Title
The Social-Ecological Influences on Physical Activity, Dietary Intake, and Obesity Among Adolescents

Author
Nam, Bora

Publication Date
2016

Peer reviewed|Thesis/dissertation

The Social-Ecological Influences on Physical Activity, Dietary Intake, and Obesity Among Adolescents

by

Bora Nam

DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Nursing

in the

Dedication

This dissertation is dedicated to

my father Jong-Hyun Nam,

my mother Mi-Kyoung Lee,

and my husband Stephen Rheem.

I have been very blessed to have all of you through my entire journey of the doctoral study.

Acknowledgements

This dissertation would not have been possible without the help and support from many people. It is my great pleasure to acknowledge people who have given me guidance, help and encouragement.

I wish to extend my utmost thanks to my dissertation chair, mentor, and advisor Dr. Jyu-Lin Chen, she has been a tremendous mentor for me during this long journey of doctoral program. I would like to thank her for encouraging my research and for allowing me to grow as a research scientist. She, as a professional role model, constantly inspired and motivated me. Her advice on both research as well as on my career have been priceless. I could not have completed my dissertation without her passionate expertise.

I would also like to thank my committee members, Dr. Oi-Saeng Hong and Dr. Roberta Rehm. I have benefited from the richness of their mentorship, warmth, and immense knowledge. I deeply appreciate them for letting my defense be an enjoyable moment, and their insightful comments and guidance which incented me to widen my research from various perspectives.

I wish to gratefully acknowledge Dr. Bruce Cooper, for his invaluable guidance on the statistical analyses. My sincere thanks goes to Dr. Christine Miaskowski who provided me an opportunity to join her research team. I also thank to Judy Mastick and the members of research team, without their precious support it would not be possible to complete this research.

To my friends and UCSF colleagues who have supported me in this journey, thank you for believing I could do this and for commiserating with me when I needed it. This journey would have been lonely without you all.

Lastly, but most importantly, I would like to deeply thank my family for their everlasting love, support, and encouragement: my mother, Mikyoung Lee; my brother Young-take Nam; and my parents-in-law, Dae and Eun Rheem. Words cannot express how grateful I am. Your prayer for me was what sustained me thus far. A special thanks to my father, Jonghyun Nam, who was my greatest supporter in pursuing a doctoral degree, he must be very proud of me in heaven. At the end I would like express appreciation to my beloved husband, Stephen Rheem who spent sleepless nights with and was always my support in the moments when there was no one to answer my queries. In all of the ups and downs during my journey of doctoral studies, he was sources of laughter, joy, and support.

The Social-Ecological Influences on Physical Activity, Dietary Intake, and Obesity Among Adolescents

Bora Nam, RN, PhD

University of California, San Francisco, 2016

Abstract

Background: Given the obesity epidemic across communities and countries worldwide, being overweight and obesity among adolescents has become a critical public health concern. Overweight and obesity in adolescence are known to negatively affect on an individual's physical, psychological, and social status. It is imperative to identify not only individual-level factors but also social-environmental factors that influence physical activity, dietary intake, and body weight in order to reduce disparities in obesity.

Objectives: Using a social-ecological framework, the aims of this dissertation were: 1) to assess the contribution of social-ecological factors to regular physical activity; 2) to explore determinants associated with dietary patterns; 3) to estimate prevalence of overweight or obese, and to identify gender-specific risk factors for obesity among California adolescents.

Methods: The data was drawn from the California Health Interview Survey (CHIS). The first and third study included a total of 2,799 adolescents in the CHIS 2011-2012 data, and the second study included 4,000 adolescents from the CHIS 2011-2012, and 2013 datasets. Data examined included the individual-level (e.g., socio-demographics, body mass index percentile) and the neighborhood-level (e.g., availability of activity resources, food environment, safety) characteristics associated with physical activity, diet, and obesity.

Results: The first study found that those of the male sex, older teenagers, and having a higher household income were significant predictors for engaging in regular physical activity. The second study revealed that unhealthy dietary patterns (low consumption of fruits and vegetables, but high consumption of fast foods and sugary drinks) were found among adolescents from Hispanic or ethnic minorities, lower socioeconomic status, second or third generation immigrants, and in rural areas. The third research study demonstrated the gender-specific factors associated with a risk of overweight or obesity among adolescents. For girls, age, race/ethnicity, income, birth-place, physical activity, and neighborhood safety were significantly associated with being overweight or obese. In contrary, only age and race/ethnicity remain significant for boys.

Conclusion: The findings extends our understanding by identifying different features both at the individual and neighborhood level that are hypothesized to influence physical activity, diet, and obesity risk among adolescents. The findings of the dissertation suggest that a multilevel approach from a social-ecological perspective is crucial to implementing interventions/policies to effectively manage the obesity epidemic and to identify root causes of obesity disparities among adolescents.

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CHAPTER 1

Introduction

Problem Statement

Over the past three decades, overweight and obesity have increased dramatically in many parts of the world, and obesity has reached epidemic proportions globally (Sun et al., 2015). With the sharp rise in prevalence, overweight and obesity have become the fifth leading risk for death globally, and at least 2.8 million people die each year as a result of being overweight or obese (World Health Organization, 2013). As the obesity epidemic worsens, Healthy People 2020 reflects these concerns with overweight/obesity and physical activity being selected as two of the top ten leading health indicators.

An important feature of this general trend is that obesity and overweight are manifesting at much younger ages, such as during the important developmental period of adolescence, than had occurred in the past (Parizkova & Hills, 2005). According to the Centers for Disease Control and Prevention (CDC, 2015), the proportion of US adolescents (age 12-19 years old) who were obese increased from 5% in 1980 to nearly 21% in 2012. Obese adolescents are 70% more likely to be obese as adults than are adolescents of normal weight (Wang & Lobstein, 2006). In addition, childhood obesity confers long-term effects on mortality and morbidity. They are more likely to develop chronic health conditions such as insulin resistance, type 2 diabetes, hypertension, stroke, and cardiovascular disease at younger age (Maffeis & Tato, 2001). The excess medical costs due to overweight adolescents in the Unites States (US) are estimated at more than $14 billion per year (Trasande & Chatterjee, 2009). In response, researchers have proposed childhood and early adolescence as a critical period in which to address the issue of obesity, and community health initiatives have shifted primary prevention strategies towards the younger ages to combat obesity.

Background and Significance

Despite decades of research focused on genetic, behavioral, and pharmacological approaches to understanding obesity, these approaches appear to be insufficient for halting the obesity epidemic. These individual factors may increase a persons' susceptibility or vulnerability to obesity, but do not sufficiently explain the cause of obesity in a modern society with ample food availability (Lake & Townshend, 2006; Poston & Foreyt, 1999). The recent rapid increase of obesity in various age groups, races, and educational levels throughout the world suggests that other significant factors need to be considered.

Two decades ago, the social-ecological approach emerged as an alternative paradigm to traditional research (Egger & Swinburn, 1997; Reidpath, Burns, Garrard, Mahoney, & Townsend, 2002). This perspective stems from growing recognition that most public health challenges require more comprehensive approaches that integrate contextual influences, such as family, school, community planning, and policy, which are embedded in the community and society at large. A significant amount of evidence from the studies using the social-ecological approach has revealed that the environmental factors are now considered the key contributing factors to the global obesity epidemic (Parizkova & Hills, 2005). Public health professionals and researchers have suggested that the next-generation interventions for obesity should start at the community-level or higher (Huang, Drewnosksi, Kumanyika, & Glass, 2009).

At an individual level, the cause of obesity is an energy imbalance between calories consumed and calories expended. However, the world in which individuals live plays a pivotal role in shaping food and physical activity choices (Frenk, 2013). There are a variety of environmental factors that determine food choice and the degree of physical activity, and they can be seen in various settings including the home, school, and neighborhood. Recently, a

number of studies have focused on neighborhood environmental influences on physical activity, food consumption, and obesity (Popkin, Duffey, & Gordon-Larsen, 2005). Factors related to neighborhood environmental influences on obesity have been examined in the literature including availability of physical activity resources and parks (Roemmich et al., 2006); neighborhood walkability (Lovasi, Neckerman, Quinn, Weiss, & Rundle, 2009; Rundle et al., 2009); neighborhood safety (Cecil-Karb & Grogan-Kaylor, 2009); and the food environment (Holsten, 2009). Evidence from these studies indicates that an obesogenic environment that promotes excessive food intake and discourages physical activity has emerged as a driving force behind the current epidemic of obesity (Saelens et al., 2012).

Much of the current literature on obesity focuses on adult or preschool and school age children, leaving a gap in the literature related to the adolescent population. The adolescent period, which involves so many changes, may produce special adaptational demands on an individual. The body looks and feels different, an individual thinks differently, may judge right and wrong differently, and engages in different types of social relationships (Stang & Story, 2005; Steinberg, 2005). The combination of all these transitions has a dramatic effect. Adolescence is full of opportunities for physical, cognitive, and psychosocial growth, but also of risks to healthy development. Risky behavior patterns, such as an unhealthy diet and a sedentary lifestyle, tend to be established early in adolescence (Markey & Kurtz, 2006). The increased need for energy and nutrients among adolescents, combined with their increasing independence, need for autonomy when making decisions, and in their interactions within social contexts, might place adolescents at an increased nutritional and metabolic risk. Thus, it is particularly important to help adolescents to maintain a healthy lifestyle that includes a balanced, nutrient-rich diet with plenty of exercise in order to prevent obesity. Once it is known how social environmental

determinants are associated with physical activity and dietary behavior, customized and effective approaches that modify the obesogenic environment could prevent this multifactorial health condition.

Theoretical Framework

Given the comprehensive context of obesity, adolescent obesity should be studied using a multidimensional approach. Thus, social-ecological theory was used in this study to provide a conceptual framework in understanding determinants of adolescent obesity (Egger & Swinburn, 1997). The social-ecological model represents a comprehensive approach to identifying the multiple potential interrelated determinants of obesity (See Figure 1). The purpose of the ecological model is to determine how each component interacts with other components, which creates a highly complex context for health outcomes. This model extends the focus beyond individual factors to integrate influences from the physical, social, and policy environments. It is relevant and useful in understanding the obesity epidemic since people are continuously influenced by the circumstances of life and their way of living within those circumstances in this industrialized society (Breslow, 1996).

Recently, research suggested that the physical, social and policy environments impact obesity by influencing a person's behaviors such as physical activity and food consumption (Popkin et al., 2005). Educating people to make healthy choices when their actual environments are not supportive will not be effective in their making behavioral changes (Stokols, 1992). In order to increase physical activity and healthy dietary intake, efforts need to focus not only on the behavioral choices of each individual, but the multiple levels of influence on those choices (e.g. individual, interpersonal, organizational, community, and public policy), and these should be addressed at the same time. The social-ecological approach has significant

implications for the people who are making health-significant choices by acknowledging that it takes a combination of both individual-level and environmental-level interventions to achieve substantial changes in health behaviors to combat obesity.

Thus, this dissertation used a theoretical framework that is derived from social-ecological theory to evaluate the relative contribution of various factors towards obesity in adolescents with a focus on neighborhood environments. Figure 2 presents a conceptual framework for this dissertation. The framework shows how obesity is determined by a complex system of both individual-and neighborhood-level factors. The neighborhood column includes neighborhood physical activity features, food environment, urbanicity, and neighborhood safety. The individual column includes age, gender, race/ethnicity, nativity/immigration status, income, educational attainment, and acculturation. This framework assumes that body weight status is influenced by an interaction with different levels of individual, social, and environmental factors. These individual-level and neighborhood-level factors can be independently associated with obesity, or act either as a barrier or a facilitator to food consumption (energy intake) and physical activity (energy expenditure), which in turn, are associated with obesity.

Overview of Dissertation

The purpose of this dissertation is to present the findings using a secondary analysis of the adolescent data from the CHIS. The overall aim of the dissertation is to identify social-ecological determinants of physical activity, dietary intake, and obesity among adolescents.

The dissertation is presented in five chapters. In this chapter, the introduction with significance of adolescent obesity as well as theoretical perspectives for risk factors of obesity, are discussed. Chapter 2 presents findings of a research study identifying individual, family, environmental determinants of adolescent physical activity. Chapter 3 presents the findings of a

research study examining effects of race/ethnicity, acculturation, socioeconomic status, and neighborhood on dietary patterns in adolescents. Chapter 4 presents findings of a research study identifying gender-specific predictors associated with the risk of being overweight or obese among adolescents. Finally, Chapter 5 presents the conclusion from the three studies including implications for health interventions/policies and recommendations for future research.

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Figure 1. *The Social-Ecological Framework for Obesity*

Reprinted from "Influence of race, ethnicity, and culture on childhood obesity: implications for prevention and treatment," by S. Caprio, 2008, *Obesity, 16*(12), 2572. Copyright 2008 by the Obesity Society.

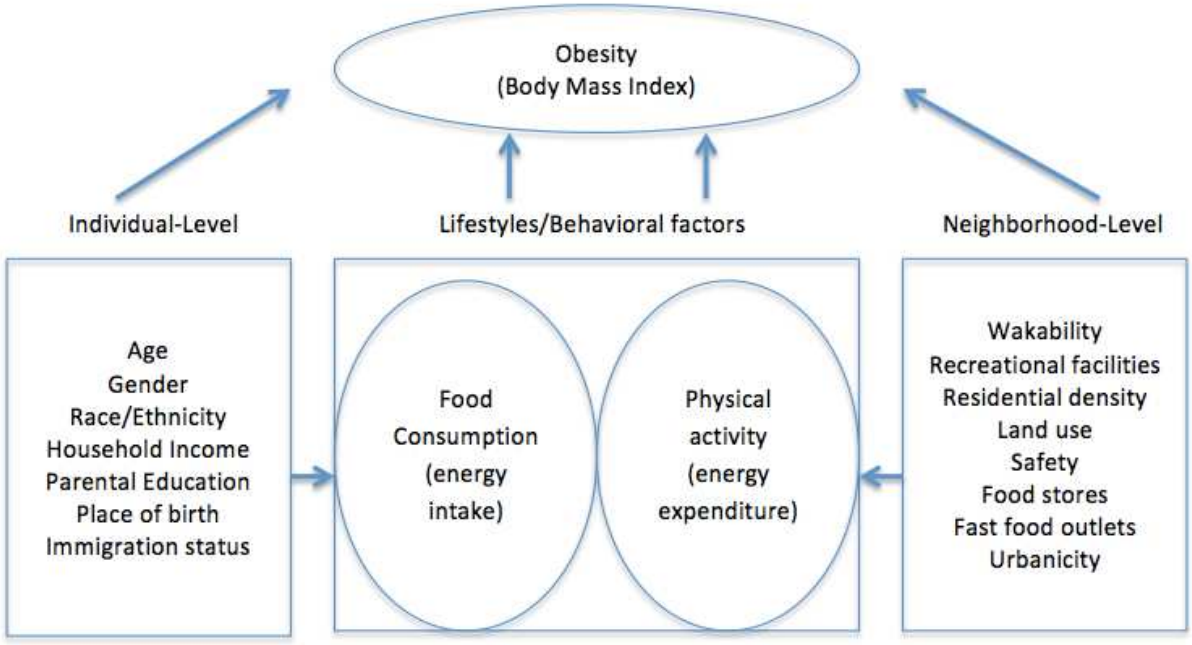

Figure 2. *A Conceptual Framework for the Study: Adolescent Obesity*

CHAPTER 2

The Role of Social-Ecological Factors on Physical Activity Among Diverse Adolescents in California

Abstract

Background: Given the importance of understanding and eliminating disparities to promote physical activity in adolescents, this study aimed to identify individual, family and environmental factors, using a social-ecological perspective, which are associated with the regular physical activity among diverse adolescents.

