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Danielle T. Barradas Date

Associations of physical activity and television viewing with various domains of child and adolescent health

By

Danielle T. Barradas
Doctor of Philosophy
Graduate Division of Biological and Biomedical Sciences
Nutrition and Health Sciences

____
Nancy J. Thompson, Ph.D., M.P.H.
Advisor

____
Heidi Michels Blanck, Ph.D.
Committee Member

____
Shifan Dai, Ph.D.
Committee Member

____
Janet E. Fulton, Ph.D.
Committee Member

____
Aryeh D. Stein, Ph.D., M.P.H.
Committee Member

Accepted:

____
Lisa A. Tedesco, Ph.D.
Dean of the Graduate School

____
Date

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Danielle T. Barradas
B.S., Florida A&M University, 2002

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An Abstract of
A dissertation submitted to the Faculty of the Graduate
School of Emory University in partial fulfillment
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ABSTRACT

Associations of physical activity and television viewing with various domains of child and adolescent health

Danielle T. Barradas

Nearly one in five youth in the US is overweight. Regular physical activity and limited television viewing are important behaviors for health, but few studies have related physical activity and TV viewing to *changes* in health among youth, or assessed the impact of sports participation as a means of acquiring physical activity. In this dissertation, relationships between weight maintenance, weight gain, and weight loss and changes in cardiovascular disease (CVD) risk factors were assessed. Associations between moderate and vigorous physical activity (MVPA) and TV viewing (TV) and changes in body mass index (BMI), percent body fat (PBF), and CVD risk factors were also examined. Differences between sports participants and non-participants were described with regard to weight-related perceptions, intentions, and practices; correlates of weight-related intentions and weight-control practices in sports participants were assessed.

MVPA was not associated with changes in BMI, PBF, blood pressure or blood lipids; TV was positively related to increases in BMI and PBF. Estimates of MVPA and TV did not vary among BMI maintainers, losers, and gainers, but greater increases in the sum of CVD risk factors and larger declines in HDL were observed among gainers, relative to maintainers. Independent of changes in BMI, TV was positively associated with increases in LDL.

Sports participants were more likely to meet MVPA and TV guidelines than non-participants. Disordered weight-control practices did not differ between sports participants and non-participants, but intention to gain weight was more common among male sports participants than non-participants. Receiving weight-related advice from a peer or adult was associated with increased odds of weight-gaining intention and using dietary supplements among male sports participants. In females, weight-loss and weight-maintenance intentions were influenced by receiving advice from a peer and adult. Perceived weight influenced intentions more than measured BMI in this subgroup.

These findings suggest that limiting TV to prevent excess increases in BMI and adiposity could have implications for reducing undesirable changes in CVD risk measures during youth. Participation in sports may be a viable mechanism to limit TV as well as provide a platform for the discussion of healthy weight-related perceptions, intentions, and practices.

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Chapter 1

Introduction

Overweight and obesity contribute greatly to a wide range of preventable causes of death.[1] In particular, overweight in childhood has been associated with a number of short- and long-term consequences including depression, arthritis, insulin resistance, diabetes, elevated blood pressure, and adverse lipid profiles.[2-6] Unfortunately, the number of youth in the United States who are overweight has risen over the past forty years.[7] The prevalence has also increased in other countries.[8] Given the serious health consequences, prevention of overweight among youth is a high priority for public health.

According to Healthy People 2010, regular physical activity, along with a healthy diet, is important for maintaining healthy body weight and this practice should begin early in childhood. Physical activity in childhood and adolescence is thought to affect health in adulthood through at least one of three proposed mechanisms (Figure 1.1).[9] The first suggests a direct effect of youth physical activity on adult health. An alternative mechanism is through an effect of childhood physical activity on physical activity habits in adulthood, which in turn impact adult health. The last alternative suggests an effect of childhood physical activity on childhood health, which is related to adult health. The scope of this dissertation is limited to the last of these mechanisms, i.e., the relationship between childhood physical activity and childhood health.

Regular physical activity in youth can be grouped into three major domains: curricular, leisure-time, and participation in sports. Curricular physical activity includes physical activity that is part of the school curriculum, usually in the form of physical education. Leisure-time physical activity includes activity that occurs on a regular basis (i.e., habitually) during leisure hours. The third domain is sports participation. This includes extra-curricular and leisure-time activity that is designed to develop or practice sport-related skills.

This dissertation examines the associations between regular leisure-time physical activity and biological risk factors for cardiovascular disease during childhood and between sports participation and weight-management intentions and behaviors during adolescence. More specifically, within the context of leisure-time physical activity, we examined the associations between physical activity and the biologic characteristics of adiposity, blood pressure, and blood lipids. In light of the increased prevalence of overweight among children and adolescents in the United States (and other countries) and a concomitant increase in morbidities associated with excess adiposity, there is a need for generalized approaches to combating this epidemic. Research has demonstrated that these adverse outcomes begin to manifest in childhood.[10-13] Thus, leisure-time physical activity is considered with regard to adiposity and other risk factors for cardiovascular disease in children. TV viewing is also considered in these analyses due to its pervasiveness in the United States and relation to BMI and cardiovascular disease risk factors among children and adolescents.[14-19]

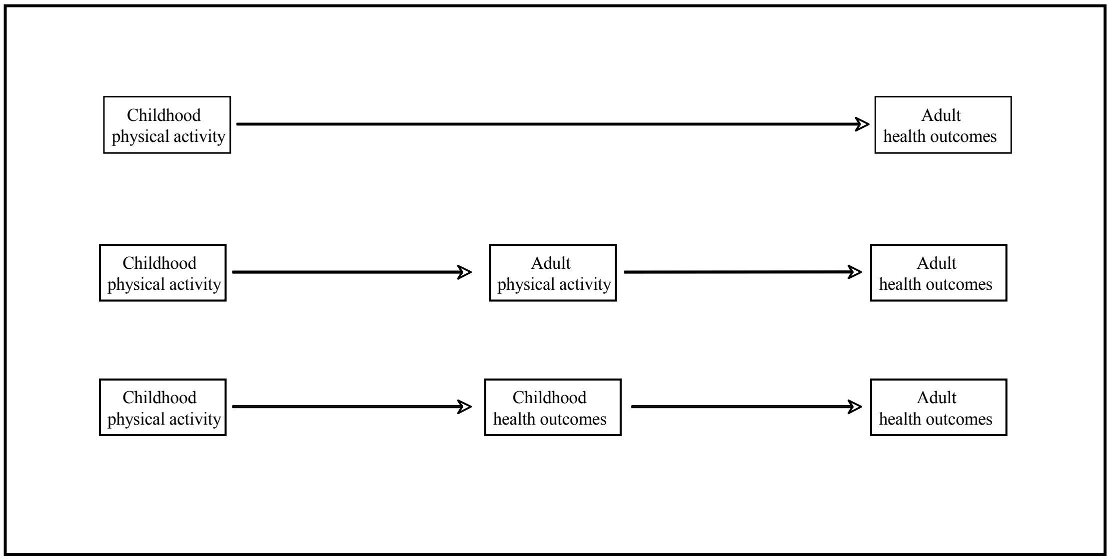
In particular, data from a longitudinal study of the natural course of cardiovascular disease risk factor development among children and adolescents residing in Texas is used to address the following research questions: (1) What is the relationship of weight maintenance, weight gain, and weight loss to changes in cardiovascular disease risk factors? (2) Are there significant associations between moderate-vigorous physical activity and TV viewing and changes in adiposity as measured by body mass index (BMI) and percent body fat? (3) Are there associations between moderate-vigorous physical activity, TV viewing and changes in cardiovascular disease risk factors, including blood pressure and blood lipids? The questions are each examined with regard to relevant covariates, including pubertal status and change in height (i.e., growth).

Sports participation, an activity that is relatively common in the US, is often viewed as a means of promoting healthy weight.[20-22] However, sports participation has also been associated with a number of unique concerns among youth. Specifically, weight-related perceptions, intentions, and behaviors, some of which are risky, have been shown to differ among adolescents who participate in sport compared to those who do not.[23-26] Many of the risky behaviors manifest during the teen years.[27] Thus, behavioral and psychosocial factors are examined within the context of sports participation among adolescents.

As a fourth goal, cross-sectional data collected among high school students in the United States and in Georgia are used to address the following questions: (1) Do sports participants differ from non-participants with regard to weight-related perceptions, weight-management intentions, and weight-control practices? (2) Among sports participants, do intentions to lose, gain, or maintain weight differ according to receipt of advice from a peer or adult, perceived body size, or measured BMI? (3) Among sports participants, do weight-control practices differ according to receipt of advice from a peer or adult, perceived body size, or measured BMI?

It is our hope that this study will contribute to a better understanding of factors important for the prevention of adverse health outcomes in young people associated with both overweight and with risky behaviors that are sometimes adopted to manage overweight or body dissatisfaction. We provide insight into the relevance of physical activity to decreasing the incidence of overweight and related adverse changes in cardiovascular disease risk factor profiles in children. We also provide a description of weight-management intentions and strategies among American youth, sports participants in particular, that may be used to inform the promotion of healthy weight-related perceptions and practices in this population.

Figure 1.1 Pathways through which physical activity during youth might influence adult health



Adapted from Twisk et al. Int J Sports Med 2002; 23: S5-7

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Chapter 2

Literature Review

Childhood and adolescence are critical periods for physical growth and psychological development. Changes occurring during this time period include, but are not limited to, changes in body size and composition; changes in physiologic measures, such as blood pressure and blood lipids; and the development of food preferences and eating behaviors. These are some of the reasons why the study of childhood and adolescent health and health behaviors is important.

Normal changes in body composition

During childhood and adolescence, there are generally substantial increases in weight and height.[1] Many factors, including gender and the onset of puberty, influence the timing and magnitude of these increases. Body weight increases among both males and females during childhood and adolescence, with about 50% of adult body weight being gained during adolescence.[2] Changes in body composition, however, vary by gender. On average, from ages 5 to 10 years, males have 1 to 3 kilograms more fat-free mass than females, with both increasing fat-free mass at similar rates. During this same time period, females have a higher percentage of body fat, which also increases at a faster rate (+1.14 kg/yr) than in males (-1.15 kg/yr).[1] Height also increases faster among males than females. During the year in which a male attains his peak height velocity, growth generally ranges from 7 to 12 centimeters; for females, growth ranges between 6 and 10 centimeters.[3] The onset of puberty further compounds these differences.

Normal changes in CVD risk factors

Studies involving children and adolescents have demonstrated a link between increases in adiposity and adverse changes in cardiovascular disease risk factors.[4-7] There are, however, changes that occur in the measures of blood pressure and blood lipids as a part of the normative growth process. Similar to body composition changes, changes in blood pressure and lipids also differ by gender and age.[8, 9] In general, both systolic and diastolic blood pressures increase among males and females until they approach adult levels.[10] Blood pressure is also related to height and growth in children and adolescents.[11, 12] Race and birth weight explain some of the variance in blood pressure among children, as well.[7, 13-16]

Unlike blood pressure, there is evidence that total cholesterol and serum lipids are inversely associated with increases in height among male and female adolescents**.** [17] Trajectories of total cholesterol from age 12 to 18 years among males and females are similar – there is a decline during early adolescence (between 12-14 years), followed by increases until adult levels are reached.[8] The components of total cholesterol, however, follow different patterns by gender. Among males, low-density lipoprotein (LDL) decreases until approximately age 15 years, followed by increases through adulthood; in females, LDL-cholesterol steadily increases from age 12 to early adulthood. There is a slight decline in high-density lipoprotein (HDL) cholesterol until about age 16 among males, which is followed by little to no change until adulthood. In contrast, there is relatively no change in HDL-level among female from adolescence into adulthood. Finally, trajectories of triglyceride levels indicate a steady decline throughout adolescence among males; among females there is a decline until about age 15, followed by an increase in levels into adulthood. These patterns are slightly exaggerated among those males and females who have elevated total cholesterol, LDL, or triglyceride levels.

Normal developmental processes and the development of nutritional behaviors

Nutritional behaviors, including food preferences and aversions are developed early in life.[18, 19] Throughout childhood, though, caregivers are the primary decision-makers with regard to children's food intake. They are responsible for the facilitation of food availability, meal times, and portion sizes.[20-22] As children age, however, the responsibility of choosing foods rests more on the child. Learning to self-regulate food choices and portions is an important part of this newfound autonomy.[23] It is not uncommon for children nearing adolescence to indulge in "junk foods" or prohibited foods as an act of defiance and to finalize autonomy in this area. During adolescence, the balance of social support shifts from parents to peers.[24] It is thought that during this time, peers become more influential in food selection behaviors. There is evidence to suggest that peers also play a role in influencing dieting and other weight-control behaviors through avenues such as social comparisons and weight-teasing.[25-27]

Deviations from normative growth, development, and behavior

Deviations both below (underweight) and above (overweight) normal weight can occur. These have typically been defined in terms of body mass—a measure of weight per unit of height. The standard measure of body mass is the body mass index (BMI). This is defined as weight in kilograms per unit of height in meters-squared. At one end of the nutritional spectrum is underweight. In the United States, underweight is typically defined as a BMI at or below the 5th percentile compared to a referent population derived from several population-based surveys, vital records, and supplementary data (1960-1995).[28] The prevalence of underweight in the United States between 1988-1994 has been estimated at 3.3% among children aged 6-18 years.[29] In addition to a relation with low birth weight, poor nutrition, limited food availability, and certain disease states, underweight among children and adolescent in the United States may also be indicative of disordered eating behaviors.[30-33]

Overweight is at the other end of the nutritional spectrum. Among children and adolescents, there has been a great deal of debate regarding appropriate definitions and terminology for describing the existence of excess body mass/fat relative to age- and sex-specific peers. The use of a definition that is both highly sensitive and highly specific is particularly important in youth. Identifying children who are overweight allows for careful monitoring and treatment of a wide range of possible co-morbidities, but incorrectly labeling a child as overweight has implications for mental and emotional health. Currently, the two most commonly used definitions of excess body fat are based on population distributions of BMI. The first, the International Obesity Task Force (IOTF) centile curves, was derived using nationally representative data from six countries (Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States).[34] The centile curves were created so that, at age 18, they would coincide with the adult cut-points of 25 kg/m^2 and 30 kg/m^2; these cut-points are used to classify overweight and obesity, respectively. The second classification of overweight in children, the Centers for Disease Control and Prevention (CDC) growth charts (2000), was based on the distribution of BMI among several nationally representative samples of American youth aged 2-20 years.[28] By this definition, overweight is defined as having a BMI greater than the 95th percentile relative to one's age- and sex-specific peers. A second category, risk of overweight, is defined as a BMI greater than or equal to the 85th percentile but lower than the 95th percentile. We decided to use the classification based upon the CDC growth charts because this classification is based on samples of children and adolescents from the United States, from which our samples were drawn. In the United States, the prevalence of overweight is 17.1% among children aged 2-19 years (2003-2004).[35] These data indicate the higher prevalence of overweight, relative to underweight, in the United States. Furthermore, its prevalence is increasing around the world.[29] For these reasons, though we will discuss some behaviors that may be related to underweight, majority of this dissertation will focus on the prevention of overweight.

Short-term problems associated with childhood overweight

Overweight in childhood is associated with a number of short-term health consequences. Mental health consequences include reduced health-related quality of life, reduced self-concept, depression, and disordered eating behavior. Functional limitations and self-reported poor general health have been associated with overweight and obesity (defined as BMI >97th percentile) among American adolescents.[36] Inverse associations between BMI and overweight with self-concept have also been observed among children and adolescents.[37, 38] Findings from a large population based study, indicated a relationship between depressed mood and the development of obesity one-year later.[39] Disordered eating is one of several unhealthy weight-related behaviors, and is linked to both body dissatisfaction and depression.[40-42] Disordered eating behaviors typically have their onset during puberty and range from skipping meals and fasting; to the use of the use of supplements, diet aids, or laxatives; to self-induced vomiting.[24, 43, 44] The latter two behaviors are generally recognized as early warning signs of symptoms of anorexia or bulimia, but they can also occur independently of these disorders. Ironically, extreme caloric restriction and other disordered eating behaviors have been linked to weight gain among adolescents.[45-47]

Short-term physical health consequences of childhood overweight include insulin resistance, elevated blood pressure, and adverse lipid profiles. The evidence base for the relationship between weight gain and overweight and adverse metabolic and cardiovascular risk profiles is strong. Prospective studies and clinical trials have both demonstrated positive relationships between weight gain and decreases in insulin sensitivity, and increases in blood pressure and blood lipids.[6, 48-50]

Long-term problems associated with childhood overweight

Overweight during childhood and adolescence has also been linked to several morbidities during adulthood. These include overweight and obesity, metabolic syndrome, diabetes, and cardiovascular disease.[51-53] For instance, the relative risk of adult overweight (BMI between 25-30 kg/m^2) among children who were at risk for overweight (BMI between the 85-95th percentiles for age and sex) between the ages of 5-14 years has been estimated at 7.0 relative to adults who were not at risk for overweight (BMI < 85th percentile).[51] The risk of being overweight or obese in adulthood among overweight children and adolescents increases with age.[51, 54] Furthermore, having at least one overweight parent compared to neither parent being overweight is associated with childhood overweight, and further increases the risk of remaining overweight in adulthood.[55] Conditions that may be associated with childhood overweight, e.g., childhood cardiovascular risk factors, have also been associated with adverse health outcomes in adulthood. For example, elevated blood pressure in childhood has been related to an increased risk of hypertension in adulthood.[56] Likewise, low HDL-cholesterol levels and abnormally high triglycerides, LDL-cholesterol, and total cholesterol have been linked to dyslipidemia, stroke, and other cardiovascular diseases in adulthood.[57-59]

Prevention of these problems

The first steps in prevention of the health problems associated with childhood obesity are to carefully describe them, and to identify their correlates and predictors. Preventing overweight, elevated blood pressure and cholesterol levels, and disordered eating practices, is particularly important because these conditions and antecedents of these conditions are relatively stable over time.[56, 59] What this means is that, by preventing these problems in childhood, we may also prevent their adult equivalents.

