categories were then reduced to six categories (aggregating *high school graduate* and *GED*) for purposes of these analyses.

Data Analysis

All analyses were performed using the SPSS Complex Sampling module with weighted data to adjust for the complex survey design, which included cluster sampling of schools with unequal probability to improve the ability to estimate racial/ethnic disparities (see Windle et al, 2004, for details). The analysis sample consisted of youth who provided data on all variables of interest (obesity, physical activity, SES, race/ethnicity, gender) at both the 5th and 7th grade assessments. The general analysis approach relied on crosstabulations to estimate prevalences and logistic regression to estimate significant differences between different groups. Odds ratios (*OR*s) were tested with 95% confidence intervals (CIs). The first set of crosstabulations and logistic regression analyses addressed the secondary aim regarding differences in prevalence of obesity and optimal physical activity at the level of interactions among gender and racial/ethnic groups, repeated at two ages in early adolescence. SES was included as a covariate in these analyses to adjust for differences among racial/ethnic groups. We do not present statistics for the main effect comparisons of females vs. males or 5th vs 7th grade, but prevalences are fully detailed in Table 1. A second set of crosstab and logistic regression analyses addressed the primary aim by testing differences in obesity prevalence at optimal versus suboptimal physical activity within subgroups as defined by race/ethnicity and gender, again at two ages in early adolescence. SES was included as a covariate in these analyses as well. The final set of analyses assessed the impact of missing data by examining differences in the prevalence of obesity, optimal physical activity, and higher SES between youth who participated and provided complete relevant data in the 7th grade assessments and those who did so only in 5th grade.

Results

The final sample consisted of 3,775 youth who provided data on the variables of interest in both 5th and 7th grades. SES was included as a covariate in all analyses.

Prevalence of Obesity and Physical Activity

Differences in prevalences are presented within same-gender groups. As shown in Table 1 and Figure 1, at both the 5th and 7th grade assessments, African American females had a higher obesity prevalence than White females (5th grade *OR* = 2.28, 95% CI [1.40, 3.72]; 7th grade *OR* = 2.20, 95% CI [1.31, 3.69]), whereas Hispanic and African American males had a higher obesity prevalence than White males (Hispanic 5th grade *OR* = 2.80, 95% CI [1.66, 4.71]; 7th grade *OR* = 2.66, 95% CI [1.61, 4.42]; African American 5th grade *OR* = 1.76, 95% CI [1.04, 2.98]; 7th grade *OR* = 1.89, 95% CI [1.18, 3.03]). There were no other significant differences in obesity within same-gender groups at 5th or 7th grade.

As shown in Table 1 and Figure 2, there were no significant racial/ethnic differences in optimal physical activity prevalence for either gender at the 5th grade assessment. At 7th grade, Hispanic females and males had a significantly lower prevalence of optimal physical activity compared to their White gender counterparts (female *OR* = 0.45, 95% CI [0.31, 0.65]; male *OR* = 0.55, 95% CI [0.38, 0.79]). There were no other differences in optimal physical activity within same-gender groups at 7th grade.

Associations between Obesity and Physical Activity

Among the sample as a whole, at the 5th grade assessment, there was no significant difference in obesity between youth of optimal versus sub-optimal physical activity. At the 7th grade assessment, youth with optimal physical activity had a lower prevalence of obesity than youth with sub-optimal physical activity (20% vs 26% obesity, *OR* = 0.77, 95% CI [0.64, 0.94]). Among females at both 5th and 7th grade, as well as males at 5th grade, there was no significant difference in obesity related to physical activity. At 7th grade, males with optimal physical activity had a lower prevalence of obesity risk than males of sub-optimal physical activity (18% vs 28% obesity, *OR* = 0.62, 95% CI [0.48, 0.80]).

Obesity risk related to physical activity is presented in Figure 3. Among females at both 5th and 7th grade, as well as males at 5th grade, there was no statistically significant difference in obesity risk between youth of optimal versus sub-optimal physical activity within any racial/ethnic-gender subgroup. At 7th grade, Hispanic and White, but not African American, males of optimal physical activity had a significantly lower prevalence of obesity risk compared to their racial/ethnic counterparts of sub-optimal physical activity (Hispanic: 23% vs 34% obesity, *OR* = 0.57, 95% CI [0.40, 0.80]; White: 8% vs 17% obesity, *OR* = 0.45, 95% CI [0.24, 0.82]).

Missing Data

Missing data represented youth who did not participate in the 7th grade assessment (7%), or youth who, while participating, did not provide data for one or more of the variables of interest (7%). As detailed in Table 2, youth who were missing 7thgrade data had a significantly higher obesity prevalence (*OR* = 1.51, 95% CI [1.26, 1.81]) and a significantly lower prevalence of higher SES (*OR* = 0.78, 95% CI [0.64, 0.96]) than those who provided complete 7th grade data. There was no difference in optimal physical activity prevalence. To assess the impact of excluding youth missing SES measurements (the most frequently omitted variable), a sensitivity analysis was conducted. Results, however, were not materially different than those presented above.

Discussion

The results show that physical activity is associated with obesity risk differentially across racial/ethnic groups, gender, and ages during early adolescence. Of the six groups examined (3 racial/ethnic x 2 gender groups) at two time points, physical activity was associated with reduced obesity risk for only Hispanic and White males, and

only in 7th grade. There was an absence of significant associations with obesity for physical activity for African American youth of either gender, and for females of any race/ethnicity. Although not consistent with the hypothesis based on prior research, these findings are consistent with other literature that has described the relationship between obesity and physical activity in children as "controversial" (Goran, Reynolds, & Lindquist, 1999; McMurray et al., 2000; Thibault et al., 2010). Our findings suggest that among females of any race/ethnicity, and among African American youth of either gender, obesity risk occurs independent of physical activity.

As a secondary aim, this study also examined differences in obesity risk and physical activity in relation to race/ethnicity and gender in early adolescence. Findings indicate a racial/ethnic-gender interaction in obesity risk with African American females and Hispanic males at highest risk compared to their same-gender cohorts. This finding is consistent with the literature (Singh, Siahpush, & Kogan, 2010), as is the finding of a lower prevalence of optimal physical activity among African American youth of both gender, as well as Hispanic females, compared to their same-gender White cohorts, in 7th grade (Kimm et al., 2002). Consistent with much literature (e.g., Goodman, Slap, & Huang, 2003; Goodman, 1999) as well is the finding of lower average parental education for African American and Hispanic youth than White youth. As we included household education level as a covariate in our analyses, our findings describe the relationship between physical activity and obesity risk independent of the marked racial/ethnic differences in household education.

The finding that physical activity is not universally, but rather is differentially associated with obesity risk is counter to the expectation that healthy weight in children is in part related to exercise. This expectation has been fostered by weight management campaigns (e.g., Let's Move!, 2011) built on reducing children's obesity through improved quality of diet and quantity of exercise. With regard to exercise, our findings suggest that this approach may not be sufficient, especially for those children in our sample (> 50%) for whom obesity risk appears not to be associated with physical activity. The finding that physical activity is not associated with obesity risk for more than half the children in our sample is consistent with a recent meta-analysis on the efficacy of school-based physical activity and nutritional education interventions in reducing the BMI of children and adolescents (Guerra, Nobre, da Silveira, & Taddei, 2014). This review of thirty-eight studies found that school-based physical activity and nutritional education interventions offered no statistically significant benefits of BMI reduction to the children in attendance (Guerra, Nobre, da Silveira, & Taddei, 2014). These findings offer further support to the argument that the approach by current weight management programs in the U.S. may not be sufficient.

This study aimed to examine the association between physical activity and obesity risk within a sample balanced for race/ethnicity and gender in early adolescence. While previous studies have examined racial/ethnic differences in obesity risk (Singh, Siahpush, & Kogan, 2010), as well as racial/ethnic and gender differences in physical activity prevalence (Kimm et al., 2002), this is the first study we are aware of that has examined the association between physical activity and obesity risk in this age range with an integrated analysis where both race/ethnicity and gender are examined within subgroups.

In addition, we have examined these relationships at two points in adolescent development, 5th and 7th grade. These dual assessments allow us to believe that the differential association between physical activity and obesity risk may manifest in youth around 6th or 7th grade, at about ages 11-13.

This study has implications for clinical care, policy, and research. The finding that physical activity is inversely associated with obesity risk for only certain racial/ethnic-by-gender subgroups, brings question to the comprehensive utility of healthy weight promoting programs (e.g., Let's Move!, 2011) built solely upon platforms of reducing weight risk through "improving children's diet and increasing exercise." Based on these findings, one might wonder whether programs such as these are sufficient, or whether they may be underserving racial/ethnic-gender subgroups of particularly high risk (e.g., African American females). At a minimum, future studies should assume within-groups differences and include race/ethnicity- by-gender interactions in the design. In sum, these findings suggest that both research and policy should address pediatric weight risk with a more targeted approach, with added focus on the groups at highest risk.

Among limitations is that, as with all studies examining cross-sectional associations, causality should not be inferred. Second is the self-reporting method of the child's physical activity. When compared to objectively measured physical activity (e.g., by accelerometer), adolescents appear to over-report weekly physical activity (Slootmaker, Schuit, Chinapaw, Seidell, & van Mechelen, 2009). There may also be variability of self-reporting across gender, because adolescent females appear to over-report activity at a slightly higher rate than males (Slootmaker et al., 2009). Finally, the Hispanic portion of our sample has roots primarily in Mexico and Central America, and because of the heterogeneity among this ethnic group, findings should not be generalized to other Hispanics with origins in other regions (e.g., Puerto Rican, Cuban).

In lieu of the differential association between physical activity and obesity risk across groups, future research should consider additional influences. Variables such as parenting style, child's self-esteem, quality of life, and family structure are just a few potential moderators that are understudied as to their influence on obesity risk among youth. In examining these influences, research should assess these and other variables within racial/ethnic-by-gender subgroups, under the assumption that these mechanisms also may vary across subgroups. Whereas the prospect of separate analyses within specific racial/ethnic and gender subgroups may be challenged by statistical power requirements, this approach is needed in assessment of weight-risk mechanisms in the U.S. if we wish to gain a higher understanding of the complexities of weight risk among youth.

References

Alaimo, K., Olson, C. M., & Frongillo, E. A.,Jr. (2001). Low family income and food insufficiency in relation to overweight in US children: Is there a paradox? *Archives of Pediatrics Adolescent Medicine, 155*, 1161-1167. doi:10.1001/archpedi.155.10.1161

Belcher, B. R, Berrigan, D., Dodd, K. W., Emken, B. A., Chou, C. P., & Spuijt-Metz, D. (2010). Physical Activity in US Youth: Impact of Race/Ethnicity, Age, Gender, & Weight Status. *Medicine and Science in Sports and Exercise, 42,* 2211–2221.

Butcher, K., Sallis, J. F., Mayer, J. A., & Woodruff, S. (2008). Correlates of physical activity guideline compliance for adolescents in 100 U.S. Cities. *Journal of Adolescent Health, 42*, 360–368.

Centers for Disease Control and Prevention, National Center for Health Statistics. (1998). *NHANES III: Anthropometric Procedures*. #98-4083.

Field, A. E., Colditz, G. A., & Peterson, K. E. (1997). Racial/ethnic and gender differences in concern with weight and in bulimic behaviors among adolescents. *Obesity Research*, *5*, 447-454.

Gazzaniga, J. M., & Burns, T. L. (1993). Relationship between diet composition and body fatness, with adjustment for resting energy expenditure and physical activity, in preadolescent children. *American Journal of Clinical Nutrition, 58*, 21– 8.