Methods: This study used a cross-sectional analysis of data from the CHIS, 2011-2012. We estimated the prevalence of regular physical activity in a sample of 2799 adolescents aged 12-17 years in California. Logistic regression analyses were used to identify factors related to engaging in regular physical activity.

Results: In California, 32% of adolescents participated in regular physical activity. In adjusted logistic regression analyses, the odds of regular physical activity were greater for males and older adolescents (15-17 years). Adolescents in the lowest income group and those who did not perceive their neighborhood as safe were significantly less likely to engage in regular physical activity.

Conclusions: These findings suggested that male sex, age over 15, higher household income, and safety of residential neighborhood are important predictors for engaging in regular physical activity among diverse adolescents in California. These findings provide information that can help in the development of more tailored and integrated intervention strategies to promote higher physical activity levels in adolescents.

Introduction

Over the past decades, overweight and obesity have increased dramatically in the US. According to the CDC (2015), the proportion of the US adolescents who were obese increased from 5% in 1980 to nearly 21% in 2012. While multiple factors contribute to obesity, physical activity plays a critical role in the development of overweight and obesity in childhood and adolescence (Hills, Andersen, & Byrne, 2011). A healthy lifestyle, including regular physical activity in childhood and adolescence, contributes to the prevention of obesity and other chronic diseases (Hallal, Victora, Azevedo, & Wells, 2006). Moreover, physical activity stimulates cognitive performance, as well as psychological health, by improving a person's mood and health (Hillman, Erickson, & Kramer, 2008). Thus, the U.S Department of Health and Human Services recommends that adolescents should participate in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) daily (U.S. Department of Health and Human Services, 2008). However, only 27.1% of adolescents met the recommendation in 2013 (CDC, 2014).

Despite the importance of engaging in regular physical activity in childhood and adolescence, it has been documented that physical activity levels decline during puberty and the following adolescent period (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008). Moreover, physical activity behaviors tend to persist from adolescence to adulthood and both have direct and indirect influences upon adult health (Telama et al., 2005), suggesting that adolescence is a critical period for physical activity promotion and the establishment of physical activity habits. Numerous studies have assessed personal factors, including biological (gender, age, ethnicity, bitrhplace status) and socioeconomic variables, in the establishment and maintenance of physical activity (Gordon-Larsen, McMurray, & Popkin, 2000; Gustafson & Rhodes, 2006; Sallis, Prochaska, & Taylor, 2000; Singh, Kogan, Siahpush, & van Dyck, 2008; Taylor, Ntoumanis,

Standage, & Spray, 2010). Decreased participation in organized sports or other vigorous physical activity has been regarded as one of the attributes causing a decline in physical activity levels during adolescence (Sallis, 2000; van Mechelen, Twisk, Post, Snel, & Kemper, 2000). However, personal factors explain only a small percentage of the variance in adolescents' physical activity, research has thus expanded to other broader approaches, such as social-ecological factors, to help identify potential barriers to physical activity in adolescents.

In response, the social-ecological approach has been used as an alternative paradigm (Egger & Swinburn, 1997; Reidpath, Burns, Garrard, Mahoney, & Townsend, 2002; Swinburn, Egger, & Raza, 1999). This perspective stems from the growing recognition that most public health challenges require more comprehensive approaches that will integrate contextual influences, such as individual, family, neighborhood, and policy, and are then embedded in the community and society at large (K.K. Davison & Birch, 2001). The environment in which individuals live plays a pivotal role in shaping their health behaviors, including physical activity (Frenk, 2013). Recent studies have shown that living in a neighborhood favorable to physical activity is positively associated with regular physical activity (K. K. Davison & Lawson, 2006; Wendel-Vos, Droomers, Kremers, Brug, & van Lenthe, 2007). However, favorable features of neighborhoods seem to vary by gender, age, income, urbanicity, race/ethnicity or immigration status (Ding, Sallis, Kerr, Lee, & Rosenberg, 2011; Singh, Yu, Siahpush, & Kogan, 2008). Assessing the underlying causes of these disparities is critical because it can provide significant information for health interventions and policies being developed to promote physical activity in a high-risk population.

Despite the growing evidence identifying the contribution of the neighborhoods to improved physical activity on adult and child populations, few have focused on adolescents and

then only with inconsistent outcomes. One study found a positive correlation between perceived access to parks and increased levels of physical activity (Mota, Almeida, Santos, & Ribeiro, 2005), another study found the association only for White and Asian adolescents and those from urban areas (Babey, Hastert, Yu, & Brown, 2008), however, another study found no association (Nelson & Woods, 2009). Perceived neighborhood safety also appears to have produced conflicting findings (Evenson et al., 2006; Motl, Dishman, Saunders, Dowda, & Pate, 2007). Moreover, these neighborhood contexts impact physical activity of adolescents differentially by their immigration status and social economic position: immigrants or low-social economic status (SES) adolescents tend to live in disadvantaged neighborhoods, and thus may have decreased activity levels due to the lack of physical activity resources, safety issue and less aesthetically pleasing surroundings (Abercrombie et al., 2008; Echeverria, Ohri-Vachaspati, & Yedidia, 2015; Gomez, Johnson, Selva, & Sallis, 2004; Sallis et al., 2000).

Given the importance of understanding and eliminating disparities to promote physical activity in adolescents and how little is known about the contribution of social-ecological factors to physical activity levels in adolescents, this study examined the role of the neighborhood environment and SES effect on physical activity at the population level using a large, ethnically diverse sample of adolescents.

Methods

Data and population

This study used adolescent data from the CHIS of 2011-2012. This biennial survey is the largest state health survey in the US, which was designed to provide population-based estimates for most California counties. Based on a multi-stage sampling design, the State of California was divided into geographic sampling strata of 41 areas. Within each geographic

stratum, the survey was accomplished by a random-digit-dialing telephone survey of California households designed to generate reliable estimates for the entire state (Babey, Hastert, Wolstein, & Diamant, 2010).

Adolescent eligibility was determined through interviews with randomly selected adult respondents who self-identified as the parent or legal guardian of adolescents living in the household (CHIS, 2012a). All data were based on the respondent's self-reporting. The adolescents were interviewed directly over the phone after consent for participation was obtained from the parent or legal guardian. This resulted in 2,799 adolescent interviews throughout the state in the CHIS 2011-2012 dataset. To capture the health needs of the growing, heterogeneous Asian population, CHIS oversampled Vietnamese and Koreans by using a combination of geographic targeting and a surname-listed sample. Because of its complex sample design, survey weights were applied to accurately represent the population of California by reducing potential biases. Detailed description of CHIS sampling and data collection methods can be found on the CHIS website (http://healthpolicy.ucla.edu/chis/Pages/default.aspx).

Measures

Dependent variable - MVPA was measured via a validated seven-day physical activity recall questionnaire from the CHIS data. Two items were used to determine whether adolescents met the required physical activity level. Sample items include: "Not including school PE (physical education), in the last 7 days, on how many days were you physically active for at least 60 minutes total per day?" and "During a typical week, on how many days are you physically active for at least 60 minutes total per day? Do not include PE." Responses ranged from 0 to 7 days. A composite average of the two items yielded a score of days per week during which the adolescent accumulated at least 60 minutes of MVPA (Prochaska, Sallis, & Long, 2001). A

positive response was defined as the adolescent engaging in regular physical activity that met the physical activity guidelines requirements: physically active for at least 60 minutes for five or more days per week.

Independent variables - Self-reported individual demographic data included gender, age (young teens: 12-14 years or older teens: 15-17 years), race/ethnicity (White, Hispanic, Asian, or African American/American Indian/Pacific Islander/other), and nativity status (birthplace: US-born or foreign-born). Family characteristics were gathered from adult respondents, which include parental educational attainment, household income, and maternal/paternal nativity. Parental educational attainment was coded as high school or less, some college, college graduate. Household income was assessed as a percent of the federal poverty level (FPL; below 100%, 100-199%, 200-299%, and above 300%). Mother and father's nativity were coded as US-born or foreign-born.

The neighborhood characteristics included urbanicity (urban, suburban, or rural), perceived accessibility of physical activity resources, and perceived neighborhood safety. Accessibility of physical activity resources was tapped by a single item, "Is there a park, playground, or open space within walking distance of your home?" A question "Do you feel safe in your neighborhood?" was utilized to measure perceived neighborhood safety. Response options included all the time, most of the time, some of the time, or none of the time.

Data analysis

Descriptive statistics were calculated initially for demographic characteristics and all major study variables. To examine the difference in physical activity levels by each covariate, including all individual, family, and neighborhood factors, the Chi-square statistic was used. Multivariate logistic regression analyses were utilized to identify factors associated with physical

activity and reported as a dichotomous outcome variable: regular activity/non-regular physical activity. First, we tested collinearity by examining the variance inflation factor. No multicollinearity was detected because none of the variance inflation factors were greater than 5. The fully adjusted model included gender, age, race/ethnicity, nativity, maternal nativity, paternal nativity, parental educational attainment, household income, urbanicity, park/playground within walking distance from home, and perceived neighborhood safety. Unadjusted and adjusted odds ratio (OR) and 95% confidence interval (CI) were calculated.

To appropriately reflect estimates of sampling error (variance estimation) due to complex sampling design, such as stratification, multistage sampling, and the use of differential sampling rates to oversample a targeted subpopulation, a replication was used (CHIS, 2012b). Replication is to draw subsample (called replicates) from the original sample, compute the estimate from each of subsample, and estimate the variance of the original sample using the variability of the subsample estimates. Jackknife technique was used to generate replicates for this research. The University of California, Los Angeles, Center for Health Policy Research provided replicate weights. Replicate weights allow researchers to generate accurate standard errors, confidence intervals, and tests of significance for population estimates.

Results

Characteristics of the study sample

The 2,799 adolescents represent an estimated 3,127,055 adolescents aged 12-17 in California. The characteristics of the study sample are summarized in Table 1. The mean age was 14.6 (SD = 0.02). About 51% of adolescents were male. Whites (33%) were the largest racial/ethnic group, followed by Hispanic (32%), Asian (13%), and others. US-born citizens constituted 87% of respondents, while almost half of their parents were from a foreign country.

Approximately, 45% of the adolescents live in an urban area, and 87% reported that they have a park or playground within walking distance from their home. Thirty-two percent of the adolescents reported they were physically active, and 50% said their neighborhood is safe all the time (See Table 1).

Comparison of regularly active and non-active participants

In the bivariate analysis (Table 2), the weighted percent of adolescents participating in vigorous or moderate physical activity was higher for males than females, in ages 15-17 years than 12-14 years, and in White than Hispanic and Asian cultures. Adolescents from household income above 300%, and adolescents whose parents were US citizens, had higher rates of regular physical activity than those whose income was below 300% and whose parents were not US citizens. The percentage of adolescents engaging in regular physical activity was lower among those in urban area than suburban and rural areas. Living in a neighborhood that was perceived as safe all the time also was weakly associated with being physically active more than a neighborhood that was perceived as safe none of the time.

Neighborhood features by nativity status

Table 3 shows the results of the bivariate analysis of neighborhood factors by nativity status. The weighted percent of having a park or playground within walking distance from the home was higher among US-born adolescents compared to foreign-born adolescents. Adolescents having a US-born mother or father also reported higher rates of having a park near the home than adolescents having a foreign-born mother or father. Adolescents with a US-born mother or a US-born father are more likely to report their neighborhood was safe all the time than adolescents with a foreign-born mother or father. However, there was no significant difference on perceived safety by adolescents' nativity.

Multivariate logistic regression analyses

Table 4 displays the results of logistic regression analyses with the crude and multivariate adjusted odds ratios and 95% confidence intervals of regular physical activity. Consistent with the bivariate findings, the odds of engaging in regular physical activity were significantly associated with gender, age, household income, maternal/paternal nativity, urbanicity, and neighborhood safety in the unadjusted model. The odds of engaging in regular physical activity are 2.4 times greater for males than females, and 1.5 times greater for older teens aged 15-17 than younger teens aged 12-14. Adolescents with household incomes below 100% of FPL had 50 percent lower odds of participating regularly than those with household incomes 300% above FPL. The odds of participating in MVPA were approximately 40 percent lower among adolescent with foreign-born mother or father. Further, the odds of regular physical activity were 1.7 times higher for adolescents from rural areas than from urban area. Adolescents who perceived their neighborhood as safe none of the time had significantly lower odds of engaging in regular physical activity compare to adolescents who perceived their neighborhood as safe all the time. Gender, age, income, and neighborhood safety remained statistically significant even after accounting for the effects of all individual, family, and neighborhood variables. However, the effects of maternal/paternal nativity and a park/playground within walking distance from the home disappeared in the adjusted model.

Discussion

The primary purpose of this study was to identify social-ecological factors, including individual, family and neighborhood factors, associated with the regular physical activity in adolescents. Our findings suggest that being male and older teenagers, having higher household income, and living in a safe neighborhood are related to engaging in regular physical activity

among diverse adolescents in California. The influences of being Hispanic, having a foreign-born parent, or living in rural area on physical activity disappeared in the fully adjusted analysis.

The gender finding is consistent with previous studies suggesting boys are more likely to be physically active regularly than girls (Babey, Tan, Wolstein, & Diamant, 2015; Floyd et al., 2011; Moore, Brinkley, Crawford, Evenson, & Brownson, 2013). One of the reasons for the gender difference can be the different perceptions of the benefits of physical activity. Boys were more likely to report competition, recognition, and increasing strength as personal incentives for exercise while girls report weight management as the main reason for engaging in physical activity (Mitchell & Olds, 1999). In addition, a study reported that boys had stronger beliefs that physical activity participation would help them to be healthy compare to girls (Vu, Murrie, Gonzalez, & Jobe, 2006).

Interestingly, our study found that older teens (age 15-17 years) reported higher levels of physical activity than young teens (age 12-14 years), which was inconsistent with the observation that physical activity declines as adolescents get older (Floyd et al., 2011; Sallis et al., 2000; Troiano et al., 2008). Discrepancy between the current result and some previous research may be due to the limited range of age groups studied. Previous studies revealed the decline of physical activity across ages by comparing adolescence with childhood or adulthood (Troiano et al., 2008). Our study may not have enough age spectrums to identify age differences because only adolescent populations were included here. Although the decline in physical activity in general seems apparent, there are some differences in age-related changes depending on physical activity type and characteristics (Sallis, 2000). Studies found that self-reported moderate intensity activities may increase during adolescence even in the presence of an overall decline in physical activity (Dumith, Gigante, Domingues, & Kohl, 2011; van Mechelen et al.,

2000). In addition, the time spent on other leisure activities increases with age compared to organized or non-organized sports as recreation-oriented motivation increases with age (Telama & Yang, 2000; van Mechelen et al., 2000). Thus, examining only summary measures of activity may not provide sufficient information to discern underlying patterns of activity.