Several non-modifiable factors have also been associated with overweight, including birth weight, puberty and pubertal timing, race, and genetics. Infants born small for gestational age, who also undergo rapid increases in weight (standard deviation score > 0.67 kg between 0 and 6 months or between 3 and 6 years), are at an increased risk for overweight in childhood.[60-62] Infants born large for gestational age are also at an increased risk for childhood overweight and other morbidities later in life, independent of adult weight.[12, 16, 61, 63] As described previously, the onset puberty is accompanied with increases in percent body fat, particularly in females.[64] Pubertal timing has also been related to higher adiposity among females who mature early, compared to their peers who enter puberty later.[49, 64, 65] Black youth, relative to whites, are more likely to become overweight during childhood.[66-68] This association has been attributed to differences in body composition, lower resting energy expenditure, and earlier puberty.[67, 69, 70] However, an independent effect of race has been demonstrated even after these factors have been accounted for.[67, 69] The development of overweight is also thought to be influenced by genetics.[71, 72] For instance, female children with an overweight mother were shown to be nearly 3 times more likely to be overweight than those with a mother who was not overweight.[72]

Behavioral factors, such as physical activity, television viewing, and dietary habits, have also been related to weight gain and overweight among youth. In particular, physical activity and participation in sports have demonstrated a protective effect with regard to increases in BMI and measures of body fat.[72-76] Conversely, television viewing has been related to weight gain and increases in adiposity.[73, 74, 76-79] Dietary factors, including snacking, dieting, and disordered eating behaviors, have also been related to weight gain and overweight among children and adolescents.[79-83] The evidence in support of the relation of physical activity, TV viewing, and dietary behaviors to overweight is substantive, though not unequivocal.[78, 84-86]

Overweight and excessive weight gains are the most widely supported correlates of elevated cholesterol and blood pressure levels in youth.[4-7, 76, 87-89] Other factors that have been associated with CVD risk factors among children and adolescents include birth weight, race, gender, puberty, and height.[11, 14, 16, 17, 48, 49, 90, 91] Similar to the development of overweight, infants born small for gestational age who undergo rapid weight gains during infancy have higher blood pressures in childhood.[12, 60] Rapid weight increases that are not associated with catch-up growth have also been related to blood pressure and cholesterol in adolescence.[60] It is widely accepted that the prevalence of hypertension is higher in Black adults than in whites.[92, 93] Research suggests that these differences begin in childhood and persist into adulthood.[11, 14, 91] Research has also shown larger increases in systolic blood pressure among black children compared to white children.[14, 91] Puberty is marked, not only by increases in body fat, but also by increases in blood pressure among males and females.[11, 94] Additionally, changes in height have also been related to increases in blood pressure.[11, 95] Conversely, growth has been related to decreases in lipoproteins among children and adolescents.[17] Physical activity and to a lesser extent, TV viewing, have also been linked to CVD risk factors, independently of adiposity.[96-100]

There are a number of shared risk factors for the development of overweight and disordered eating behaviors. Both have been linked to dieting, maternal weight concerns and behaviors, weight-teasing by family members or peers, exposure to magazine articles on weight loss, body dissatisfaction, and overweight status.[46, 82, 101-103] Other correlates of disordered eating and overweight are pubertal development and timing of puberty, involvement in activities emphasizing weight or shape, and emotional factors.[43, 104-107] Correlates of supplement and steroid usage are similar to those of other disordered eating behaviors, including body size dissatisfaction and being a football player.[108, 109] Participation in sports has also been related to increased disordered eating behaviors, particularly among youth participating in sports where weight or body size is emphazsized.[105, 106]

The common denominator – physical activity

Different domains of physical activity have been linked to the health outcomes and behaviors presented in this review. Habitual physical activity has been associated with adiposity, overweight, blood pressure, and blood cholesterol levels. While sports participation has also been associated with reduced body weight, this dissertation will focus on its association with disordered eating to control weight.

Physical activity, television viewing, and adiposity

Longitudinal studies of incident overweight and obesity in children provide support for a relationship between the development of overweight and physical activity and "screen time" (television viewing, videos, and video games).[78, 110] Several prospective studies have examined the association of childhood physical activity and TV viewing with adolescent or adult BMI, BMI z-score, and percent body fat. Many of these studies have found significant associations between childhood physical activity [74, 111, 112] or TV viewing[112] and measures of body composition and adiposity in adolescence or adulthood, others have not.[74, 78, 84] Longitudinal studies describing changes in BMI and adiposity have suggested a positive association between TV viewing[113-115] and screen time[116] and change in BMI or body fat. There is also evidence to support an inverse relationship between physical activity and change in BMI or body fat.[117, 118] While informative, several of these studies were conducted only among females [74, 111, 113, 114] and few examined changes in the percentage of body fat. In only one study did the researchers simultaneously adjusted analyses for pubertal status and change in height (growth). To determine whether there is an independent association between changes in BMI and percent body fat and physical activity and TV viewing, these factors must be accounted for. Studies should also be inclusive of males and females of various ages.

Physical activity and cardiovascular disease risk factors

Collectively, cross-sectional studies have supported the existence of inverse associations between physical activity and diastolic and systolic blood pressure, total cholesterol, triglyceride, and positive associations with HDL.[98, 119] Some have found that associations differ by gender. In a cross-sectional study of Finnish children, physical activity was associated with HDL in males only and with TG in males and females.[97] Relations to blood pressure and triglycerides to physical activity have been observed independently of fitness, even though fitness has been touted as a better predictor of cardiovascular risk than physical activity.[120, 121] The most obvious limitation of these studies are their inability to assess temporality of associations, though this is probably less of an issue than when describing correlates of adiposity and overweight.

There have been relatively few studies of physical activity and changes in CVD risk factors. Much of the research that is available on the topic has been conducted in children with elevated risk factor levels or obesity.[122-124] Two of these studies found a significant association between physical activity and systolic pressure;[122, 123] in the remaining study, decreases in DP, TG, and TC/HDL were associated with activity.[124] Many of the studies of childhood physical activity and childhood health haven taken place over a short period of follow-up.[125-127] It is reasonable to believe that any effect of physical activity on measures of CVD risk would occur in a relatively short amount of time. However, when the effects of growth and maturity are considered, studies lasting for only 1-2 months may not have been long enough to observe effect, particularly in apparently healthy youth.

Overwhelmingly, studies of childhood physical activity on adult CVD risk factors and outcomes have shown null findings. [128-131] In studies, reporting significant findings, some associations have been in unexpected directions.[129, 130] For instance, Hasselstrom et al. (2002) noted a positive correlation between physical activity during adolescence and systolic blood pressure in young adulthood. It seems more likely that physical activity during childhood and adolescence influences childhood health, which then impacts adult health.

Sports participation and disordered weight-management practices

With regard to weight-related issues (i.e. body image and perception, weight-change intentions, and weight-management practices), both positive and negative effects of sports participation have been observed. For instance, in a descriptive study using the 1997 YRBS data, Pate et al. (2000) demonstrated that male sports participants had lower odds of trying to lose weight compared to non-participants; intentions to maintain or gain weight were not considered in this analysis. The authors reported no differences in the proportions of sports participants and non-participants with regard to vomiting or the use of diet pills to lose weight. The proportion of white female sports participants who reported having ever used an anabolic steroid was lower than that of their peers who were not involved in sport. The opposite was true among Hispanic females involved in sports. Two years later, a subsequent examination of YRBS data also indicated no effect of sports team membership on abnormal eating or weight control behavior, defined as fasting, using diet pills, self-induced vomiting or laxative use to control weight in the past 30 days.[132] Both of these studies used nationally representative data, but neither was inclusive of the range of weight-related intentions or weight-management behaviors. In the latter study, the authors only reported bivariate associations, with no regard for race, sex, or age. Studies conducted in smaller groups of adolescents have indicated that sports participants are not at an increased risk for disordered eating behaviors when compared to non-participants.[133, 134]

There are also studies that describe a range of negative weight-related perceptions and behaviors among sports participants. Based on studies describing weight-related issues in samples consisting of only sports participants, it appears that youth involved in weight-related sports (i.e. those sports where it is important to achieve or maintain a certain weight for competition, such as wrestling and ballet) are at an increased risk of being dissatisfied with their bodies, trying to lose or gain weight, and engaging in disordered eating practices.[105, 106] Vertalino et al. (2007) have recently described the prevalence of various unhealthy weight-control behaviors among youth involved in weight-related sports compared to those not involved in sports of this nature. Males involved in weight-related sports had more than five times higher odds of self-induced vomiting in the past week compared to their non-participating peers; a two-fold higher odds ratio was observed among female participants in weight-related sports. Similarly, laxative use in the week prior to the survey was associated with weight-related sports participation among males. The authors also collected information on the participants' use of vomiting, diet pills, laxatives, or diuretics in the past year to control their weight. While similar associations were observed between this dependent measure and participation in a weight-related sport, it was apparent that the prevalence of past-year use was higher than past-week use. This is suggestive either of a transient nature of these behaviors or experimentation. Nonetheless, earlier studies of cheerleaders, dancers and skaters have reported similar findings.[135, 136] In one of the few analyses that has described associations between weight-related behaviors and participation in any sport, a positive correlation was found between sports participation and the use of steroids, prohormones, and ephedrine and symptoms of muscle dysmorphia.[137] This study was conducted in a sample of adolescent boys *(n=269).* In multivariate analyses, adjusted for BMI, self esteem, negative affect, and other interpersonal and social factors, only sports participation and tendencies toward muscle dysmorphia had odds ratios indicating a positive association with lifetime weight-control substances. A major limitation of this study is that it included only male participants, and the findings are most likely not generalizable beyond the study sample. Also, the dependent measure was lifetime substance abuse, which does not allow for the assessment of whether the participant was currently using one of the substances of interest. This is an important distinction because research suggests that the use of legal and illegal substances to control weight may be transient.[106] Most of these studies do not draw comparisons between sports participants and non-participants; instead the bulk of the research on weight-related intentions and behaviors among sport participation is limited to analyses of specific sports. While this is informative, it increases the difficulty of deciphering the impact of sports participation on weight-related issues relative to non-participation.

Summary

With regard to studies of adiposity and CVD risk factor development among children and adolescents, there is evidence to suggest an effect of physical activity and TV viewing on both. In general, studies on this topic have been limited by poor measurement of activity and TV viewing behaviors, short follow-up time, and failure to account for factors such as growth and pubertal development. Furthermore, little is known about the relation between physical activity and changes in adiposity and CVD risk factors over a relatively short period of time. In light of the stability of these measures over time, prevention of adverse changes in adiposity, blood pressure, and blood lipids during childhood may ultimately have a notable impact on adult health.

Developmental changes during adolescence, which are marked by increases in personal agency and decision-making, make this an important time in the development of behaviors that may persist into adulthood as well. During this time, youth also seek the approval and advice of their age-peers. Personal appearance is particularly important during adolescence, as teens are increasingly weight-conscious. In light of the changes in body composition that occur during puberty, it is not surprising that disordered eating behaviors have been documented among adolescents. These behaviors are feared to be more prevalent among sports participants because in addition to the issues of peer acceptance, they also have to contend with expectations surrounding performance and competition. Few studies, however, have documented the prevalence of disordered eating behaviors among sports participants, relative to their peers who are not involved in sport. Even fewer studies have documented correlates and predictors of disordered eating in this population. Given the widespread participation in sport in the United States and the unique weight-related concerns among sports participants, it is important to identify predictors of deleterious weight-management strategies, including disordered eating behaviors in order to inform preventative efforts in this population.

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Chapter 3

Methods

The specific objectives of this study were to: (1) assess associations between moderate-vigorous physical activity and TV viewing and annual changes in BMI percentile and percent body fat; (2) examine the relation of weight maintenance and weight gain in children and adolescents to changes in cardiovascular disease (CVD) risk factors; (3) investigate the existence of associations between moderate-vigorous physical activity and TV viewing and changes in systolic blood pressure, diastolic blood pressure, LDL-cholesterol, HDL-cholesterol, and triglycerides; (4) describe the prevalence of intentions to lose, gain, and maintain weight; perceived body size; and participation in various weight-management practices, including disordered eating behaviors in sports participants and non-participants; (5) describe correlates of intentions to lose, gain, and maintain weight; perceived body size; and participation in various weight-management practices in sports participants.

Data from three studies were used to conduct these analyses. Secondary analyses of data from Project HeartBeat! were used to assess BMI percentile, body fat percentage, and cardiovascular disease risk factors. Secondary analysis of national survey data from the Youth Risk Behavior Survey (2005) was used to describe weight-related intentions, perceptions, and behaviors among adolescent sports participants and non-participants. Survey data collected in Muscogee County, Georgia were used in analyses of correlates of weight-management intentions, perceptions, and behaviors among sports participants. All statistical analyses were conducted using SAS version 9.1 (SAS Institute, Cary, NC) and SPSS version 16.0 (SPSS, Inc., Chicago, IL).

General Considerations

Adequate validity and reliability of study parameters is required in order to make inferences about the associations/relationships between variables of interest within a study population. Validity is a measure of how well data represent “truth”, i.e., accuracy. Though there are several types of validity that should be considered, they can be grouped into measures of internal validity and external validity.[1] Internal validity deals with the integrity of the data within the study population, while external validity is an indication of generalizability of the findings to populations other than the population under study. The most common threats to validity include selection bias, confounding, and misclassification bias. In all analyses presented in this text, we have attempted to minimize these issues. For example, we reported any differences observed between the original study sample and the analytic sample after applying the exclusion criteria. In addition to including potential confounders in multivariate analyses, we also include the baseline value of the outcome to account for any other possible confounders that we were unable to control. In Project HeartBeat!, all biological variables were carefully measured by trained staff and underwent regular quality assurance procedures to reduce measurement error and misclassification. Physical activity and food intake were recalled by the participants, increasing the possibility for reporting error (i.e., recall bias). Guided interviews were conducted in an effort to minimize inaccurate recall. Analyses to examine the validity of these data were also conducted (unpublished data);[2] a more detailed description of the methodology used to gather physical activity and food intake data is provided in the Variable Measurement section of this chapter.

Reliability is a measure of the reproducibility of data, i.e., precision.[3] Reliability can be measured in a variety of ways. Common methods include comparing measures as recorded by two different raters/observers (inter-rater reliability); comparing measures reported at two different times by the same respondent (test-retest); and assessing the consistency of items included together on a survey/questionnaire (internal consistency). It is important to note that in order for a measurement to be valid, it must have adequate reliability.

Project HeartBeat!

Project HeartBeat! was a longitudinal study of cardiovascular risk factor development in children and adolescents conducted by the University of Texas School of Public Health

Epidemiology Research Center. Three cohorts of children aged 8, 11, and 14 years at entry into the study (n=678) were observed over a 4-year period (October 1991-August 1995) to assess the natural course of development of cardiovascular disease (CVD) risk factors. Extensive assessments of risk factors were conducted three times per year at 4-month intervals by trained staff. Equipment used to measure body composition and CVD risk factors were calibrated at least weekly.

Study Setting

Children participating in Project HeartBeat! resided in either The Woodlands or Conroe, Texas. The Woodlands is a planned community with a population that was 92% white, 4% Hispanic, 2% Black, and 2% other race/ethnic groups at the beginning of the study. Conroe's population was 75% white, 13% black, and 12% other race/ethnic groups (includes Hispanics). Middle- to upper-income strata were typical of The Woodlands, while lower- to middle-income strata were more typical of Conroe. Participants were recruited to participate with the assistance of local health departments, school districts, churches, and community agencies. Black children were over-sampled and comprised about 20% of the overall study population; the remainder of the participants was mostly white.[4] Specific exclusion and inclusion criteria for each analysis are listed in each chapter.

Variable Measurement

Body Composition. Height, weight, and several other anthropometric measures were taken every four months while the participant wore scrubs. Height was measured to the nearest 0.1 centimeter, and weight was measured to the nearest 0.1 kilogram. Measurement equipment was checked and calibrated on a daily and/or weekly basis. BMI was calculated using the following formula: weight/height^2 (kg/m^2) and age- and sex-specific percentiles were derived using the growth charts published by the Centers for Disease Control and Prevention.[5] These percentiles were created using data from the National Health Examination Survey cycles II and III (NHES II and NHES III, 1963-65 and 1966-70, respectively) and the National Health and

Nutrition Examination Survey cycles I, II, and III (NHANES I (1971-74), NHANES II (1976-80), and NHANES III (1988-1994)). Data from these nationally representative, cross-sectional surveys were supplemented with data from the United States (1968-80, 1985-94), Wisconsin (1989-94), and Missouri Vital Statistics (1989-94), the Fels longitudinal study (1960-1994), and the Pediatric Nutrition Surveillance System (1975-94) in order to increase representation of certain subgroups. Prior to the generation of the curves, data for NHANES III subjects ages 6 and older were excluded to avoid an upward shift of the weight and BMI curves, which would have led to fewer children being classified as at risk for overweight (85^{th} centile $\leq$ BMI < 95^{th} centile) and overweight (BMI $\geq 95^{th}$ centile). Data for very low birth weight (VLBW, <1500 gm) infants were also excluded because the growth patterns of VLBW infants are very different than infants born at a higher birth weight. Smoothed curves were then generated for 10 percentiles: 3^{rd}, 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 85^{th}, 90^{th}, 95^{th}, and 97^{th}. The 85^{th} and 95^{th} percentiles are of particular relevance to the analyses presented in this dissertation.

Percent body fat was estimated on the basis of anthropometric and bioelectric impedance data using standard methods and the sex-specific prediction equations of Guo et al.[6] Specific skinfolds collected and used in the estimation of body fat were the lateral calf skinfold among males and females; the midaxillary skinfold and arm muscle circumference in males; and the triceps and subscapular skinfolds in females.[6] The correlation between body fat measurements derived by dual x-ray absorptiometery (DXA) or multi-component methods and bioelectric impedance ranges from 0.55 to 0.96.[7] The accuracy of impedance measurements is influenced by factors such as sex, hydration status, and selection of prediction equations.[8] The use of anthropometric (skinfold) data, in addition to impedance estimates, has been shown to improve estimation of body fat via impedance methodology. Findings of a study (age range: 7-25 years) conducted using the same prediction equations used in our analyses indicated coefficients of variation (CV) of 5.02 among males and 5.80 among females.[6] The coefficient of variation can be interpreted as a unitless measure of variability of an individual variable; it can also be used to quantify error in variables predicted using modeling techniques.[9] Lower values for the CV are indicative of smaller residuals relative to predicted values, suggesting only a small degree of error.

Blood Pressure. Blood pressure was collected every 4 months using standard mercury sphygmomanometers and arm cuffs sized appropriately for the subject's measured arm circumference. An alternative instrument for measuring blood pressure is the random zero sphygmomanometer; however, this instrument has been shown to underestimate both systolic and diastolic blood pressure.[10, 11] The major advantage to using random zero is the ability to reduce end-digit preference (i.e., the tendency for recorders to round the last digit of blood pressure measurements to 0 or 5) among recorders, but intensive training and ongoing quality assurance should reduce this type of systematic. Furthermore, the tighter cuff and longer period of inflation associated with using the random zero sphygmomanometer might be unacceptable when dealing with young populations.