Goodman, E. (1999). The role of socioeconomic status gradients in explaining differences in US adolescents' health. *American Journal of Public Health, 89,* 1522 – 1528.

Goodman, E., Slap, G. B., & Huang, B. (2003). The public health impact of socioeconomic status on adolescent depression and obesity. *American Journal of Public Health, 93,* 1844-1850.

Goran, M. I., Hunter, G., Nagy, T. R., & Johnson, R. (1997). Physical activity related energy expenditure and fat mass in young children. *International Journal of Obesity, 21*, 171– 178.

Goran, M. I., Reynolds, K. D., & Lindquist, C. H. (1999). Role of physical activity in the prevention of obesity in children. *International Journal of Obesity, 23* (suppl): S18–33.

Gortmaker, S. L., Lee, R., Cradock, A. L., Sobol, A. M., Duncan, D. T. & Wang, Y. C. (2012). Disparities in youth physical activity in the united states: 2003–2006. *Medicine and Science in Sports and Exercise, 44,* 888–893.

Guerra, P. H., Nobre, M. R. C., da Silveira, J. A. C., & Taddei, J. A. A. C. (2014). School-based physical activity and nutritional education interventions on body mass index: A meta-analysis of randomized community trials–Project PANE. *Preventive medicine*.

Janicke, D. M., Sallinen, B. J., Perri, M. G., Lutes, L. D., Huerta, M., Silverstein, J. H., & Brumback, B. (2008). Comparison of parent-only vs family-based interventions for overweight children in underserved rural settings: outcomes from project STORY. *Archives of Pediatrics & Adolescent Medicine*, *162,* 1119-1125.

Janssen, I., & LeBlanc, A. G. (2010). Review Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *7,* 1-16.

Jiménez-Pavón, D., Kelly, J., & Reilly, J. J. (2010). Associations between objectively measured habitual physical activity and adiposity in children and adolescents: Systematic review. *International Journal of Pediatric Obesity*, *5,* 3-18.

Kaufman, J. S., Cooper, R. S., & McGee, D. L. (1997). Socioeconomic status and health in blacks and whites: the problem of residual confounding and the resiliency of race. *Epidemiology, 8,* 621–628.

Kimm, S. Y. S., Glynn, N. W., Kriska, A. M., Barton, B. A., Kronsberg, S. S., Daniels, S. R., . . . Liu K. (2002). Decline in physical activity in black girls and white girls during adolescence. *New England Journal of Medicine, 347*, 709-715.

Kuczmarski, R. J., Ogden, C. L., Grummer-Strawn, L. M. et al. (2000). CDC growth charts: United States. *Advance Data, 314*, 1–27.

Let's Move! (2011). *Take Action.* Retrieved March 17, 2011 from the Let's Move! Web site http://www.letsmove.gov/action.php

McMurray, R. G., Harrell, J. S., Deng, S., Bradley, C. B., Cox, L. M., & Bangdiwala, S. I. (2000). The influence of physical activity, socioeconomic status, and ethnicity on the weight status of adolescents. *Obesity Research, 8*, 130-139. doi:10.1038/oby.2000.14

Norman, G. J., Adams, M. A., Kerr, J., Ryan, S., Frank, L. D., & Roesch, S. C. (2010). A latent profile analysis of neighborhood recreation environments in relation to adolescent physical activity, sedentary time, and obesity. *Journal of Public Health Management and Practice: JPHMP*, *16,* 411-419.

Prochaska, J. J., Sallis, J. F., & Long, B. (2001). A physical activity screening measure for use with adolescents in primary care. *Archives of Pediatrics and Adolescent Medicine, 155,* 554–559.

Prochaska, J. J., Zabinski, M. F., Calfas, K. J., Sallis, J. F., & Patrick, K. (2000). PACE+: interactive communication technology for behavior change in clinical settings. *American Journal of Preventive Medicine, 19,* 127- 131.

Sallis, J. F., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical activity of children and adolescents. *Medicine and science in sports and exercise*, *32,* 963-975.

Schuster, M. A., Elliott, M. N., Kanouse, D. E., Wallander, J. L., Tortolero, S. L., Ratner, J. A., et al. (2012). Racial and ethnic health disparities among fifth-graders in three cities. *New England Journal of Medicine, 367*, 735–745.

Singh, G. K., Siahpush, M., & Kogan, M. D. (2010). Rising social inequalities in US childhood obesity, 2003–2007. *Annals of Epidemiology, 20*, 40-52. doi:http://dx.doi.org/10.1016/j.annepidem.2009.09.008

Slootmaker, S. M., Schuit, A. J., Chinapaw, M. J., Seidell, J. C., van Mechelen, W. (2009). Disagreement in physical activity assessed by accelerometer and self-report in subgroups of age, gender, education and weight status. *International Journal of Behavioral Nutrition and Physical Activity, 6,* 17.

Sweat, V., Bruzzese, J. M., Albert, S., Pinero, D. J., Fierman, A., & Convit, A. (2011). The Banishing Obesity and Diabetes in Youth (BODY) Project: Description and feasibility of a program to halt obesity-associated disease among urban high school students. *Journal of Community Health,* doi:10.1007/s10900-011-9453-8

Thibault, H., Contrand, B., Saubusse, E., Baine, M., & Maurice-Tison, S. (2010). Risk factors for overweight and obesity in French adolescents: physical activity, sedentary behavior and parental characteristics. *Nutrition*, *26*, 192-200.

Treuth, M. S., Figueroa-Colon, R., Hunter, G. R., Weinsier, R. L., Butte, N. F., & Goran, M. I. (1998). Energy expenditure and physical fitness in overweight vs non-overweight prepubertal girls. *International Journal of Obesity*, *22,* 440-447.

Williams, D. R., & Collins, C. (1995). US socioeconomic and racial differences in health: patterns and explanations. *Annual Review of Sociology, 21,* 349–386.

Windle, M., Grunbaum, J. A., Elliott, M. et al. (2004). Healthy passages – A multilevel, multimethod longitudinal study of adolescent health. *American Journal of Preventive Medicine, 27*, 164–172.

World Health Organization. (2004). Young People's Health in Context. Health Behavior in School-aged Children (HBSC) Study: *International Report from 2001/2002 Survey: Health Policy for Children and Adolescents no. 4*. Denmark: WHO.

Table 1

Obesity, Physical Activity, and Socioeconomic Prevalences (weighted %)

	(weighted *N*)[a]	Obese (≥ 95th %ile BMI)	Optimal Physical Activity (5-7 days/ week)	Higher SES (≥ college degree)
5th grade assessment[b]	(3,817)	26.0	24.5	29.2
Female[b]	(1,877)	24.4	22.5	26.8
African American	(575)	31.6	19.6	21.5
Hispanic	(883)	23.9	23.0	8.8
White	(419)	15.4	25.4	71.9
Male[b]	(1,940)	27.7	26.5	31.6
African American	(609)	25.7	27.7	25.7
Hispanic	(831)	36.1	24.4	11.0
White	(500)	16.0	28.6	72.9
7th grade assessment[b]	(3,801)	23.7	33.1	29.5
Female[b]	(1,871)	23.7	28.6	27.2
African American	(571)	30.6	32.0	22.6
Hispanic	(886)	23.8	20.9	10.0
White	(414)	13.9	40.4	70.4
Male[b]	(1,930)	23.8	37.4	31.8
African American	(598)	22.9	40.7	27.1
Hispanic	(841)	30.8	27.8	11.2
White	(491)	12.8	50.0	72.6

Note. SPSS complex sampling results for dichotomous variables expressed as weighted %. Assessments conducted in 5th and 7th grades with the same participants.
[a]Weighted *N* based on sampling plan specific to each assessment.
[b]Aggregated racial/ethnic proportions are not representative of 2013 U.S. population distribution.

Table 2

Comparison at 5th Grade Between Youth with Complete and Missing Data in the 7th Grade Assessment (weighted %)

		Obese	Optimal Physical Activity	Higher SES
	(weighted *N*)	(≥ 95th ile BMI)	(5-7 days/ Week)	(≥ college degree)
Complete data 5th grade	(4,487)	27.3	24.3	28.5
Complete data 7th grade	(3,817)[b]	26.0	24.5	29.2
Missing data 7th grade[a]	(669)	34.7	23.2	24.3
OR [CI]		1.51 [1.26, 1.81]	0.93 [0.71, 1.21]	0.78 [0.64, 0.96]
OR [CI] with SES covariate		1.47 [1.23, 1.76]	0.94 [0.71, 1.23]	--

Note. Weighted data from SPSS complex sampling results for dichotomous variables. SES, socioeconomic status.
[a]Missing from 7th grade due to not participating in the 7th grade assessment or, if participating, BMI, PA, or SES measure was not completed.
[b]Weighted *N* of 3,817 based on Wave 1 complex samples plan.

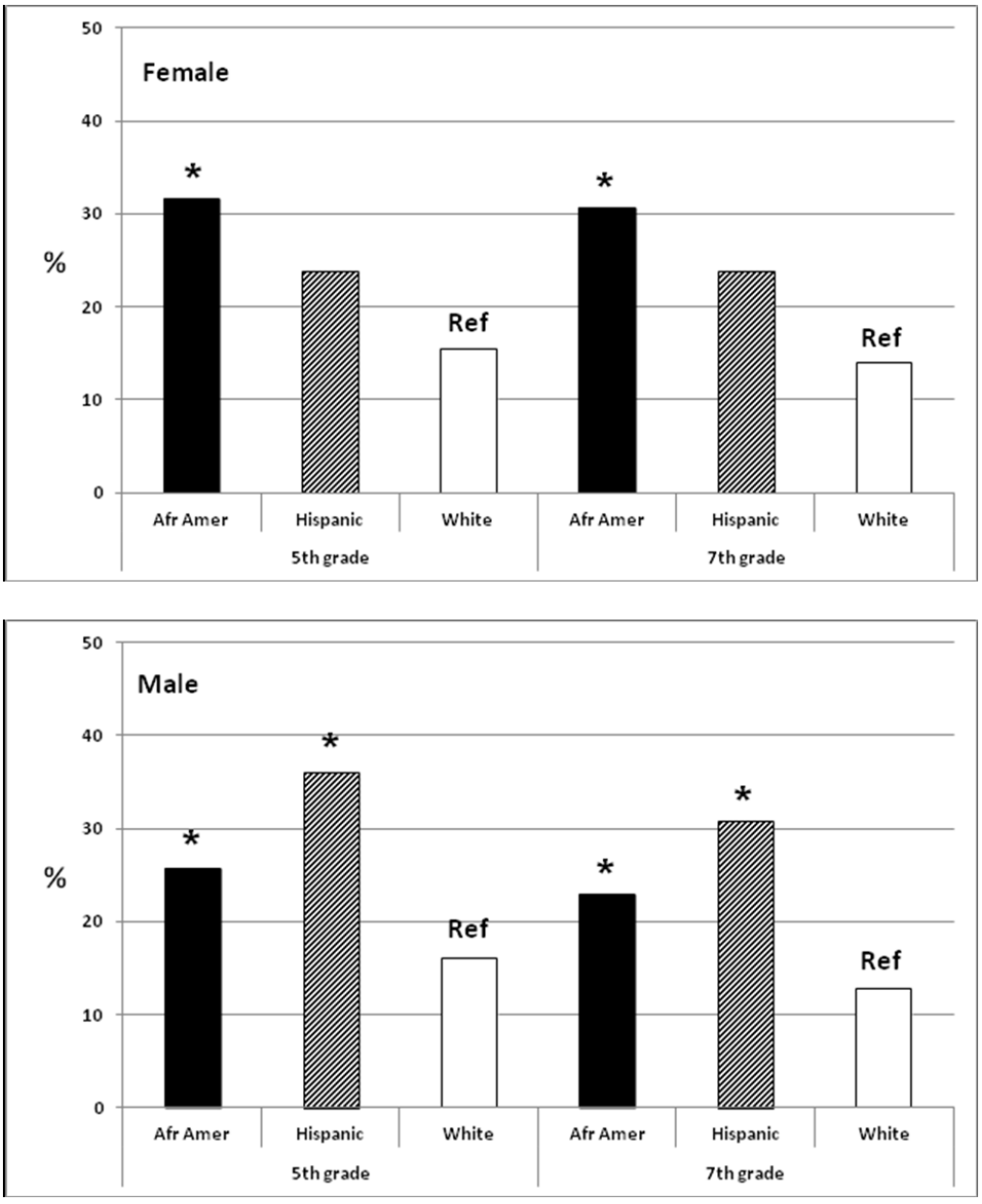

Figure 1. Obesity prevalence across race/ethnicity and gender at 5th and 7th grade assessments. Afr-Amer, African American; Ref, reference category = White; *statistically-significant ($p < .05$) odds ratio (*OR*) as referenced to White group (Ref); SES included as a covariate.