Some family factors have emerged as determinants of physical activity. In the fully adjusted model, adolescents from the lowest household income group were much less likely to report being physically active than those of the high-income group. Similar to our finding, prior studies on adolescents and physical activity found higher SES is associated with a higher level of physical activity in adolescents (Stalsberg & Pedersen, 2010). Adolescents from lower income families have fewer opportunities to participate in sports and other physical activity alternatives because of financial issues or poor parental support (Janssen, Boyce, Simpson, & Pickett, 2006). Moreover, low-income people often encounter challenging social and environmental barriers to physical activity such as unsafe neighborhoods and traffic conditions, less access to parks and recreational facilities, lack of time due to work, poor health, lack of social support for exercise, and lack of meaningful transportation options (Duncan, Duncan, Strycker, & Chaumeton, 2002). Thus, interventions need to identify strategies to reduce barriers to physical activity in adolescents from low SES.

In the unadjusted model, both maternal and paternal nativities were associated with regular physical activity. Similar to previous findings (Singh, Yu, et al., 2008; Springer et al., 2010), adolescents with a US-born mother or father have a higher level of physical activity compared to adolescents with a foreign-born mother or father. Lower physical activity levels among immigrant adolescents may present cultural and social barriers. Immigrant parents may hinder their child participation in physical activity by making them dedicate more time for

academic performance or learning activities (Yu, Huang, Schwalberg, & Kogan, 2005). Additionally, immigrants may not be fully aware of physical resources in their neighborhood and its safeness, plus language may act as a barrier to effective communication. However, the effect of parental nativity on physical activity disappeared with full accounting of other covariates. Further analysis was conducted to identify specific mechanisms that were driving the nativity differentials in physical activity. This study showed that adolescents having a foreign-born mother or father had a significantly lower income than adolescents having a US-born mother or father. Also, adolescents with a US-born parent are more likely to live in neighborhoods favorable to outdoor physical activity and safety compared to those of a foreign-born parent. There is also evidence that physical activity differs between immigrants and the US-born population, and that acculturation modifies the health and behavioral risks of immigrants (Afable-Munsuz, Ponce, Rodriguez, & Perez-Stable, 2010; Evenson, Sarmiento, Tawney, Macon, & Ammerman, 2003). However, there are an inadequate number of studies on neighborhood disparities related to physical activity among immigrant adolescents. Rigorous study should be conducted in the future to identify the mechanism of neighborhood factors and patterns of physical activity for this increasing immigrant population. Understanding the mechanisms underlying physical activity for immigrant ethnic groups could provide a significant empirical foundation for developing culturally sensitive interventions.

This study also identified environmental influences on physical activity in adolescents. In the unadjusted model, this study found that adolescents from urban areas reported that they were less likely to be physically active compared to adolescents from suburban or rural areas in California, which was different from the findings of other studies that have shown that urban adolescents are more likely to be physically active (Liu et al., 2012; Moore et al., 2013).

However, this result is consistent with the findings from previous CHIS data, and was explained by the fact that access to a safe park or open space is limited among California adolescents living in urban areas (Babey, Brown, & Hastert, 2005). For teens living in urban areas, they are more likely to be physically active if they have access to a safe park, while access to a safe park does not influence the levels of physical activity for rural adolescents. However, the effect of urbanicity also disappeared in the fully adjusted model. Similar to parental nativity, the association between urbanicity and physical activity might be confounded by economic factors as well as resource allocations for physical activity, because low-income adolescents tend to live in communities that lack adequate access to a safe parks and other open spaces for physical activity (Powell, Slater, Chaloupka, & Harper, 2006).

Neighborhood safety appeared to play a significant role in determining the level of regular adolescent physical activity. The study found that living in a safe neighborhood is significantly associated with engaging in physical activity. Concerns about crime and safety could inhibit a person from using their neighborhood for recreational purposes and/or transportation to physical activity sites. One study suggested that feeling unsafe in one's neighborhood was associated with decreased confidence in the ability to be physically active (Bennett et al., 2007). While early adolescence is a time of increased autonomy, some parents may discourage their child from walking or cycling in the unsafe park or local streets. Safety is a frequently mentioned facilitator for positive physical activity. Unfortunately, the association between safety and physical activity has been mixed, and some studies showed safety as significant predictor of physical activity only for girls (Babey et al., 2008; Babey et al., 2015; Floyd et al., 2011; Voorhees, Yan, Clifton, & Wang, 2011). This inconsistency may be explained by diversity in measures of neighborhood safety and different perceptions about safety.

Adolescents, particularly girls, were found to be more likely not participating in organized sports than younger children, suggesting that promoting a safe neighborhood for walking and cycling may be an important way to increase physical activity. A future study should follow-up to examine gender differences and how they affect neighborhood safety related to adolescent physical activity.

This study did not find a statistically significant association between having a park or playground near the home and regular physical activity among adolescents. The results of the current analysis are inconsistent with previous research (Babey et al., 2015; Boone-Heinonen, Casanova, Richardson, & Gordon-Larsen, 2010; Edwards, Hooper, Knuiman, Foster, & Giles-Corti, 2015), and this discrepancy may be explained by the concept that parks and open spaces for physical activity are more suitable for young children than teens (Sallis et al., 2000). Floyd and colleagues suggested that physical activity in adolescents is more relevant when associated with other organized sports or recreational facilities rather than a park.

The current study extends our understanding by identifying specific individual, family, and neighborhood factors related to physical activity among adolescents. The theoretical construct of the social-ecological model adopted in this study contributes to a better understanding of the multidimensional nature of physical activity. However, this study has some limitations. First, the physical activity measure was based on self-reports of adolescents and this may lead to bias. There is a concern of recall issues, particularly among the younger population. Also, the questions of physical activity used in the current study excluded physical activity in school, which may be more relevant for students. Second, our analysis lacked information on direct neighborhood-based measures of the neighborhood environment. The indicators such as neighborhood walkability, land-use mix, population density, street pattern,

sidewalk coverage, vehicular traffic, and public transportation as measured by Geographic Information System (GIS) application can provide complementary information for characterizing the neighborhood environment related to physical activity. Third, a cross-sectional design provides a snapshot of a sample population at a specific time point, causal relationships between variables cannot be determined.

Despite these limitations, the information yielded in this study demonstrates that availability of safe places for activity is important for California adolescents engaging in regular physical activity. The study suggests that targeted strategies for promoting physical activity may be needed for adolescents from low-income and immigrant parents to reduce the disparities in physical activity. Future studies should examine the role of these specific cultural and parental influences as well as neighborhood environmental dynamics, when explaining ethnic-immigrant differentials in adolescents' physical activity. It would be valuable to identify if adolescents of immigrant parents in specific age groups, gender, SES strata, or neighborhood are at particularly high risks of physical inactivity in order to address disparities and to propose policies for them.

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Table 1. *Characteristics of California Adolescents, California Health Interview Survey 2011-2012 (N=2,799)*

	Category	Unweighted N	Weighted %	SE
Gender	Male	1,430	51.2	0.00
	Female	1,369	48.8	0.00
Age	12-14	1,378	48.7	0.00
	15-17	1,421	51.3	0.00
Race/ethnicity	Hispanic	848	31.8	1.12
	White	1,153	33.5	1.00
	Asian	263	12.6	0.97
	Other	535	22.1	1.08
Parental education	High school or less	1,100	39.8	1.19
	Some college	635	23.1	1.30
	Bachelor's or higher	1,064	37.1	1.25
Poverty level	Below 100% FPL	570	21.5	1.31
	100-199% FPL	640	23.3	1.28
	200-299% FPL	346	13.6	1.03
	Above 300% FPL	1,243	41.6	1.17
Nativity	US-born	2,449	86.6	1.25
	Foreign-born	350	13.4	1.25
Mather's nativity	US-born	1,507	52.3	1.40
	Foreign-born	1,292	47.7	1.40
Father's nativity	US-born	1,496	50.8	1.34
	Foreign-born	1,303	49.2	1.34
Urbanicity	Urban	987	45.1	0.99
	Suburban	1,217	41.3	1.24
	Rural	595	13.6	0.91
Park/playground near home	Yes	2,419	87.0	1.16
	No	380	13.0	1.16
Neighborhood Safety	All of the time	1,490	50.2	1.29
	Most of the time	1,051	39.1	1.33
	Some of the time	238	9.6	0.96
	None of the time	20	1.1	0.34
Regular MVPA	Yes	919	32.2	1.34
	No	1,880	67.8	1.34

Table 2. *Adjusted Percent of Adolescent Participating in Regular Physical Activity*

Factor	Regular PA Weighted % (SE)	No PA Weighted % (SE)	X^2	P value
Gender				
Male	41.1 (2.03)	58.9 (2.03)	108.36	0.000
Female	22.7 (1.67)	77.3 (1.67)		
Age				
12-14 young teens	27.4 (1.78)	77.6 (1.78)	27.89	0.001
15-17 teenagers	36.7 (1.92)	63.3 (1.92)		
Race/ethnicity				
White	38.1 (2.21)	61.9 (2.21)	32.30	0.012
Hispanic	26.7 (2.33)	73.3 (2.33)		
Asian	27.1 (4.74)	72.9 (4.74)		
Others	33.9 (2.87)	66.1 (2.89)		
Parental Education				
High school	29.4 (2.49)	70.6 (2.49)	6.77	0.283
Some College	34.6 (2.91)	63.4 (2.91)		
Bachelor's or higher	33.6 (2.03)	66.4 (2.03)		
Household income				
Below 100% FPL	22.1 (2.50)	77.9 (2.50)	41.26	0.001
100-199% FPL	33.6 (3.40)	66.4 (3.40)		
200-299% FPL	30.8 (3.46)	69.2 (3.46)		
Above 300% FPL	37.0 (1.73)	63.0 (1.73)		
Nativity				
US-born	32.9 (1.40)	67.1 (1.40)	4.05	0.306
Foreign-born	27.6 (4.68)	72.4 (4.68)		
Mather's nativity				
US-born	36.7 (1.55)	63.3 (1.55)	12.03	0.001
Foreign-born	27.2 (2.15)	72.8 (2.15)		
Father's nativity				
US-born	37.3 (1.62)	62.7 (1.62)	35.37	0.000
Foreign-born	26.8 (2.10)	73.2 (2.10)		
Urbanicity				
Urban	28.3 (2.37)	71.7 (2.37)	20.32	0.045
Suburban	33.8 (2.13)	66.2 (2.13)		
Rural	39.9 (4.31)	60.1 (4.31)		
Park/playground near home				
Yes	33.0 (1.36)	67.0 (1.36)	6.48	0.161
No	26.3 (4.42)	73.7 (4.42)		
Safe neighborhood				
All the time	34.6 (1.77)	76.4 (1.77)	18.94	0.073
Most of the time	29.9 (2.36)	70.1 (2.36)		
Some of the time	32.4 (6.07)	67.6 (6.07)		
None of the time	2.6 (1.67)	97.4 (1.67)		

Table 3. *Comparisons of Neighborhood Features by Parental Nativity Status*

Factor	Mother's nativity		Father's nativity	
	US-born	Foreign-born	US-born	Foreign-born
Park/playground near home				
Yes	89.7*	84.2*	90.0*	84.2*
No	10.3*	15.8*	10.2*	15.8*
Safe neighborhood				
All the time	54.8*	45.1*	56.3*	43.9*
Most of the time	37.8*	40.5*	37.1*	41.1*
Some of the time	6.8*	12.7*	6.0*	13.4*
None of the time	0.6*	1.7*	0.7*	1.6*
Income				
High-income ≥ 200%	60.5*	39.5*	70.5*	29.5*
Low-income <200%	30.4*	69.6*	39.4*	60.6*

* Significant at $p<.01$.

Table 4. *Logistic Regression of Factors Associated with MVPA among Adolescents*

Factor	Unadjusted Model		Adjusted Model[a]	
	OR	**95% CI**	**OR**	**95% CI**
Individual Characteristics				
Gender				
Female	1.00		1.00	
Male	**2.37**	**1.85-3.05****	**2.38**	**1.83-3.10****
Age				
12-14	1.00		1.00	
15-17	**1.54**	**1.21-1.95****	**1.50**	**1.16-1.93****
Race/ethnicity				
White	1.00		1.00	
Hispanic	**0.59**	**0.44-0.80** **	0.83	0.53-1.29[b]
Asian	0.60	0.35-1.03	0.79	0.46-1.38
Others	0.83	0.60-1.14	1.00	0.71-1.41
Nativity				
US-born	1.00		1.00	
Foreign-born	0.78	0.48-1.28	1.18	0.72-1.94
Family Characteristics				
Parental education				
HS or less	1.00		1.00	
Some college	1.27	0.87-1.86	0.95	0.61-1.49
College graduate	1.22	0.90-1.65	0.77	0.51-1.17
Household income				
Above 300% FPL	1.00		1.00	
200-299% FPL	0.76	0.53-1.08	0.69	0.47-1.02
100-199% FPL	0.86	0.62-1.19	0.89	0.59-1.33
Below 100% FPL	**0.48**	**0.35-0.67****	**0.54**	**0.36-0.80****

[a] Adjusted for all covariates presented in this table.
[b] Difference in significance between unadjusted and adjusted model
* Significant at p<.05.
** Significant at p<.01.

Table 4. *(Continued)*

Factor	Unadjusted Model		Adjusted Model[a]	
	OR	**95% CI**	**OR**	**95% CI**
Family Characteristics				
Mather's nativity				
US-born	1.00		1.00	
Foreign-born	**0.64**	**0.50-0.83****	0.93	0.64-1.36[b]
Father's nativity				
US-born	1.00		1.00	
Foreign-born	**0.62**	**0.48-0.79****	0.83	0.54-1.28[b]
Neighborhood characteristics				
Urbanicity				
Urban	1.00		1.00	
Suburban	1.29	0.95-1.76	1.15	0.84-1.59
Rural	**1.68**	**1.05-2.68***	1.51	0.97-2.35[b]
Park/playground near home				
No	1.00		1.00	
Yes	1.38	0.87-2.19	1.50	0.93-2.43
Safe neighborhood				
All the time	1.00		1.00	
Most of the time	0.81	0.60-1.08	0.91	0.66-1.25
Some of the time	0.91	0.52-1.60	1.21	0.69-2.12
None of the time	**0.05**	**0.01-0.19****	**0.09**	**0.02-0.34****

[a] Adjusted for all covariates presented in this table.
[b] Difference in significance between unadjusted and adjusted model
* Significant at p<.05.
** Significant at p<.01.

CHAPTER 3

Effects of Race/Ethnicity, Acculturation, Social-Economic Status, and Neighborhood on Dietary Patterns Among California Adolescents

Abstract

Background: Recently, attention has turned towards possible social ecological influences on food choices, however, only a few studies have investigated this influence in the adolescent population. The purpose of this paper is to explore individual, family and neighborhood factors influencing eating behaviors and food choices among a large, ethnically diverse sample of adolescents.

Methods: This study used data from the 2011-2012 and 2013 CHIS datasets of 4,000 adolescents between 12 and 17 years old. Data examined included the individual (adolescent's age, gender, race/ethnicity, body mass index percentile, and immigration status), the family (parental educational attainment, household income, and birthplace of parents), and neighborhood characteristics (urbanicity and the Modified Retail Food Environment Index) as associated with dietary behaviors.

Results: The odds of meeting the five-a-day fruits and vegetables consumption were significantly lower among Hispanic, second-generation immigrants, and low-income adolescents. Hispanic and third generation adolescents were more likely to consume fast foods. The odds of soda consumption were higher for boys, ethnic minorities, and adolescents from low-household income families and those from the lowest parental education category. Additionally, rural adolescents drank more sugary drinks.