Baseline blood pressure was defined as the mean of 6 measurements from two recorded values at three separate visits within a 2-week period. Subsequent blood pressure measurements were determined as the mean value from 4 measurements obtained at two separate visits because reliability of blood pressure measurements was not largely improved by inclusion of data from a third visit.[12] Korotkoff phases 1, 4, and 5 were measured for each child. For the analyses presented here, phase 1 was used to represent systolic pressure and phase 5 for diastolic pressure based on recommendations of the National High Blood Pressure Education Program.[13] Participants were examined after being seated for at least five minutes. Two measurements were taken, one minute apart from each other. Measurement of blood pressure in children has been shown to be relatively reliable, particularly when repeated measurements are taken and there are multiple observers responsible for these measurements, which was true of this study.[14]

Blood Lipids. Plasma and serum lipid concentrations were also measured every 4 months via standardized protocol.[15] Plasma lipid concentrations were determined in samples obtained by a trained phlebotomist during an in-home interview, after an overnight (8-12 hours) fast. The blood was kept at 4 º C and was separated within one hour of collection. Aliquots were stored at -70 º C until being processed in the Lipid Research Laboratory at Baylor College of Medicine. A Cobas Fara II analyzer was used for the enzymatic process of cholesterol determination. Standards of performance for the intra- and inter-assay required that coefficients of variation not exceed 3%. LDL-cholesterol was calculated using the equation: total cholesterol - (triglyceriges/5 + HDL).[16] The correlation between measured LDL and LDL estimated from this equation was 0.98 among adults with normal lipid profiles.[16]

Physical Activity. A physical activity interview was administered by a trained interviewer once per year to collect information about the subject's activities (both active and sedentary) during the previous 24 hours. Published estimates of physical activity energy expenditure in metabolic equivalents (METS) were used to classify intensity of physical activity into moderate (3-6 METS), vigorous (> 6 METS), and moderate-vigorous (≥ 3 METS) categories.[17] Activities, minutes spent in each activity (total minutes), and minutes spent *actively* participating in each activity (true minutes) were recorded. True minutes were used in all analyses presented in this dissertation. Other minutes were not considered in these analyses because they did not describe time spent actually engaged in activity. Minutes spent watching television were also included in the activity recall. In addition to the amount of time spent watching television, participants were also probed to recall the names of the television shows they had viewed. The physical activity/TV recall was adapted from a 7-day recall instrument modified for use with pre-adolescent children and validated among third and fifth grade children.[2] The correlation between activity measured via accelerometer (Caltrac) and minutes reported on the physical activity interview was 0.63 among 5th graders and 0.47 among 3rd graders.[2] Baseline physical activity and television were used in all analyses in an effort to reduce error in the measure as the standard errors of the measures at any given point in time were large.

Caloric Intake. A 7-day quantified food frequency questionnaire (FFQ) was administered by a trained interviewer to obtain an estimate of the subject's usual consumption of specific foods during the week prior to the interview (137 items). Both frequency of consumption and estimated portion size for the foods were collected to estimate caloric intake.[18] Portion sizes of the foods was estimated using two-dimensional food models and household food models (cups, teaspoons, tablespoons, etc.) as aids. Food-specific and brand-specific standard serving sizes of foods (such as slices of bread, cans of soft drinks, tacos from Taco Bell, etc.) were also used. Data were entered into the Food Frequency Data Entry and Analysis Program (FFDEAP, U Texas) in order to calculate the nutrient and portion size of each food consumed and to produce the summary daily nutrient values. Regardless of the subject's age, it was recommended that the adult who was most involved in food preparation be present for the first interview. Children under 11 years of age were required to have a parent or knowledgeable informant who was involved with food preparation present. The questionnaire was created by Project HeartBeat! investigators specifically for this study population using 3-day food records of children from the targeted communities in grades 5-12.[19] In a study conducted among 90 male and female HeartBeat! participants, the Spearman correlations between energy reported on the FFQ and energy reported on 3-day food records were 0.37, 0.57, and 0.46 among participants in the 8, 11, and 14 year cohorts, respectively (unpublished data). While low, these estimates are consistent with other estimates of energy intake based on FFQ data among children and adolescents.[20]

Maturation and Growth. Sexual maturation was obtained every four months via direct observation. Female participants were questioned about their date of menarche 3 times per year until reaching menarche; after which they were questioned about their menstrual cycles. Secondary sex characteristics, such as growth of pubic hair, breast and genital development, were assessed 3 times per year until Tanner stage 5 was reached on two successive occasions for pubic hair and breasts among females and pubic hair and genitals among males.[21] For the analyses included here, stage of breast (females) and accessory organ (males) development were used.

Tanner staging was collapsed into the following categories for analyses: pre-puberty (stage I); puberty ongoing (stages II-IV); post-puberty (stage V) in order to decrease the degrees of freedom and conserve study power to detect associations.

During childhood and adolescence, there are additional energy requirements for catabolic processes, i.e. growth. As a proxy for growth, the rate of annual height change for each participant was calculated as the slope of the regression lines obtained by plotting each measurement of height against age at the time of measurement. This method allowed for the use of all available data for each participant and should estimate the rates of change more closely than taking the difference between the initial and final measurements.[22]

Race. Race/ethnicity data were collected via questionnaire. Categories available for selection were White, Black/African-American, Hispanic, and Asian, Native American, Alaskan Natives/Pacific Islander). For analyses, the race variable was collapsed into black vs. non-black because the proportion of Hispanics and other racial/ethnic groups in our sample was small. This was also consistent with the recruitment strategy of Project HeartBeat!.[4]

Human Subjects

Analysis of Project HeartBeat! data was exempt from review by the Emory University Institutional Review Board.

Youth Risk Behavior Survey (YRBS)

The YRBS is a survey administered by the CDC and completed by youth in grades 9-12 in classrooms at public, parochial, and other private schools, selected from among all fifty states and the District of Columbia. The survey collects data on tobacco use; unhealthy dietary behaviors; inadequate physical activity; alcohol use; sexual behaviors and sexually transmitted infections; and behaviors that contribute to unintentional injuries and violence. Detailed methods for the YRBS have been published elsewhere.[23]

Sampling for inclusion in the YRBS survey administration is complex. In 2005, there were 1261 primary sampling units (PSUs), which are counties, subareas of large counties, and groups of smaller, adjacent counties, that formed the first stage of the sampling frame. Of these, 57 were selected using probability-based sampling based on overall school enrollment size for the PSU. Next, public and private schools with grades 9 through 12 classes were selected from within these 57 PSUs (n=203). Of these, 159 schools participated (school response rate= 78%). Questionnaires were completed by 86% of the sample students (total response rate= 67%). After exclusions due to implausible height, weight, and BMI data and logical inconsistencies, 13,917 questionnaires were available for analysis.

YRBS questions selected for inclusion in our analyses were those pertaining to weight-related perceptions and intentions and weight-management strategies. The test-retest reliability of the 1999 YRBS questionnaire was assessed and has been reported elsewhere [24]. A kappa statistic (κ) is a measure of agreement between the test- and retest-item prevalence estimates. An item is said to have excellent reliability if $\kappa > 0.75$, good reliability if κ is between 0.40 and 0.75, and marginal reliability if $\kappa < 0.40$ [9]. The mean kappa was 0.50 for the dietary behavior items and 0.55 for the physical activity behaviors. Kappa for perceived overweight and trying to lose weight were 0.59 and 0.58, respectively. The kappa statistics for the various weight-management practices ranged from 0.40-0.57; thus all items used in our analyses had good reliability.

Data on the validity of YRBS items, including self-reported height and weight is scant. In a convenience sample of high school students who had completed the YRBS in 1999, the Pearson correlation coefficients between self-reported and measured height and weight were 0.90 and 0.93, respectively.[18] BMI resulting from self-reported and measured height and weight data were also high (r= 0.89). There were differences in the reporting biases among subgroups within the study sample. For example, White students were more likely than students who were Black, Hispanic, or other race/ethnicities to overestimate their height. Females were also more likely than males to underreport their weight. When BMI was categorized based on the CDC growth curves (2000), 71% of participants were classified the same way regardless of whether self-reported or measured height and weight data were used. Information on the validity of the height and weight data from the 2005 YRBS administration has not been published, however, correlations between BMI calculated from measured and self-reported height is generally high among male and female adolescents (range: 0.79-0.93).[25] It is difficult to validate a perception, but it is possible to measure the alignment of a perception and truth. One study found that nearly 51% of normal weight participants (BMI <85th percentile based on measured height and weight) perceived themselves to be "about right"; almost 24% of participants who were at risk for overweight (BMI= 85 - <95th percentile) perceived themselves as overweight; 54% of overweight participants (BMI ≥ 95th percentile) perceived themselves as such.[26] We've found perceived body size to be moderately correlated with BMI (calculated from self-reported height and weight) among males (r= 0.57, 95% CI= 0.56-0.59) and females (r= 0.51, 95% CI= 0.50-0.53) who participated in the 2005 YRBS. Furthermore, 67% of underweight males perceived themselves as such; nearly 70% of normal weight males perceived themselves to be "about right" with regard to body size; nearly 77% of overweight males perceived themselves as overweight (Table 3.1). Among females, 55% of underweight participants identified themselves as underweight; 66% of normal weight females responded that they were "about right"; nearly 90% of overweight females perceived themselves as such. Weight-related intention was also included in several analyses. There was some initial concern regarding whether participants made a clear distinction between trying to maintain their weight versus not trying to do anything about their weight. We were unable to locate any information about the validity (published or through direct communication with staff at the CDC) data on the development of the weight-related intention item. We were, however, able to confirm that, within our sample, male and female participants who reported an intention to maintain weight were, in fact, different than those participants who responded that they were not trying to do anything about their weight on the following factors: perceived body size, dieting to manage weight, exercising to manage weight, and using disordered methods (fasting, vomiting, laxative) to manage weight (Table 3.2). These two groups did not differ with respect to grade level, indicating that the differences are not a result of differences in cognitive ability.

Muscogee County data

Cross-sectional analyses of weight-related intentions, perceptions, and behaviors were conducted using data collected in Muscogee County, Georgia. The sample consisted of high school students who participated in sports screenings required for participation on school-based and community-based sports teams. Questionnaires were completed by the participants and the measurement of height and weight were conducted in one day in July of 2006. The sample consisted of 859 boys and girls between the ages of 13 and 18 years old.

Study Setting

The population of Muscogee County in 2006 was 188,660.[27] The racial makeup of the county was 46.4% White, 46.5% Black or African American, 3.8% Hispanic of Latino, 2.7% from other racial/ethnic groups (Native American, Asian, Pacific Islander, and other races), and 1.7% from two or more races. The median household income was $35,130. The Muscogee County School District contains 64 schools and alternative centers, consisting of 35 elementary schools, 12 middle schools, eight high schools, and nine program centers.[28] The district has approximately 33,000 students ranging from Pre-K through twelfth grade. The sample for this study was derived from this population and its surrounding areas.

Study Design

Participant Enrollment. Participants were junior high and high school students in attendance at a one-day health screening. A health screening and physician approval is required by Muscogee County School District prior to participation on any sports teams. The Hughston Foundation (formerly the Hughston Sports Medicine Foundation) provides these screenings at a reduced cost to participants and their parents as a service to the Muscogee County community.

Prior to the screening, participants and their parents completed a brief medical history form and parents were required to sign consent forms on behalf of their children. Several stations were available at the health screening, which was held at the gymnasium of a local school. These stations included height/weight, blood pressure, vision, fitness testing, and the questionnaire used to obtain information for this analysis. Participants were asked by a Hughston Foundation volunteer to complete the questionnaire and place it face down in a specified box. No incentives were provided to the participants, their coaches, or friends for participation in this study.

Study Questionnaire. Participants completed a five-item questionnaire (Appendix A1) about their weight-related intentions, perceptions, and behaviors. Specific items asked about participants' intentions to lose, gain, or maintain their current body weight; their perceptions of their current weight; their receipt of weight-related advice from a peer and/or adult; the methods they had used in the past 30 days to manage their weight; and their involvement on specific sports teams. Two of these items, weight-management intentions and perceived weight, are currently included in the Youth Risk Behavior Surveillance Survey. The reliability and validity of these items were described in the previous section. The strategy question was also based on a YRBS item but was modified to include two additional response options geared towards weight-gaining behaviors - eat more food, more calories, or foods high in fat; take performance enhancing products, such as creatine or protein. The advice item was created for this study by the researchers; reliability and validity data are not available for this item. This information was matched to sex and age data, which were collected in another survey administered by a staff member or volunteer of the Hughston Foundation.

Physical Measures. Participants wore lightweight t-shirts and gym shorts and were asked to remove their shoes during the height and weight measurements. Height was measured with a freestanding stadiometer to the nearest inch; weight was measured on a portable digital scale to the nearest pound.

Human Subjects. Written consent was obtained from the parents of study participants before the youth received the study questionnaire. Analysis of Muscogee County data was exempt from review by the Hughston Foundation and Emory University Institutional Review Boards.

Table 3.1 Agreement between perceived and measured body size among males and females

	BMI (n=11,997)				
Perception	Underweight	Normal	At risk for overweight	Overweight	*Total*
Males					
Underweight	86 (67.2)	845 (22.9)	33 (3.7)	39 (4.0)	*1003*
Very underweight	20 (15.6)	74 (2.0)	4 (0.4)	16 (1.6)	*114*
Slightly underweight	66 (51.6)	771 (20.8)	29 (3.2)	23 (2.3)	*889*
About right	39 (30.5)	2583 (69.8)	480 (53.7)	190 (19.3)	*3292*
Overweight	3 (2.3)	270 (7.3)	381 (42.6)	754 (76.7)	*1408*
Slightly overweight	1 (0.8)	259 (7.0)	371 (41.5)	612 (62.3)	*1243*
Very overweight	2 (1.6)	11 (0.3)	10 (1.1)	142 (14.4)	*165*
Total	*128*	*3698*	*894*	*983*	*5703*
Females					
Underweight	63 (55.3)	503 (11.3)	30 (2.9)	23 (3.4)	*619*
Very underweight	9 (7.9)	63 (1.4)	4 (0.4)	4 (0.6)	*80*
Slightly underweight	54 (47.4)	440 (9.9)	26 (2.5)	19 (2.8)	*539*
About right	43 (37.7)	2954 (66.3)	256 (24.5)	46 (6.8)	*3299*
Overweight	8 (7.0)	997 (22.4)	761 (72.7)	610 (89.8)	*2376*
Slightly overweight	5 (4.4)	950 (21.3)	681 (65.0)	383 (56.4)	*2019*
Very overweight	2 (2.6)	47 (1.1)	80 (7.6)	227 (33.4)	*357*
Total	*114*	*4454*	*1047*	*679*	*6294*

Values are n (percent).

Table 3.2 Characterization of participants who indicated an intention to maintain weight versus no weight-related intention (i.e., do nothing)

		Do nothing	Maintain	$P > \|\chi^2\|$
Males	N	1153	1197	
	BMI			
	Underweight	2.6, 0.4	1.1, 0.4	0.16
	Normal weight	76.8, 1.9	76.3, 1.5	
	At risk for overweight	12.7, 1.5	14.5, 1.6	
	Overweight	8.0, 0.9	8.1, 1.0	
	Perceived body size			
	Underweight	16.5, 1.5	7.4, 0.7	<0.001
	About right	70.1, 1.9	82.2, 1.4	
	Overweight	13.4, 1.2	10.4, 1.1	
	Strategy			
	Diet	5.1, 0.9	23.0, 1.4	<0.001
	Exercise	28.8, 1.8	62.2, 1.9	<0.001
	Disordered	2.5, 0.7	6.4, 0.9	0.002
	Grade			
	9	30.3, 1.7	29.9, 1.6	0.47
	10	27.3, 1.7	28.7, 1.6	
	11	22.2, 1.7	19.5, 1.2	
	12	20.2, 1.4	22.0, 1.6	

Table 3.2 cont. Characterization of participants who indicated an intention to maintain weight versus no weight-related intention (i.e., do nothing)

		Do nothing	Maintain	$P > \|\chi^2\|$
Females	N	905	1126	
	BMI			
	Underweight	4.2, 0.8	2.8, 0.7	<0.0001
	Normal weight	82.2, 1.8	91.2, 1.3	
	At risk for overweight	9.8, 1.7	5.0, 1.0	
	Overweight	3.8, 0.9	1.0, 0.3	
	Perceived body size			
	Underweight	14.0, 1.5	11.1, 1.2	<0.0001
	About right	71.6, 1.9	84.5, 1.1	
	Overweight	14.4, 1.3	4.4, 0.8	
	Strategy			
	Diet	13.2, 1.2	31.2, 2.1	<0.0001
	Exercise	27.8, 2.3	61.5, 2.6	<0.0001
	Disordered	4.0, 1.0	7.4, 1.1	0.03
	Grade			
	9	26.2, 1.8	29.6, 2.1	0.47
	10	28.0, 1.9	25.1, 1.8	
	11	24.3, 1.8	23.8, 1.6	
	12	21.5, 1.8	21.5, 1.7	

Values are percent, standard error.

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Chapter 4

Associations between weight maintenance and changes in cardiovascular disease risk factors among children and adolescents: Project HeartBeat!

Abstract

The purpose of this analysis was to assess whether weight maintenance was associated with changes in blood pressure and blood lipids among youth. Data from Project HeartBeat!, a longitudinal study of the natural course of cardiovascular disease (CVD) risk factor development among youth residing in Texas, were used for this analysis. Participants were 8, 11, or 14 years old upon entry into the study and underwent measurement of anthropometric indices and CVD risk factors three times per year for a maximum of 4 years. These data included height, weight, systolic (SP) and diastolic blood pressure (DP), total cholesterol (TC), HDL, and triglyceride (TG). Race/ethnicity was also collected. A summary score was created by summing the standardized values of SP, DP, TC, TG, and -1*HDL. Weight maintenance was defined as having a mean change in BMI percentile units (BMIp) within 1 standard deviation of the mean (4.1 body mass index percentile units, BMIp) per year. Weight loss was classified as a reduction of greater than 4.1 BMIp. Weight gainers were those who had an increase of greater than 4.1 BMIp. Generalized linear modeling was used to compare mean changes in blood pressure and blood lipid values across categories of weight maintenance, loss, and gain while controlling for possible cohort effects, race/ethnicity, change in height, and baseline blood pressure or blood lipid. Summary score changes were not significantly different from zero among maintainers (mean= -0.1 units, 95% CI= -0.4, 0.2). On average, summary scores decreased by 0.7 units (95% CI= -1.2, -0.2) among weight losers and increased by 0.8 units among weight gainers (95% CI= 0.3, 1.3). HDL cholesterol decreased by -0.1 mg/dl (95% CI= -0.14, -0.02) among weight maintainers and -0.3 mg/dl (-0.4, -0.1) among gainers, but was no change in HDL was observed among participants who lost weight (0.04, 95% CI= -0.1, 0.2). Differences in mean changes between weight maintainers, losers, and gainers did not reach statistical significance for SP, DP, TC, or

TG. Weight maintenance, loss and gain were differentially associated with changes in CVD risk factor summary score and HDL but not other individual CVD risk factors. It may be important to identify strategies to encourage weight maintenance and loss among youth in order to promote favorable changes in overall CVD risk factor profiles during childhood and adolescence. Additional studies on this topic are needed in more contemporary and diverse populations.