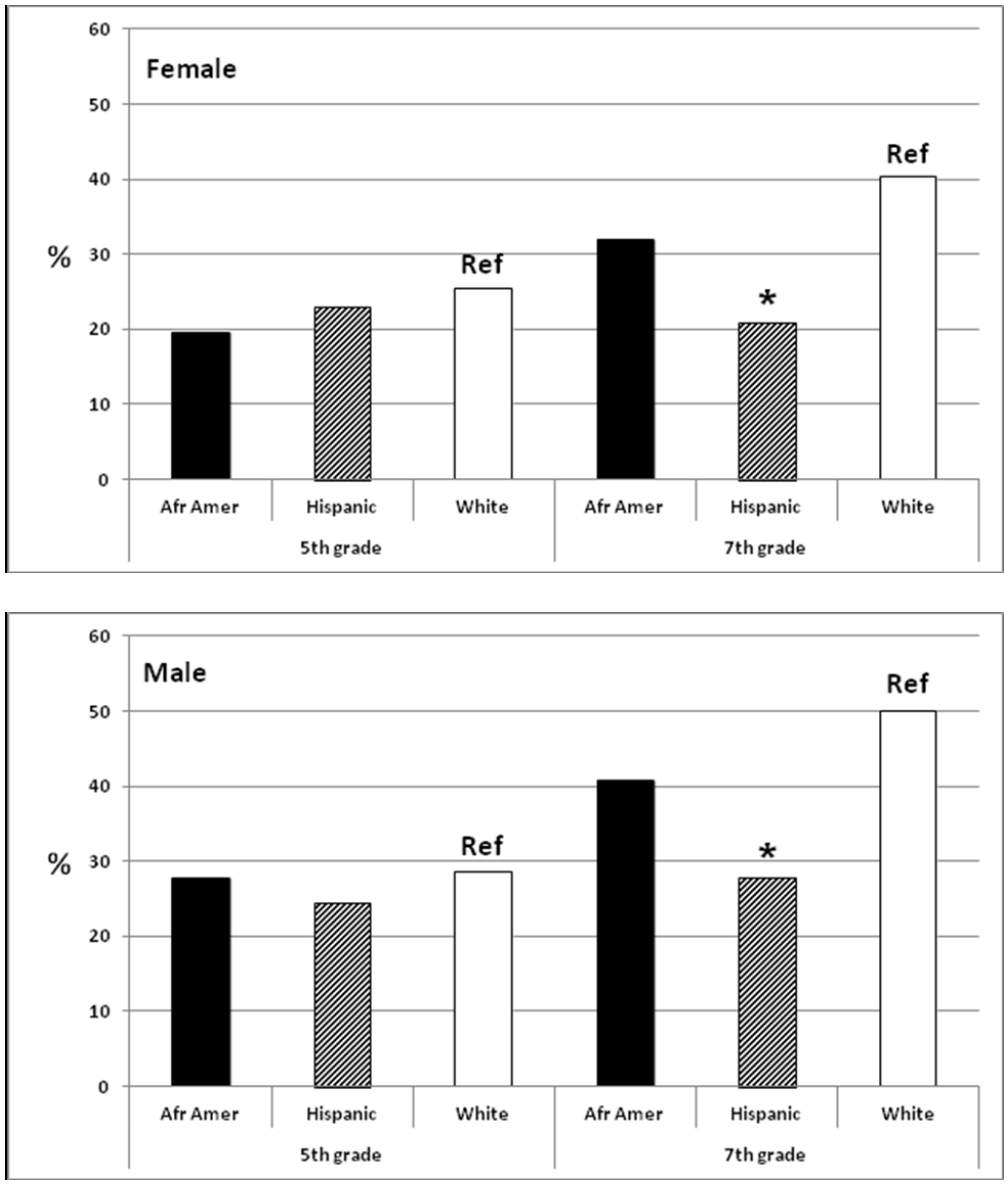

Figure 2. Optimal physical activity prevalence across race/ethnicity and gender at 5th and 7th grade assessments. Afr-Amer, African American; Ref, reference category; *statistically-significant ($p < .05$) odds ratio (*OR*) as referenced to reference-category group (Ref); SES included as a covariate.

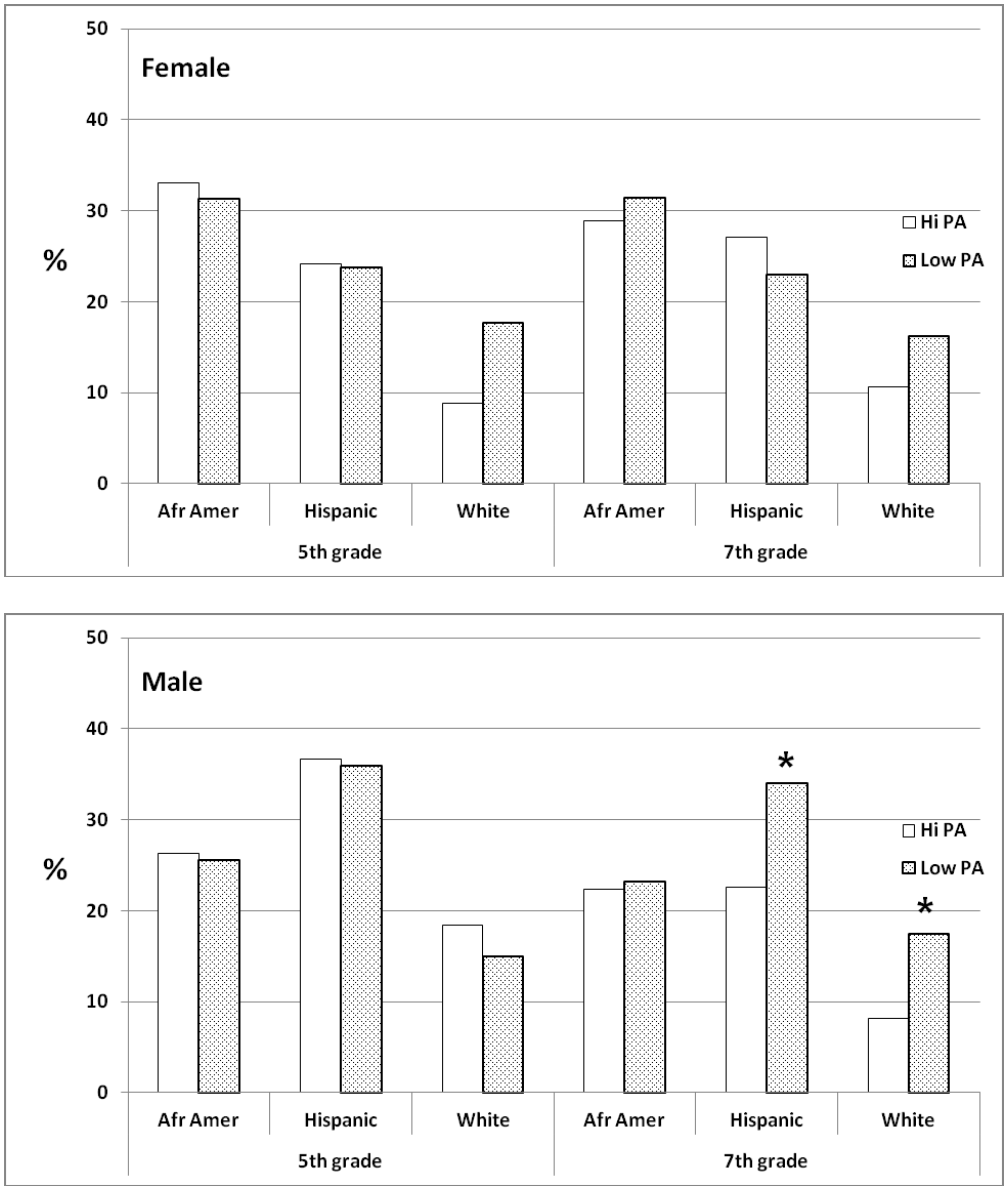

Figure 3. Obesity prevalence across physical activity level for racial/ethnic and gender groups at 5th and 7th grade assessments. Afr-Amer, African American; Hi PA, optimal physical activity; Low PA, sub-optimal physical activity; within-groups *statistically-significant ($p < .05$) odds ratio (*OR*) as referenced to optimal physical activity group; SES included as a covariate.

Are Diet and Physical Activity Associated With Obesity in Early Adolescence?

Chris Fradkin, MA

Psychological Sciences, University of California, Merced.

Acknowledgements: The Healthy Passages™ study is funded by the Centers for Disease Control and Prevention, Prevention Research Centers (Cooperative Agreements CCU409679, CCU609653, CCU915773, U48DP000046, U48DP000057, U48DP000056, U19DP002663, U19DP002664, and U19DP002665). The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the CDC. The authors have no conflict of interest to disclose. No author received any form of payment to produce this paper. The contributions made to this research by study participants in the Birmingham, Houston, and Los Angeles areas, other Healthy Passages™ investigators, field teams at each site, and the CDC Division of Adolescent and School Health are gratefully acknowledged.

Address correspondence to: Chris Fradkin, MA, SSHA, UC Merced, 5200 N. Lake Rd, Merced, CA 95343, cfradkin@ucmerced.edu.

Abstract

Objective: Research finds considerable variability in the associations between dietary and physical activity behaviors and obesity, among youth of different racial/ethnic groups. This study examined the relationship between dietary and physical activity behaviors and obesity risk during early adolescence in African American, Hispanic, and White youth. ***Methods:*** Data were from the Healthy Passages^{TM} study, which enrolled 4,824 African American, Hispanic, and White 5th graders in a population-based, longitudinal study, and assessed them again 2 years later. Weight status was classified using standard criteria from measured BMI into Non-Obese and Obese (27%, in 5th grade). The dietary behaviors of fruit, vegetable, fast food, and sugar-sweetened beverage consumption and the physical activity behaviors of moderate/vigorous activity and TV viewing were measured based on self-report from child. ***Results:*** Within-racial/ethnic-gender groups analyses revealed associations between dietary and physical activity behaviors and obesity risk in fewer than half the racial/ethnic-gender groups examined. No association was found between any of the behaviors and obesity risk among African American youth. There was also unexpected directionality in the associations between fruit, fast food, and sugar-sweetened beverage intake and obesity risk. Physical activity was the only behavior examined that displayed the expected (inverse) association with obesity risk. ***Conclusions:*** These findings suggest that diet and physical activity have sparse and sometimes unexpected associations with obesity risk among early adolescents, and that there is variability in these associations among racial/ethnic-gender groups. Further within-groups studies are needed to consider unexamined moderators among this age group.