Conclusions: This study highlights racial, socioeconomic status, and immigration differences in dietary practices among California adolescents related to specific dietary intake. These disparities in dietary patterns among adolescents indicate the need for culturally specific interventions to promote healthy food consumption in all adolescents.

Introduction

Adolescence is a critical period for establishing dietary habits that can then be sustained throughout life (Story, Neumark-Sztainer, & French, 2002). During adolescence, eating behaviors and nutritional health are impacted by dramatic physical and developmental transitions. Failure to meet an increased demand for energy and healthy nutrients related to rapid physical growth may increase the risk for a number of health consequences, including obesity as well as hypertension, diabetes, and cardiovascular disease (Cavadini, Siega-Riz, & Popkin, 2000). An inadequate intake of fruits and vegetables is estimated to have caused the prevalence of gastrointestinal cancers (World Health Organization, 2015). Moreover, because of greater autonomy and independence during adolescence, dietary patterns acquired during adolescence are likely to continue into adulthood (Story et al., 2002).

Due to the importance of healthy dietary behaviors, an expert committee on child and adolescent obesity recommended specific dietary behavior guidelines for children and adolescents (Barlow, 2007): encouraging the consumption of more than five servings of fruits and vegetables per day, and limiting consumption of sugar-sweetened beverages and restaurant fast food. However, prior studies reported that the quality of the diet declines from childhood to adolescence with decreased fruits and vegetables consumption and increased sugar-sweetened drink consumption (Lytle, Seifert, Greenstein, & McGovern, 2000). Recent national data showed that approximately 90% of adolescents are not meeting the recommendations for fruits and vegetables, while at the same time, exceeding the recommendations for fat and added sugars (Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010). This result emphasizes the need for dietary interventions that encourage adolescents to make healthy food choices, such as low fat, low added sugar, and adequate fruits and vegetables consumption.

Over the years, interventions aimed at modification of adolescent eating behaviors have been challenging, and impact has been limited. This may be partly due to an inadequate understanding of the factors associated with adolescent eating behaviors. Concern for improving the dietary behaviors of adolescents has become a national priority; however, the development of effective strategies requires an understanding of adolescent eating behaviors and the multiple and interacting factors that influence these behaviors. Studies have shown that birthplace, racial/ethnic minorities and low socioeconomic status (SES) are associated with unhealthy dietary patterns (Hanson & Chen, 2007; Satia-Abouta, Patterson, Neuhouser, & Elder, 2002a).

Recently, attention has turned towards neighborhood environmental influences on food choices, and several studies have presented evidence that the food environment affects dietary patterns (Glanz, 2009; Lytle, 2009). Previous researchers found that differences in neighborhood-level characteristics may alter accessibility to healthy or unhealthy foods in adult population (Pearce, Blakely, Witten, & Bartie, 2007). However, to date, only a few studies have examined the neighborhood's environmental impact on food consumption in adolescents. One study found that the lack of availability of healthy foods in the neighborhood is a barrier to healthy diet choices among low-income adolescents (Evans, Wilson, Buck, Torbett, & Williams, 2006), and another study reported that adolescents' perception of their neighborhood as dangerous may limit their access to healthy foods (Dodson et al., 2009). In addition, a study in California found that adolescents with fast-food restaurants near their schools consumed fewer servings of fruits and vegetables, but more servings of soda (Davis & Carpenter, 2009). However, another study of California adolescents did not find any associations between the neighborhood environment and dietary intake (An & Sturm, 2012).

The notion that multiple levels of factors influence eating behaviors has been recognized, however, few studies have examined these factors in association with adolescents' eating behaviors using a social-ecological model. Thus, the purpose of this paper is to explore factors that influence adolescent eating behaviors and food choices. Personal, social, and economic factors affecting food choices were examined, as well as environmental contexts among a large, ethnically diverse sample of adolescents. Ultimately, this paper can provide evidence for developing tailored interventions and policies specific to the recipients to enhance healthful eating behaviors for adolescents.

Methods

Data and population

To understand the factors associated with dietary practices in California adolescents, this study used adolescent data from the 2011-2012 and 2013 CHIS datasets. The CHIS is the largest state health survey in the US, and used a cross-sectional population-based survey for most California counties. Based on a multi-stage sampling design, with random-digit-dialing telephone survey of California households, it was designed to represent California's diverse population with oversampling of specific populations including Koreans, Vietnamese, and American Indians/Alaska Native (AIAN).

This study included a total sample of 4,000 adolescents aged 12 to 17 years. Adolescent eligibility was determined through interviews with randomly selected adult respondents who had to be the parent or legal guardian of the adolescents living in the household (CHIS, 2012a). All data were based on adolescents' self-report over the phone interview. To capture the rich diversity of the California population, interviews were conducted in five languages: English, Spanish, Chinese (Mandarin and Cantonese dialects), Vietnamese, and Korean. Interviews in

all languages were administered using Westat's computer-assisted telephone interviewing (CATI) system. The interview completion rate for adolescent was 43.7 percent. To produce population estimates from the CHIS data, weights were applied to the sample data to compensate for the probability of selection and a variety of other factors, some directly resulting from the design and administration of the survey (CHIS, 2012b). The sample was weighted to represent the non-institutionalized population for each sampling stratum and statewide. This weighting procedure can reduce biases because non-respondents may have different characteristics than respondents. Detailed sampling and data collection description can be found on the CHIS website (http://healthpolicy.ucla.edu/chis/Pages/default.aspx).

For the information on the food environment, the modified Retail Food Environment Index (mRFEI) data was attained from the CDC website (http://www.cdc.gov/obesity/resources/reports.html). Since the CDC provided the mRFEI score by the census-tract FIPS (The Federal Information Processing Standard), an application was submitted to the Data Access Center (DAC) at the UCLA Center for Health Policy Research to access confidential geographic identifiers. DAC created the custom data file for the research project, and merged the mRFEI data with CHIS data by the respondent's residential FIPS code. After the DAC's review process, the merged data file was provided to the principal investigator. This study was approved by the committee on human research at the University of California, San Francisco.

Measures

The outcome variables were self-reported measures on dietary practices. CHIS included five questions to identify respondents' consumption of fruits and vegetables, fast food, soda, and sugary drinks. All dietary behaviors were dichotomized based on professional dietary guidelines

or evidence supported by the literature. Adolescents were asked about the dietary intake of fruits and vegetables: "Yesterday, how many servings of fruit, such as an apple or banana, did you eat?" and "Yesterday, how many servings of other vegetables like green salad, green beans, or potatoes did you have?" The total fruits and vegetables intake was dichotomized into the recommended five-a-day servings of fruits and vegetables or non- fruits and vegetables servings. Adolescents were also asked about beverage (soda and sugary drinks) consumption patterns: "Yesterday, how many glasses or cans of soda that contain sugar, such as Coke, did you drink?" and "Yesterday, how many glasses or cans of sweetened fruit drinks, sports, or energy drinks, did you drink?" Responses for these items were dichotomized into less than one time/day and one time or more/day. Lastly, respondents were also asked about their fast food consumption: "In the past 7 days, how many times did you eat fast food? Include fast food meals eaten at school or at home, or at fast-food restaurants, carryout, or drive-thru." Responses were dichotomized to represent any fast-food consumption versus none in the past week.

The independent variables for this study included the following socio-demographic data: adolescent's age, gender, race/ethnicity (White, Hispanic, Asian, or others), body mass index (BMI) percentile, and immigration status. Adolescents reported their weight and height, and then their BMI and BMI percentile were computed. Adolescents were considered to be overweight or obese if the BMI percentile was greater than the 85^{th} percentile. Immigration status was defined as first generation if they were born outside the US, second generation if US-born with one or more foreign-born parents, and third generation or later if the adolescent and both parents were US-born. Parental educational attainment, household income, and parental nativity were also included. Parental educational attainment was coded as high school or less, at least some college, or college graduate. Household income was assessed by a percent of the federal poverty level

(FPL; below 300% and above 300%). Mother and father's nativity were coded as US-born or foreign-born.

The modified retail food environment index (mRFEI) was used to assess the food environment. The mRFEI measured the number of healthy and less healthy food retailers within census tracts across each state as defined by typical food offerings in specific types of retail stores. Out of the total number of food retailers considered healthy or less healthy in a census tract, the mRFEI represents the percentage that are healthy.

$$mRFEI = \frac{\#\ Healthy\ Food\ Retailers}{\#\ Healthy\ Food\ Retailers + \#Less\ Healthy\ Food\ Retailers}$$

Healthy food retailers included supermarkets, larger grocery stores, supercenters, and produce stores within census tracts or ½ mile from the tract boundary. The following stores, as defined by North American Industry Classification Codes (NAICS), were included: supermarkets and larger grocery stores (NAICS 445110; supermarkets further defined as stores with >= 50 annual payroll employees and larger grocery stores defined as stores with 10–49 employees); fruit and vegetable markets (NAICS 445230); warehouse clubs (NAICS 452910). Fruit and vegetable markets included establishments that sell produce and including both markets and permanent stands. Less healthy food retailers included fast food restaurants, small grocery stores, and convenience stores within census tracts or ½ mile from the tract boundary. Fast food stores were defined according to NAICS code 722211(fast food restaurants). Convenience stores were defined according to NAICS code 445120 (convenience stores) or NAICS code 445110 (small groceries) where the number of employees was three or fewer. The mRFEI was calculated on the basis of available data for every food retailer around the country. A zero score indicated that no healthy food retailers are located in the census tract, and higher scores indicated a more healthful food environment. For analysis, the mRFEI score was split into three tertiles: low, middle, high

mRFEI (Greer, Schieb, Schwartz, Onufrak, & Park, 2014). The neighborhood characteristics also included urbanicity. ZIP codes were assigned into four urbanization categories (Urban, Second-City, Suburban, and Town/Rural) based on analysis of population density grids obtained from regularly updated geo-boundaries, redistricting updates, and population estimates.

Data analysis

The CHIS 2011-2012 and 2013 data and the mRFEI data were merged using STATA version 13.0. To yield optimal statewide estimates, replicate weights were used to account for survey design effects of stratified cluster sampling. Standard errors were corrected by using the jackknife method. Descriptive statistics were calculated initially for demographic characteristics and all study variables. To examine difference in dietary practices by each covariate, the Chi-square statistic was used. Multivariate logistic regression analyses were fitted to predict the factors associated with dietary behaviors as dichotomous outcome variables: fruits and vegetables, fast food, soda, and sugary drinks. The model included gender, race/ethnicity, BMI, immigration status, maternal nativity, paternal nativity, parental educational attainment, household income, urbanicity, and mRFEI. Adjusted odds ratio (OR) and 95% confidence interval (CI) were calculated. The significant level was set at $p < .05$.

Results

Study population

Four thousand adolescents represented an estimated 3,117,012 adolescents aged 12-17 who resided in California. Table 1 shows descriptive statistics of the sample population. About 51% of the adolescents were male, and their mean age was 14.6 (SD = 0.02). Approximately one-third of adolescents identified themselves as White, while about 31% identified themselves as Hispanic, and about 12% as Asian. Approximately one-third of the respondents were

overweight or obese. There were about 11% of first generation and 43% of second generation adolescents, while 46% reported themselves as being third generation or higher. Almost 38% of adolescents reported that their parents' highest level of education was high school or less, and 57% adolescents lived within 300% of FPL. Approximately, 46% of adolescents lived in urban areas, and 13% adolescents lived in rural area (See Table 1).

Dietary Practices of adolescents

Table 2 gives the prevalence of dietary practices among adolescents, and Table 3 shows the bivariate association between dietary practices and factors. Only 25% of California teens met the five-a-day goal for fruits and vegetables. Total fruits and vegetables intake varied significantly by race/ethnicity. The proportion was lowest among Hispanic adolescents with about 19% consuming five or more fruits and vegetables servings in the previous day, and highest among Asian adolescents with 37% meeting the fruits and vegetables consumption goal, whereas about 27% of White adolescents did so. The percent of adolescents consuming five or more fruits and vegetables servings was significantly higher among adolescents whose parents have graduate degrees than adolescents whose parents have less than a high school diploma. Adolescents in households with incomes above 300% of FPL had higher percent of consuming fruits and vegetables than their counterparts. Immigration status was also significantly associated with fruits and vegetables intake. First generation adolescents had higher percent of fruits and vegetables intake than second and third generations. Total fruits and vegetables intake was not significantly associated with their neighborhood factors.

About three quarters of California adolescents reported that they ate fast food at least one time in the past week. Hispanic adolescents had a significantly higher percent of having fast food (84%) than White (72%) and other race/ethnic groups (75-76%). Adolescents from household

income below 300% FPL, whose parents have a high school diploma or less, and whose parents are foreign-born had higher rates of consuming fast food than their counterparts. Though, neighborhood factors were not significantly related to fast food consumption.

Approximately, 40% of adolescents had a soda or sugary drinks during the previous day. Boys were more likely to drink soda or sugary drinks compared to girls. The highest percentage of adolescents who consumed soda during the previous day was found among Hispanic adolescents, and White adolescents were found to have the lowest percentage of soda consumption. Adolescents whose parents have a high school diploma or less and adolescents from household incomes below 300% FPL had a higher rate of consuming soda than adolescents whose parents have graduate degree, and from household income above 300% FPL. Higher levels of soda consumption was found among adolescents with a foreign-born mother or father. Third generation adolescents had lower rates of soda consumption compared to first and second generations. Although the mRFEI was not associated with soda and sugary drinks consumption, adolescents living in rural areas showed significantly higher rates of sugary drinks consumption.

Multivariate logistic Analyses

Table 4 displays the results of logistic regression with the fully adjusted odds ratios and 95% confidence intervals of dietary practices. Consistent with the bivariate findings, the odds of meeting the five-a-day fruits and vegetables consumption were significantly associated with race/ethnicity, immigration status, parental educational attainment and household income level. Hispanic adolescents were 47% less likely to consume five or more fruits and vegetables daily than White adolescents. Compared with first generation adolescents, second generation adolescents were 43% less likely to meet the fruits and vegetables daily recommendation. Adolescents from lower income household were 42% less likely to consume five or more fruits

and vegetables daily than those in higher income groups. The associations between total fruits and vegetables consumption and parent educational attainment disappeared after the adjustment for all covariates. The neighborhood factors, mRFEI and urbanicity were not significantly association with fruits and vegetables intake.

After the adjustment for all covariates, the associations between fast food consumption and parental educational level, household income, and mother/father's nativity became insignificant. However, race/ethnicity and immigration status were still significantly associated with fast food consumption: Hispanic adolescents had approximately two times the odds of eating fast food than their White counterparts, and third generation adolescents had 2.9 times the odds of eating fast food than the first generation.

Compare to girls, boys were approximately 1.5 times more likely to drink soda and sugary drinks. The odds of soda consumption was 1.6 time higher for Black/AIAN/Pacific Islanders(PI)/other compared to White adolescents. Moreover, Hispanic and Black/AIAN/PI/other had 1.5 times greater odds, and Asians had 1.9 times greater odds of sugary drinks consumption than White adolescents. The odds of soda consumption were 1.4 times higher for adolescents from a low-household income family than a high-income family, and an adolescent whose parent had at least college degree were 40% lower odds of consuming soda than adolescents whose parents have a high school diploma or less. Further, the odds of consuming sugary drinks were 1.5 times greater for rural adolescents than urban adolescents.