Introduction

Childhood overweight has recently become an important public health issue because of its increased prevalence, as well as its relationship to a number of physical and mental health disorders, which include depression, impaired glucose tolerance, elevated blood pressure, and adverse lipid profiles.[1-4] In the Dietary Guidelines for Americans (2005), it is suggested that a healthy weight be maintained throughout childhood and that overweight children reduce the rate of body weight gain, while allowing for growth and development.[5] Several studies provide evidence in support of the tracking of relative weight from childhood through adulthood.[6-8] Among these is the Bogalusa Heart Study, which has provided a wealth of information on the development of obesity and overweight among children and adolescents into adulthood. In particular, childhood levels of both BMI and triceps skinfolds were associated with adult levels of BMI and adiposity among participants in the Bogalusa Heart Study.[9] The magnitude of these associations increased with childhood age and relative fatness of the children. Thus, maintaining a healthy weight during childhood and adolescence may reduce the risk of overweight and obesity in adulthood, possibly reducing the prevalence of associated co-morbidities among adults in the future.

Indeed, physiologic changes consistent with atherogenesis have been noted in overweight and obese adolescents.[10-12] Cross-sectional and longitudinal analyses utilizing data from the Bogalusa Heart Study have also provided a great deal of insight into these relationships. These studies indicate increased odds of elevated insulin, systolic blood pressure, diastolic blood pressure, total cholesterol, triglycerides, and LDL as well as low HDL among overweight children (BMI > 95th percentile) compared to their non-overweight counterparts.[13] Longitudinal changes in relative weight have also been associated with changes in insulin, lipids, and blood pressure among children and adolescents.[13] Findings from yet another well-known longitudinal study, the Minneapolis Children’s Blood Pressure Study, suggest that weight gain during childhood (<13 years) and adolescence (13-18 years) is significantly related to CVD risk factors (cholesterol, triglycerides, HDL, LDL, and SBP) in early adulthood.[14]

Despite the aforementioned findings and the U.S. Dietary Guidelines recommendations regarding maintenance of a healthy weight, there is scant research on the concept of weight maintenance among children and adolescents. An intensive search of MEDLINE and PSYC INFO did not yield any studies that sought to define or describe weight maintenance among children. Only one study has proposed definitions of weight maintenance and weight loss among adolescents. In this study, definitions of weight maintenance (-1sd≤ change≤+1sd), weight loss (change < -1sd), and weight gain (change > 1sd) were based on deviations from the mean weight z-score, which was derived using the Centers for Disease Control and Prevention (CDC) growth charts.[15] The primary objective of this chapter was to assess the relationship between a similar definition of weight maintenance and weight gain and changes in cardiovascular disease risk factors among children and adolescents who were participants in Project HeartBeat! This chapter also includes a brief discussion of alternatives/options to defining weight maintenance among children and adolescents.

Methods

Project HeartBeat!

Project HeartBeat! was a longitudinal study of cardiovascular risk factor development in children and adolescents conducted by the University of Texas School of Public Health Epidemiology Research Center. Three cohorts of children aged 8, 11, and 14 years upon entry into the study, were enrolled in the study (n=678). These children were observed over a 4-year period (October 1991-August 1995) to assess the natural course of development of cardiovascular disease risk factors. Additional information about the methodology of Project HeartBeat! has been published elsewhere.[16]

Measures

Height and weight were measured every four months while the participant wore scrubs. Measurement equipment was checked and calibrated on a daily and/or weekly basis. BMI was calculated using the standard formula, weight/height^2 (kg/m^2). Age- and sex-specific BMI percentiles were determined using the 2000 CDC growth charts.[17]

Blood pressure was measured using standard mercury sphygmomanometers, and a complete set of standard blood pressure cuffs was available at each station to ensure appropriate cuff selection for each participant. Participants were examined after being seated for at least five minutes. Two measurements, taken one minute apart, were recorded for each participant. Two separate appointments were scheduled within two weeks of the initial examination, for a total of three occasions at baseline. At subsequent examinations, only two blood pressure measurements were required on two occasions one week apart. Systolic and diastolic (Korotkoff phase 5) blood pressure were used in the present analysis. National Heart, Lung, and Blood Institute criteria (2004) were used to classify borderline high (prehypertensive) and high (hypertensive) blood pressure as systolic or diastolic blood pressure greater than the 90th percentile and greater than the 95th percentile for sex, age, and height percentile, respectively.[18] These percentiles are based on data from NHANES 1999-2000 and are widely used in clinical and research settings.

Plasma lipid concentrations were determined in samples obtained by a trained phlebotomist during an in-home interview after an overnight (8-12 hours) fast. The blood was kept at 4 º C and was separated within one hour of collection. Aliquots were stored at -70 º C until being processed in the Lipid Research Laboratory at Baylor College of Medicine. A Cobas Fara II analyzer was used for the enzymatic process of cholesterol determination. Standards of performance for the intra- and inter-assay required that coefficients of variation not exceed 3%. LDL-cholesterol was calculated using the equation: total cholesterol - (triglyceriges/5 + HDL).[19] The National Cholesterol Education Program (NCEP) criteria were used to classify total cholesterol and triglyceride levels as either normal (≤ 75th percentile), borderline high (75th-95th percentile), or high (>95th percentile).[20] Specific cutpoints are listed in Appendix B1.

Pubertal status was assessed via direct observation by trained personnel 3 times per year using Tanner Stage until stage 5 was reached on two successive occasions for pubic hair and breast development among females and pubic hair and accessory sex organ (genital) development among boys.[21] For this analysis, stage of breast (females) or genital development (males) was used to describe sexual maturation. These measures were collapsed into three categories: prepubescent (stage I), pubescent (stages II-IV), and post-pubescent (stage V).

Race was obtained from a questionnaire completed by caregivers at baseline. Race/ethnicity categories included in the questionnaire were White, Black/African-American, Hispanic, Asian, and Native Americans, Alaskan Natives, and Pacific Islanders). The race variable was collapsed into black vs. non-black because the proportion of Hispanics and other racial/ethnic groups in our sample was small.

Exclusion criteria and missing data

The initial sample consisted of 678 males and females. Participants were excluded based on the following criteria: having fewer than 3 measurements of height, weight, blood pressure, and blood lipid data (after baseline measure was deleted, n=101). The analytic sample consisted of 577 participants. Compared to the original study population, mean baseline values of age (t= 0.29), systolic blood pressure (t= -1.04), diastolic blood pressure (t= 0.05), total cholesterol (t= 0.59), HDL-cholesterol (t= 0.57), and triglycerides (t= -0.68) did not differ significantly between the initial sample (i.e., prior to exclusions) and the analytic sample. Distributions of sex and race did not differ between the initial and analytic samples.

Statistical analyses

All analyses were conducted using SAS version 9.1 (SAS Institute, Cary, NC) and SPSS Base 16 (SPSS, Inc., Chicago, IL). Unadjusted means and 95% confidence intervals were calculated for each variable of interest.

Receiver Operator Characteristic Curves. Receiver operator characteristic (ROC) curves were generated to determine if change in BMI or change in BMI percentile was a more sensitive indicator for developing a high blood pressure or blood lipid value at final measurement, given a normal or borderline baseline value. Curves were not plotted for blood pressure change because there were no participants with high diastolic pressure at final measurement, and only 2 participants had high systolic pressure at the time of final measurement. Instead, a summary variable was created with a value of 1 if at least one of the blood pressure or blood lipid values was high at final measurement and a value of 0 otherwise. Sensitivity and specificity were calculated using standard formulas: sensitivity= true positives/all participants with disease; specificity= true negatives/all participants without the disease. Sensitivity vs. 1-specificity were plotted for BMI and BMI percentile change ranging from 0.1 to 20.

Definition of weight maintenance. Change scores for age- and sex-specific BMI percentile, height, blood pressure, and blood cholesterol were calculated for each participant with at least three measurements for each variable. The respective change scores were defined as the slopes of the regression lines obtained by plotting each measurement of BMI percentile, height, systolic blood pressure, diastolic blood pressure, triglycerides, LDL, and HDL by age, after removal of the baseline value. This method allowed for the use of all available data for each participant who met the inclusion criteria and should estimate the rates of change more closely than simply taking this difference between the initial and final measurements.[22] The use of regression generally produces unbiased estimates and also allows for the estimation of error. Removal of the baseline values should reduce the inherent correlation between change scores and the respective baseline values. A summary score was created by summing the standardized values of SP, DP, TC, TG, and -1*HDL. Distributions of BMI percentile change were examined for discontinuities in the data that might be suggestive of natural cutpoints. No such discontinuities were observed, and the distribution was approximately normal. As a result, we defined weight maintenance as having a BMI percentile change within one standard deviation of the mean change for this sample, which was equal to 4.1 BMI percentile units. This definition was consistent with the categorization of weight loss, weight maintenance, and weight gain among adolescents in a study by Boutelle et al.[15]

Multivariate analyses. Generalized linear models (PROC GLM) were used to test the significance of associations between weight maintenance (versus weight gain) and mean changes in blood pressure and plasma lipid concentrations, while adjusting for sex, cohort, black race, change in height, baseline blood pressure or lipid values, and length of follow-up. Initial models were also adjusted for pubertal stage at baseline, but there was no evidence of confounding by pubertal stage in models describing any of the outcomes of interest (i.e., means were essentially unchanged upon removal or inclusion of pubertal stage in the linear models). Thus, in favor of a more parsimonious model, pubertal stage was not included in the presented analyses. Additionally, interaction terms between weight change/maintenance and the following covariates were tested for significance using backwards elimination procedures: sex, cohort, and race. None were significant, so only naïve models were included in analyses. The presence of collinearity among independent variables and covariates was ruled out by examining variance inflation factors; all were less than 5.

PROC GLM was used to determine if there were significant differences in mean changes in BMI and BMI percentile by final CVD risk factor status (normal-borderline high vs. high). Though the "outcome" variable was continuous and the "exposure" was categorical, PROC ANOVA was not used because an assumption of the ANOVA procedure is a balanced design (i.e., data has an equal numbers of observations for every combination of the classification variable). Our data failed to meet this assumption, so the GLM procedure was used because there is no expectation of a balanced design. Least-square techniques are also robust, and the resulting estimates are unbiased with minimum variance when assumptions of normality are met, even in the presence of missing data and confounding. Use of this procedure also allowed for the computation of estimates of the outcome variables after adjustment for covariates (i.e., covariates were held constant at their mean values).

Results

Sample description. The analytic sample was equally comprised of males and females

(Table 1). Nearly 50% of the participants were 8 years old at the time of their initial visit. This may be a result of the over sampling of 8 year olds in anticipation of losses to follow-up/withdrawals. Despite attempts to also oversample Black children, only 19% of the sample was a part of this racial/ethnic group. Among participants in the analytic sample, the incidence of low HDL was 5%. The incidence of high triglycerides was 12% (data not shown).

ROC curves. BMI performed slightly better as an indicator of high blood pressure or lipid values at final measurement than BMI percentile when changes were small, but it appeared that the sensitivity of BMI percentile was a more appropriate measure to use when changes were larger (Appendices B2, B3, B4). Neither BMI nor BMI percentile change, however, appeared to be a good indicator of progression to high blood lipid values.

Differences in sociodemographic characteristic among BMI percentile change groups. A smaller proportion of males were classified as weight gainers ($\bar{x}$= 38.0%, 95% CI= 26.7-49.3%), as opposed to weight maintainers ($\bar{x}$= 50.1%, 95% CI= 45.4-54.8%) or losers ($\bar{x}$= 61.0, 95% CI= 50.1-71.9%). Conversely, there were a greater proportion of female gainers ($\bar{x}$= 62.0%, 95% CI= 50.7-73.3%) than weight maintainers ($\bar{x}$= 49.9%, 95% CI= 45.2-54.6%) or losers ($\bar{x}$= 39.0%, 95% CI= 28.1-49.9%). With regard to age and cohort, there were no significant differences in the proportion of weight change/maintenance among participants in the 8- and 11-year cohorts. But a higher proportion of participants who lost weight ($\bar{x}$= 39.0%, 95% CI= 27.8-49.9%) were in the 14-year cohort than weight maintainers ($\bar{x}$= 22.6%, 95% CI= 17.9-27.3%) or gainers ($\bar{x}$= 14.1%, 95% CI= 12.8-25.6%). Only two participants classified as weight losers were Black.

Differences in baseline and change variables among BMI percentile change groups. Weight gainers ($\bar{x}$= 41.8, 95% CI= 37.1, 46.5) had lower baseline BMI percentile values than weight losers ($\bar{x}$= 54.9, 95% CI= 50.0, 59.7) and maintainers ($\bar{x}$= 61.7, 95% CI= 58.8, 64.5). Weight gainers ($\bar{x}$= 54.0, 95% CI= 52.4, 55.7) had lower baseline diastolic blood pressures than weight losers ($\bar{x}$= 58.6, 95% CI= 56.7, 60.5) and lower baseline triglyceride ($\bar{x}$= 69.9, 95% CI= 64.1, 75.8) and summary score ($\bar{x}$= -0.8, 95% CI= -1.4, -0.2) values than maintainers ($\bar{x}$= 81.0, 95% CI= 77.1, 85.0) and $\bar{x}$= 0.1, 95% CI= -0.2, 0.3, respectively). On average, a reduction in HDL was observed among weight gainers ($\bar{x}$= -0.2, 95% CI= -0.3, -0.1) compared to no significant change among weight losers ($\bar{x}$= 0.1, 95% CI= -0.01, 0.3).

Multivariate analyses. In adjusted analyses, mean change in summary score was higher among participants who gained weight ($\bar{x}$= 0.8, 95% CI= 0.3, 1.3) compared to those who lost ($\bar{x}$= -0.7, 95% CI= -1.2, -0.2) or maintained ($\bar{x}$= -0.1, 95% CI= -0.4, 0.2) weight (Table 2). Similarly, decreases in HDL were greater among weight gainers ($\bar{x}$= -0.3, 95% CI= -0.4, -0.1) compared to participants who lost weight ($\bar{x}$= 0.04, 95% CI= -0.1, 0.2). There were no significant differences between males and females with regard to mean changes in any of the risk factor variables or summary score. Changes in summary score, systolic blood pressure, total cholesterol, and triglycerides were higher among participants in the 8 y cohort than participants in the 11 y cohort. Additionally, mean changes in diastolic blood pressure, total cholesterol, and HDL-cholesterol were higher among 8 year-olds than 14 year-olds. Black participants had larger decreases in triglycerides than non-Black participants. No significant differences in changes in other CVD risk factors were observed between Black and non-Black participants. Models describing changes in summary score and HDL accounted for 26% and 22% of the variance in these variables, respectively.

Sensitivity analysis. To determine if there was an added benefit of maintaining a BMI lower than the 85^{th} percentile for age and sex with regard to short-term changes in cardiovascular disease risk factors, we restricted the sample to participants with baseline BMI values greater than the 5^{th} percentile but lower than the 85^{th} percentile (n=420). "BMI Gain" was then defined as having a BMI at or above the 85^{th} percentile at final measurement *or* having a BMI percentile increase greater than 1 s.d. (i.e., 4.1); "BMI Maintenance" was defined as having a BMI less than the 85^{th} percentile at final measurement *and* a change in BMI percentile between -1 s.d. and +1 s.d. The definition for "BMI Loss remained the same, i.e., < -1 s.d. There were no observable differences in associations between changes in cardiovascular disease risk factors and BMI change/maintenance among participants with BMI < 85th percentile at baseline and those with BMI's above this threshold at baseline. As a result, the analyses presented here were conducted using the entire sample, and categories of weight maintenance and weight loss were based on BMI percentile change, with no restrictions placed on baseline or final BMI values.

Discussion

The primary objective of this chapter was to assess whether weight maintenance among children and adolescents is inversely associated with changes in blood pressure and blood lipids. We found that when weight maintenance is defined as having a mean annual change in BMI percentile within ± 1 s.d. (i.e., 4.1 units) and weight loss and weight gain are defined accordingly, an association exists between weight maintenance/change and changes in summary score and HDL.

In comparison to a study of over 1700 adolescents ages 16-18 by Boutelle et al.,[15] we observed mean weight changes that were 5.2 and 3.1 lbs higher among female and male maintainers, respectively. The analysis by Boutelle et al. used data from the NHANES 1999-2000 and 2001-2002, including a weight history questionnaire, to gather information about one-year self-reported weight changes among participants. Our study, however, included males and females who were 8, 11, and 14 years old at their initial examinations, and it is expected that younger children would have larger annual increases in weight than older adolescents due to growth. Based on the authors' reports of a high (r=0.96) correlation between self-reported and measured weight, it is unlikely that the use of self-reported weight in the NHANES study in comparison with our use of measured weight contributed to the observed differences. It is, however, noteworthy that our definition of weight maintenance was based on changes in BMI percentile versus weight z-scores. A major advantage of our approach is that changes in height were factored into the calculation of BMI percentile changes, while the use of weight does not allow for this adjustment. This is especially important when considering body composition changes among youth across a wide age range.

More than 10 years ago, Himes and Dietz[23] suggested that an annual increase of more than 2 kg/m^2 may be associated with health risks. In our sample, a 4.1 unit increase in BMI percentile (i.e., 1 s.d.) was comparable to an increase of about 0.6 kg/m^2 per year and was associated with decreased HDL. Furthermore, our findings were similar among participants who maintained a BMI lower than the 85th percentile in addition to having a BMI percentile slope lower than 4.1 units during the study period. This suggests that, over a relatively short period of time, maintaining one's BMI percentile is more important for the prevention of adverse changes in cardiovascular disease risk factors than staying below a defined threshold. This is not to suggest that achieving and maintaining a BMI lower than the 85th percentile (or < 25 kg/m^2) is not an important and appropriate goal for children and adolescents, as the tracking of BMI through childhood and adolescence and into adulthood has been well established.[6-8] Additionally, BMI at or above the 85th percentile is associated with pre-hypertension (systolic or diastolic blood pressure greater than the 90th but less than the 95th age- and sex-specific percentile), hypertension (systolic or diastolic blood pressure $\geq 95^{th}$ percentile), low HDL (<35 mg/dl), and elevated triglycerides (>110 mg/dl) among children and adolescents.[24-26]

It is understood that the results of these analyses are largely dependent upon the choice of definition for weight maintenance. There were several reasons we chose to use this definition in lieu of other possible options. First, despite the fact that our data suggest that change in BMI is more closely related to the development of elevated blood lipids (HDL and triglycerides) than change in BMI percentile, it seems that this observation is only true at smaller levels of change. The ROC curves for BMI change and BMI percentile change began to converge as respective change scores increased. Additionally, BMI percentile change is intuitively the preferred measure among children and adolescents because sex, age, and changes in height are taken into account. Furthermore, unlike standard definitions for overweight and obesity among adults, criteria for raw BMI (i.e., BMI measures that are not standardized to a reference population) that have been used in the literature are highly variable. There are however, widely recognized and used definitions of overweight and risk of overweight among children and adolescents which are based on BMI percentile. Because the reference growth charts that are used to assess BMI percentiles are organized by sex and age, it is possible to account for expected height and weight increases as youth age.