Keywords: obesity, children, adolescents, diet, physical activity

Introduction

Approaches to address childhood obesity in the U.S. are grounded on the assumption that dietary and physical activity behaviors are directly linked to weight status. This assumption appears well-founded based on studies that find: fruit and vegetable consumption (a common proxy for a healthy diet) is linked to healthy weight (USDA, 2010); fast food and sugar-sweetened beverage consumption (common proxies for an unhealthy diet) is linked to unhealthy weight (Babey, Jones, Yu, & Goldstein, 2009; Malik, Shulze, & Hu, 2006); physical activity is linked to healthy weight (Butcher, Sallis, Mayer, & Woodruff, 2008); and sedentary behavior is linked to unhealthy weight (Rennie, Johnson, & Jebb, 2005). On the most basic level, children's weight is a product of energy intake (through foods and beverages consumed) and energy expenditure (through physical activity, resting metabolic rate, and the thermic effect of food; Hill, Wyatt, & Peters, 2012). For children to maintain healthy weight as their body size increases across development, these components must be balanced over time (Woods & Seeley, 2005). While acknowledging other components that affect the energy balance equation (e.g., genetics, psychosocial health, built environment, policies, marketing), we will focus here on the proximal determinants of this energy balance, namely dietary and physical activity behaviors, and their associations with obesity in youth.

Research has reported differences in these weight-related behaviors across racial/ethnic, and gender groups (Arcan, Kubik, Fulkerson, & Storey, 2009; McNutt et al., 1997). For example, soda and fast food consumption among African American youth is notably higher than among non-Hispanic White youth (Hastert, Babey, Diamant, & Brown, 2005). And physical activity among male youth is notably higher than among female youth (McMurray et al., 2000). There are also marked differences in obesity risk, with the prevalence for African American and Hispanic being higher than White youth (Ogden, Carroll, Kit, & Flegal, 2012). However gender differences are also present, with African American female and Hispanic male youth being at higher risk for obesity than their same gender racial/ethnic peers (Kumanyika & Grier, 2006). Whereas these studies have been informative as to differences in obesity risk specific to race/ethnicity and gender, few studies have examined the relationship between dietary and activity behaviors and obesity within an integrated analysis across racial/ethnic groups with consideration also for gender differences.

Healthy weight-promoting programs (e.g., Let's Move!, 2011) promote consumption of fresh fruit and vegetables. While fresh fruit and vegetable consumption among overweight adults has been linked to slower weight gain (Ledoux, Hingle, & Baranowski, 2011), among children this relationship is less consistent. In fact, a review of fruit and vegetable intake and adiposity found the expected inverse relationship among children in only half the studies (Ledoux et al., 2011). This inconsistent association suggests that other factors influencing weight status must also be considered, such as intake of less-than-healthy foods (fast foods, sugar sweetened drinks) and physical activity (Ledoux et al., 2011).

The relationship between fruit and vegetable consumption and weight may also be moderated by gender. For example, one longitudinal study of 9-14 year-olds found an

inverse relationship between vegetable intake and Body Mass Index (BMI) change among the boys, but not among the girls (Field, Gillman, Rosner, Rockett, & Colditz, 2003). Nonetheless, some studies do find diets with a minimum of five servings of fruits and vegetables a day to be inversely associated with adiposity in children (ADA, 2006; McCrory et al., 1999). Although studies have examined children's fresh fruit and vegetable consumption in home (MacFarlane, Crawford, Ball, Savige, & Worsley, 2007) and school (Robinson-O'Brien, Burgess-Champoux, Haines, Hannan, & Neumark-Sztainer, 2010) environments, we are aware of no study that has examined fresh fruit and vegetable consumption across and within racial/ethnic and gender groups to clarify possible disparities in these associations.

Studies more consistently indicate that fast food consumption is linked to obesity in children (Giammattei, Blix, Marshak, Wollitzer, & Pettitt, 2003; Tucker, Seljaas, & Hager, 1997). Historically, fast food consumption among 2- to 18-year-olds has "increased 5-fold" from the mid-1970s to the mid-1990s (Davis & Carpenter, 2009), a period during which obesity in children more than tripled (Ogden et al., 2012). Although studies have examined the impact of socioeconomics and the built environment on fast food availability and consumption (Algert, Agrawal, & Lewis, 2006) and have theorized about the impact of today's larger serving portions on the weight of children (Deckelbaum & Williams, 2001), again we are aware of no study that has examined fast food consumption and its relationship with obesity across and within racial/ethnic and gender groups.

Along with fast food, consumption of soda and other sugar-sweetened beverages has risen to the point where the average adolescent now consumes around 39 pounds of sugar annually from these products (Babey et al., 2009). As with fast food consumption, sugar-sweetened beverage consumption is linked to obesity risk in youth (Harnack, Stang, & Story, 1999; Malik, Shulze, & Hu, 2006). Whereas studies have examined variability of sugar-sweetened beverage consumption across race (Arcan, Kubik, Fulkerson, & Storey, 2009), no study we are aware of has examined the association of this consumption with obesity risk with due consideration for race/ethnicity and gender in youth.

The second component of the energy balance equation, energy expenditure, is derived primarily from physical activity. Studies have found a gradient relationship between physical activity and weight status in children, with reduction in BMI, and related indicators of weight status, mostly along the continuum of physical activity. (Lohman et al., 2006; Ness et al., 2007). Whereas these studies are consistent in their portrayal of the relationship between physical activity and pediatric weight risk, they have neglected to address possible differences across and within racial/ethnic and gender groups.

Furthermore, there are no studies that we know of that have examined the joint and unique associations between a range of dietary and physical activity behaviors and obesity risk within specific racial/ethnic and gender groups. We focus here on the developmental period of early adolescence (ages 10-13) because children frequently adopt weight-related behaviors around this time that sustain through adolescence into adulthood (WHO, 2004; Windle et al., 2004). Driven by the main research question

whether diet and physical activity behaviors have different associations with obesity risk across and within racial/ethnic and gender groups, we hypothesize based on prior research, that there will be: (1) an inverse relationship between fruit and vegetable consumption and obesity risk; (2) a positive relationship between fast food and sugar-sweetened beverage consumption and obesity risk; and (3) an inverse relationship between physical activity and obesity risk in general. We will test these hypotheses both between and within African American, Hispanic, and White male and female groups at two time points in early adolescence, in 5th and 7th grade, to examine developmental trends in dietary and physical activity behaviors and their associations with obesity risk.

Method

We used data from Healthy Passages™, a multi-site longitudinal community cohort study of adolescent health and health behaviors and their correlates initiated in 2004 (Schuster et al., 2012; Windle et al., 2004). Data from Waves I and II were used, collected from the same cohort of youth while in 5th grade and then two years later when they generally were in 7th grade. Institutional review boards at each research site approved the Healthy Passages™ study.

Participants

Participants were recruited from public schools in: (1) 10 contiguous public school districts in and around Birmingham, Alabama, (2) 25 contiguous public school districts in Los Angeles County, California, and (3) the largest public school district in Houston, Texas. Eligible schools had an enrollment of at least 25 5th-graders, representing over 99% of students enrolled in regular classrooms in the three areas. To ensure adequate sample sizes of non-Hispanic African-American, Hispanic, and non-Hispanic White youth, we took a random sample of schools using probabilities that were a function of how closely a school's racial/ethnic mix corresponded to the site's racial/ethnic target, as detailed elsewhere (Windle et al., 2004). Information was disseminated to the 5th-graders in 118 selected schools, with 11,532 students, to bring to their parents (or caregivers). Permission to be contacted was returned by 6,663, of which 5,147 (77%) completed both a parent and a youth interview. Exclusion criteria included not attending a regular academic classroom or having a parent who could not complete interviews in English or Spanish. The 6% who were not identified by their parents as being African-American, Hispanic, or White (details below) were excluded from the analysis, resulting in 4,824 with the unweighted (weighted) distribution of 36% (30%) African-American, 38% (47%) Hispanic, and 26% (23%) White, 51% (51%) females, and youth age $M = 11.11$ ($SD = .56$) at 5th grade. Other demographic information for this sample has been presented elsewhere (Schuster et al., 2012). The retention rate at 7th grade assessment was 93%, resulting in 4,491 with age $M = 13.06$ ($SD = .59$) with an essentially identical distribution across race/ethnicity and gender as at 5th grade.

Procedures

The full Healthy Passages™ assessment protocol was completed with a child and parent separated in private spaces at their home or a research facility by two trained interviewers using both computer-assisted personal interview and computer-administered self interview methods (Windle et al., 2004). The parent could choose whether material would be presented in English or Spanish (prepared using standard back-translation methods; Bravo, Woodbury-Fariña, Canino, & Rubio-Stipec, 1993). The same procedures were used for the 7th grade assessment.

Dependent Variable: Obesity

Body Mass Index (BMI) calculations were based on weight and standing height obtained according to standard anthropometric protocols (Centers for Disease Control and Prevention, 1998) by trained and certified interviewers. Height was measured, with the participant in bare feet or socks, to the nearest millimeter using a portable stadiometer. Weight was measured to the nearest 0.1 kg using a Tanita electronic digital scale. Sex-specific ratios of children's BMI, based on weight for height by age (months), were calculated according to CDC guidelines (Kuczmarski et al., 2000), with obese defined as BMI ≥ 95th percentile.

Dietary and Physical Activity Variables

Dietary behavior was measured by child report using items adapted from the School-Based Nutrition Monitoring (SBNM) secondary level student questionnaire (Hoelscher, Day, Kelder, & Ward, 2003), a food frequency questionnaire (FFQ) covering dietary behavior over the past seven days. The SBNM has been found to be an appropriate instrument for assessment of dietary behavior of early adolescents (Hoelscher et al., 2003). Validity testing comparing the SBNM dietary items to responses on a 24-hour recall, considered the gold standard method (McPherson, Hoelscher, Alexander, Scanlon, & Serdula, 2000), found agreement ranging from 51-54%, with κ statistics of 0.33 and Spearman correlations ranging from 0.40-0.57, and reproducibility testing found agreement ranging from 72-81%, with κ statistics from 0.60-0.71 and correlations from 0.73-0.87 (Hoelscher et al., 2003). Baranowski and Domel (1994) indicate that accuracy of dietary recall is present in children by age 10. The following specific dietary variables were obtained:

Fruit consumption was measured by items that separately assessed the youth's consumption of fruit and 100% fruit juice over the past week. For example: "During the past 7 days, how often did you eat a serving of fruit?" and "During the past 7 days, how often did you drink a cup, glass, bottle, or can of 100% fruit juices such as orange juice, apple juice, or grape juice? Do not count punch, Kool-Aid, sports drinks, Sunny Delight." Fruit and 100% fruit juice intake was totaled and transformed into servings/day and then dichotomized into "higher" (*3+ servings/day*) and "lower" (*< 3 servings/day*) categories to resemble USDA daily intake guidelines (USDA, 2010).

Vegetable consumption was measured by items that separately assessed the youth's consumption of salad, potatoes (excluding French fries and chips), carrots, and miscellaneous vegetables over the past week. For example: "During the past week, how

often did you eat a serving of green salad? A green salad is made with lettuce, spinach, and other leafy green vegetables." Items were totaled and transformed into servings/day and then dichotomized into "higher" (*3+ servings/day*) and "lower" (*< 3 servings/day*) categories to resemble USDA daily intake guidelines (USDA, 2010).