Discussion

This study highlights racial and immigration differences in dietary practices among California adolescents as well the SES' impact as related to specific dietary intake. In multivariate regressions, substantial differences in dietary behaviors were found among the

race/ethnic subgroups. Hispanics had lower odds of consuming fruits and vegetables than Whites. Moreover, Hispanics had a significantly higher risk of consuming fast food and sugary-sweetened beverages compared to Whites. This finding for Hispanic adolescents is consistent with previous studies on unhealthy diet patterns of Hispanic children and adolescents, who consumed higher amounts of sugary drinks, calorie-dense foods, low in fiber and high in fat foods, sodium and carbohydrates (Wilson, Adolph, & Butte, 2009),(Guerrero, Ponce, & Chung, 2015). Also, consistent with prior research (Park, Blanck, Sherry, Brener, & O'Toole, 2012), Black and other minority ethnic groups also had substantially higher odds of drinking soda and sugary drinks than White adolescents.

Previous research suggested that SES might have an influence on racial/ethnic disparities in dietary intakes. Household income has been a significant influence on the quality of diet in US households (Casey et al., 2006). Studies have found poor dietary quality among children from low-income families (Perez-Escamilla, 2009; Wilson et al., 2009). Fruits and vegetables intakes were significantly lower in children from lower SES households (Lorson, Melgar-Quinonez, & Taylor, 2009; Riediger, Shooshtari, & Moghadasian, 2007), and they often choose low-cost vegetable options, such as canned vegetables and potato fries (Drewnowski & Darmon, 2005). Approximately 24 % of Latino and 26% of Black families are living in poverty compared to 10% of White and 12% of Asian families (DeNavas-Walt & Proctor, 2015), plus low income families do not have enough money for everyone to eat full and nutritious meals. Thus, there is an increased risk of unhealthy dietary intake and obesity among the children in low-income households (Drewnowski & Darmon, 2005).

Consistent with these findings, our study also showed that adolescents from household incomes below 300% of FPL had only roughly half the odds of consuming five-a-day fruits and

vegetables than those with household incomes above 300%. In addition, soda consumption was significantly higher among adolescents from low-income households compared to the high-income group. Another SES indicator, parental education was also significantly associated with dietary practices in adolescents. Higher levels of parent educational attainment were strongly associated with high fruit intake, high vegetable intake, and low soda intake in the previous day. These findings are consistent with previous research showing that adolescents from the families with higher levels of education consumed more servings of fruits and vegetables (Riediger et al., 2007; Xie, Gilliland, Li, & Rockett, 2003), and drank less soda (Han & Powell, 2013). Moreover, parents receiving a higher education were more health conscious and more likely to affect their child's food selection (Pearson, Biddle, & Gorely, 2009). The results emphasize the need for healthy diet intervention and the priority should be given to adolescents from Hispanic and Black/AIAN/PI/other cultures and those with low SES.

Immigration status differences were observed in our study. First generation adolescents were more likely to consume five-a-day fruits and vegetables during the previous day compared to second or third generation adolescents. Moreover, third generation adolescents had 2.9 times higher odds of consuming fast food than first generation adolescents. These results are also consistent with previous findings that lower fruits and vegetables intakes and higher fat intake were associated with greater acculturation (Neuhouser, Thompson, & Solomon, 2004; Satia-Abouta et al., 2002a; te Velde, Wind, van Lenthe, Klepp, & Brug, 2006). Despite socioeconomic disadvantages, studies have documented that first generation immigrants have better health than non-immigrant Americans, called the immigrant paradox (Gordon-Larsen, Harris, Ward, & Popkin, 2003). Immigration to a new country causes a substantial shift in a person's lifestyle and environment. In particular, dietary acculturation can be seen frequently,

and the adoption of the dietary practices of the US (diets high in fat and low in fruits and vegetables) is of concern because this dietary pattern can result in an increased risk of chronic diseases (Satia-Abouta, Patterson, Neuhouser, & Elder, 2002b). Therefore, dietary intervention should be emphasized while encouraging immigrants to retain their traditional healthful eating patterns, adopting only the more healthful dietary practices of their new country.

In our study, either maternal or paternal nativity was not significantly associated with dietary practices. Although parent nativity can be use as proxy measure of acculturation, parent nativity itself may not have enough information to validate the differences in dietary practices among adolescents. Including detailed information on the length of their US residency, race/ethnicity, acculturation level, and the language acculturation of parents will provide a more accurate and comprehensive view of their dietary acculturation. Since diet is a major but modifiable risk factor for many chronic diseases, understanding how the process of acculturation influences dietary patterns will potentially reduce disparities for developing many of the chronic diseases and conditions in the immigrant population.

Our study found some association between urbanization and dietary intake. Consistent with prior research (Bolton et al., 2016; Xavier, Hardman, Andrade, & de Barros, 2014), adolescents from rural areas had higher odds of consuming sugary drinks than urban adolescents. Studies have consistently indicated that living in areas with limited access to supermarkets, limited selection of nutritious and fresh foods, and an increased cost of fruits and vegetables are significantly associated with unhealthy dietary intake. The association between urbanicity and dietary patterns might be confounded by economic factors because low-income populations tend to live in the neighborhood where there are high rates of food insecurity. Consistently, our data showed that the urban areas had the largest low-income group while the suburban had the largest

high-income group. A study conducted in California reported that both rural and urban areas experienced less access to food outlets and healthy food options than suburban areas. Limitations in these physical environments can lead to difficulties in maintaining a healthy dietary intake (Durazo et al., 2011).

To further examine disparities in the accessibility of healthy food and beverage choices, we examined the relationship between the food environment (mRFEI) and dietary practices, however, we did not detect a significant relationship. Studies increasingly are examining how the food environment influences adolescent dietary behaviors by encouraging or discouraging access to healthy food (California Department of Public Health, 2013; Ding et al., 2012; Svastisalee, Holstein, & Due, 2012; The California Center for Publich Health Advocacy, 2007), but the specific impact of the food environment on diet and weight remains somewhat unclear. Given the lack of standardization of food environment metrics and differences among the populations studied, it is difficult to generalize the relationship evidence between the food environment and health. Although we use the mRFEI score as proxy for the food environment, there are some limitations. The mRFEI scores did not include the information about the distance to food retailers, cost of foods, or density of food outlets, neither does it tell whether the foods were actually offered in each store. Besides, farmers' markets were not included in the mRFEI, because national data on the location of famers' markets was not available at the time the mRFEI scores were calculated.

A major strength of this study is the population-level analysis with a large, racially/ethnically diverse sample of adolescents to examine various obesogenic dietary practices. In addition, using an objective GIS-based measure of the food environment provided complementary information for characterizing the neighborhood environment related dietary

behaviors in adolescents. However, the findings of the study are subject to some limitations. First, this study was based on cross-sectional survey, eliminating the ability to decipher a causal relationship among study variables. Further research should follow to confirm the findings and examine causal mechanisms in order to provide appropriate interventions. In addition, dietary intakes were based on self-reports and not validated, thus the data could have resulted in a misclassification of the number of adolescents meeting the dietary recommendations. Lastly, there are limitations in studying child and adolescent populations. For instance, their travel patterns are highly associated with their parents' patterns since they seldom travel to food markets by themselves. This issue needs to be addressed. Some of them may be living in more than one household (due to divorce, separation, or other reasons), and defining their residence should be considered carefully. The mRFEI is limited as it depends on the size of the geographical unit of analysis (Truong, Fernandes, An, Shier, & Sturm, 2010). The researchers should consider the operational definition of the concept "access", which is a broad and complex concept reflecting the cultural, social and economic factors, and it cannot be fully explained by geographic proximity.

Overall, adolescence is an important developmental age accompanied by notable declines in a range of healthy behaviors. This study addresses an important question on the association of individual, family, and environmental factors with dietary practices among adolescents. The results suggest that race, SES, and immigration status were particularly associated with adolescents' dietary patterns. These disparities in dietary patterns among adolescents indicate the need for targeted interventions for those individuals at high risk and culturally specific interventions to promote healthy food consumption. Future research should examine potential explanations for these disparities, including neighborhood level environments which facilitate or

hinder healthy diets, so appropriate interventions can be designed and implemented to address the healthy diet of adolescents.

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Table 5. *Descriptive Statistics of Adolescents, California Health Interview Survey 2011-2012 & 2013 (N=4,000)*

Characteristics		Unweighted N	Weighted %	SE
Age		4,000	Mean 14.6	0.02
Gender	Male	2,000	51.2	0.00
	Female	2,000	48.8	0.00
Body weight	Normal	2,750	67.1	1.27
	Overweight or obese	1,250	32.9	1.27
Race/ethnicity	White	1,678	34.2	0.89
	Hispanic	1,187	31.0	0.99
	Asian	345	11.8	0.81
	Other	790	23.0	0.88
Parental education	High school or less	1,536	38.4	1.05
	Some college	1,776	45.0	1.17
	Graduate	688	16.6	0.75
Poverty level	Below 300% FPL	2,181	57.3	0.93
	Above 300% FPL	1,819	42.7	0.93
Immigrant status	1st generation	410	11.1	0.94
	2nd generation	1,651	43.3	1.20
	3rd generation	1,939	45.6	1.15
Mother's nativity	US-born	2,223	53.1	1.19
	Foreign-born	1,777	46.9	1.19
Father's nativity	US-born	2,186	52.1	1.16
	Foreign-born	1,814	47.9	1.16
Urbanity	Urban	1,429	45.8	0.94
	2nd city	862	17.3	0.76
	Suburban	854	23.9	0.96
	Rural	855	13.0	0.73
mRFEI	Low	1,028	36.2	1.24
	Middle	1,001	31.9	1.20
	High	1,060	31.9	1.25

Table 6. *Descriptive Statistics of Adolescent Dietary Practices*

Characteristics		Unweighted N	Weighted %	SE
5FV*	< 5/day	2,945	74.8	1.09
	≥ 5/day	1,055	25.2	1.09
Fruits	< 2/day	1,671	41.5	1.34
	≥ 2/day	2,329	58.5	1.34
Vegetables	< 2/day	2,343	59.5	1.29
	≥ 2/day	1,657	40.5	1.29
Fast food	No	1,030	23.3	1.14
	Yes	2,970	76.7	1.14
Soda	No	2,502	59.8	1.14
	Yes	1,498	40.2	1.14
Sugary drinks	No	2,470	62.4	1.12
	Yes	1,530	37.6	1.12

* Five-a-day fruits and vegetables.

Table 7. *Bivariate Analysis of Dietary Practices by Factors (weighted %)*

Factor	5FV[†]		Fast food		Soda		Sugary drinks	
	Yes	No	Yes	No	Yes	No	Yes	No
Gender								
Male	26.5	73.5	76.5	23.5	45.5*	54.5*	40.7*	59.3*
Female	23.8	76.2	76.9	23.1	34.7*	65.3*	34.3*	65.7*
Body weight								
Normal	26.7	73.3	76.5	23.5	37.4*	62.6*	38.4	61.6
Overweight	22.1	77.9	77.2	22.8	46.0*	54.0*	35.9	64.1
Race/ethnicity								
White	27.4*	72.6*	71.7*	28.3*	33.1*	66.9*	33.5	66.5
Hispanic	19.3*	80.7*	83.4*	16.6*	47.2*	52.8*	39.8	60.2
Asian	36.8*	63.2*	74.5*	25.6*	35.8*	64.2*	42.1	57.9
Others	23.9*	76.1*	76.3*	23.7*	43.6*	56.4*	38.5	61.5
Parental Education								
High school	22.3*	77.7*	81.3*	18.7*	50.9*	49.1*	39.6	60.4
Some College	24.7*	75.3*	74.8*	25.2*	34.3*	65.7*	36.3	63.7
Graduate	33.3*	66.7*	71.3*	28.7*	31.6*	68.4*	36.3	63.7
Household income								
Below 300% FPL	21.6*	78.4*	79.4*	20.6*	47.0*	53.0*	39.0	61.0
Above 300% FPL	30.0*	70.0*	73.0*	27.0*	31.2*	68.8*	35.6	64.4
Immigrant status								
1st generation	34.2*	65.8*	73.7*	26.3*	40.2*	59.8*	33.8	66.2
2nd generation	24.0*	76.0*	80.0*	20.0*	44.5*	55.5*	40.1	59.9
3rd generation	24.1*	75.9*	74.3*	25.7*	36.2*	63.8*	36.2	63.8
Mother's nativity								
Foreign-born	26.6	73.4	79.0*	21.0*	44.4*	55.6*	38.6	61.4
US-born	23.9	76.1	74.7*	25.3*	36.5*	63.5*	36.7	63.3
Father's nativity								
Foreign-born	26.1	73.9	79.6*	20.4*	44.7*	55.3*	38.9	61.1
US-born	24.3	75.7	74.1*	25.9*	36.1*	63.9*	36.4	63.6
Urbanity								
Urban	23.5	76.5	78.8	21.2	41.4	58.6	39.4*	60.1*
2nd City	25.7	74.3	73.0	27.0	41.8	58.2	33.0*	67.0*
Suburban	26.6	73.4	75.8	24.2	33.9	66.1	32.9*	67.1*
Rural	27.8	72.2	76.1	23.3	43.6	56.4	47.4*	52.6*
mRFEI								
Low	23.3	76.7	78.9	21.0	42.0	58.0	35.9	64.1
Middle	27.0	73.0	73.1	26.9	38.7	61.3	36.7	63.3
High	26.2	73.8	75.5	24.5	43.1	57.0	38.1	58.1

*Significant at p<.05.

† Five-a-day fruits and vegetables.

Table 8. *Adjusted Odds Ratios (95% CI) of Dietary Practices among Adolescents*

Factors	5FV**	Fast food	Soda	Sugary drinks
Individual Characteristics				
Gender				
Female	1.00	1.00	1.00	1.00
Male	1.29 (0.95-1.76)	0.94 (0.68-1.29)	**1.56 (1.23-1.99)†**	**1.52 (1.18-1.95)†**
Body weight				
Normal	1.00	1.00	1.00	1.00
Overweight	0.97 (0.68-1.40)	0.90 (0.66-1.22)	1.01 (0.78-1.31)	0.77 (0.58-1.01)
Race/ethnicity				
White	1.00	1.00	1.00	1.00
Hispanic	**0.53 (0.36-0.79)†**	**1.93 (1.28-2.90)†**	1.39 (0.84-2.30)	1.48 (1.00-2.16)
Asian	0.90 (0.51-1.59)	1.16 (0.62-2.17)	1.07 (0.65-1.77)	**1.85 (1.08-3.16)†**
Others	0.88 (0.60-1.31)	1.17 (0.85-1.61)	**1.55 (1.08-2.22)†**	**1.45 (1.02-2.06)†**
Immigrant status				
1st generation	1.00	1.00	1.00	1.00
2nd generation	**0.57 (0.35-0.94)†**	1.51 (0.87-2.62)	1.30 (0.83-2.04)	1.49 (0.96-2.31)
3rd generation	0.70 (0.30-1.65)	**2.85 (1.30-6.26)†**	1.82 (0.84-3.92)	1.45 (0.63-3.35)

*Adjusted for all covariates presented in this table.
** Five-a-day fruits and vegetables.
† Significant at $p<.05$.