Rather than use change in BMI percentile, change in weight could have also been used, as weight is easy to measure and easily understood by the general population. It is not, however, suitable for measuring weight maintenance among children and adolescents. Weight without any information with regard to height or age is meaningless when describing healthy development and growth. Raw weight also fails to account for increases in weight that accompany growth.

Yet another alternative to the approach used in these analyses would have been based on definitions of risk for overweight and overweight, rather than a sample distribution. Weight maintenance could have been defined as having a BMI less than the 85th percentile for age and sex at baseline and final measurements. Having a BMI greater than or equal to the 85th percentile has been associated with prehypertension[24-26], hypertension[25], low HDL[25], and elevated triglycerides[25] among children and adolescents. Additionally, associations between at risk for overweight and elevated total cholesterol and borderline high LDL have been demonstrated among male eight graders.[25] There are, however, inherent problems with this definition of weight maintenance, including failure to distinguish between youth who undergo small increases in BMI and those who have large increases in BMI but do not achieve a BMI greater than or equal to the 85th percentile. A closely related alternative would have been to define weight maintenance as having a BMI less than the 95th percentile at baseline and final measurements. The major disadvantages of using this definition are similar to those described for the aforementioned definition. An additional problem with this definition is that the 95th percentile may not identify youth who are at risk for persistent overweight early enough to intervene. There is also a lack of congruence between adolescent and adult definitions of overweight and obesity. The following example of this discontinuity has been presented by Gordon-Larsen et al.[r27]: an 18-year-old female with a BMI of 30.2 would not be considered overweight because her BMI is less than the 95th percentile. But if she were to remain the same weight and height, at the age of 21, she would be classified as obese by the adult standards. For these reasons, we believe the definition used here was a good starting point for looking at weight maintenance in a sample of children and adolescents.

The findings presented here should be interpreted in light of some methodological limitations. First, the observational study design does not allow inferences regarding causality to be made. Furthermore, this analysis was based on a maximum of 4 years of data. As a result, these findings may not be generalizable over longer periods of time, such as from childhood to adulthood. We used the sample distribution of BMI percentile to define weight maintenance and weight changes; as a result, these findings may not be applicable to contemporary populations or populations outside the US. A major strength of this analysis, however, was the use of multiple measurements of weight, height, and CVD risk factors for each participant, which allowed us to examine annual *rates* of change in these variables.

To our knowledge, this is one of the first studies to suggest a definition of weight maintenance (with respect to weight loss and weight gain) that is associated with short-term changes in cardiovascular risk factors among children and adolescents. Additional studies are needed to validate these findings in more diverse populations. We hope that this research will encourage dialogue in the scientific community regarding appropriate definitions of weight maintenance among youth that identify those children who are at a reduced risk of adverse health outcomes, while allowing for increases in height and weight associated with normal growth and pubertal development.

Table 4.1 Description of sample demographics and CVD risk factors: Project HeartBeat!

	All participants n=577	BMI percentile change group (n=577)		
		Maintainers (n=429)	Losers (n=77)	Gainers (n=71)
BMI percentile	58.3 (56.0, 60.7)	61.7 (58.88, 64.5)	54.9 (50.0, 59.7)	41.8 (37.1, 46.5)
Weight, lbs	53.3 (51.9, 54.7)	54.2 (52.4, 55.9)	48.6 (45.9, 51.4)	53.4 (50.3, 56.6)
Systolic pressure, mm Hg	100.5 (99.8, 101.2)	100.4 (99.6, 101.3)	102.2 (99.9, 104.5)	99.2 (97.1, 101.3)
Diastolic pressure, mm Hg	56.1 (55.4, 56.8)	56.0 (55.2, 56.8)	58.6 (56.7, 60.5)	54.00 (52.35, 55.65)
Total cholesterol, mg/dl	161.8 (159.6, 163.9)	162.4 (159.9,164.9)	157.5 (151.9,163.2)	162.4 (155.9,169.0)
HDL, mg/dl	51.0 (50.0, 51.9)	50.7 (49.7, 51.8)	50.2 (47.4, 53.0)	53.3 (50.5, 56.0)
Triglycerides, mg/dl	79.4 (76.1, 82.7)	81.0 (77.1, 85.0)	78.8 (69.0, 88.5)	69.9 (64.1, 75.8)
Summary score	-0.0 (-0.2, 0.2)	0.1 (-0.2, 0.3)	0.4 (-0.3, 1.0)	-0.8 (-1.4, -0.2)
Δ BMI percentile	-0.01 (-0.3, 0.3)	-0.1 (-0.3, 0.1)	-6.3 (-6.8, -5.8)	7.3 (6.4, 8.2)
Δ Systolic pressure, mm Hg	0.00 (-0.04, 0.04)	0.01 (-0.03, 0.05)	-0.1 (-0.2, 0.01)	0.1 (-0.05, 0.2)
Δ Diastolic pressure, mm Hg	0.00 (-0.02, 0.02)	-0.01 (-0.04, 0.01)	0.1 (0.01, 0.2)	-0.01 (-0.1, 0.1)
Δ Total cholesterol, mg/dl	-0.00 (-0.2, 0.2)	0.02 (-0.2, 0.2)	-0.2 (-0.6, 0.3)	0.05 (-0.4, 0.5)
Δ HDL, mg/dl	0.00 (-0.01, 0.01)	0.00 (-0.1, 0.1)	0.1 (-0.01, 0.3)	-0.2 (-0.3, -0.05)
Δ Triglycerides, mg/dl	-0.00 (-0.2, 0.2)	0.1 (-0.1, 0.3)	-0.3 (-0.7, 0.1)	-0.3 (-0.6, 0.1)
Δ Summary score	0.02 (-0.2, 0.2)	0.04 (-0.2, 0.3)	-0.4 (-0.9, 0.1)	0.4 (-0.2, 1.0)
Sex, % (95% CI)				
Males	50.1 (46.0, 54.2)	50.1 (45.4, 54.8)	61.0 (50.1, 71.9)	38.0 (26.7, 49.3)
Females	49.9 (45.8, 54.0)	49.9 (45.2, 54.6)	39.0 (28.1, 49.9)	62.0 (50.7, 73.3)
Cohort, y, % (95% CI)				
8	47.3 (43.2, 51.4)	49.7 (45.0, 54.4)	39.0 (28.1, 49.9)	42.3 (30.8, 53.8)
11	28.9 (24.8, 33.0)	27.7 (23.0, 32.4)	22.1 (11.2, 33.0)	43.7 (32.2, 55.2)
14	23.7 (19.6, 27.8)	22.6 (17.9, 27.3)	39.0 (27.8, 49.9)	14.1 (2.8, 25.6)
Race, % (95% CI)				
Non-black	81.1 (77.9, 84.3)	79.5 (75.7, 83.3)	97.4 (93.8, 100)	73.2 (62.9, 83.5)
Black	18.9 (15.7, 22.1)	20.5 (16.7, 24.3)	2.6 (0, 6.2)[1]	26.8 (16.5, 37.1)

Values are unadjusted mean (95% CI) unless otherwise noted; [1] n= 2

Table 4.2 Results of analysis of covariance for changes in cardiovascular disease risk factors: Project HeartBeat!

	Δ Summary score	Δ Systolic blood pressure	Δ Diastolic blood pressure	Δ Total cholesterol	Δ HDL cholesterol	Δ Triglycerides
Δ BMI percentile						
Maintain (ref)	-0.12 (-0.39, 0.15)	-0.01 (-0.06, 0.03)	-0.06 (-0.10, -0.03)	-0.14 (-0.36, 0.09)	-0.08 (-0.14. -0.02)	-0.25 (-0.44, -0.06)
Lose	-0.70 (-1.23, -0.17)	-0.09 (-0.18, -0.01)	-0.00 (-0.08, 0.07)	-0.55 (-1.00, -0.10)	0.04 (-0.08, 0.17)	-0.57 (-0.94, -0.19)
Gain	0.78 (0.26, 1.29)	0.06 (-0.02, 0.14)	-0.01 (-0.08, 0.05)	0.14 (-0.29, 0.57)	-0.26 (-0.38, -0.14)	-0.19 (-0.56, 0.17)
Sex						
Female (ref)	-0.24 (-0.59, 0.12)	-0.05 (-0.11, 0.01)	-0.04 (-0.09, 0.01)	-0.25 (-0.55, 0.04)	-0.08 (-0.16, -0.00)	-0.30 (-0.55, -0.05)
Male	0.21 (-0.13, 0.55)	0.02 (-0.04, 0.07)	-0.02 (-0.06, 0.03)	-0.11 (-0.40, 0.18)	-0.12 (-0.20, -0.04)	-0.37 (-0.61, -0.13)
Cohort, y						
8	0.31 (-0.05, 0.66)	0.08 (0.02, 0.14)	0.06 (0.01, 0.10)	0.64 (0.35, 0.93)	0.13 (0.05, 0.21)	0.01 (-0.24, 0.25)
11	-0.63 (-1.03, -0.23)	-0.06 (-0.13, 0.00)	-0.04 (-0.09, 0.02)	-0.61 (-0.95, -0.27)	-0.04 (-0.14, 0.05)	-0.55 (-0.83, -0.26)
14	0.28 (-0.28, 0.85)	-0.06 (-0.16, 0.03)	-0.10 (-0.18, -0.02)	-0.58 (-1.05, -0.10)	-0.38 (-0.51, -0.25)	-0.47 (-0.86, -0.07)
Race						
Nonblack (ref)	0.09 (-0.17, 0.34)	-0.03 (-0.07, 0.02)	-0.08 (-0.14, -0.01)	-0.20 (-0.42, 0.01)	-0.05 (-0.11, 0.01)	0.01 (-0.14, 0.19)
Black	-0.11 (-0.58, 0.35)	0.00 (-0.08, 0.07)	0.02 (-0.01, 0.06)	-0.16 (-0.56, 0.24)	-0.14 (-0.25, -0.03)	-0.68 (-1.01, -0.35)
Model R^2, F	0.26, 22.0	0.39, 39.8	0.12, 9.0	0.20, 16.2	0.22, 17.7	0.46, 54.7

n=577

Values are least-square means (95% CI)

Models include BMI percentile change, sex, cohort, race, change in height, baseline summary score (blood pressure or cholesterol, where appropriate), and follow-up time

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Chapter 5

Associations between changes in measures of body composition and physical activity and television viewing among children and adolescents: Project HeartBeat!

Abstract

Prospective studies have examined relationships between physical activity and television viewing during childhood and measures of adiposity in adulthood. Few studies, however, have assessed short-term associations between physical activity and TV viewing and changes in adiposity among children and adolescents. The purpose of this study was to investigate the existence of an association between annual changes in BMI percentile (ΔBMI percentile) and percent body fat (ΔPBF) and physical activity (PA) and TV viewing among male and female youth (n=460). Project HeartBeat!, was a longitudinal study (1991-1995) of cardiovascular risk factor development among youth aged 8, 11, and 14 years upon entry into the study. ΔBMI and ΔPBF were calculated as slopes of the regression lines obtained by regressing each measurement (excluding the initial measurement) of BMI percentile and percent body fat onto age. Multivariate linear regression analysis, adjusted for sex, pubertal status, change in height, and baseline BMI, was used to assess the independent associations between ΔBMI and moderate-vigorous PA, and TV viewing. Associations between ΔPBF and moderate-vigorous PA and TV viewing were assessed in a similar manner. Physical activity was not significantly associated with ΔBMI or ΔPBF. Watching ≥ 2 hours of TV per day (vs. <1 hour) was associated with a significant increase of 1.1 BMI percentile units and a 0.2% increase in body fat. This study provides additional support for efforts to reduce TV viewing time as a mechanism for preventing excessive weight gain among children and adolescents.

Introduction

Childhood and adolescence are periods of rapid growth and development. Under "normal" circumstances increases in weight during this time are a result of increases in fat-free mass relative to fat mass.[1] However, in light of the high prevalence of overweight among children and adolescents in the United States,[2, 3] it appears that increases in fat mass among youth are becoming more prevalent. Excess fat and body mass obtained during childhood are associated with a number of adverse outcomes in childhood and adolescence[4-6], and adulthood.[7-9] At the most basic level, weight gain occurs when energy intake exceeds energy expenditure. In growing children, however, the catabolic effects of growth must also be taken into account. Thus, reducing caloric intake, or dieting, is not recommended for weight reduction in children. Furthermore, dieting in children and adolescents has been associated with the development of disordered eating behaviors and weight gain.[10-13] Alternatively, children and adolescents can regain or maintain energy balance by increasing their energy expenditure through participation in physical activity. To this end, several expert panels and health organizations have set forth recommendations and guidelines for optimal levels of physical activity for general health benefits, including prevention of excess weight gain.[14-16] Most recently, Strong et al.[16] have suggested that a minimum of 30 minutes per day of moderate-vigorous activity is necessary to reduce overweight and at least 60 minutes of activity is desirable for optimal health. Television viewing has also been identified as a behavior linked to the development of overweight in children and adolescents. Proposed mechanisms for this relationship include increased caloric consumption[17-19] and displacement of active pursuits.[20] There is a great deal of evidence in support of the former, but findings regarding the latter are less well supported. [17, 21, 22] Regardless of the mechanism, the American Academy of Pediatrics and the Surgeon General have set forth the guideline that children ages 2 and older not watch more than 2 hours of television programming each day.[14, 23]

While it is clear that there is some association between physical activity and television viewing and adiposity in children and adolescents, it is less clear whether these behaviors are associated with changes in adiposity. Longitudinal studies of incident overweight and obesity in children provide support for a relationship between the development of overweight and physical activity and "screen time" (television viewing, videos, and video games).[24, 25] Several prospective studies have examined the association of childhood physical activity and TV viewing with adolescent or adult BMI, BMI z-score, and percent body fat. Many of these studies have found significant associations between childhood physical activity [13, 26, 27] or TV viewing[13] and measures of body composition and adiposity in adolescence or adulthood. At least one study has failed to provide evidence in support of this relationship.[27] Longitudinal studies describing changes in BMI and adiposity have suggested a positive association between TV viewing[28-30] and screen time[31] and change in body mass index (BMI) or body fat. There is also evidence to support an inverse relationship between physical activity and change in BMI or body fat.[32, 33] While informative, several of these studies were conducted only among females [26-29] and few examined changes in the percentage of body fat. With the exception of the study by Berkey et al.[31] none of these studies simultaneously adjusted for pubertal status (which is associated with differential changes in fat-free and fat mass in children and adolescents), caloric intake, and change in height (growth). To determine whether there is an independent association between changes in BMI and percent body fat and physical activity and TV viewing, these factors must be accounted for. Thus, the primary objective of this analysis was to assess the association between the dependent measures (annual changes in BMI and percent body fat) and physical activity and TV viewing. A secondary objective was to examine the association between weight maintenance and physical activity and TV viewing.

Methods

Data collection

Project HeartBeat! was a longitudinal study of cardiovascular risk factor development in children and adolescents.[34] Three cohorts of children, aged 8, 11, and 14 years upon entry into the study, were observed over a 4-year period (October 1991-August 1995) to assess the natural course of development of cardiovascular disease risk factors. Measurement equipment was checked and calibrated on a daily and/or weekly basis.

Dependent Measures. Body mass index was calculated using the following formula: weight/height^2 (kg/m^2). Percentiles of BMI were derived using growth charts published by CDC.[35] Percent body fat was calculated using bioelectric impedance analysis. Height, weight, and percent body fat were measured every four months while the participant wore scrubs. The specific methodology used for these measurements has been previously reported.[36]

Activity Measures. To assess duration and intensity of physical activity, an activity interview was administered to the participants by a trained interviewer at the initial assessment to collect information about the participant's activities during the previous 24 hours. A parent or caregiver was required to be present for 8- to10-year-old participants. Activities and minutes spent actively participating in each activity were recorded. Minutes spent watching television were also included in the physical activity recall. The recall was adapted from a 7-day recall instrument, modified for use with pre-adolescent children.[37] In a validation study, the correlation between activity measured via accelerometer (Caltrac) and minutes reported on the physical activity interview was 0.63 among 5th graders and 0.47 among 3rd graders.[37] Based upon published estimates of physical activity energy expenditure in metabolic equivalents (METS), labels of moderate (3-6 METS) and vigorous (> 6 METS) intensity were assigned to activities[38]. Moderate-vigorous physical activity was considered to be ≥ 3 METS in this analysis.

Control Measures. Pubertal status was assessed via direct observation by trained personnel 3 times per year using Tanner Stage until stage 5 was reached on two successive occasions for pubic hair and breast development among females and pubic hair and accessory sex organ (genital) development among boys.[1] For this analysis, stage of breast (females) or genital development (males) at the baseline assessment was used to describe sexual maturation. The rate of change in height between initial and final examinations was also considered, to account for increased energy requirements due to catabolism and growth in children and adolescents.

A 7-day quantified food frequency questionnaire (FFQ) was administered to participants by a trained interviewer to obtain an estimate of the subject's usual consumption of specific foods during the week prior to the interview (137 items). The questionnaire was created by Project HeartBeat! investigators specifically for this study population, using 3-day food records of children from the targeted communities in grades 5-12.[39] Information on race/ethnicity was also collected.

Exclusions and missing data

The initial sample consisted of 678 males and females. Participants were excluded based on the following criteria: having fewer than 3 height, weight, or percent body fat measurements (n=100); missing pertinent data, such as physical activity, TV viewing, pubertal stage, caloric intake (n=137). One participant was also excluded based on extremely high (>4 SD) reported values of physical activity and TV viewing. The final analytic sample consisted of 460 males and females (68%). There were no significant differences in the analytic sample compared to the original study population with regard to baseline BMI percentile (t= -0.86), baseline body fat percent (t= 0.73), MVPA (t= -0.24), TV viewing (t= -0.23), sex, pubertal stage, or race.

Variable specification

Visual inspection of the normal probability plots (P-P plots) for annual changes in BMI percentile and examination of the skewness, kurtosis, and Kolmogorov-Smirnov test statistic indicated departures from normality. Sensitivity analyses demonstrated the procedure reserved for normally distributed data, i.e., linear regression analysis, was robust, i.e., findings did not differ when transformed variables were used in lieu of the original variables. Thus, despite the non-normal distribution of these variables, analyses of changes in BMI percentile and percent body fat were conducted using parametric procedures in order to preserve simplicity.