Fast food consumption was measured by items that addressed the number of fast food meals or snacks the youth consumed in the last week. For example: "During the past 7 days, how often did you eat a meal or snack from a fast food restaurant, such as McDonalds, Pizza Hut, Burger King, Kentucky Fried Chicken, or Taco Bell?" Items were totaled and then dichotomized into "higher" (*> 2 meals or snacks/week*) and "lower" (*≤ 2 meals or snacks/week*) categories. In the absence of any formal guidelines regarding fast food consumption, this resulted in identifying approximately the upper quartile in consumption.

Sugar sweetened beverage consumption was measured by items that addressed the number of sodas and non-soda sugar-sweetened drinks (e.g., punch, Kool-Aid, sports drink) the youth consumed in the last week. For example: "During the past 7 days, how often did you drink a glass, can, or bottle of soda or soft drinks?" and "During the past 7 days, how often did you drink a cup, box, bottle, or can of any punch, Kool-Aid, sports drinks, Sunny Delight, or other sweet drinks?" Soda and non-soda sugar-sweetened beverage intake was totaled and transformed into servings/day and then dichotomized into "higher" (*> 14 servings/week*) and "lower" (*≤ 14 servings/week*) categories. In the absence of any formal guidelines regarding sugar sweetened beverage consumption, this resulted in identifying approximately the upper quartile in consumption.

Physical activity was assessed by self-report using one item adapted from the PACE+ 60-minute screening measure for moderate-to-vigorous physical activity (MVPA) (Prochaska, Zabinski, Calfas, Sallis, & Patrick, 2000): "On how many of the past 7 days did you exercise or take part in any kind of exercise or physical activity in which you were moving for at least 60 or more minutes?" This item has shown strong test-retest reliability (ICC = 0.72) as well as moderate correlation with accelerometer ($r = 0.37$, $p < .001$) (Prochaska, Sallis, & Long, 2001). Responses ranged from 0 to 7 days. Scores were dichotomized into "higher" (*5-7 days/week*) and "lower" (*<5 days/week*) categories, with the higher category corresponding with the physical activity guideline recommendations for this age group (Butcher, Sallis, Mayer, & Woodruff, 2008).

Television viewing was measured by five items that assessed the youth's television viewing across the week (school day afternoon, school day night, Friday night, Saturday, Sunday). For example for the school night: "On a usual school night, that is Monday, Tuesday, Wednesday, or Thursday, about how many hours do you watch television from 7pm until you go to bed?" Items were totaled and then dichotomized into "higher" (*30+ hours/week*) and "lower" (*< 30 hours/week*) categories, with the higher category corresponding with the "at-risk" categories for sedentary behavior for this age group (Crespo et al., 2001; Staiano, Harrington, Broyles, Gupta, & Katzmarzyk, 2013).

Exposure variables

For *race/ethnicity*, the parent was asked which one or more of seven racial/ethnic categories describe the child. The child was classified as Hispanic if so indicated

regardless of other racial/ethnic indication. Children not categorized as Hispanic were classified as non-Hispanic African American, non-Hispanic White, or other (which was excluded from analysis).

SES was indexed by parent report of household's highest year of education completed (7 levels) because it is the most stable indicator of SES (Williams & Collins, 1995) and is considered best for use with members of racial/ethnic minority groups, who do not receive the same financial gains for equivalent years of education as do Whites (Kaufman, Cooper, & McGee, 1997; Williams, 1999). Seven categories reflected the highest education completed (*< 9th grade to > 4-year college degree*), which were dichotomized into "higher" (*≥ 4-year college degree*) and "lower"(*< 4-year college degree*) categories for purposes of these analyses.

Data Analysis

All analyses were performed using SPSS Complex Sampling module with weighted data to adjust for the complex survey design, which included clustered sampling of schools with unequal probability to improve the ability to estimate racial/ethnic disparities (see Windle et al, 2004, for details). Preliminary crosstabs analyses were conducted to describe prevalence of obesity, dietary and physical activity behaviors, and SES; logistic regression tests were then conducted separately for males and females to estimate differences across race/ethnicity. Bonferroni adjustments were applied constraining differences to significance at $p < .0167$ (.05/3 groups).

The main analysis examined the unique and joint contributions to obesity risk from the dietary and physical activity variables, separately in each racial/ethnic and gender group at each assessment occasion. For this purpose, all six dietary and physical activity variables were simultaneously entered in a logistic regression with obesity status as the dependent variable, controlling for SES. Significance of individual variables was tested with *OR*s with 95% CIs, whereas the significance of the regression model as a whole was tested with Wald *F*, with significance at $p < .05$. Because all variables were examined simultaneously in these analyses, the results represent the individual contribution of each behavioral variable to obesity risk independent of, or adjusted by, the other variables and SES.

To provide full information about the association of the dietary and physical activity variables with obesity, bivariate logistic regression analyses were conducted in addition. Significant differences in obesity risk associate with a specific behavior were expressed in odds ratios (*OR*s) with 95% confidence intervals (CIs). Whereas findings from these bivariate analyses are presented in tabular form, they are not discussed further because we emphasized the multivariable analysis that provides information about unique contribution of the dietary and physical activity behaviors to obesity risk when considered simultaneously rather than in isolation.

Results

Prevalences of Obesity and Dietary and Physical Activity Behaviors

The following results are shown in Table 1.

Obesity. Although not a focus of this study, for completeness we report and compare obesity prevalences. African American and Hispanic females had significantly higher obesity prevalence than White females at both the 5th and 7th grade assessments. At the 5th grade assessment, African American females had significantly higher obesity prevalence than Hispanic and White females Hispanic males had significantly higher obesity prevalence than White males at both the 5th and 7th grade assessments. At the 7th grade assessment, African American and Hispanic males had higher obesity prevalence than White males.

Fruit consumption. At the 5th grade assessment, Hispanic females had a significantly higher fruit consumption (3+ servings/day) than African American and White females, while Hispanic males had a significantly higher than White males. At the 7th grade assessment, for both males and females, Hispanic youth had a significantly higher fruit consumption than White youth.

Vegetable consumption. At the 5th grade assessment, Hispanic females had a significantly higher vegetable consumption (3+ servings/day) than White females, while African American and Hispanic males had a significantly higher vegetable consumption than White males. At the 7th grade assessment, there were no significant differences in higher vegetable consumption between racial/ethnic groups for either males or females.

Fast food consumption. At the 5th grade assessment, for both males and females, African American youth had a significantly higher fast food consumption (> 2 meals or snacks/week) than Hispanic and White youth. At the 7th grade assessment, for both males and females, African American youth had a significantly higher fast food consumption than Hispanic youth, who were higher than White youth.

Sugar-sweetened beverage consumption. At the 5th grade assessment, for both males and females, African American youth had a significantly higher sugar-sweetened beverage consumption (> 14 servings/week) than Hispanic and White youth. At the 7th grade assessment, for both males and females, African American youth had a significantly higher prevalence of higher sugar-sweetened beverage consumption than Hispanic youth, who were higher than White youth.

Physical activity. At the 5th grade assessment there were no significant differences in higher physical activity (5-7 days/week) among the three racial/ethnic groups for either males or females. At the 7th grade assessment, for both males and females, White youth had a significantly higher physical activity than African American youth, who were higher than Hispanic youth.

Television viewing. At both the 5th and 7th grade assessments, for both males and females, African American youth had a significantly higher television viewing (30+ hours/week) than Hispanic youth, who were higher than White youth.

Associations of Dietary and Physical Activity Behaviors with Obesity Risk

Results from the multivariable examination of the unique and joint contribution of dietary and physical activity behaviors are emphasized in this study and presented in Table 2. Results of bivariate associations of the same behaviors with obesity risk are presented in Table 3 for completeness.

Females. At the 5th grade assessment adjusting for the contribution of all other behaviors and SES, increased obesity risk was associated only with higher television viewing among African American females, and only with higher fruit consumption among Hispanic females. Among White females, a reduced obesity risk was associated only with higher fast food consumption. At the 7th grade assessment, there was a reduced obesity risk associated only with higher fast food consumption among African American females and only with higher sugar sweetened beverage consumption among Hispanic females. Among White females, obesity risk was not associated with any of the behaviors at this assessment.

Males. At the 5th grade assessment, obesity risk was not associated with any of the behaviors for males of any racial/ethnic group. At the 7th grade assessment when adjusting for the contribution of all other behaviors and SES, a reduced obesity risk was associated with higher physical activity among Hispanic and White males, while in addition among White males, there was an increased obesity risk associated with higher fast food consumption,. Among African American males in 7th grade, obesity risk was not associated with any of the behaviors.

Discussion

The primary aim of this study was to examine the unique and joint contribution of the dietary and activity variables presumed to be associated with obesity risk among a racially- and ethnically-mixed sample of early adolescents. The results portray largely an absence of and unpredictability of relationships between the dietary and physical activity behaviors examined here and obesity risk in diverse youth assessed in 5th and 7th grade. Among the six groups examined (3 racial/ethnic x 2 gender groups) at two time points, a relationship between any of the behaviors and obesity risk was observed in only four of 12 analyses (for 5th and 7th grade Hispanic females, 5th grade White females, 7th grade White males), when controlling for SES. There was no relationship between any of the six behaviors and obesity risk in the remaining two thirds of the groups. Of note was an absence of relationship between the dietary and physical activity behaviors and obesity risk among African American youth of either gender at either time point. None of the relationships that were observed were replicated across the two assessment occasions. Findings also revealed an unexpected directionality between specific dietary behaviors and obesity risk among certain racial/ethnic-gender groups (e.g., higher fruit consumption associated with increased obesity risk among 5th grade Hispanic females; higher fast food consumption associated with reduced obesity risk among 5th grade White females). Of note as well is the finding that of the six behaviors examined (4 diet, 2 activity), only physical activity and television viewing displayed expected associations (inverse and positive, respectively) with obesity risk.

Consequently, these dietary and physical activity behaviors had differential associations with obesity risk across racial/ethnic and gender groups and ages. Moreover, vegetable intake, a dietary variable with purported beneficial effects on obesity risk, had no significant association among any of the racial/ethnic-gender groups at either time point of assessment. The associations between several of the dietary behaviors (fruit, fast

food, sugar-sweetened beverages) and obesity risk were in the opposite direction from hypotheses, and inconsistent with current weight management programs based upon the premise of increasing children's intake of fruit and vegetables while decreasing their consumption of "junk foods." These implications will be discussed later.

As a secondary aim, this study examined differences in diet and activity behaviors among different to racial/ethnic and gender groups in early adolescence. In all but one instance, African American and Hispanic youth reported higher fruit, vegetables, fast food, and sugar-sweetened beverage intake and television viewing, as well as less physical activity compared to same-gender White youth. The higher intake of fruit among Hispanic compared to White youth is consistent with prior research (McCarthy, Wolff, Bianco-Simeral, Crozier, & Goto, 2012), as is the higher intake of fast food and sugar-sweetened beverages among African American compared to White youth (Hastert, Babey, Diamant, & Brown, 2005). Also consistent with the literature is finding higher television viewing among African American and Hispanic compared to White youth (Crespo et al., 2001). Whereas these group differences in behaviors are consistent with past studies, the relationship especially between the dietary behaviors and obesity risk is unexpected, and in some ways controversial.

Our finding that fast food and sugar-sweetened beverage consumption was associated with reduced obesity risk among certain subgroups (5^{th} grade White and 7^{th} grade Hispanic girls) is counter to the expectation that consumption of high-caloric, high-fat food increases obesity risk. One possible explanation for this finding may be that children in these groups under-report their consumption of fast food and sugar-sweetened beverages. If so, this would be consistent with studies that link energy intake underreporting with weight status, with higher underreporting among girls of obese and overweight BMI compared to girls of healthier BMI (Lanctot, Klesges, Stockton, & Klesges, 2008). The counterintuitive finding that fruit intake was associated with increased obesity risk among the subgroup of 5^{th} grade Hispanic may be explained by the significantly higher intake of fruit among Hispanic (40%) girls when compared to African American (24%) and White (22%) girls in our sample.