Table 8. *(Continued)*

Factors	5FV**	Fast food	Soda	Sugary drinks
Family Characteristics				
Parental education				
HS or less	1.00	1.00	1.00	1.00
Some college	0.86 (0.59-1.25)	0.89 (0.63-1.25)	**0.60 (0.42-0.85)†**	0.98 (0.73-1.32)
Graduate	1.26 (0.87-1.83)	0.97 (0.61-1.54)	0.65 (0.39-1.08)	1.08 (0.75-1.55)
Household income				
Above 300% FPL	1.00	1.00	1.00	1.00
Below 300% FPL	**0.58 (0.43-0.79)†**	1.16 (0.84-1.60)	**1.39 (1.05-1.85)†**	1.04 (0.77-1.40)
Mother's nativity				
US-born	1.00	1.00	1.00	1.00
Foreign-born	1.53 (0.91-2.57)	1.40 (0.84-2.36)	1.12 (0.74-1.69)	0.80 (0.50-1.28)
Father's nativity				
US-born	1.00	1.00	1.00	1.00
Foreign-born	1.40 (0.87-2.26)	1.43 (0.80-2.59)	1.16 (0.67-2.00)	1.09 (0.66-1.81)
Neighborhood characteristics				
Urbanicity				
Urban	1.00	1.00	1.00	1.00
2nd city	1.38 (0.99-1.94)	0.73 (0.52-1.03)	1.25 (0.92-1.71)	0.79 (0.61-1.03)
Suburban	1.04 (0.73-1.48)	1.04 (0.71-1.53)	0.98 (0.68-1.40)	0.74 (0.55-1.00)
Rural	1.37 (0.88-2.11)	0.90 (0.44-2.57)	1.33 (0.89-2.00)	**1.46 (1.00-2.14)†**
mRFEI				
High	1.00	1.00	1.00	1.00
Middle	1.11 (0.77-1.58)	1.15 (0.80-1.66)	0.95 (0.73-1.25)	0.82 (0.60-1.13)
Lowest	0.90 (0.66-1.23)	0.84 (0.62-1.16)	0.80 (0.61-1.06)	0.78 (0.58-1.06)

*Adjusted for all covariates presented in this table.
** Five-a-day fruits and vegetables.
† Significant at $p<.05$.

CHAPTER 4

Gender-Specific Factors Associated with Risk of Overweight and Obesity Among California Adolescents

Abstract

Background: It is imperative to understand the factors that contribute to obesity disparities in adolescents, because obesity is related to a series of adverse health effects and it tracks into adulthood. Thus, the purpose of this study was to examine the association between individual, environmental, social, and cultural factors and obesity in adolescents. We were especially interested in gender specific risk factors on obesity in adolescents.

Methods: Data were from the CHIS, 2011-2012, and the study sample included a total of 2,799 adolescents aged 12 to 17 years. Weighted multivariate logistic regression analyses were utilized to identify gender specific risk factors associated with being overweight.

Results: The prevalence of overweight or obese California adolescents was 32.4% (boys: 35.5%, girls: 29.2%). In our study, boys were significantly more likely to be overweight or obese than girls. In the adjusted multivariate model, age and race/ethnicity were significantly associated with being overweight or obese among boys. For girls, race/ethnicity, household income, place of birth, physical activity, and neighborhood safety were significantly associated with being overweight or obese.

Conclusions: Gender differences found in our study may lead to novel gender-focused interventions. The findings also highlighted the need for a concerted multilevel prevention and intervention effort aimed at the individual, family, and neighborhood levels. These factors can serve to identify at-risk adolescents, and potentially lead researchers and clinicians to develop interventions specific to the unique developmental, cultural, and environmental needs of target populations.

Introduction

Obesity and overweight are serious and growing public health challenges in the United States and elsewhere in the world (Pearce & Witten, 2010). Adolescence, the period when pubertal growth spurts occur, is the critical period for the development of obesity (Alberga, Sigal, Goldfield, Prud'homme, & Kenny, 2012). According to the CDC, the proportion of US adolescents who were obese increased from 5% in 1980 to nearly 21% in 2012. Preventing and controlling overweight issues and obesity in adolescents is a public health priority because obese adolescents are 70% more likely to be obese as adults than are adolescents of normal weight. (Wang & Lobstein, 2006) Besides, obese adolescents are more likely to develop chronic health conditions such as insulin resistance, type 2 diabetes, hypertension, stroke, and cardiovascular disease at younger age (Maffeis & Tato, 2001), which can lead to increase medical costs associated with obesity and its related health conditions (Trasande & Chatterjee, 2009). Because of this consequence, researchers have proposed that childhood and early adolescence be considered as a critical period to address the issue of obesity.

Contributing factors to adolescent obesity and overweight may be genetic, behavioral, cultural, social or environmental in nature. Up to date, researchers have primarily focused on individual factors such as gender, socio-economic position, physical activity, and dietary habits (Puhl & Heuer, 2010). However, little progress has been made in halting the obesity epidemic. Thus, the social-ecological approach emerged as an alternative paradigm to traditional research (Egger & Swinburn, 1997; Reidpath, Burns, Garrard, Mahoney, & Townsend, 2002; Swinburn, Egger, & Raza, 1999). This perspective stems from growing recognition that most public health challenges require more comprehensive approaches to integrate contextual influences, such as family, school, neighborhoods, and culture, which are embedded in the community and society at

large (Davison & Birch, 2001).

At an individual level, the cause of obesity is an energy imbalance between calories consumed and calories expended. However, the world in which individuals live plays a pivotal role in shaping food and physical activity choices (Frenk, 2013). There is a growing body of evidence that the neighborhood environment has a great impact on food choices, activity patterns and weight changes (Popkin, Duffey, & Gordon-Larsen, 2005). The neighborhood environment can include both physical aspect such as availability and accessibility of physical activity resources and fast food outlets, and social aspect such as perceived safety (Galvez, Pearl, & Yen, 2010; Handy, Boarnet, Ewing, & Killingsworth, 2002; Lee, Mikkelsen, Srikantharajah, & Cohen, 2008). In addition, cultural factors may attribute to development of obesity. Previous study has reported substantial disparities among racial/ethnic minorities in the prevalence of obesity (CDC, 2013). Acculturation, often examined by proxy measures such as language preference and place of birth, may at least partly reflect cultural and normative influences on obesity by creating opportunities or barriers for obesogenic behaviors (Liu, Probst, Harun, Bennett, & Torres, 2009).

The existing weight disparities at adolescence are of concern and suggest that this disparity may become more prominent given that obesity tracks into adulthood. It is imperative to understand the underlying factors that contribute to these disparities because obesity is related to a series of adverse health effects. However, current literature provides partial, incomplete, and sometimes conflicting findings regarding the association of various individual and social environmental factors on adolescent obesity. Thus, a comprehensive study, based on a social-ecological model, which combines these different types of factors is highly needed specifically for the adolescent population. In addition, gender differences in energy expenditure and

requirements among adolescence due to biological, psychosocial, and cultural influences have been well documented (Sweeting, 2008). Recent studies suggest that gender differences may play a critical role in the development of obesity, thus research should pattern adolescent obesity separately for boys and girls, and gender-focused interventions have been advocated to reduce obesity and overweight in childhood and adolescence (Simen-Kapeu & Veugelers, 2010).

In this study, we examined cross-sectional data of California adolescents to identify individual, environmental, social, and cultural factors associated with overweight and obesity, and to determine if such associations were gender-specific. Understanding these mechanisms underlying obesity for diverse adolescent population could provide a significant empirical foundation for developing tailored, integrated interventions for obesity prevention.

Methods

Data and population

To understand the factors associated with dietary practices in California adolescents, this study used adolescent data from the 2011-2012 CHIS. The CHIS is the largest state health survey in the US using a cross-sectional population-based survey for most California counties. Based on a multi-stage sampling design, a random-digit-dialing telephone survey of California households was designed to represent California's diverse population with oversampling of specific population including Koreans, Vietnamese, and American Indians/Alaska Natives.

This study sample included a total of 2,799 adolescent aged 12 to 17 years. Adolescent eligibility was determined through interviews with randomly selected adult respondents who identified as the parent or legal guardian of adolescents living in the household. All data were based on adolescents' self-report over the phone interview. To capture the rich diversity of the California population, interviews were conducted in five languages: English, Spanish, Chinese

(Mandarin and Cantonese dialects), Vietnamese, and Korean. Interviews in all languages were administered using Westat's computer-assisted telephone interviewing (CATI) system. The interview completion rate for adolescent was 42.7 percent. To produce population estimates from the CHIS data, weights were applied to the sample data to compensate for the probability of selection and a variety of other factors, some directly resulting from the design and administration of the survey. The sample was weighted to represent the non-institutionalized population for each sampling stratum and statewide. This weighting procedure can reduce biases because non-respondents may have different characteristics than respondents. Detailed description of the CHIS study design and sampling can be found on the CHIS website (http://healthpolicy.ucla.edu/chis/Pages/default.aspx).

Measures

As an outcome measure, self-reported height and weight from the CHIS were used to compute BMI. After BMI was calculated, the age-and gender-specific BMI percentile was calculated. The percentile indicated the relative position of the adolescent's BMI among adolescents of the same sex and age. An adolescent is considered to be overweight if their BMI percentile is greater than 85th, but less than 95th percentile. If the BMI percentile is equal to or greater than the 95th percentile it is considered obese. We combined the overweight and obese categories in our statistical analysis into a single category (called AROW and defined as BMI ≥85th percentile) because the pattern and direction of results were similar in both groups.

The independent variables for this study were race/ethnicity, measures of SES, acculturation, health behaviors, and neighborhood environment. We categorized race/ethnicity on the basis of self-report as White, Black, Hispanic, Asian, or American Indian/Pacific Islander/Other. Measure of SES included parental education attainment and household income

level. Parental educational attainment was coded as less than high school, high school graduate, some college, or college graduate and/or higher. Household income was assessed by a percent of the federal poverty level, and we grouped income as below 100%, 100-199%, 200-299%, and above 300% of FPL. As a proxy measure of acculturation, we examined adolescent's place of birth (US-born or Foreign-born) and language spoken at home. Language spoken at home was coded as English only, English and one other language, or other than English.

For health behaviors, we included physical activity and dietary habits. To examine regular physical activity, two items were used to determine whether adolescents met the required physical activity level. Sample items included: "Not including school PE, in the past 7 days, on how many days were you physically active for at least 60 minutes total per day?" and "During a typical week, on how many days are you physically active for at least 60 minutes total per day? Do not include PE." A composite average of the 2 items yielded a score of days per week the adolescent accumulated at least 60 minutes of MVPA. A positive respondent was defined as engaging in regular physical activity, if the adolescent met the physical activity guidelines requirements: physically active for at least 60 minutes for five or more days per week. To examine dietary habits, we assessed the survey questions on consumption of fruits and vegetables, fast food, and soda. Adolescents were asked about their dietary intake: "Did you eat 5 servings of fruits and vegetables yesterday?" (Yes=0, No=1); "In the past 7 days, how many times did you eat fast food? Include fast food meals eaten at school or at home, or at fast-food restaurants, carryout, or drive-thru."; "Yesterday, how many glasses or cans of soda that contain sugar, such as Coke, did you drink?" A composite of the three items yielded a score of dietary habits, and scores of ≤ 1, 2-4, and 5-21 were categorized as good, moderate, and bad dietary habits (Ahn, Juon, & Gittelsohn, 2008).

To examine the neighborhood environment, we assessed whether there is a park or playground within walking distance of the home (coded as yes or no) and whether the school serves fast food from restaurants (coded as yes or no). We also assessed neighborhood safety. A scale of neighborhood safety was constructed from three items measuring the respondents' level of agreement on with the following statements: 1) "The park or playground closest to where I live is safe during the day;" 2) "The park or playground closest to where I live is safe at night;" 3) "Do you feel safe in your neighborhood?" These items were measured by the respondents' level of agreement on a 4-point scale. A composite score was categorized as poor (≤6), moderate (7-9), and good (≥10) safety.

Data analysis

Descriptive analyses were conducted describing demographic characteristics and all major study variables. To examine difference in AROW by each covariate, the Chi-square statistic was used. Weighted multivariate logistic regression analyses were utilized to identify factors associated with AROW (BMI ≥85th percentile) as a dichotomous outcome variable. As an initial step, assessment for multicollinearity was conducted to check for high intercorrelations among independent variables. There was strong correlation between language spoken at home and years living in the US. Thus, language spoken at home, which had more significant correlation with AROW, was selected for the multivariate analyses. Dietary practices, such as consumption of fruits and vegetables, fast food, and soda, were combined into a single index of dietary habits. Then, unadjusted and adjusted odds ratio (OR) and 95% confidence interval (CI) were calculated. The fully adjusted model included gender, age, race/ethnicity, acculturation, SES, physical activity, dietary habits, park/playground within walking distance from home, presence of fast food at school, and perceived neighborhood safety. All regression analyses were

conducted separately for boys and girls. To yield optimal states estimates, replicate weights were used to account for survey design effects of stratified cluster sampling. Standard errors were corrected with STATA 13.0 by using the jackknife method. The significant level was set at $p < .05$.

Results

The 2,799 adolescents represented an estimated 3,127,055 adolescents aged 12-17 in California (See Table 1). The mean age was 14.6 (SD = 0.02). About 51% of adolescents were male. Approximately one third of adolescents identified themselves as White, while about 32% identified themselves as Hispanic and about 13% as Asian. Twenty-two percent of respondents lived below the FPL, and 22% of their parents had less than a high school diploma. US-born citizens constituted 87% of respondents and 50% of respondents speak only English at home. Approximately 87% reported that they have a park or playground within walking distance from their home, 21% attended schools that included restaurants serving fast food, and 45% of respondents had a good neighborhood safety score. There was no gender difference in characteristics of respondents except for regular physical activity. Boys were more likely than girls to be participating in regular physical activity (41% vs. 23%, $p<.001$).

Approximately 32% of adolescents had a BMI greater than 85th percentile (AROW), and the prevalence of AROW differed by sex with boys were more likely than girls to be AROW (36% vs. 29%, $p=.044$). In the bivariate analysis (Table 2), Black adolescents were at the highest risk, followed by Hispanics, then American Indian/Pacific Islander/others for both boys and girls. Adolescents whose parent had less than a high school diploma, and whose family income below FPL, also had a higher prevalence of AROW. Further, adolescents who spoke other than English, and who lived in the unsafe neighborhoods, showed higher rates of AROW for both

boys and girls. The prevalence of AROW was higher among boys who were 12-14 years of age and foreign-born boys than 15-17 year olds and US-born boys. Girls who do not participate in regular physical activity also had a significantly higher percentage of being AROW.

In the multivariate analyses, age and race/ethnicity were associated with AROW among boys (Table 3). In the adjusted model, older adolescents in high school were less likely than younger adolescents in middle school to be AROW. Black male adolescent had three times greater odds of being AROW than White male adolescent. Both Hispanic and American Indian/Pacific Islander/others had 2.3 times greater odds of being AROW than White adolescents, even after controlling for other covariates. The significance of the parents' education, household income, place of birth, language at home, dietary habit score, and neighborhood safety score in the unadjusted model disappeared after adjustment of other factors. Physical activity, presence of a park or playground within walking distance of home, and the presence of restaurant serving fast food at school were not significantly associated with AROW among boys.