The independent variables, mean moderate-vigorous activity and mean TV viewing, were positively (right) skewed with modes of 0 min/d and positive kurtosis. These variables were transformed into categorical variables as follows: moderate-vigorous physical activity (min/d) –

0-29, 30-59, ≥60; TV viewing (min/d) – 0-59, 60-119, ≥120. Dummy variables were created for physical activity and TV viewing, with reference groups of ≥ 60 min/d and 0-59 min/d, respectively. Covariates, caloric intake, baseline BMI percentile, and baseline percent body fat were also positively skewed with positive kurtosis. Again, due to the robust nature of linear regression techniques, these variables were not transformed or categorized prior to use in analyses. Change in height was approximately normal and was treated as a continuous variable in all analyses. Tanner stage was collapsed into three categories: prepubescent (stage I), pubescent (stages II-IV), and post-pubescent (stage V). The original race/ethnicity categories were White, Black/African-American, Hispanic, and other (includes Asians, Native Americans, Alaskan Natives, and Pacific Islanders). The race variable was collapsed into black vs. non-black because the proportion of Hispanics and other racial/ethnic groups in our sample was small.

Statistical analyses

All analyses were conducted in SAS, version 9.1 (SAS Institute, Cary, N.C.). Annual change scores for BMI percentile, percent body fat, and height were calculated for each participant with at least three measurements for each variable (equivalent to one year). The respective change scores were defined as the slopes of the regression lines, obtained by plotting each measurement (excluding the initial measurement) of BMI percentile, percent body fat, and height by age. This method allowed for the use of all available data for each participant and should estimate the rates of change more closely than simply taking this difference between the initial and final measurements.[40]. By excluding the baseline measures from the slope calculations, we hoped to decrease the inherent negative correlation between an initial variable measurement and change in the respective variable. We also sought to influence the temporality of the data so that participation in physical activity and TV viewing preceded any changes in BMI or percent body fat.

A priori, the decision was made to include baseline body composition (i.e., BMI percentile or percent body fat), sex, pubertal stage, and height change as covariates in the analyses because there is a substantial pool of scientific literature describing associations between these factors and body composition.[41-45] Additionally, Spearman correlations were calculated in order to determine whether other variables, such as race and baseline caloric intake, should be included in subsequent analyses. The direction and magnitude of correlations between the dependent variables (BMI percentile change and percent body fat change) and these covariates (baseline BMI percentile/percent body fat, sex, pubertal stage, change in height, caloric intake, and race) were examined among males, females, and males and females together. A similar analysis was conducted to assess correlations between the independent variables (MVPA and TV viewing) and the covariates under consideration. If a variable was significantly associated with at least one of the dependent variables and at least one of the independent variables, that variable was retained for entry into a multivariate model. Multivariate linear regression was used to quantify associations between changes in BMI percentile and percent body fat and MVPA and TV viewing, while controlling for the covariates selected for inclusion. We also conducted a sub-analysis to determine if vigorous physical activity, rather than moderate-vigorous physical activity, would exhibit a stronger association with changes in BMI percentile or percent body fat. The association between MVPA and TV viewing and a variable describing weight maintenance (described in previous chapter) was also assessed using multivariate logistic regression analysis.

Results

Description of sample

Median baseline BMI percentile was 59.0 (inter-quartile range, IQR= 35.7-84.3) among male and female participants; median percent body fat was 22.6 (IQR= 17.5-29.4) (Table 1). Differences between males and females with regard to baseline body composition were not statistically significant. In general, total changes in BMI percentile (mean, se= 1.15, 0.61) and percent body fat (mean, se= -1.12, 0.23) were very small over the 3-year study (data not shown). Median annual changes in body composition measures were also very small. The inter-quartile ranges of these two measures, however, reflect notable annual increases and decreases among at least 25% of the sample. Changes in BMI percentile were more marked than those observed in percent body fat.

Males and females reported a median of 50 minutes of MVPA per day (IQR= 19-105m/d) and 75 minutes of TV viewing (IQR= 30-140 m/d). While the majority (55%) of the study sample was not meeting current physical activity recommendations of 60 m/d, a higher proportion of males than females participated in at least 60 minutes of MVPA each day. Thirty-four percent of participants reported watching TV for more than 2 hours per day. Overall, the majority of the sample was prepubescent and only 16% of participants were black.

Bivariate Correlations

Among males and females, sex (r=0.14), change in height (r= 0.18), and black race (r= 0.17) were significantly correlated with annual change in BMI percentile (Table 2). Baseline body fat percent (r= -0.33), sex (r=0.22), and change in height (r= -0.28) were significantly correlated with annual change in percent body fat. The correlation between pubertal stage and change in percent body fat was -0.03 among males and females. Notably, the correlation was negative among males (r= -0.26), but positive among females (r= 0.16).

MVPA was inversely correlated with baseline percent body fat (r= -0.13), sex (r= -0.16), baseline pubertal stage (r= -0.11), and Black race (r= -0.13) among males and females (data not shown). TV viewing was positively correlated with baseline BMI percentile (r= 0.12), baseline percent body fat (r= 0.09) and pubertal stage (r= 0.15).

Baseline BMI percentile (or percent body fat), pubertal stage, and sex were included in all multivariate models describing changes in body composition because these variables were associated with at least one of the dependent (BMI percentile change and percent body fat change) and one of the independent (MVPA and TV viewing) variables under examination. As a result of the divergent correlations between change in percent body fat and pubertal stage among males and females, a term to describe the interaction between sex and pubertal stage was also included in the model describing changes in percent body fat.

Change in BMI percentile

The association between MVPA and change in BMI percentile was null (Table 3). Annual BMI percentile change was, however, associated with TV viewing, even after adjustment for baseline BMI percentile, change in height, baseline pubertal stage, male sex, and length of study follow-up. Participants who watched 2 or more hours of television per day, had an average of 1 unit increase in BMI percentile per year when compared to those who watched less than 1 hour of TV per day.

Change in Percent body fat

Participation in MVPA was not significantly associated with annual change in percent body fat (Table 3). Conversely, TV viewing was positively associated with change in percent body fat, such that participants who viewed 2 or more hours of TV per day had a 0.2% increase in body fat compared to those who watched less than 1 hour of TV per day. Percent body fat at baseline and change in height were inversely associated with change in percent body fat. Being in the pubertal or post-pubertal stage had a stronger relationship with changes in percent body fat among females than males. Based on the regression parameter estimates, a male with the following characteristics: ≥ 2 hours of TV/day; < 30 minutes of MVPA/day; baseline body fat = 24%; height slope (i.e., mean annual change) = 17 cm (6.7 inches), would be expected to have an increase in percent body fat of 1.7 before beginning puberty, 0.2 during the first stages of puberty, and 1.2 in the latter stages of puberty. A female with the same characteristics would be expected to have an increase in percent body fat of 1.8 before beginning puberty, 0.8 during the first stages of puberty, and 2.2 in the latter stages of puberty.

A sensitivity analysis was conducted to determine if caloric intake at baseline confounded the associations between MVPA or TV viewing and changes in body composition. However, estimates did not change when caloric intake was included in the regression models describing changes in BMI percentile or percent body fat.

Weight Maintenance

The associations between MVPA and weight maintenance and TV viewing and weight maintenance were not significantly different from null. Males had 1.7 times higher odds of maintaining their BMI within 4.1 percentile (i.e., 1 s.d.) than females.

Vigorous Physical Activity

There were no differences with respect to parameter estimates or variance explained between models used to assess the effects of vigorous physical activity on changes in BMI percentile and percent body fat compared to the combination of moderate-vigorous physical activity.

Discussion

Few studies have examined the relationship between physical activity and TV viewing and changes in adiposity among children and adolescents. In the present study, we assessed the association between moderate-vigorous physical activity and TV viewing and annual changes in BMI percentile and percent body fat over a 3-year period. We did not observe evidence to support a significant association of change in BMI or percent body fat with physical activity. We did see significant associations between TV viewing and BMI percentile and percent body fat changes among males and females, such that increases in both BMI percentile and percent body fat were higher among those who viewed 2 or more hours of TV daily compared to those who viewed less than 1 hour. Our findings were suggestive of a dose response relationship between TV viewing and changes in body composition, but our analyses lacked sufficient power to detect the smaller changes in BMI percentile and percent body fat associated with lower levels of TV viewing.

Our findings are consistent with at least two other longitudinal analyses of the association between changes in BMI and physical activity and TV viewing. The first was an analysis of BMI change and TV viewing among females aged 7, 9, and 11 years.[28] Davison et al. [28] found that girls who exceeded the American Academy of Pediatrics' TV viewing recommendations at all ages (7, 9, and 11) exhibited a significantly greater increase in BMI between ages 7 and 11 years than girls who never exceed the recommendation. The second analysis was based on data from the NHLBI Growth and Health Study.[29] The authors of this study reported a steeper 4-year increase in BMI per hour of daily TV viewing among white females who spent more time watching TV at age 10. In spite of the consistency of these findings, limitations of these studies include the exclusion of males, and failure to adjust for caloric intake and growth. In our study, change in height was consistently associated with BMI percentile change in males and females. Failure to adjust for some measure of growth in previous studies may have affected their results. Future studies of changes in adiposity in growing children and adolescents should include an indicator of growth as an important factor that is related to changes in BMI and body fat.

Our findings were also similar to those reported by Berkey et al.[31] Both analyses were adjusted for race, change in height, Tanner stage, and caloric intake; however, the present analysis included only TV viewing as opposed to other dimensions of screen time or sedentary behavior. The study by Berkey et al. also included more than 10,000 participants, making it possible to detect much smaller effect sizes than was possible in our study. Berkey et al. were also able to assess whether the association between BMI changes and TV viewing differed by baseline BMI status.[31] Notable strengths of our study, by comparison, are that our study also included 8 year-old children (compared to 9-14 year-olds), and considered a longer follow-up period (3 years vs. 1 year).

We observed a difference in the relationship between puberty and percent body fat change among males and females. This finding was consistent with expected changes in fat mass and fat-free mass that occur as males and females age and mature. For example, males generally have declines in fat mass and increases in fat-free mass during puberty, while females generally exhibit no change or increases in the rate of fat accumulation. It is possible that the amount of physical activity observed among males and females in this sample was not sufficient to offset the expected changes in percent body fat, but the amount of TV viewing was high enough to exacerbate these changes.

The finding that TV viewing, but not physical activity, was associated with BMI percentile and percent body fat changes is an area for future investigation. Our regression models included physical activity and television viewing simultaneously. Thus, the observed associations between TV viewing and BMI percentile and percent body fat changes were independent of moderate- vigorous physical activity. TV viewing may be associated with increased intake due to snacking, thereby influencing changes in BMI and percent body fat. However, we ran models with and without adjustment for caloric intake, and did not note any differences in the observed associations. We also cannot rule out the possibility that the measure of TV viewing may have been more valid than the activity measures because children may have more accurately recalled the names and duration of television programs compared to various physical activities performed throughout the day. It is also possible that this is a valid finding. Physical activity may be associated with simultaneous increases in fat-free mass and decreases in fat mass, potentially masking or attenuating any association between activity and BMI. This explanation, however, would not hold true for why we failed to observe a significant association between physical activity and changes in percent body fat.

Some studies have found that vigorous activity has a greater effect than moderate activity on BMI/body fat in youth, [46-48] but we did not observe any significant associations between change in body fat and physical activity. In contrast, reports from the Framingham Children's study found an inverse relationship between physical activity at age 4 and 7-year change in BMI, i.e., higher levels of activity at age 4 were associated with smaller increases in BMI, triceps skinfolds, and the sum of five skinfolds among males and females.[30] Discrepancies between their findings and ours may be the result of differences in the ages of our participants and methods. Our participants were older, and the length of follow-up in our study was shorter. We also adjusted for the additional factors of pubertal stage and height change because our sample was comprised of a larger age range.

The most notable difference between our study and the Framingham study was the use of an objective measure of physical activity in the Framingham study, increasing the validity of their physical activity measure in comparison to ours. In addition, they used the sum of five skinfold measurements to assess body fat, while we used bioelectric impedance. Nonetheless, bioelectric impedance has been shown to be a reliable method for assessing body fat in children and adolescents.[49] Use of sex- and age- specific equations that also included various anthropometric measurements also served to increase the accuracy of this measure in our sample.[49, 50]

The use of a 24-hour physical activity recall to assess time spent in physical activity and viewing television was a major limitation of our study. In an attempt to achieve higher validity, participants were asked about the time spent in various physical activities throughout the day and then further probed with regard to time spent *actively* participating in activities. In addition, the names of specific programming and whether they had watched the entire program were also included in the interview to improve estimates of TV viewing time.

Despite the resulting reduction in study power, we also made a decision to categorize physical activity and TV viewing based on expert recommendations, so the results might more readily be translated into practice. Finally our analytic design does not allow us to make any inferences regarding causality in the associations we assessed. In spite of these limitations, this study provides an examination of short-term associations between physical activity and TV viewing and measures of adiposity among a wide age range of children and adolescents. Our findings indicate a small, but significant, increase in BMI percentile among youth who exceeded TV viewing recommendations. Over a 5-year period, however, the accumulation of these increases may be large enough to shift the trajectory of one’s growth curve. While television viewing is but one domain of sedentary behavior, this study provides additional support for efforts to reduce TV viewing time as a mechanism to prevent excessive weight gain among children and adolescents.

Table 5.1 Characteristics among males and females in Project HeartBeat!

	Males and Females (n=460)	Males (n=224)	Females (n=236)
	Median (IQR)	**Median (IQR)**	**Median (IQR)**
BMI percentile slope	-0.04 (-2.3, 1.9)	-0.3 (-3.2, 1.3)	0.3 (-1.8, 2.5)
Body fat slope, %	0.03 (-0.4, 0.3)	-0.2 (-0.5, 0.3)	0.2 (-0.2, 0.4)
Baseline BMI percentile	59.0 (35.7, 84.3)	59.6 (36.2, 85.5)	57.0 (35.0, 83.5)
Baseline body fat, %	22.6 (17.5, 29.4)	20.2 (16.0, 26.8)	24.6 (19.7, 30.8)
MVPA, m/d	50 (19, 105)	69 (28, 120)	40 (15, 90)
TV viewing, m/d	75 (30, 140)	90 (30, 150)	60.0 (22, 125)
Caloric intake, kcal/d	2146 (1695, 2664)	2308 (1760, 2821)	2013 (1640, 2539)
	% (95% CI)	**% (95% CI)**	**% (95% CI)**
MVPA, m/d			
< 30	31.7 (27.4, 36.0)	25.5 (19.8, 31.2)	37.7 (31.5, 43.9)
30-59	22.8 (19.0, 26.6)	21.0 (15.7, 26.3)	24.6 (19.1, 30.1)
≥ 60	45.4 (40.9, 49.9)	53.6 (47.1, 60.1)	37.7 (31.5, 43.9)
TV viewing, m/d			
< 60	37.4 (33.0, 41.8)	37.1 (30.8, 43.4)	37.7 (31.5, 43.9)
60-119	28.3 (24.2, 32.4)	24.1 (18.5, 29.7)	32.2 (26.2, 38.2)
≥ 120	34.4 (30.1, 38.7)	38.8 (32.4, 45.2)	30.1 (24.2, 36.0)
Maturation Stage			
Pre-puberty	54.8 (50.3, 59.3)	59.8 (53.4, 66.2)	50.0 (43.6, 56.4)
During puberty	37.4 (33.0, 41.8)	34.8 (28.6, 41.0)	39.8 (33.6, 46.0)
Post puberty	7.8 (5.3, 10.3)	5.4 (2.4, 8.4)	10.2 (6.3, 14.1)
Race			
Black	16.3 (12.9, 19.7)	14.7 (10.1, 19.3)	17.8 (12.9, 22.7)
Non-black	83.7 (80.3, 87.1)	85.3 (80.7, 89.9)	82.2 (77.3, 87.1)

MVPA= moderate-vigorous physical activity

Table 5.2 Bivariate Spearman correlations between physical activity, TV viewing, and potential covariates among males and females: Project HeartBeat!

	Males and Females (n=460)	Males (n=224)	Females (n=236)
BMI percentile slope			
MVPA, m/d	0.03	0.07	0.04
TV viewing, m/d	0.05	0.10	0.09
Baseline BMI percentile	-0.07	0.04	**-0.16**
Height slope, m	**0.18**	**0.19**	**0.22**
Sex	**0.14**	--	--
Pubertal stage	0.01	0.07	-0.08
Race	**0.17**	0.10	**0.23**
Caloric intake, kcal/d	-0.04	-0.00	-0.03
Body fat percent slope			
MVPA, m/d	-0.09	-0.07	-0.06
TV viewing, m/d	-0.00	0.03	0.09
Baseline body fat, %	**-0.33**	**-0.35**	**-0.42**
Height slope, m	**-0.28**	**-0.20**	**-0.30**
Sex	**0.22**	--	--
Pubertal stage	-0.03	**-0.26**	**0.16**
Race	0.08	0.07	0.07
Caloric intake, kcal/d	-0.07	-0.06	-0.04

Correlation coefficients in bold-type are significant at $p<0.05$.

Table 5.3 Results of linear regression analyses describing annual changes in BMI percentile and percent body fat: Project HeartBeat!

	Δ BMI percentile (Estimate (SE))	Δ Percent body fat (Estimate (SE))
MVPA, m/d		
< 30	-0.23 (0.39)	0.07 (0.05)
30-59	-0.20 (0.42)	0.05 (0.06)
≥ 60	REF	REF
TV viewing, m/d		
< 60	REF	REF
60-119	0.78 (0.41)	0.04 (0.06)
≥ 120	**1.07 (0.40)**	**0.18 (0.05)**
Baseline BMI percentile	**-0.02 (0.006)**	--
Baseline percent body fat	--	**-0.03 (0.003)**
Δ Height, m	**0.18 (0.09)**	**-0.05 (0.01)**
Baseline pubertal stage		
Pre-	-0.54 (0.79)	**1.42 (0.25)**
During	-0.31 (0.73)	**-0.55 (0.15)**
Post-	REF.	REF.
Male sex	**-0.68 (0.34)**	**0.35 (0.12)**
Sex*Puberty interaction	--	**0.44 (0.08)**
Adjusted R^2	0.36	0.34

n= 460;
Estimates in bold-type are significant at p<0.05;
Models adjusted for MVPA, TV viewing, baseline BMI percentile (or percent body fat), Δheight, pubertal stage at baseline, male sex, and length of follow-up.

Table 5.4 Association between weight maintenance and physical activity and TV viewing among adolescents: Project HeartBeat!