This study aimed to illuminate the relationship that diet and physical activity have with obesity risk within a sample balanced for race/ethnicity and gender in early adolescence. Previous studies have examined racial/ethnic differences in obesity risk (Singh, Siahpush, & Kogan, 2010), as well as racial/ethnic and gender differences in physical activity prevalence (Kimm et al., 2002). However, this is the first study we are aware of that has examined the relationship between both diet and physical activity and obesity risk in this age range with an integrated analysis where both race/ethnicity and gender are examined as well as their interaction. In light of differences in diet and activity behaviors across race/ethnicity and gender (Arcan, Kubik, Fulkerson, & Storey, 2009; McCarthy et al., 2012), this within-subgroups approach is needed to better understand the associations between behavior and weight status in youth. Also of note is the multivariate (vs. bivariate) approach in this study, which reveals the unique and joint association of behaviors with obesity, as they function within the constellation of the whole. As no single behavior is solely responsible for weight status and they do not occur in isolation, examining the "constellation" of behaviors appears more relevant to untangling the

relationship between the hypothesized proximal behaviors of diet and activity and weight status, than a methodology where each is examined only individually.

Among limitations must be noted that, as with all studies examining cross-sectional associations, causality should not be inferred. Second is the self-reporting of the child's dietary and physical activity behavior. As previously noted (Forrestal, 2011; Lanctot et al., 2008), there may be underreporting of fast food and sugar-sweetened beverage consumption among certain subgroups of our sample (higher BMI, African American). In addition to underreporting, there is also reliance on recall of these behaviors, which was over seven days. The 24-hour recall method for assessing dietary intake is generally acknowledged to be preferable (Burrows, Martin, & Collins, 2010; McPherson et al., 2000), but is challenging to implement in very large samples as here. Corroborating child's self-report with proxy report, as has been done in other studies (Williams, Wake, Hesketh, Maher, & Waters, 2005), however would be an enhancement. Finally, the Hispanic portion of our sample has familial roots primarily in Mexico, and because of its within-group heterogeneity, findings should not be generalized to other Hispanic ethnicities (e.g., Puerto Rican, Cuban).

In light of the unexpected and differential associations that specific dietary and physical activity behaviors evidence here with obesity risk in diverse early adolescents, future research should consider moderators to illuminate under which conditions associations may and may not occur. Variables such as parenting style, child's self-esteem, and family structure are just a few potential moderators as of yet incompletely examined for their influence on obesity risk among diverse youth. Additionally, in examining these influences, research should assess such variables within racial/ethnic-gender subgroups, under the assumption that their roles may vary across the different groups. Whereas the prospect of separate analyses within specific racial/ethnic and gender subgroups may challenge statistical power requirements, this approach appears necessary to gain a better understanding of the complexities of obesity risk in youth. This approach is especially needed in a country as diverse as the U.S., if we wish to understand between-groups differences in obesity risk and how those mechanisms differ.

This study may have preliminary implications for interventions and policy regarding obesity in childhood. The finding that diet and physical activity behaviors that are generally thought to be associated with reduced obesity, but are so only among certain racial/ethnic-gender subgroups, brings question to the utility of healthy weight promoting programs built solely on a platform of "improving children's diet and increasing exercise" (see Schwartz & Brownell, 2010 for critiques of such programs). Based on these findings, one might argue that such programs would be reducing children's weight risk primarily for White children, who are at lowest obesity risk among the three major racial/ethnic groups, and less so for the groups at highest risk, African American girls and Hispanic boys. At a minimum, future efforts should assume group differences and address race/ethnicity-by-gender interactions in designing such programs. In sum, findings from this study suggest that both obesity intervention and policy should address pediatric obesity risk with a more targeted approach, with added focus on the groups at highest risk (e.g., African American girls and Hispanic boys).

References

ADA. Position of the american dietetic association: Individual-, family-, school-, and community-based interventions for pediatric overweight. (2006). *Journal of the American Dietetic Association, 106*, 925-945. doi:10.1016/j.jada.2006.03.001

Algert, S. J., Agrawal, A., & Lewis, D. S. (2006). Disparities in access to fresh produce in low income neighborhoods in Los Angeles. *American Journal of Preventive Medicine, 30*, 365–370.

Arcan, C., Kubik, M. Y., Fulkerson, J. A., & Story, M. (2009). Sociodemographic differences in selected eating practices among alternative high school students. *Journal of the American Dietetic Association*, *109*, 823-829..

Babey, S. H., Jones, M., Yu, H., & Goldstein, H. (2009). Bubbling over: soda consumption and its link to obesity in California. *Policy brief (UCLA Center for Health Policy Research)*, (PB2009-5), 1.

Baranowski, T., & Domel, S. B. (1994). A cognitive model of children's reporting of food intake. *The American journal of clinical nutrition*, *59*, 212S-217S.

Bravo, M., Woodbury-Fariña, M., Canino, G. J., & Rubio-Stipec, M. (1993). The Spanish translation and cultural adaptation of the Diagnostic Interview Schedule for Children (DISC) in Puerto Rico. *Culture, Medicine and Psychiatry*, *17*, 329-344.

Brener, N. D., Collins, J. L., Kann, L., Warren, C. W., & Williams, B. I. (1995). Reliability of the youth risk behavior survey questionnaire. *American Journal of Epidemiology, 141*, 575-580.

Brownson, R. C., Chriqui, J. F., Burgeson, C. R., Fisher, M. C., & Ness, R. B. (2010). Translating epidemiology into policy to prevent childhood obesity: The case for promoting physical activity in school settings. *Annals of Epidemiology, 20*, 436-444. doi:DOI: 10.1016/j.annepidem.2010.03.001

Burrows, T. L., Martin, R. J., & Collins, C. E. (2010). A systematic review of the validity of dietary assessment methods in children when compared with the method of doubly labeled water. *Journal of the American Dietetic Association*, *110*, 1501-1510.

Butcher, K., Sallis, J. F., Mayer, J. A., & Woodruff, S. (2008). Correlates of physical activity guideline compliance for adolescents in 100 U.S. Cities. *Journal of Adolescent Health, 42*, 360–368.

Centers for Disease Control and Prevention, National Center for Health Statistics. (1998). *NHANES III: Anthropometric Procedures*. #98-4083.

Crespo, C. J., Smit, E., Troiano, R. P., Bartlett, S. J., Macera, C. A., & Andersen, R. E. (2001). Television watching, energy intake, and obesity in US children: results from the third National Health and Nutrition Examination Survey, 1988-1994. *Archives of pediatrics & adolescent medicine*, *155*, 360.

Davis, B., & Carpenter, C. (2009). Proximity of Fast-Food Restaurants to Schools and Adolescent Obesity. *American Journal of Public Health, 99,* 1-6.

Deckelbaum, R. J., & Williams, C. L. (2001). Childhood obesity: the health issue. *Obesity research*, *9*(S11), 239S-243S.

Eck, L. H., Klesges, R. C., Hanson, C. L., & Slawson, D. (1992). Children at familial risk for obesity: an examination of dietary intake, physical activity and weight status. *International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity*, *16*, 71.

Field, A. E., Gillman, M. W., Rosner, B., Rockett, H. R., & Colditz, G. A. (2003). Association between fruit and vegetable intake and change in body mass index among a large sample of children and adolescents in the United States. *International journal of obesity*, *27*, 821-826.

Forrestal, S. G. (2011). Energy intake misreporting among children and adolescents: A literature review. *Maternal & Child Nutrition, 7*, 112-127. doi:10.1111/j.1740-8709.2010.00270.x

Gazzaniga, J. M., & Burns, T. L. (1993). Relationship between diet composition and body fatness, with adjustment for resting energy expenditure and physical activity, in preadolescent children. *The American journal of clinical nutrition*, *58*, 21-28.

Giammattei, J., Blix, G., Marshak, H. H., Wollitzer, A. O., & Pettitt, D. J. (2003). Television watching and soft drink consumption: Associations with obesity in 11- to 13-year-old schoolchildren. *Archives of Pediatrics & Adolescent Medicine, 157*, 882-886. doi:10.1001/archpedi.157.9.882

Goran, M. I., Hunter, G., Nagy, T. R., & Johnson, R. (1997). Physical activity related energy expenditure and fat mass in young children. *International journal of obesity*, *21*, 171-178.

Goran, M. I., Reynolds, K. D., & Lindquist, C. H. (1999). Role of physical activity in the prevention of obesity in children. *International Journal of Obesity*, *23*, S18-S33.

Haerens, L., Vereecken, C., Maes, L., & De Bourdeaudhuij, I. (2010). Relationship of physical activity and dietary habits with BMI in the transition from childhood to adolescence: a 4-year longitudinal study. *Public Health Nutrition, 13*, 1722–1728.

Harnack, L., Stang, J., & Story, M. (1999). Soft drink consumption among US children and adolescents: nutritional consequences. *Journal of the American Dietetic Association*, *99*, 436-441.

Hastert, T. A., Babey, S. H., Diamant, A. L., & Brown, E. R. (2005). More California teens consume soda and fast food each day than five servings of fruits and vegetables. *Policy brief (UCLA Center for Health Policy Research)*, (PB2005-8), 1-7.

Hill, J. O., Wyatt, H. R., & Peters, J. C. (2012). Energy balance and obesity. *Circulation, 126,* 126-132.

Hoelscher, D. M., Day, R. S., Kelder, S. H., & Ward, J. L. (2003). Reproducibility and validity of the secondary level School-Based Nutrition Monitoring student questionnaire. *Journal of the American Dietetic Association*, *103*, 186-194.

Jeffery, R. W., Baxter, J., McGuire, M. & Linde, J. (2006). Are fast food restaurants an environmental risk factor for obesity? *International Journal of Behavioral Nutrition and Physical Activity, 3,* 2.

Kant, A. K., & Graubard, B. I. (2013). Family income and education were related with 30-year time trends in dietary and meal behaviors of american children and adolescents. *The Journal of Nutrition, 143*, 690-700. doi:10.3945/jn.112.165258

Kaufman, J. S., Cooper, R. S., & McGee, D. L. (1997). Socioeconomic status and health in blacks and whites: the problem of residual confounding and the resiliency of race. *Epidemiology, 8,* 621–628.

Kimm, S. Y. S., Glynn, N. W., Kriska, A. M., Barton, B. A., Kronsberg, S. S., Daniels, S. R., . . . Liu K. (2002). Decline in physical activity in black girls and white girls during adolescence. *New England Journal of Medicine, 347*, 709-715.

Klesges, R. C., Keith Haddock, C., & Eck, L. H. (1990). A multimethod approach to the measurement of childhood physical activity and its relationship to blood pressure and body weight. *The Journal of pediatrics*, *116*, 888-893.

Kuczmarski, R. J., Ogden, C. L., Grummer-Strawn, L. M., Flegal, K. M., Guo, S. S., Wei, R., ... & Johnson, C. L. (2000). CDC growth charts: United States. *Advance data*, (314), 1.

Kumanyika, S., & Grier, S. (2006). Targeting interventions for ethnic minority and low-income populations. *Future Child, 16,* 187–207.