In the adjusted multivariate model, race/ethnicity, household income, physical activity, and neighborhood safety were significantly associated with AROW among girls. Black girls were 3.2 times more likely to be AROW than White girls, and both Hispanic and American Indian/Pacific Islander/others were 1.8 times more likely to be AROW than White girls. Adolescents who lived below the federal poverty threshold had 2.2 times greater odds of being AROW than adolescents whose household income were above 300% of FPL. Foreign-born girls had 50% less odds of being AROW than US-born girls. Girls who did not engaged in regular physical activity were three times more likely to be AROW than those who maintained regular physical activity. Further, girls who lived in unsafe neighborhood had 2.2 times higher odds of

being AROW than girls who lived in safe neighborhood. The associations between parents' education, language at home, and dietary habits disappeared in the fully adjusted model. Age, presence of a park or playground within walking distance of home, and the presence of restaurant serving fast food at school were not significantly associated with AROW among girls.

Discussion

Obesity and overweight remain a serious public health concern among California adolescents, affecting about one third of adolescents with males having a higher prevalence than females. We found similarities and differences in the risk factors for being overweight or obese by gender. Disparities in the risk for obesity were found in both boys and girls among Black, Hispanic, and other ethnic minorities compared to Whites. Gender differences in the risk factors included income, levels of physical activity, and neighborhood safety.

The prevalence estimates of 32.4% (boys: 35.5%, girls: 29.2%) for obesity or being overweight in our study are quite similar to those observed in the national NHANES 2011-2012 data (All: 34.5%, boys: 35.1%, girls: 33.8%) (Ogden, Carroll, Kit, & Flegal, 2014). Similar to the national data, boys in our study were significantly more likely to be AROW than girls. This result suggests that independent predictors of AROW vary based on the gender of California adolescents. The higher risk of being overweight in boys than in girls may be due to biological and behavioral differences. A study found that boys were more likely than girls to spend time in sedentary behaviors such as watching television and playing video games (Marshall, Gorely, & Biddle, 2006). Moreover, females tend to meet nutritional recommendations and regard foods as a way to influence health, while males eat more fast foods (Kiefer, Rathmanner, & Kunze, 2013). These differences may due to differences in cultural and societal expectations of ideal body weights and images (Sweeting, 2008).

In both genders, we found significant differences in the odds of AROW among racial/ethnic groups. Consistent with previous studies (Ahn et al., 2008; Flegal et al., 2010; Ogden, Carroll, Kit, & Flegal, 2012; Ogden et al., 2014), Blacks followed by Hispanic and American Indian/Pacific Islander/others had significantly higher odds of AROW than their White counterparts. These substantial racial/ethnic disparities remained statistically significant even after adjusting for SES, acculturation, health behaviors, and neighborhood environments. Differing attitudes towards body weights and social and cultural norms toward acceptance of overweight and unhealthy diets may explain racial/ethnic differences (Cachelin, Rebeck, Chung, & Pelayo, 2002; K. A. T. Wickrama, Wickrama, & Bryant, 2006). For example, studies have found that Black and Hispanic adolescents reported more positive attitudes toward obesity (Barroso, Peters, Johnson, Kelder, & Jefferson, 2010; Latner, Stunkard, & Wilson, 2005). Further, discrimination against minorities in the use of health, educational, and recreational facilities also might explain racial/ethnic differences (Karlsen & Nazroo, 2002).

For boys, we found a significant association between age and the prevalence of AROW. Older boys were less likely than younger boys to be AROW. This may be attributed to the fact that boys and girls experience different changes in body composition with the onset of puberty (Ahmed et al., 1999). Girls gain more fat mass than boys, whereas boys gain greater fat-free mass than girls. Also, higher total energy expenditure among boys after puberty is strongly associated with lower BMI (Goran & Sun, 1998). Another component of total energy expenditure is the physical activity level. Our previous study confirmed that California adolescents who were older teenagers had a higher level of physical activity than young teens (Nam, Rehm, Hong, & Chen, 2016).

Although a significant association was observed between the dietary habit score and

being AROW in an unadjusted analysis of the boys, this did not persist after controlling for other factors in multivariate analysis. Since we examined dietary patterns from only three questions in regards to the food consumption on the previous day, and the dietary habit score has not been validated, using dietary habit score as a proxy measure of adolescents' dietary intake may not accurately represent an adolescent's diet behavior. Moreover, since caloric and nutrient intake was not reflected in this item, we cannot rigorously compare the dietary patterns between students who reported high dietary habit scores and low dietary habit scores.

For girls, adolescents whose parents had low-income levels were more likely to be AROW. Previous studies suggested that SES influences, in a variety of ways, the high prevalence of obesity (Gordon-Larsen, Adair, & Popkin, 2003). Family level SES may impact dietary intake of adolescents through differences in access to healthy food and food choices (Xie, Gilliland, Li, & Rockett, 2003). In addition, limited financial and supportive (transportation) resources may make it difficult for adolescents to participate in recreational and sports opportunities (Voorhees et al., 2009). Moreover, socioeconomically disadvantaged parents are more likely to transmit their unhealthy behaviors and risky-lifestyles to their child (K. A. S. Wickrama, Conger, Wallace, & Elder, 1999). Further, studies suggested that lower SES families are more likely to live in obesogenic environments with limited access to healthy foods and recreational facilities, but they would have a higher exposure to fast foods and live in unsafe/unwalkable neighborhoods (Morland, Wing, & Diez Roux, 2002; Voorhees et al., 2009).

Our SES finding was consistent with a longitudinal study that identified the relationship between socio-economic disadvantage and obesity as significantly stronger for girls than boys (Pudrovska, Reither, Logan, & Sherman-Wilkins, 2014). The impact of gender differences and SES on obesity may be due to the socio-cultural norms of girls' body image. The stigma of

obesity appears to affects women more strongly than men, and socialization to be attentive to the body appearance is more intensive and begins earlier in life for girls than for boys (McLaren & Kuh, 2004). Moreover, girls are more susceptible to the influence of limited recreational and sports opportunities due to the lack of universal physical activity opportunities compared to boys. Finally, the stress of socioeconomic disadvantage may affect girls' BMI indirectly via food intake (Pasquali, 2012). Since girls tend to increase food consumption as a mechanism to cope with stressors, the risk of binge eating may increase.

Participating in regular physical activity was significantly associated with AROW among girls. Many studies have reported that physical activity plays a critical role in the prevention of overweight and obese children and adolescents (Hallal, Victora, Azevedo, & Wells, 2006; Hills, Andersen, & Byrne, 2011). The intensity, duration, and the total amount of physical activity in the obese group was significantly less than normal weight adolescents (Ekelund et al., 2002). It is possible that gender differences observed in the association between physical activity and obesity may relate in part to differences in activity patterns and the perception of benefits between boys and girls. Primary reasons for engaging in physical activity for girls were weight management, whereas boys were more likely to report competition, recognition, and increasing strength as personal incentives for exercise (Vu, Murrie, Gonzalez, & Jobe, 2006). Thus, the influence of physical activity on body weight may become more prominent among girls than boys.

We also found that a perceived threat to neighborhood safety was significantly associated with AROW among adolescent girls. Neighborhood safety may be attributed to obesity through several pathways: concerns about neighborhood safety might decrease their confidence and willingness to engage in outdoor physical activity and thus facilitate sedentary behavior, plus promoting their use of non-ambulatory transportation options (Duncan, Johnson, Molnar, &

Azrael, 2009). Moreover, fear of violence and crime can increase a persons' stress level causing a release of cortisol, and a high level of cortisol may lead to being overweight (Roemmich, Smith, Epstein, & Lambiase, 2007). Our finding is consistent with previous studies that showed that neighborhood safety had a significance only for girls (Babey, Hastert, Yu, & Brown, 2008; Babey, Tan, Wolstein, & Diamant, 2015; Floyd et al., 2011; Voorhees, Yan, Clifton, & Wang, 2011). Studies have documented significant gender differences, and girls' participation in out-door activities is limited compared to boys due to cultural norms and parental safety concerns (Bailey, Wellard, & Dismore, 2004; Bocarro et al., 2015). Adolescent girls were found not to participate in organized sports more than younger children and boys, suggesting that promoting a safe neighborhood for walking and cycling may be an important way to increase physical activity and prevent obesity in adolescent girls.

Although neighborhood factors considered in our study are theoretically important aspects of a neighborhood's physical environment, we did not find significant association between the presence of park or playground and AROW. As the majority of the respondents reported that park or playground were available near home, it might be difficult to discern the effect of park accessibility. In addition, we used the measure of the presence of fast foods at school, but this may not fully describe their greater exposure of unhealthy food. Since the measures used in our study apparently have some limitations due to secondary analysis of existing data, we cannot simply conclude that environmental factors do not influence AROW. Future research should investigate appropriate proxies for positive food environments for adolescents, as well as the mechanisms between the food environment, adolescent's food choices, and AROW.

Our study included a large number of Asian and minority populations, and could estimate the risk of being overweight or obese among these understudied populations. However, a number of limitations to this study deserve mention. Because it is a cross-sectional survey, a determination of causal associations cannot be made. Also, BMI was determined by self-report in this study instead of by direct measurement. Self-report may lead to an underestimate of obesity and persons who are overweight (Brener, McManus, Galuska, Lowry, & Wechsler, 2003). Our study analyzed only risk factors measured in CHIS, and not all of the neighborhood characteristics in the theoretical framework could be captured by the available data. Since secondary data are usually not collected for the same purpose as in the original research, appropriateness of the measurements may be an issue. For example, our study explored the presence of a park or playground near the home and the presence of restaurants serving fast food at schools without considering the quality of recreational facilities and barriers to access, and the overall exposure to fast food outlets or promotions in the neighborhood. Thus, these indirect measures of the concept may not able to accurately capture the neighborhood's physical environment.

In summary, independent predictors of obesity or being overweight in diverse California adolescents have been characterized in this study including those that are gender-specific. Gender differences related to obesity or being overweight are important to identify and may lead to novel gender-focused interventions. The results also highlight the need for a concerted multilevel prevention and intervention effort within the community (e.g., improving neighborhood safety), family (e.g., prioritizing low-income, non-White, immigrant minorities), and individual levels (e.g., promoting physical activity and a healthy diet). These factors can serve to identify at-risk adolescents, and potentially lead researchers and clinicians to develop

interventions specific to the unique developmental, cultural, and environmental needs of target populations.

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Table 9. *Characteristics of Adolescent Respondents by Sex, California Health Interview Survey 2011-2012 (N=2,799)*

Category	Total, weighted % (SE)	Boys, weighted % (SE)	Girls, weighted % (SE)	Sex difference, P value
Sex				
Male	51.2 (0.00)			
Female	48.8 (0.00)			
Age, y (mean 14.58 ± 0.02)				
12-14	48.7 (0.00)	48.6 (0.00)	48.7 (0.00)	
15-17	51.3 (0.00)	51.4 (0.00)	51.3 (0.00)	.000
Race/ethnicity				
White	33.5 (1.00)	34.2 (1.31)	32.9 (1.50)	
Hispanic	31.8 (1.12)	32.0 (1.66)	31.5 (1.76)	
Asian	12.6 (0.97)	11.7 (1.55)	13.5 (1.03)	
Black	5.2 (0.48)	5.6 (0.71)	4.9 (0.79)	
AI/PI/other	16.9 (1.03)	16.5 (1.47)	17.3 (1.49)	.806
Parent's education				
< High school	22.0 (1.01)	23.0 (1.50)	21.1 (1.72)	
High school	17.8 (1.19)	18.2 (1.69)	17.4 (1.74)	
Some college	23.1 (1.30)	21.0 (1.58)	25.2 (1.84)	
College or more	37.1 (1.25)	37.9 (1.86)	36.3 (1.81)	.378
Household income				
<100% FPL	21.5 (1.31)	19.9 (1.52)	23.2 (2.07)	
100-199% FPL	23.3 (1.28)	24.2 (1.56)	22.3 (1.85)	
200-299% FPL	13.6 (1.03)	14.0 (1.64)	13.1 (1.33)	
≥300% FPL	41.6 (1.17)	41.8 (1.69)	41.4 (1.90)	.554
Place of birth				
US-born	86.6 (1.25)	87.7 (1.88)	85.5 (1.59)	
Foreign-born	13.4 (1.25)	12.3 (1.88)	14.5 (1.59)	.373
Language spoken at home				
English	49.5 (1.47)	49.6 (1.98)	49.3 (2.35)	
English & other	9.5 (1.00)	9.2 (1.68)	9.9 (1.13)	
Other	41.0 (1.24)	41.2 (1.90)	40.8 (2.22)	.938

Table 9. *(Continued)*

Category	Total, weighted % (SE)	Boys, weighted % (SE)	Girls, weighted % (SE)	Sex difference, P value
Regular vigorous or moderate physical activity				
Yes	32.2 (1.33)	41.1 (2.03)	22.8 (1.67)	
No	67.8 (1.33)	58.9 (2.03)	77.2 (1.67)	.000
Dietary habit score				
Good	23.7 (1.03)	22.9 (1.80)	24.5 (1.63)	
Moderate	58.1 (1.23)	57.1 (2.01)	59.0 (2.10)	
Bad	18.3 (0.98)	20.0 (1.60)	16.5 (1.59)	.364
Park or playground within walking distance of home				
Yes	87.0 (1.16)	85.9 (1.93)	88.3 (1.02)	
No	13.0 (1.16)	14.1 (1.93)	11.7 (1.02)	.227
School serves fast foods				
Yes	20.9 (1.24)	21.8 (1.95)	20.0 (1.56)	
No	77.6 (1.21)	77.2 (1.90)	78.1 (1.58)	.312
Neighborhood safety score				
Good	44.5 (1.38)	47.5 (1.89)	41.4 (1.95)	
Moderate	49.6 (1.38)	47.6 (1.80)	51.7 (2.10)	
Poor	5.8 (0.80)	4.9 (1.05)	6.9 (1.26)	.104
BMI				
Normal	67.6 (1.31)	64.5 (2.17)	70.8 (1.87)	
AROW	32.4 (1.31)	35.5 (2.17)	29.2 (1.87)	.044