	Estimate (SE)	OR (95% CI)
MVPA, m/d		
< 30	-0.003 (0.26)	0.99 (0.60, 1.66)
30-59	0.33 (0.28)	1.39 (0.80, 2.41)
≥ 60	REF	REF
TV viewing, m/d		
< 60	REF	REF
60-119	-0.26 (0.27)	0.77 (0.45, 1.31)
≥ 120	-0.43 (0.27)	0.65 (0.39, 1.10)
Baseline BMI percentile	**0.01 (0.004)**	**1.01 (1.00, 1.02)**
Δ Height, m	-0.10 (0.06)	0.91 (0.81, 1.02)
Baseline pubertal stage		
Pre-	0.32 (0.53)	1.38 (0.49, 3.90)
During	0.17 (0.49)	1.18 (0.46, 3.06)
Post-	REF	REF
Male sex	**0.53 (0.23)**	**1.70 (1.08, 2.67)**

Estimates in bold-type are significant at $p<0.05$;
Model adjusted for MVPA, TV viewing, baseline BMI percentile, Δheight, pubertal stage at baseline, male sex, and length of follow-up.

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Chapter 6

Associations between physical activity, television viewing, and changes in cardiovascular disease risk factors among children and adolescents: Project HeartBeat!

Abstract

There is evidence to support a relationship between physical activity (PA) and cardiovascular disease (CVD) risk factors. Few studies, however, have examined the association between childhood PA and changes in blood pressure (systolic and diastolic) and blood lipids (total cholesterol, LDL, HDL, and triglycerides), independent of changes in BMI. The purpose of this study was to investigate these associations in a sample of children who participated in a longitudinal study (1991-1995) of CVD risk factor development. The participants were ages 8, 11, and 14 years at baseline. Change scores for each of the CVD risk factors were calculated. A summary score was also created by summing the standardized values of blood pressure and blood lipids for each participant. Multivariate linear regression was used to quantify the associations between moderate-vigorous PA, TV viewing, and changes in CVD risk factors, while controlling for sex, race, pubertal status, height change, baseline CVD risk factor value, change in BMI percentile, and selected interactions terms. A positive association was observed between TV viewing (≥120 min/d vs. <60 min/d) and changes in LDL (estimate, se= 0.41, 0.16). Puberty, especially among females, was an important factor for describing changes in the blood lipids and the summary score. No other non-zero associations were observed between PA or TV viewing and changes in CVD risk factors. These findings do not support the utility of promoting increased physical activity or less TV viewing in order to prevent adverse changes in CVD risk factor profiles among youth.

Introduction

Childhood and adolescence are marked by various changes in blood pressure and blood lipids. National reference data suggest that the nature and pattern of these changes differ between males and females, with shifts in direction occurring at different ages for each gender.[1, 2] It is desirable to identify youth with large adverse changes in cardiovascular disease (CVD) risk factors as several of these measures, including blood pressure, LDL-cholesterol, and HDL-cholesterol, have been shown to track into adulthood.[3-7] Clustering of these risk factors also displays moderate stability over time.[3] While studies have demonstrated cross-sectional associations between cardiovascular risk factors and physical activity during childhood and adolescence,[8-13] few have examined associations between physical activity and TV viewing and changes in cardiovascular disease risk factors over time.

Some evidence in support of associations between measured physical activity and changes in CVD risk factors is available from clinical trials and intervention studies. Findings from a dietary intervention study suggested an inverse association between physical activity and systolic blood pressure over a three-year period.[14] Diastolic blood pressure and LDL were not significantly associated with physical activity in this study, although there was a trend toward lower LDL with higher amounts of activity; HDL and triglycerides were not included in the analysis. This study was conducted among prepubescent males and females with elevated LDL, offering limited generalizability beyond this study population.

Some physical activity-related interventions and trials have demonstrated beneficial effects of exercise and aerobic training on blood pressure and blood lipids, [14-18] while others have not.[19-21] These studies, however, have often been conducted in children and adolescents with increased risk for CVD (e.g., they were overweight or obese, pre-hypertensive, or had a family history of CVD),[14, 16, 17] generally lasted for less than six months,[17-20] and included children within narrow age ranges.[17, 19, 20] This leaves relatively little information available regarding the relationship between physical activity and TV viewing and CVD risk among apparently healthy children and adolescents. The omission of studies examining associations between television viewing and changes in blood pressure and blood lipids is also unfortunate because TV viewing is a major component of sedentary behavior, and youth today are more involved in sedentary pursuits than children of past generations.[22] Access to televisions by children and adolescents is high and reports based on national data place daily television viewing at four or more hours per day among 26% of the population. Furthermore, television viewing is a moderately stable behavior during childhood and adolescence.[23, 24] Understanding television viewing's potential impact on cardiovascular disease risk factors during childhood may have relevance for understanding longer-term relationships between childhood behaviors and adult health.

In examining the potential associations between physical activity and changes in cardiovascular risk factors, and television viewing and changes in cardiovascular risk factors, it is important also to consider the influence of BMI changes, growth, and puberty. Evidence exists in support of an association between each of these factors and blood pressure and/or blood lipids. [25-30] Physical activity and TV viewing have also been shown to be associated with changes in BMI and other indirect measures of adiposity.[31-33] Thus, analyses examining associations between physical activity and changes in cardiovascular risk factors must also account for changes in BMI, in order to assess the independent influence of physical activity.

The objective of this analysis was to investigate the existence of an association between the CVD-risk dependent measures (annual changes in systolic pressure, diastolic pressure, plasma triglyceride, LDL-cholesterol, and HDL-cholesterol) and physical activity and television viewing, after adjustment for race, change in height, pubertal stage, baseline blood pressure or blood lipids, and change in BMI percentile.

Methods

Data collection

Project HeartBeat! was a longitudinal study of cardiovascular risk factor development in children and adolescents. Three cohorts of children, aged 8, 11, and 14 years upon entry into the study, were observed over a 4-year period (October 1991-August 1995) to assess the natural course of development of cardiovascular disease risk factors. Measures of body composition, blood pressure, and blood cholesterol components were obtained three times per year during the study period by trained staff. Measurement equipment was checked and calibrated on a daily and/or weekly basis. Specific details about Project HeartBeat! have been published previously. [34]

Dependent Measures. Standard mercury sphygmomanometers were used in order to capture systolic pressure (SBP) and phases 4 and 5 of diastolic blood pressure (DBP). The fifth Korotkoff phase of diastolic pressure was used in this analysis because it has been recommended for use as the standard measure of diastolic pressure by the National High Blood Pressure Education Program.[2] A complete set of standard blood pressure cuffs was available at each station to ensure appropriate cuff selection for each participant. Participants were examined after being seated for at least five minutes. Two measurements were taken, one minute apart from each other. Two separate appointments were scheduled within two weeks of the initial examination for a total of three occasions at baseline. At subsequent examinations, only two blood pressure measurements were required on two occasions one week apart.

HDL-cholesterol, triglycerides (TG), and total cholesterol were determined in samples obtained by a trained phlebotomist during an in-home interview, after an overnight (8-12 hours) fast. The blood was kept at 4 º C and was separated within one hour of collection. Aliquots were stored at -70 º C until being processed in the Lipid Research Laboratory at Baylor College of Medicine. A Cobas Fara II analyzer was used for the enzymatic process of cholesterol determination. Standards of performance for the intra- and inter-assay required that coefficients of variation not exceed 3%. LDL-cholesterol was calculated using the equation, total cholesterol - (triglyceriges/5 + HDL).[35]

Activity Measures. To assess duration and intensity of physical activity, an activity interview was administered to the participants by a trained interviewer at the baseline assessment and anniversary visits to collect information about the participant's activities during the previous

24 hours. A parent or caregiver was required to be present for 8- to10-year-old participants to assist in completion of the interview. Activities and minutes spent actively participating in each activity were recorded. Minutes spent viewing television were also included in the physical activity recall. The recall was adapted from a 7-day recall instrument, modified for use with pre-adolescent children. In a validation study, the correlation between activity measured via accelerometer (Caltrac) and minutes reported on the physical activity interview was 0.63 among 5th graders and 0.47 among 3rd graders. Based upon published estimates of physical activity energy expenditure in metabolic equivalents (METS), labels of moderate (3-6 METS) and vigorous (> 6 METS) intensity were assigned to activities.[36] The sum of moderate-vigorous physical activity (MVPA, ≥3 METS) at the baseline assessment was used in this analysis.

Control Measures. Height and weight were measured every four months, while the participant wore scrubs. Body mass index (BMI) was calculated using the following formula: weight/height^2 (kg/m^2). Percentiles of BMI were derived using growth charts published by the Centers for Disease Control and Prevention (CDC).[37] A 7-day quantified food frequency questionnaire (FFQ) was administered to participants by a trained interviewer to obtain an estimate of the subject's usual consumption of specific foods during the week prior to the interview (137 items). The questionnaire was created by Project HeartBeat! investigators, specifically for this study population, using 3-day food records of children from the targeted communities in grades 5-12.[38]

Pubertal status was assessed via direct observation by trained personnel 3 times per year using Tanner Stage until stage 5 was reached on two successive occasions for pubic hair and breast development among females and pubic hair and accessory sex organ (genital) development among boys.[39] For this analysis, stage of breast (females) or genital development (males) was used to describe sexual maturation. Change in height between initial and final examinations was also considered because height is associated with blood pressure in children and adolescents.[2] Information on race/ethnicity was also collected.

To assess their role as confounders, the correlations of BMI percentile change, height change, sex, pubertal stage, race, and caloric intake with both the independent (changes in blood pressures and blood lipids) and the dependent variables (MVPA and TV viewing) were calculated.

Exclusions and missing data

The initial sample consisted of 678 males and females. Participants were excluded based on the following criteria: having two or fewer systolic or diastolic blood pressure, plasma triglyceride, LDL-cholesterol, HDL cholesterol, or BMI percentile measurements (after excluding the baseline value, n=100), missing baseline physical activity, TV viewing, or pubertal stage (n=137). One participant was excluded based on extreme values reported for physical activity and TV viewing (>4 s.d.). The final analytic sample consisted of 460 males and females (68%). There were no significant differences in the analytic sample compared to the original study population with regard to the distributions of sex, race, physical activity, or TV viewing. Baseline values of diastolic blood pressure (mean, se= 56.1, 0.3 mm Hg), plasma triglycerides (mean, se= 80.5, 1.6 mg/dl), plasma LDL-cholesterol (mean, se= 94.1, 0.9 mg/dl), plasma HDL-cholesterol (mean, se= 50.7, 0.4 mg/dl), or BMI percentile (mean, se= 59.3, 1.1) also did not differ between the excluded participants and those in the analytic sample. Mean systolic blood pressure was significantly higher among excluded participants (mean, se= 100.9, 0.3 mm Hg) than those included in the analytic sample.

Variable specification

Visual inspection of the normal probability plots (P-P plots) for baseline moderate-vigorous physical activity and TV viewing, were positively (right) skewed with modes of 0 min/d and positive kurtosis. As a result, these variables were categorized in the following manner: moderate and vigorous physical activity (min/d) – 0-29, 30-59, ≥60; TV viewing (min/d) – 0-59, 60-119, ≥120. Dummy variables were created for physical activity and TV viewing, with reference groups of ≥60 min/d and 0-59 min/d, respectively. Tanner stage was collapsed into three categories: prepubescent (stage I), pubescent (stages II-IV), and post-pubescent (stage V). The original race/ethnicity categories were White, Black/African-American, Hispanic, and other (includes Asians, Native Americans, Alaskan Natives, and Pacific Islanders). The race variable was collapsed into black vs. non-black because the proportion of Hispanics and other racial/ethnic groups in our sample was small. All other variables were treated as continuous.

Statistical Analyses

All analyses were conducted in SAS, version 9.1 (SAS Institute, Cary, NC). A summary CVD risk factor score was created by standardizing blood pressure and blood lipid values and then applying the following formula: zSBP + zDBP + zTG + zLDL – zHDL. Change scores were defined as the slopes of the regression lines obtained by plotting each measurement of the summary score, systolic blood pressure, diastolic blood pressure, triglycerides, LDL, HDL, BMI percentile, and height by age after deleting the respective baseline values. These change scores were calculated for each participant with at least three measurements for each variable (equivalent to one year) after exclusion of the baseline value. This method allowed for the use of all available data for each participant and should estimate the rates of change more closely than simply taking this difference between the initial and final measurements.[40] The use of regression generally produces unbiased estimates and also allows for the estimation of error

Characteristics of the participants described in this analysis, including baseline values of the summary score, blood pressure, and blood lipids and the respective change scores, were summarized for the entire analytic sample and also by sex. Linear regression analyses were then used to assess associations between changes in blood pressure and categories of moderate-vigorous physical activity and TV viewing. The following interaction terms were assessed for significance in all models using backwards elimination techniques in conjunction with the evaluation of the likelihood ratio statistics (with and without the interaction term included in the model): race*pubertal stage, sex*pubertal stage, sex*race, sex*ΔBMI percentile, and sex*Δheight. These terms were chosen because initial examination of the correlation coefficients describing the associations between the dependent measures and the covariates indicated a difference (with regard to direction and/or magnitude) between males and females or black participants and non-black participants. Final regression models were adjusted for black race, pubertal stage, baseline BMI, baseline blood pressure (systolic or diastolic), change in height, BMI percentile change, and significant interaction terms. The associations between physical activity and television viewing and changes in the plasma lipid measures and the CVD risk factor summary score were assessed in a similar manner.

Results

Sample Description

Blood pressure and blood cholesterol levels remained relatively stable from year to year, i.e., the estimates for mean annual change in blood pressure and blood cholesterol did not differ from zero (data not shown). Median values and the inter-quartile ranges for each measure are presented in Table 1. Annual change in the summary score was the most variable of the measures considered, followed by changes in triglycerides and LDL-cholesterol.

The majority of male participants reported participating in moderate-vigorous physical activity for at least 60 minutes each day, while most females reported fewer than 60 minutes of moderate-vigorous physical each day. Males and females did not differ with regard to the duration of daily TV viewing; more than 30% of male and female participants watched TV for 2 or more hours each day. Approximately 16% of the study sample was black (Table 1).

Bivariate Correlations

With the exception of caloric intake, each of the potential covariates was significantly correlated with at least one of the independent variables and one or more of the dependent variables (Table 2 and Appendix C1). Thus, all variables except caloric intake were retained for use in the multivariate regression models.

Multivariate Associations

We did not observe any non-null associations between moderate-vigorous physical activity and changes in blood pressure or blood lipids (Table 3). The association between MVPA and change in HDL approached significance (estimate, se= 0.10, 0.06; p=0.08). Relative to viewing less than one hour of TV each day, the highest level of TV viewing was associated with an increase in LDL-cholesterol, (estimate, se= 0.41, 0.16). All other associations between TV viewing and changes in blood pressure and blood lipids were consistent with zero.

With the exception of LDL-cholesterol, baseline values of the CVD risk factors were all positively associated with their respective change scores. Change in BMI percentile was positively associated with change in the summary score (estimate, se= 0.08, 0.03) and inversely associated with change in HDL (estimate, se= -0.02, 0.007). Change in height was inversely associated with changes in diastolic blood pressure, LDL-cholesterol, and HDL-cholesterol. Male sex was only positively associated with change in systolic blood pressure. Pubertal stage at baseline was positively associated with HDL; conversely, pubertal stage was inversely associated with changes in the summary score, triglycerides, and LDL-cholesterol. Finally, Black race was inversely associated with changes in the summary score and triglycerides, but positively associated with changes in LDL-cholesterol and HDL-cholesterol. The models tested explained between 7% (Δ diastolic pressure) and 42% (Δ triglycerides) of the variance in the CVD risk factor change scores.

Ultimately, we observed greater declines in LDL-cholesterol among post-pubertal females than post-pubertal males; differences between males and females either prior to the onset of puberty or during puberty were not apparent. Furthermore, we observed an increase in LDL among females prior to puberty relative to post-pubertal females that was similar in magnitude to the decrease in LDL among pubertal males relative to post-pubertal males. For example, a non-black male (with median values of height change, BMI percentile change, and baseline LDL-cholesterol) who engaged in fewer than 30 min/d of MVPA and at least 2 hours/d of TV viewing was predicted to have a decrease in LDL of -2.35, -2.85, and -2.18 mg/dl before, during, and after puberty, respectively. Under the same assumptions, we'd expect to observe changes of -2.30, -3.2, and -2.93 in a non-black female before, during, and after puberty, respectively.

Discussion

In the present study, we examined the association of moderate-vigorous physical activity and TV viewing with annual changes in blood pressure (systolic and diastolic) and plasma lipids (triglycerides, LDL, and HDL) over a three-year period. We observed a significant association between television viewing and increases in LDL-cholesterol. No other non-zero associations were observed.

We were unable to locate any observational studies that had assessed associations between physical activity and *changes* in cardiovascular risk factors during childhood and adolescence for comparison. However, Craig et al. (1996) demonstrated a significant inverse association between physical activity (measured via recall) and LDL-cholesterol one-year later among preadolescent girls. In their study, there was decline in LDL of 1 mg/dl per hour/week of physical activity. Also, in a longitudinal analysis of associations between LDL and blood pressure and physical activity over a three-year period in 8-10 year-old children with elevated LDL, systolic blood pressure and LDL cholesterol were inversely associated with MET-h/week of activity.[14] Data from clinical and intervention trials have also been informative. A two-week diet and exercise trial consisting of 2-2.5 hours per day of supervised physical activities conducted in youth aged 8-17 years old was effective in lowering systolic and diastolic blood pressure, total cholesterol, LDL-cholesterol, and triglycerides.[41] These children were overweight, with mean BMI greater than the 90th age- and sex-specific percentiles. It is unknown whether these changes were sustained over time, particularly after such a short training program. At least one other study among overweight and obese children has reported similar findings.[16] While these findings are useful, it is also desirable to determine whether an association exists between increased physical activity/reduced TV viewing and CVD risk measures among youth who are not overweight or at an increased risk for CVD. Very few studies to this end have been conducted. Those that have, have often demonstrated null findings with regard to physical activity and changes in lipids or blood pressure,[19, 21] or have been conducted in small samples of special populations, such as sports participants[18] or children with elevated blood pressures[17] or lipids.[14]

While at least one prospective study has observed a positive correlation between physical activity and blood pressure,[42] our findings support the findings of an evidence-based review of the effects of physical activity on various health outcomes and biological markers in children – there appears to be very little association between physical activity and blood pressure among children who are not pre-hypertensive or hypertensive at baseline.[43]

The observation that TV viewing, but not physical activity, was positively associated with LDL-cholesterol is of note. In this sample, the correlation between television viewing and moderate-vigorous physical activity was very small, so it is unlikely that TV viewing masked the association of LDL with physical activity. Proposed mechanisms for an association between TV viewing and increased risk of cardiovascular disease have hinged upon probable mediation by BMI or caloric consumption.[12] Caloric intake was not correlated with any of the CVD risk factors in this study. Change in BMI percentile was significantly associated with changes in the summary score and HDL-cholesterol, however, the observed effect estimates were small.