Ledoux, T. A., Hingle, M. D., & Baranowski, T. (2011). Relationship of fruit and vegetable intake with adiposity: A systematic review. *Obesity Reviews, 12*, e143-e150. doi:10.1111/j.1467-789X.2010.00786.x

Lanctot, J. Q., Klesges, R. C., Stockton, M. B., & Klesges, L. M. (2008). Prevalence and characteristics of energy underreporting in African-American girls. *Obesity, 16,* 1407–1412.

Let's Move! (2011). *Take Action.* Retrieved March 17, 2011 from the Let's Move! Web site http://www.letsmove.gov/action.php

Lohman, T. G., Ring, K., Schmitz, K. H., Treuth, M. S., Loftin, M., Yang, S., ... & Going, S. (2006). Associations of body size and composition with physical activity in adolescent girls. *Medicine and science in sports and exercise*, *38*, 1175-1181. doi:10.1249/01.mss.0000222846.27380.61. PMID:16775560.

Loos, R. J., & Bouchard, C. (2003). Obesity—is it a genetic disorder? *Journal of Internal Medicine, 254,* 401-425.

MacFarlane, A., Crawford, D., Ball, K., Savige, G., & Worsley, A. (2007). Adolescent home food environments and socioeconomic position. *Asia Pacific journal of clinical nutrition*, *16*, 748-756.

Malik, V. S., Schulze, M. B., & Hu, F. B. (2006). Intake of sugar-sweetened beverages and weight gain: a systematic review. *The American journal of clinical nutrition*, *84*, 274-288.

McCarthy, E., Wolff, C., Bianco-Simeral, S., Crozier, J., & Goto, K. (2012). The Effects of a School-Based Nutrition Intervention on Fruit and Vegetable Preferences, Self-Efficacy, and Consumption among Low-Income, Hispanic and White Middle-School Students. *Journal of Child Nutrition & Management*, *36*, n2.

McCrory, M. A., Fuss, P. J., McCallum, J. E., Yao, M., Vinken, A. G., Hays, N. P., & Roberts, S. B. (1999). Dietary variety within food groups: association with energy

intake and body fatness in men and women. *The American journal of clinical nutrition*, *69*, 440-447.

McMurray, R. G., Harrell, J. S., Deng, S., Bradley, C. B., Cox, L. M., & Bangdiwala, S. I. (2000). The influence of physical activity, socioeconomic status, and ethnicity on the weight status of adolescents. *Obesity Research, 8*, 130-139. doi:10.1038/oby.2000.14

Mcnutt, S. W., Hu, Y., Schreiber, G. B., Crawford, P. B., Obarzanek, E., & Mellin, L. (1997). A longitudinal study of the dietary practices of black and white girls 9 and 10 years old at enrollment: the NHLBI Growth and Health Study. *Journal of Adolescent Health*, *20*, 27-37.

McPherson, R. S., Hoelscher, D. M., Alexander, M., Scanlon, K. S., & Serdula, M. K. (2000). Dietary assessment methods among school-aged children: validity and reliability. *Preventive Medicine*, *31*, S11-S33.

Ness, A. R., Leary, S. D., Mattocks, C., Blair, S. N., Reilly, J. J., Wells, J., ... & Riddoch, C. (2007). Objectively measured physical activity and fat mass in a large cohort of children. *PLoS medicine*, *4*, e97. doi:10.1371/journal.pmed.0040097

Obarzanek, E., Schreiber, G. B., Crawford, P. B., Goldman, S. R., Barrier, P. M., Frederick, M. M., & Lakatos, E. (1994). Energy intake and physical activity in relation to indexes of body fat: the National Heart, Lung, and Blood Institute Growth and Health Study. *The American journal of clinical nutrition*, *60*, 15-22.

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2012). Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. *JAMA: The Journal of the American Medical Association, 307*, 483-490. doi:10.1001/jama.2012.40

Ogden, C. L., Flegal, K. M., Carroll, M. D., & Johnson, C. L. (2002). Prevalence and trends in overweight among US children and adolescents, 1999-2000. *JAMA: The Journal of the American Medical Association, 288*, 1728-1732. doi:10.1001/jama.288.14.1728

Ogden, J., Reynolds, R., & Smith, A. (2006). Expanding the concept of parental control: a role for overt and covert control in children's snacking behaviour? *Appetite, 47,* 100-106.

Prochaska, J. J., Sallis, J. F., & Long, B. (2001). A physical activity screening measure for use with adolescents in primary care. *Archives of Pediatrics & Adolescent Medicine*, *155*, 554.

Prochaska, J. J., Zabinski, M. F., Calfas, K. J., Sallis, J. F., & Patrick, K. (2000). PACE+: interactive communication technology for behavior change in clinical settings. *American Journal of Preventive Medicine*, *19*, 127-131.

Rennie, K. L., Johnson, L., & Jebb, S. A. (2005). Behavioural determinants of obesity. *Best Practice & Research Clinical Endocrinology & Metabolism*, *19*, 343-358. doi:10.1016/j.beem.2005.04.003.

Robinson-O'Brien, R., Burgess-Champoux, T., Haines, J., Hannan, P. J., & Neumark-Sztainer, D. (2010). Associations Between School Meals Offered Through the National School Lunch Program and the School Breakfast Program

and Fruit and Vegetable Intake Among Ethnically Diverse, Low-Income Children. *Journal of School Health*, *80*, 487-492.

Schmidt, M., Affenito, S. G., Striegel-Moore, R., Khoury, P. R., Barton, B., Crawford, P., ... & Daniels, S. (2005). Fast-food intake and diet quality in black and white girls: the National Heart, Lung, and Blood Institute Growth and Health Study. *Archives of pediatrics & adolescent medicine*, *159*, 626.

Schuster, M. A., Elliott, M. N., Kanouse, D. E., Wallander, J. L., Tortolero, S. R., Ratner, J. A., ... & Banspach, S. W. (2012). Racial and ethnic health disparities among fifth-graders in three cities. *New England journal of medicine*, *367*, 735-745.

Schwartz, M. B., & Brownell, K. D. (2010). Local and National Policy-Based Interventions: To Improve Children's Nutrition. In *Pediatric Obesity* (pp. 451-460). Springer New York.

Selassie, M., & Sinha, A. C. (2011). The epidemiology and aetiology of obesity: A global challenge. *Best Practice & Research Clinical Anaesthesiology, 25*, 1-9. doi:10.1016/j.bpa.2011.01.002

Staiano, A. E., Harrington, D. M., Broyles, S. T., Gupta, A. K., & Katzmarzyk, P. T. (2013). Television, adiposity, and cardiometabolic risk in children and adolescents. *American journal of preventive medicine*, *44*, 40-47.

Taveras, E. M., Berkey, C. S., Rifas-Shiman, S. L., Ludwig, D. S., Rockett, H. R., Field, A. E., ... & Gillman, M. W. (2005). Association of consumption of fried food away from home with body mass index and diet quality in older children and adolescents. *Pediatrics*, *116*, e518-e524.

Tucker, L. A., Seljaas, G. T., & Hager, R. L. (1997). Body fat percentage of children varies according to their diet composition. *Journal of the American Dietetic Association, 97*, 981-986. doi:DOI: 10.1016/S0002-8223(97)00237-X

US Department of Agriculture and US Department of Health and Human Services. (2010). *Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010.* Retrieved from http://www.cnpp.usda.gov/DGAs2010-DGACReport.htm

Williams, D. R. (1999). Race, SES and health: the added effects of racism and discrimination. *Annals of the New York Academy of Sciences, 896*, 173–188.

Williams, D. R., & Collins, C. (1995). US Socioeconomic and Racial Differences in Health: Patterns and Explanations. *Annual Review of Sociology*, *21*, 349-386.

Williams, J., Wake, M., Hesketh, K., Maher, E., & Waters, E. (2005). Health-related quality of life of overweight and obese children. *JAMA: the journal of the American Medical Association*, *293*, 70-76.

Windle, M., Grunbaum, J. A., Elliott, M., Tortolero, S. R., Berry, S., Gilliland, J., ... & Schuster, M. (2004). Healthy passages: A multilevel, multimethod longitudinal study of adolescent health. *American Journal of Preventive Medicine*, *27*, 164-172.

Woods, S. C., & Seeley, R. J. (2005). Regulation of appetite, satiety and energy metabolism. In J. Antel, N. Finer, D.Heal, & G. Krause (Eds.), *Obesity and Metabolic Disorders,* (pp. 93-107). Amsterdam: IOS Press.

World Health Organization. (2004). Young People's Health in Context. Health Behavior in School-aged Children (HBSC) Study: *International Report from 2001/2002 Survey: Health Policy for Children and Adolescents no. 4*. Denmark: WHO.

Table 1

Prevalences of Obesity, Diet and Activity Behaviors, and Socioeconomic Status (weighted %)

	(*N*)	Obese ≥ 95th %ile BMI	High Fruit 3+ servings/ day	High Vegetable 3+ servings/ day	High Fast Food > 2 servings/ week	High SSB > 14 servings/ week	High Physical Activity 5-7 days/ week	High TV Viewing 30+ hrs/ week	High SES ≥ college degree
					5th Grade (age *M* = 11.11)				
Female	(2,196)	25.2	30.8	24.1	19.7	19.4	22.6	26.7	26.7
Afr Amer	(671)	33.0[a]	24.1[a]	22.6[ab]	26.9[a]	25.0[a]	19.9[a]	41.1[a]	21.5[a]
Hispanic	(1,031)	24.7[b]	39.5[b]	27.9[a]	17.9[b]	18.7[b]	23.2[a]	23.9[b]	8.7[b]
White	(494)	15.7[c]	21.9[a]	18.1[b]	13.9[b]	13.4[b]	24.8[a]	13.1[c]	71.4[c]
Male	(2,290)	29.4	27.0	20.3	20.7	21.1	26.0	26.5	30.2
Afr Amer	(688)	25.7[a]	25.1[ab]	22.0[a]	32.0[a]	31.1[a]	27.6[a]	38.0[a]	23.9[a]
Hispanic	(1,027)	38.5[b]	31.1[a]	22.9[a]	16.3[b]	15.9[b]	23.9[a]	25.3[b]	11.5[b]
White	(575)	17.5[a]	21.8[b]	13.7[b]	15.2[b]	18.7[b]	28.0[a]	14.8[c]	71.2[c]
					7th Grade (age *M* = 13.06)				
Female	(1,998)	25.1	35.3	25.3	27.6	28.3	28.4	27.6	27.2
Afr Amer	(607)	31.5[a]	37.7[ab]	26.7[a]	38.4[a]	40.7[a]	32.0[a]	40.8[a]	23.3[a]
Hispanic	(951)	25.5[a]	36.2[a]	25.0[a]	26.3[b]	25.3[b]	20.4[b]	26.9[b]	9.9[b]
White	(439)	15.5[b]	29.9[b]	24.1[a]	15.7[c]	17.6[c]	40.8[c]	10.7[c]	70.2[c]
Male	(2,080)	24.8	34.0	23.9	25.9	29.6	37.4	25.7	31.2
Afr Amer	(650)	23.7[a]	32.5[ab]	25.2[a]	35.6[a]	42.3[a]	40.6[a]	42.7[a]	26.6[a]
Hispanic	(915)	32.0[b]	39.6[a]	25.5[a]	26.8[b]	28.2[b]	28.0[b]	20.8[b]	11.1[b]
White	(514)	13.5[c]	25.8[b]	19.7[a]	12.1[c]	15.9[c]	50.3[c]	12.9[c]	72.6[c]

Note. Results are from SPSS complex sampling analysis for dichotomous variables. Aggregated racial/ethnic proportions not representative of 2013 U.S. population distribution. Assessments conducted in 5th and 7th grades with the same participants. Afr Amer, African American; SSB, Sugar-sweetened beverage; SES, socioeconomic status.