Table 10. *Adjusted Percent of Overweight or Obese among Adolescents by Sex*

	Boys, % (SE)			Girls, % (SE)		
	AROW	**Normal**	**P-value**	**AROW**	**Normal**	**P-value**
Age						
12-14	40.8 (3.09)	59.2 (3.09)		29.4 (2.78)	70.6 (2.78)	
15-17	30.5 (2.87)	69.5 (2.87)	**.015**	28.9 (2.34)	71.1 (2.34)	0.879
Race/ethnicity						
White	21.8 (2.46)	78.2 (2.46)		20.3 (2.28)	79.7 (2.28)	
Hispanic	45.7 (4.09)	54.3 (4.09)		38.3 (3.39)	61.7 (3.39)	
Asian	32.2 (10.42)	67.8 (10.42)		12.6 (4.62)	87.4 (4.62)	
Black	45.9 (9.25)	54.1 (9.25)		54.1 (8.86)	45.9 (8.86)	
AI/PI/other	42.9 (5.81)	57.1 (5.81)	**.002**	35.1 (4.71)	64.9 (4.71)	**.000**
Parent's education						
<High school	49.7 (5.13)	50.3 (5.13)		40.7 (4.37)	59.3 (4.37)	
High school	39.7 (6.51)	60.3 (6.51)		28.2 (4.52)	71.8 (4.52)	
Some college	36.5 (4.10)	63.5 (4.10)		27.8 (3.33)	72.2 (3.33)	
College or more	24.3 (3.06)	75.7 (3.06)	**.001**	23.9 (3.18)	76.1 (3.18)	**.014**
Household income						
<100% FPL	48.7 (6.04)	51.3 (6.04)		42.8 (4.60)	57.2 (4.60)	
100-199% FPL	40.5 (4.22)	59.5 (4.22)		33.0 (4.43)	67.0 (4.43)	
200-299% FPL	32.6 (5.56)	67.4 (5.56)		27.1 (5.36)	72.9 (5.36)	
>300% FPL	27.2 (2.50)	72.8 (2.50)	**.002**	20.1 (2.50)	79.9 (2.50)	**.000**
Place of birth						
US-born	33.4 (1.96)	66.6 (1.96)		30.1 (2.08)	69.9 (2.08)	
Foreign-born	49.9 (7.95)	50.1 (7.95)	**.023**	23.4 (4.69)	76.6 (2.69)	.234
Language spoken at home						
English	28.7 (2.37)	71.3 (2.37)		27.8 (2.49)	72.2 (2.49)	
English and 1 other	42.2 (12.28)	57.8 (12.28)		13.1 (3.99)	86.9 (3.99)	
Other than English	42.2 (3.58)	57.8 (3.58)	**.051**	34.7 (2.91)	65.4 (2.91)	**.001**
Regular physical activity						
Yes	33.7 (3.34)	66.3 (3.34)		13.3 (2.09)	86.7 (2.09)	
No	36.7 (2.55)	63.3 (2.55)	.441	33.8 (2.32)	66.2 (2.32)	**.000**
Dietary habit score						
Good	27.0 (3.52)	73.0 (3.52)		23.8 (2.62)	76.2 (2.62)	
Moderate	37.9 (3.15)	62.1 (3.15)		30.7 (2.73)	69.3 (2.73)	
Bad	38.3 (4.48)	61.7 (4.48)	.073	31.7 (4.73)	68.3 (4.73)	.224
Park or playground within walking distance of home						
Yes	34.5 (1.84)	65.5 (1.84)		28.4 (2.01)	71.6 (2.01)	
No	41.3 (8.55)	58.7 (8.55)	.381	34.8 (5.76)	65.2 (5.76)	.287
School serves fast food						
Yes	37.9 (7.31)	62.1 (7.31)		24.9 (4.48)	75.1 (4.48)	
No	35.1 (2.11)	64.9 (2.11)	.406	29.8 (1.99)	70.2 (1.99)	.204
Neighborhood safety score						
Good	29.0 (2.41)	71.0 (2.41)		24.9 (2.66)	75.1 (2.66)	
Moderate	40.6 (3.52)	59.4 (3.52)		30.4 (2.58)	69.6 (2.58)	
Poor	48.5 (12.36)	51.5 (12.36)	**.017**	45.9 (9.25)	54.1 (9.25)	**.033**

Table 11. *Risk Factors for Overweight or Obese among Adolescents by Sex*

Factors	Boys		Girls	
	Unadjusted OR	Adjusted OR	Unadjusted OR	Adjusted OR
Age (referent: 12-14 y)				
15-17	**0.64 (0.45-0.91)**	**0.59 (0.39-0.89)**	0.97 (0.69-1.37)	1.03 (0.73-1.45)
Race/ethnicity (referent: White)				
Hispanic	**3.01 (1.88-4.83)**	**2.28 (1.28-4.05)**	**2.44 (1.66-3.58)**	**1.79 (0.91-3.55)**
Asian	1.71 (0.59-4.97)	1.17 (0.52-2.65)	0.57 (0.23-1.41)	0.68 (0.20-2.31)
Black	**3.04 (1.40-6.60)**	**2.85 (1.26-6.48)**	**4.61 (2.23-9.56)**	**3.16 (1.45-6.86)**
AI/PI/other	**2.69 (1.57-4.62)**	**2.30 (1.36-3.91)**	**2.12 (1.33-3.38)**	**1.78 (1.02-3.12)**
Parental education (referent: Less than high school)				
High school	0.66 (0.32-1.36)	0.71 (0.35-1.42)	**0.57 (0.33-1.00)**	0.76 (0.41-1.39)
Some college	**0.58 (0.34-1.00)**	0.82 (0.43-1.56)	**0.56 (0.36-0.89)**	0.83 (0.43-1.59)
College or more	**0.32 (0.19-0.57)**	0.53 (0.24-1.19)	**0.46 (0.28-0.77)**	1.01 (0.49-2.07)
Household income (referent: Above 300% FPL)				
200-299% FPL	1.30 (0.74-2.27)	0.94 (0.49-1.80)	1.47 (0.79-2.74)	1.41 (0.69-2.89)
100-199% FPL	**1.82 (1.21-2.75)**	0.99 (0.60-1.65)	**1.96 (1.16-3.30)**	1.46 (0.83-2.57)
Below 100% FPL	**2.54 (1.44-4.46)**	1.09(0.50-2.38)	**2.96 (1.88-4.67)**	**2.22 (1.20-4.10)**
Place of birth (referent: US-born)				
Foreign-born	**1.98 (1.06-3.73)**	1.65 (0.86-3.19)	0.71 (0.40-1.25)	0.62 (0.32-1.20)
Language at home (referent: English only)				
English and 1 other	1.82 (0.66-4.98)	1.58 (0.75-3.33)	**0.39 (0.18-0.86)**	0.59 (0.19-1.83)
Other than English	**1.81 (1.22-2.69)**	0.82 (0.48-1.42)	**1.37 (1.00-1.89)**	0.87 (0.44-1.72)

Table 11. *(Continued)*

Factors	Boys		Girls	
	Unadjusted OR	Adjusted OR	Unadjusted OR	Adjusted OR
Regular physical activity (referent: Yes)				
Non-regular physical activity	1.14 (0.81-1.61)	0.97 (0.67-1.40)	**3.33 (2.19-5.04)**	**3.05 (1.96-4.74)**
Dietary habit score (referent: Good)				
Moderate	**1.65 (1.08-2.52)**	1.52 (0.96-2.41)	1.41 (0.95-2.09)	1.19 (0.76-1.87)
Bad	**1.68 (1.00-2.85)**	1.52 (0.87-2.67)	1.48 (0.92-2.38)	1.17 (0.70-1.97)
Park/playground within walking distance from home (referent: Yes)				
No	1.33 (0.66-2.68)	1.07 (0.56-2.05)	1.34 (0.77-2.34)	1.30 (0.67-2.51)
School serves fast food (referent: No)				
Yes	1.12 (0.58-2.20)	1.04 (0.54-1.99)	0.78 (0.47-1.30)	0.79 (0.46-1.37)
Neighborhood safety score (referent: Good)				
Moderate	**1.68 (1.16-2.43)**	1.27 (0.83-1.94)	1.31 (0.91-1.91)	1.11 (0.74-1.65)
Bad	2.31 (0.84-6.36)	1.81 (0.69-4.80)	**2.56 (1.20-5.47)**	**2.21 (1.05-4.66)**

CHAPTER 5

Conclusion

Summary of Findings

This dissertation described the nature of adolescent obesity by focusing on identifying the various types of factors associated with physical activity, dietary patterns, and being overweight or obese from a social-ecological perspective. The findings from the three research studies in this dissertation contributed to the extant literature about the role of social-environmental factors in explaining adolescent obesity.

The first study (Chapter 2) identified the meaningful individual, family, and neighborhood factors that contributed to regular physical activity among adolescents. The prevalence of participating in regular physical activity was 32% among California adolescents. The findings suggested that male sex, older teenagers, and higher household income were significant predictors for engaging in regular physical activity. These findings also provided strong evidence that living in a safe neighborhood positively affected regular physical activity. However, there was no significant association between having a park or playground near the home and physical activity. The study suggests the need for future interventions and policies to promote physical activity among this population, which should consider neighborhood safety influences along with individual approaches.

The second study (Chapter 3) investigated predictors associated with dietary patterns of adolescents. This study highlighted racial, socioeconomic status, immigrant, and neighborhood differences in dietary patterns among California adolescents. Unhealthy dietary patterns (low consumption of fruits and vegetables with a high consumption of fast foods and sugary drinks) were found among adolescents from Hispanic or ethnic minorities, lower SES, second or third generation immigrants, and in rural areas. These disparities in dietary patterns among adolescents indicated the need for culturally specific interventions, and that targeting should be given to

socioeconomically disadvantaged adolescents to promote healthy food consumption in adolescents.

The third research study (Chapter 4) demonstrated the gender-specific factors associated with the risks of being overweight or obesity among adolescents. The prevalence of overweight or obese California adolescents was 32.4% (girls: 29.2%, boys: 33.5%). For girls, age, race/ethnicity, income, place of birth, physical activity, and neighborhood safety were significantly associated with being overweight or obese. In contrary, only age and race/ethnicity remain significant for boys. These findings provide important information about gender differences that can be used to generate gender-focused interventions. The findings also highlight the need for a concerted multilevel prevention and intervention effort aimed at the individual, family, and neighborhood levels.

Implications and Recommendations for Future Research & Interventions

The dissertation findings have several important implications for adolescent obesity prevention research, practice, and policy. Overall, the dissertation findings highlight that adolescent overweight and obesity are influenced by individual, social, environmental, and cultural factors. Understanding the complex mechanisms underlying obesity for diverse adolescent population provides a significant empirical foundation for obesity prevention by developing tailored, integrated interventions. This also suggests that adolescent obesity prevention interventions for adolescents may need to take a comprehensive approach, rather than focusing on a singular focus.

First of all, this dissertation research found racial/ethnic disparities in physical activity, dietary intake, and obesity among adolescents. Compare to White adolescents, Hispanic/Black/American Indians/Pacific Islanders and other ethnic minorities were less likely to

participate in regular physical activity and more likely to have unhealthy diets. Moreover, they had significantly higher odds of being overweight or obese than their White counterparts. Previous research suggested that social economic status maybe related to these racial/ethnic disparities. In the Unites States, more than half of all low-income families are racial minorities (Turner & Fortuny, 2009), and approximately 24 % of Latino and 26% of Black families are living in poverty compared to 10% of White and 12% of Asian families (DeNavas-Walt & Proctor, 2015). Residential segregation for racial minorities and low-income groups has been widely witnessed (Reardon et al., 2009), and they are exposed to numerous structural disadvantages (including limited access to healthy foods and physical activity resources, safety concerns, and a lack of healthcare and social services) that may play a significant role in driving these disparities. In addition, they share and inherit their own social norms and cultural values that may have an influence on health behaviors and outcomes. The findings from this dissertation also confirmed social economic disparities: that is, lower levels of family income were associated with increased odds of inactivity, unhealthy diets, and obesity. Since racial minorities and socioeconomically disadvantaged people often encounter social and environmental barriers and challenges, public health initiatives should target disadvantaged adolescents to reduce gaps between the most advantaged and disadvantaged, and interventions should consider the diverse socioeconomic and cultural profiles of all race/ethnic groups. Future studies with large cohorts of adolescents are needed to capture the ethnic heterogeneity and to generalize the findings nationally. In addition, future studies should be followed to investigate the mediating influence of these neighborhood pathways on the relationship between segregation and obesity.

Second, immigration status differences were observed in our study. First generation adolescents were more likely to have healthy diets, however, the relationships to physical

activity and obesity were disappeared after adjusting for socio-demographics. This pattern is different from most traditional assimilation models, which predict better health and behavioral outcomes the longer those immigrants stay in the US (McCullough & Marks, 2014; Singh, Kogan, & Yu, 2009). McCullough and Marks (2014) referred to this pattern of second-and third-generation immigrant adolescents being more vulnerable to obesity than are first-generation youth as the "immigrant paradox". To better understand this paradox, the population-level pattern in adolescent obesity should be examined by including the social environmental correlates of health for the immigrants. Further analysis of this study showed that adolescents from immigrant family had a significantly lower income and were less likely to live in neighborhoods favorable to outdoor physical activity and safety compared to those from native family. The relationship between immigration status/acculturation and obesity maybe modified by social environmental factors, such as access to recreational facilities, outdoor parks, safety, fast food outlets, and the availability of healthy food options. Since immigrant populations are remarkably diverse, further analysis is required to examine the extent to which patterns of physical activity, diet, and obesity vary by ethnicity, level of acculturation, and neighborhood factors. Understanding these mechanisms underlying obesity for immigrant ethnic groups could provide a significant empirical foundation for developing culturally sensitive obesity prevention interventions.

Third, gender difference in the prevalence of being overweight or obese and the risk factors for being overweight or obese among adolescents were identified in this study. Male adolescents and female adolescents go through different process of physical development including growth spurts, body composition, and muscle growth during puberty, which result in differences in energy expenditure and requirements (Stang. J. & Story, 2005). During

adolescence, they also experience socially constructed attitudes and beliefs for each gender toward body image and weight from peers, media, society, and culture (Sweeting, 2008). These gender differences may have influence on the etiology of overweight and obesity as well as physical activity levels and eating behaviors (Simen-Kapeu & Veugelers, 2010). Thus, research should pattern adolescent obesity and health behaviors separately for boys and girls to increase our understanding of adolescent obesity mechanism and to optimize obesity prevention interventions.

There is a growing body of evidence that neighborhood environments have a great impact on food choices, activity patterns, and weight changes. The findings from this study found that perceived neighborhood safety is a significant environmental factor for physical activity and obesity. Public health initiatives should address concern of neighborhood safety and incorporate safety issue into adolescent obesity prevention strategies. However, a neighborhood's physical environments, such as availability of physical activity resources near at home, retail food environment, and exposure to fast food at school, were not significant in this dissertation. Since environmental approaches and the concept of the neighborhood environment for adolescent population are still in a burgeoning stage, conceptual frameworks are still evolving, and there is a lack of consensus on operational definitions of environmental influences. This dissertation study used only a small number of indicators to characterize neighborhoods because of limited indicators available in the dataset. Therefore, a further adolescent obesity study should be followed to identify appropriate measures for adolescents' neighborhood environments, and optimal combinations of attributes to better understand the environmental influences. Furthermore, using indicators measured by GIS (Geographic Information System) may provide

complementary information for characterizing a neighborhood environment related to adolescent obesity.

Lastly, continuing research to improve the rigor of the study design is required. Changes to diet and physical activity patterns may help explain the relationship between predicting factors and obesity. However, this dissertation research did not include physical activity and diet behaviors as mediators. Future research may need to consider the mediation effect by using multilevel structural equation modeling or path analysis to evaluate the theoretical framework explaining the etiology of obesity. In addition, the difficulty in establishing causality was the biggest disadvantage of this cross-sectional study since it only provides a snapshot of a sample population and potential relationships at a specific time point. There is currently a lack of longitudinal studies to examine social ecological influences on changes in adolescent's activity, diet, and weight status. Therefore, future research should consider a longitudinal design to investigate changes in adolescent activity, diet, and body weight longitudinally related to changes in the neighborhood environment, and to assess causality between environmental factors and health.

Overall, this dissertation identifies different features, both at the individual- and neighborhood-level, that are hypothesized to influence physical activity, diet, and obesity risk among adolescents, and extends our understanding of the field. In order to understand the etiology of adolescent obesity, the dissertation findings suggests that a multilevel approach, from a social-ecological perspective, will be crucial to implementing interventions/policies to effectively manage the obesity epidemic and identify root causes of obesity disparities. Traditional education approaches targeted at the individual level alone are less effective and likely to make the disparities worse. Health interventions and policies should take a greater

account of ethnic and social diversity, and offer extra support to those with the greatest disadvantages to address the need to reduce disparities in adolescent obesity. Furthermore, we should move beyond the narrow focus that targets the individual as the solution for obesity, and address health-promoting changes to the environments in which we live as this will have more promising and lasting positive impacts.

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