[a,b,c]Different superscripts within gender and race/ethnicity subgroups for column variable indicate statistically significant difference between subgroups (with $p < .05/3 = .0167$ to adjust for simultaneous hypotheses).

Table 2

Logistic Regression of the Joint and Unique Associations of Dietary and Activity Behaviors with Obesity Risk by Race/Ethnicity and Gender at 5th and 7th Grade Assessments

	(*N*)	High Fruit 3+ servings/ day	High Vegetable 3+ servings/ day	High Fast Food > 2 servings/ week	High SSB > 14 servings/ week	High Physical Activity 5-7 days/ week	High TV Viewing 30+ hrs/ week	High SES ≥ college degree	Model Wald *F*[a]
					5th Grade (age *M* = 11.11)				
Female	(2,196)	--	--	--	--	--	1.65 [1.27, 2.14]	0.60 [0.47, 0.77]	8.88**
Afr Amer	(671)	--	--	--	--	--	1.52 [1.08, 2.12]	--	--
Hispanic	(1,031)	1.72 [1.22, 2.43]	--	--	--	--	--	0.63 [0.41, 0.99]	4.07**
White	(494)	--	--	0.31 [0.10, 1.00]	--	--	--	--	3.58**
Male	(2,290)	--	--	0.69 [0.52, 0.91]	--	--	--	0.47 [0.35, 0.62]	6.55**
Afr Amer	(688)	--	--	--	--	--	--	--	--
Hispanic	(1,027)	--	--	--	--	--	--	0.54 [0.35, 0.85]	2.54*
White	(575)	--	--	--	--	--	--	--	--

(table continues)

					7th Grade (age *M* = 13.06)				
Female	(1,998)	--	--	--	--	--	1.41 [1.10, 1.81]	0.51 [0.38, 0.69]	4.35**
Afr Amer	(607)	--	--	0.65 [0.47, 0.89]	--	--	--	--	--
Hispanic	(951)	--	--	--	0.46 [0.27, 0.78]	--	--	0.41 [0.24, 0.73]	2.89*
White	(439)	--	--	--	--	--	--	0.38 [0.17, 0.86]	--
Male	(2,080)	--	--	--	--	0.71 [0.56, 0.91]	--	0.52 [0.39, 0.70]	4.59**
Afr Amer	(650)	--	--	--	--	--	--	--	--
Hispanic	(915)	--	--	--	--	0.71 [0.50, 1.00]	--	--	--
White	(514)	--	--	2.79 [1.52, 5.14]	--	0.51 [0.29, 0.92]	--	0.54 [0.32, 0.92]	3.26**

Note. Only significant results from SPSS complex sampling analysis are presented. Simultaneous regressions of dichotomous variables. *OR*s reflect independent contribution of each variable while controlling for the others. Assessments conducted in 5th and 7th grades with the same participants. Afr Amer, African American; SSB, Sugar-sweetened beverage; SES, socioeconomic status. [a]Wald *F* significant at **p* < .05 or ***p* < .01.

.

Table 3

Bivariate Logistic Regression of Obesity Risk Associated with Individual Dietary and Activity Behaviors by Race/Ethnicity and Gender at 5th and 7th Grade Assessments

	(*N*)	High Fruit 3+ servings/ day	High Vegetable 3+ servings/ day	High Fast Food > 2 servings/ week	High SSB > 14 servings/ week	High Physical Activity 5-7 days/ week	High TV Viewing 30+ hrs/ week	High SES ≥ college degree
				5th Grade (age *M* = 11.11)				
Female	(2,196)	--	--	--	--	--	1.72 [1.34, 2.21]	0.56 [0.45, 0.71]
Afr Amer	(671)	--	--	--	--	--	1.53 [1.10, 2.13]	--
Hispanic	(1,031)	1.53 [1.08, 2.18]	--	--	--	--	--	0.63 [0.40, 0.99]
White	(494)	--	--	--	--	--	1.88 [1.03, 3.45]	0.42 [0.20, 0.88]
Male	(2,290)	--	1.31† [1.03, 1.66]	0.71† [0.55, 0.93]	--	--	--	0.47† [0.36, 0.62]
Afr Amer	(688)	--	--	--	--	--	--	--
Hispanic	(1,027)	--	--	--	--	--	--	0.53 [0.34, 0.82]
White	(575)	--	--	--	--	--	--	--

(table continues)

				7th Grade (age *M* = 13.06)				
Female	(1,998)	--	--	--	--	--	1.43 [1.13, 1.81]	0.51 [0.38, 0.69]
Afr Amer	(607)	--	--	0.65 [0.48, 0.88]	--	--	--	--
Hispanic	(951)	--	--	--	0.52 [0.33, 0.83]	--	--	0.44 [0.26, 0.77]
White	(439)	--	--	--	2.38 [1.09, 5.18]	--	2.51 [1.31, 4.84]	0.30 [0.13, 0.70]
Male	(2,080)	--	--	--	--	0.64 [0.50, 0.81]	--	0.50 [0.38, 0.66]
Afr Amer	(650)	--	--	--	--	--	--	--
Hispanic	(915)	--	--	--	--	0.68 [0.49, 0.94]	--	--
White	(514)	--	--	2.91 [1.60, 5.28]	--	0.49 [0.28, 0.84]	--	0.47 [0.29, 0.77]

Note. Only significant results from SPSS complex sampling bivariate regressions analyses are presented. Assessments conducted in 5th and 7th grades with the same participants. Afr Amer, African American; SSB, Sugar-sweetened beverage; SES, socioeconomic status.

Summary and Conclusions

This dissertation examined the relationship between dietary and physical activity behavior and obesity risk among a diverse sample of adolescents. In the examination of the relationship between physical activity and obesity risk, an inverse association between physical activity and obesity risk was found, but only among Hispanic and White males in 7th grade. There was no relationship between physical activity and obesity risk among youth in 5th grade, females, or African American males or females. Racial/ethnic differences in obesity prevalence and physical activity were found as well. When controlling for socioeconomic differences, in 5th and 7th grade, African American females had higher obesity prevalence than White females, and African American and Hispanic males had higher obesity prevalence than White males. In 7th grade, White females and males reported higher physical activity than their same gender Hispanic counterparts. In the examination of the holistic relationship between multiple dietary and activity behaviors (4 and 2, respectively) and obesity risk, associations between behavior and obesity risk were present in fewer than half the racial/ethnic-gender groups examined. Vegetable intake, a dietary variable with purported beneficial effects on obesity risk, had no significant relationship with obesity risk among any of the racial/ethnic-gender groups at either time point of assessment.

The results also revealed unexpected directionality in the associations between fruit, fast food, and sugar-sweetened beverage intake and obesity risk. In fact, of the six behaviors examined, physical activity was the only behavior that displayed the expected (inverse) association with obesity risk, and that in fewer than half the racial/ethnic-gender groups examined. No association was found between any of the behaviors and obesity risk among African American youth. Racial/ethnic differences in obesity prevalence, SES, and dietary and physical activity behaviors were found as well. African American females and Hispanic males had the highest obesity prevalence within their same gender groups. White youth had higher SES than African American youth who had higher SES than Hispanic youth. And in all but one instance, African American and Hispanic youth reported higher fruit, vegetables, fast food, and sugar-sweetened beverage intake and television viewing, as well as less physical activity compared to same gender White youth. Thus, the behavioral variables examined evidenced differential association with obesity risk among the racial/ethnic-gender groups contained within the sample.

Methodologically, this dissertation takes a somewhat different tack. It does so for the sake of story impact (read- and relate-ability). With the exception of the holistic analysis of the joint and unique associations of dietary and activity behaviors with obesity risk by race/ethnicity and gender (see p. 41), most analyses contained herein compared main effects within the six racial/ethnic-gender subgroups noted earlier. While it could be argued that a regression based format may be more sophisticated, I stand by the methodology herein. In this dissertation, the within-groups output describes unique associations between variables of distinct population groups (e.g., 5th grade Hispanic female, 7th grade White male); while a regression-based output would have described a collective association between variables (β_0) with moderation as per demographic coding ($\beta_1 x_1$ = race/ethnicity; $\beta_2 x_2$ = gender; $\beta_2 x_2$ = SES; $\beta_3 x_3$ = assessment time, etc.). For

sanctity of story, I opted for the emphasis on distinct population groups that the within-groups approach used herein employed.

The findings of this dissertation have implications for interventions and policy. In fact, the findings challenge a concept fundamental to many policy makers and social scientists: the notion of the presumed proximal determinants of adolescent weight (diet and physical activity behavior). Based on these findings, the proximal determinants of weight appear less proximal and less determinant than policy makers give them credit for. This discovery suggests that there are behind the scenes variables that moderate the relationship between diet and physical activity behavior and obesity risk, and that these variables may have a much larger role in adolescent weight risk than previously presumed. The need for a wider scope in addressing obesity risk is supported by a recent review that found that school-based physical activity and nutritional education interventions yielded no statistically significant benefits of BMI reduction to the children in attendance (Guerra, Nobre, da Silveira, & Taddei, 2014). These findings offer support to the argument that the "proximal determinant" approach of current weight management programs in the U.S. (e.g., Let's Move!, 2011) may not be sufficient.

In addition to the sparse relationship between the behavioral variables examined and obesity risk, this dissertation also revealed differential association between the individual behavioral variables and obesity risk across the six racial/ethnic-gender groups examined. This finding cries out for a more targeted approach from weight management programs in their interventions for the nation's youth. Particularly notable in the findings was an absence of association between any of the six behavioral variables examined and obesity risk among African American youth. In light of African American female youth being at highest risk for obesity among their same gender peers (see p. 18), this finding begs for research aimed at sorting out the correlates of weight class among this highly at-risk group.

Among limitations of this research is that, as with all correlational research, causality should not be inferred. Second is the self-reporting of the child's dietary and physical activity behavior. As previously noted (Forrestal, 2011; Lanctot et al., 2008), there may be underreporting of fast food and sugar-sweetened beverage consumption among certain subgroups of our sample (higher BMI, African American). In addition to underreporting, there is also reliance on recall of these behaviors, which was over seven days. The 24-hour recall method for assessing dietary intake is generally acknowledged to be preferable (Burrows, Martin, & Collins, 2010; McPherson et al., 2000), but is challenging to implement in very large samples as here. Corroborating child's self-report with proxy report, as has been done in other studies (Williams, Wake, Hesketh, Maher, & Waters, 2005), however would be an enhancement. Self-reporting of child's physical activity may be an issue, too. When compared to objectively measured physical activity (e.g., by accelerometer), adolescents appear to over-report weekly physical activity (Slootmaker, Schuit, Chinapaw, Seidell, & van Mechelen, 2009). There may also be gender variability, because adolescent females appear to over-report activity at a slightly higher rate than males (Slootmaker et al., 2009). Finally, the Hispanic portion of our sample has familial roots primarily in Mexico, and because of its within-group

heterogeneity, findings should not be generalized to other Hispanic ethnicities (e.g., Puerto Rican, Cuban).

Management of pediatric obesity requires understanding of the mechanisms of obesity, and how these mechanisms may vary among different population groups. The findings of this dissertation suggest that the mechanisms of obesity risk may be much more complex than presumed. This evidence on its own challenges the utility of weight management programs that are solely grounded on reduction of weight risk though modification of children's diet and activity. The findings herein call for future research to consider the moderating influences of parenting style, child's self-esteem, quality of life, and family structure, and their place in the energy balance equation. The findings also call for a more targeted approach to weight management for youth. In a nation as diverse ethnically and culturally as the U.S., research and policy must account for variability between racial/ethnic-gender subgroups and design studies, policy, and programs accordingly.