We observed several significant interactions with sex among many of the variables, including puberty, race, and change in height, in relation to changes in the CVD risk factors that were assessed. This study is not the first to find differential associations with measures of blood pressure and blood lipids between males and females.[13, 44] These differences may be due, in part, to the differing physiologic changes in blood pressure and blood lipids that are accompanied by growth and maturation.

In interpreting these findings, there are some limitations that must be acknowledged. While the observational study design does allow us to examine associations over time, it does not provide evidence of causal relationships. Also, the use of a self-report, rather than objective, measure of physical activity probably resulted in a large degree of measurement error, which would have substantially weakened our ability to see significant findings. It would have been interesting to assess how changes in physical activity relate to changes in CVD risk factors, however, our physical activity instrument did not have adequate reliability to assess changes in physical activity over the study period. Overall, the magnitude of the mean annual changes observed in blood pressure and blood lipids was very small, making it difficult to detect meaningful changes in these measures. Based on the trajectories seen in reference populations, it is also possible that changes in the selected risk factors are non-linear, though we suspect that changes over a short period of time, i.e., one year would be approximately linear. Though we did not control for parental variables, such as parental cardiovascular disease history, we did adjust for several factors that are thought to be related to blood pressure and lipids in children and adolescents, including maturation, changes in height, and changes in BMI percentile.

Findings from this analysis do not support the utility of increasing of physical activity or decreasing TV viewing to prevent adverse changes in CVD risk factor profiles of youth. There is limited evidence of a relationship between changes in BMI percentile and changes in CVD risk factors in this population. The identification of factors associated with adverse changes in CVD risk factor profiles continues to be an area for further study, which can be enhanced through the use of objective and validated measures among larger, contemporary samples.

Table 6.1 Biological characteristics, physical activity, and TV viewing among males and females: Project HeartBeat!

	Males and Females	Males	Females
	Median (IQR)	Median (IQR)	Median (IQR)
Δ Summary score	0.12 (-1.65, 1.39)	0.29 (-1.45, 1.66)	-0.03 (-1.82, 1.22)
Δ Systolic pressure, mm Hg	-0.004 (-0.27, 0.29)	0.08 (-0.16, 0.33)	-0.06 (-0.37, 0.20)
Δ Diastolic pressure, mm Hg	-0.005 (-0.17, 0.19)	-0.007 (-0.17, 0.21)	-0.001 (-0.17, 0.17)
Δ Triglycerides, mg/dl	-0.42 (-1.35, 0.86)	-0.46 (-1.48, 0.97)	-0.39 (-1.22, 0.83)
Δ LDL cholesterol, mg/dl	-0.03 (-0.78, 0.83)	0.04 (-1.00, 0.87)	-0.08 (-0.74, 0.73)
Δ HDL cholesterol, mg/dl	0.01 (-0.40, 0.35)	-0.06 (-0.51, 0.34)	0.06 (-0.33, 0.37)
Δ BMI percentile	-0.04 (-2.27, 1.88)	-0.30 (-3.23, 1.26)	0.31 (-1.78, 2.51)
Baseline			
Summary score	-0.12 (-1.82, 1.57)	0.07 (-1.91, 1.65)	-0.27 (-1.67, 1.54)
Systolic pressure, mm Hg	99.0 (94.0, 105.0)	100.0 (94.0, 106.5)	98.0 (93.0, 104.0)
Diastolic pressure, mm Hg	56.0 (50.0, 61.0)	56.0 (50.0, 62.0)	55.0 (50.0, 61.0)
Triglycerides, mg/dl	70.0 (54.0, 92.0)	68.0 (53.0, 91.0)	71.5 (55.0, 92.0)
LDL cholesterol, mg/dl	92.8 (79.6, 109.9)	92.9 (78.3, 110.7)	92.1 (80.7. 108.4)
HDL cholesterol, mg/dl	50.0 (42.5, 57.0)	50.0 (42.0, 57.0)	50.0 (43.0, 57.0)
BMI percentile	59.0 (35.7, 84.3)	59.6 (36.2, 85.5)	57.0 (35.0, 83.5)

Table 6.1 cont. Biological characteristics, physical activity, and TV viewing among males and females: Project HeartBeat!

	Males and Females	Males	Females
	Percent (95% CI)	Percent (95% CI)	Percent (95% CI)
MVPA, m/d			
< 30	31.7 (27.4, 35.9)	25.5 (19.8, 31.2)	37.7 (31.5, 43.9)
30-59	22.8 (19.0, 26.6)	21.0 (15.7, 26.3)	24.6 (19.1, 30.1)
≥ 60	45.4 (40.9, 49.9)	53.6 (47.1, 60.1)	37.7 (31.5, 43.9)
TV viewing, m/d			
< 60	37.4 (33.0, 41.8)	37.1 (30.8, 43.4)	37.7 (31.5, 43.9)
60-119	28.3 (24.2, 32.4)	24.1 (18.5, 29.7)	32.2 (26.2, 38.2)
≥ 120	34.4 (30.1, 38.7)	38.8 (32.4, 45.2)	30.1 (24.2, 36.0)
Maturation Stage			
Pre-puberty	54.8 (50.3, 59.3)	59.8 (53.4, 66.2)	50.0 (43.6, 56.4)
During puberty	37.4 (33.0, 41.8)	34.8 (28.6, 41.0)	39.8 (33.6, 46.0)
Post-puberty	7.8 (5.3, 10.3)	5.4 (2.4, 8.4)	10.2 (6.3, 14.1)
Race			
Black	16.3 (12.9, 19.7)	14.7 (10.1, 19.3)	17.8 (12.9, 22.7)
Non-black	83.7 (80.3, 87.1)	85.3 (80.7, 89.9)	82.2 (77.3, 87.1)

n= 460

Table 6.2 Bivariate Spearman correlations between changes in cardiovascular disease risk factors and behavioral and biological variables: Project HeartBeat!

	Males and Females n=460	Males n=224	Females n=236	Blacks n=75	Non-blacks n=385
Δ Summary score					
MVPA, m/d	0.07	0.07	0.03	0.10	0.06
TV viewing, m/d	0.07	0.05	0.09	0.10	0.08
Baseline summary score	0.37*	0.50*	0.22*	0.34*	0.37*
Δ BMI percentile	0.24*	0.26*	0.25*	0.03	0.27*
Δ Height, m	0.08	-0.08	0.20*	0.12	0.07
Sex	-0.13*	--	--	0.18	-0.15*
Pubertal stage	0.04	0.31*	-0.17*	-0.08	0.07
Race	-0.02	-0.13	0.09	--	--
Caloric intake, kcal/d	0.06	0.08	0.01	-0.01	0.07
Δ Systolic pressure, mm Hg					
MVPA, m/d	0.14*	0.07	0.15*	0.14	0.16*
TV viewing, m/d	0.09	0.07	0.08	0.18	0.06
Baseline systolic pressure, mm Hg	0.31*	0.46*	0.16*	0.45*	0.29*
Δ BMI percentile	0.16*	0.18*	0.20*	0.04	0.17*
Δ Height, m	0.27*	0.09	0.39*	0.37*	0.25*
Sex	-0.18*	--	--	0.12	-0.24*
Pubertal stage	-0.03	0.26*	-0.24*	-0.10	-0.02
Race	0.05	-0.08	0.18*	--	--
Caloric intake, kcal/d	0.06	0.12	-0.05	-0.16	0.12*

Table 6.2 cont. Bivariate Spearman correlations between changes in cardiovascular disease risk factors and behavioral and biological variables: Project HeartBeat!

	Males and Females n=460	Males n=224	Females n=236	Blacks n=75	Non-blacks n=385
Δ Diastolic pressure, mm Hg					
MVPA, m/d	0.06	0.11	0.002	0.31*	0.003
TV viewing, m/d	-0.07	-0.18*	0.04	-0.22	-0.04
Baseline diastolic pressure, mm Hg	0.19*	0.24*	0.13	0.18	0.19*
Δ BMI percentile	-0.08	-0.17*	0.002	-0.03	-0.08
Δ Height, m	-0.12*	-0.23*	-0.003	-0.06	-0.13*
Sex	-0.03	--	--	-0.03	-0.02
Pubertal stage	-0.01	0.05	-0.06	0.002	-0.004
Race	-0.10*	-0.09	-0.11	--	--
Caloric intake, kcal/d	-0.04	-0.03	-0.08	-0.002	-0.07
Δ Triglycerides, mg/dl					
MVPA, m/d	0.02	0.03	0.02	-008	0.01
TV viewing, m/d	0.01	0.01	0.03	0.14	002
Baseline triglycerides, mg/dl	0.57*	0.60*	0.54*	0.46*	0.56*
Δ BMI percentile	0.13*	0.19*	0.06	-0.20	0.23*
Δ Height, m	0.09	0.01	0.16*	0.15	0.11*
Sex	0.04	--	--	0.13	0.03
Pubertal stage	-0.03	0.04	-0.12	-0.13	0.002
Race	-0.23*	-0.23*	-0.23*	--	--
Caloric intake, kcal/d	-0.02	0.06	-0.09	0.01	-0.04

Table 6.2 cont. Bivariate Spearman correlations between changes in cardiovascular disease risk factors and behavioral and biological variables: Project HeartBeat!

	Males and Females n=460	Males n=224	Females n=236	Blacks n=75	Non-blacks n=385
Δ LDL cholesterol, mg/dl					
MVPA, m/d	-0.08	-0.05	-0.12	-0.17	-0.05
TV viewing, m/d	0.07	0.09	0.05	-0.18	0.10
Baseline LDL, mg/dl	-0.19*	-0.16*	-0.23*	-0.11	-0.20*
Δ BMI percentile	0.09*	0.11	0.09	0.001	0.09
Δ Height, m	-0.29*	-0.34*	-0.24*	-0.32*	-0.29*
Sex	-0.01	--	--	0.05	-0.01
Pubertal stage	0.03	0.01	0.07	-0.24*	0.06
Race	0.11*	0.10	0.11	--	--
Caloric intake, kcal/d	0.02	-0.03	-0.08	-0.09	0.05
Δ HDL cholesterol, mg/dl					
MVPA, m/d	-0.03	-0.04	0.01	-0.14	-0.04
TV viewing, m/d	-0.10*	-0.20*	0.02	-0.17	-0.07
Baseline HDL, mg/dl	0.25*	0.35*	0.16*	0.33*	0.25*
Δ BMI percentile	-0.24*	-0.29*	-0.23*	-0.20	-0.23*
Δ Height, m	-0.18*	-0.20*	-0.12	-0.05	-0.19*
Sex	0.10*	--	--	-0.17	-0.15*
Pubertal stage	-0.17*	-0.44*	0.06	-0.16	-0.17*
Race	-0.08	0.06	-0.20*	--	--
Caloric intake, kcal/d	-0.13*	-0.11	-0.12	-0.24*	-0.12*

MVPA= moderate-vigorous physical activity; Δ= slope (change); * correlation coefficient is significant at $p<0.05$

Table 6.3 Results of linear regression analyses describing changes in cardiovascular disease risk factors: Project HeartBeat!

	Δ Summary score	Δ Systolic blood pressure, mm Hg	Δ Diastolic blood pressure, mm Hg	Δ Triglycerides, mg/dl	Δ LDL cholesterol, mg/dl	Δ HDL cholesterol, mg/dl
MVPA, m/d						
< 30	0.10 (0.23)	-0.03 (0.04)	-0.01 (0.03)	0.13 (0.18)	0.10 (0.15)	-0.03 (0.06)
30-59	-0.10 (0.25)	-0.05 (0.04)	0.01 (0.03)	0.12 (0.19)	0.14 (0.17)	0.10 (0.06)
≥ 60	REF.	REF.	REF.	REF.	REF.	REF.
TV viewing, m/d						
< 60	REF.	REF.	REF.	REF.	REF.	REF.
60-119	-0.05 (0.24)	0.007 (0.04)	-0.01 (0.03)	-0.33 (0.18)	0.20 (0.16)	0.04 (0.06)
≥ 120	0.14 (0.24)	0.02 (0.04)	-0.04 (0.03)	0.07 (0.18)	**0.41 (0.16)**	-0.001 (0.06)
Baseline summary score	**0.38 (0.04)**	--	--	--	--	--
Baseline SBP, mm Hg	--	**0.03 (0.003)**	--	--	--	--
Baseline DBP, mm Hg	--	--	**0.01 (0.002)**	--	--	--
Baseline triglycerides, mg/dl	--	--	--	**0.03 (0.002)**	--	--
Baseline LDL, mg/dl	--	--	--	--	**-0.01 (0.003)**	--
Baseline HDL, mg/dl	--	--	--	--	--	**0.01 (0.002)**
Δ BMI percentile	**0.08 (0.03)**	0.008 (0.005)	0.001 (0.004)	0.02 (0.02)	0.04 (0.02)	**-0.02 (0.007)**
Δ Height, m	0.02 (0.05)	-0.01 (0.02)	**-0.06 (0.02)**	-0.12 (0.11)	**-0.26 (0.04)**	**-0.15 (0.04)**
Male sex	-0.24 (0.79)	**0.30 (0.11)**	0.03 (0.03)	0.004 (0.15)	-0.45 (0.35)	0.14 (0.20)
Baseline pubertal stage						
Pre-	**-5.12 (1.10)**	0.06 (0.08)	-0.004 (0.07)	-0.35 (0.36)	-0.97 (0.72)	**1.59 (0.29)**
During	**-3.38 (0.67)**	-0.007 (0.07)	-0.06 (0.06)	**-0.65 (0.32)**	**-1.07 (0.44)**	**0.78 (0.17)**
Post-	REF.	REF.	REF.	REF.	REF.	REF.
Black race	**-2.13 (0.86)**	-0.24 (0.15)	-0.07 (0.04)	**-0.81 (0.21)**	**0.36 (0.18)**	**0.48 (0.20)**
Adjusted R^2	0.28	0.36	0.07	0.42	0.18	0.24

n= 460; Values are parameter estimates (standard error); Δ summary score: also adjusted for length of follow-up, sex*puberty, sex*race; Δ systolic blood pressure: also adjusted for length of follow-up, sex*race, sex*Δheight; Δ diastolic blood pressure: also adjusted for length of follow-up, sex*Δheight; Δ triglyceride: also adjusted for length of follow-up, sex*Δheight; Δ ldl-cholesterol: also adjusted for length of follow-up, sex*puberty; Δ hdl-cholesterol: also adjusted for length of follow-up, sex*puberty, sex*race, sex*Δheight

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Chapter 7

Differences in weight-related outcomes by sports participation among adolescents in the US: 2005 Youth Risk Behavior Survey

Abstract

Despite the high prevalence of sports participation in the US, few studies have examined weight-related outcomes in this population, which have been shown to differ with regard to body image concerns. This study compared the prevalence of weight-related variables between sports participants and non-participants using data from the 2005 Youth Risk Behavior Survey. Logistic regression analysis, adjusted for age, race, and overweight status, was used to assess associations between participation in at least one sport (vs. none) and the following: perceived body size; intentions to lose, gain, and maintain weight; use of exercise, dieting, diet supplements, fasting, vomiting/laxatives, and selected combinations of these methods; and meeting physical activity (PA) and TV recommendations. Among males, sports participants reported higher proportions of intention to gain weight (odds ratio, OR= 1.9, 95% CI= 1.5-2.4), exercising to manage weight (OR= 1.3, 95% CI= 1.2-1.5), and meeting moderate-vigorous PA recommendations (OR= 3.4, 95% CI= 2.9-4.0) than non-participants. The proportion of females involved in sports who used exercise alone (OR= 1.9, 95% CI= 1.6-2.3) or a combination of diet and exercise to manage weight (OR= 1.3, 95% CI= 1.1-1.6) and met both PA and TV recommendations (OR= 2.7, 95% CI= 2.2-2.3) was higher than that of females not involved in sports. Odds of fasting as a weight-management strategy (OR= 0.8, 95% CI= 0.7-0.9) were lower among females involved in sports compared to non-participants. Perceived body size or intentions did not differ by sports participation status among females. Differences in weight perceptions and weight-control goals exist between youth involved in sports and non-participants. More studies are needed to describe unique issues surrounding sports involvement, particularly perceptions of body size and weight-gaining intentions among adolescent males.

Introduction

Sports participation has been regarded as a means of promoting health in youth, owing to positive associations with grades[1], self-concept[1, 2], depression[2], and body weight.[3] In 2003, the prevalence of sports participation among adolescents in the United States was estimated at 58%.[4] Despite the high prevalence of sports participation, youth involvement in sports has been understudied with regard to weight-related perceptions, intentions, and behaviors. Based on the literature that is available on this topic, it appears that there are important differences between youth sports participants and non-participants surrounding these issues [5-8]. For example, Ferron (1999) found that athletic adolescents had a better body image than other adolescents [5], while Rainey et al. (1998) have suggested that some athletes are more likely to perceive themselves as overweight than sedentary non-athletes [6]. Thus, it is unclear whether or not youth involved in sports have a better body image than those who are not involved in sports. Regardless, it is possible that body image and perceptions of one's body size influences weight-related attitudes, intentions, and behaviors in youth sports participants, as it does in youth in the general population [9, 10]. This is important because perceived body size has been associated with weight-change intentions and weight-management behaviors [9-11].

In 1999, 75% of males and 85% of females enrolled in high schools throughout the US reported an intention to lose, maintain, or gain weight [12]. Findings from existing studies indicate that the prevalence of these intentions differ among youth who participate in sports [3, 6, 7]. Male sports participant were less likely than non-participants to indicate that they were trying to lose weight [3]. Conversely, Rainey et al. (1998) reported that moderate-activity and high-activity sports participants were more likely than sedentary non-participants to have an intention to lose weight [6]. Trying to gain weight has also been reported as higher among male and female sports participants than non-participants [7]. It is not clear just how weight-related intentions differ between sports participants and non-participants, but behavioral theory suggests that intention precedes behavior[13]. Thus, it is not enough to know the prevalence of weight-related perceptions and weight-management intentions in youth; researchers must go one step further and examine the behaviors associated with perceived body size and weight-change intentions in this population.

The Surgeon General's Call to Action (2001), the American Academy of Pediatrics, and the World Health Organization have all put forth guidelines and recommendations that encourage the use of physical activity and a modified diet to lose weight among overweight youth [14, 15]. Unfortunately, in addition to these recommended practices, youth also have access to and have reported using non-recommended strategies, such as diet pills, laxatives, diuretics, and protein supplements and other performance enhancing substances, to lose, gain, and maintain weight [11, 12, 16, 17]. There is evidence to suggest that the likelihood of engaging in these non-recommended practices differs between sports participants and non-participants [3, 18]. Vertalino (2007) found that the use of any extreme behavior (i.e., vomiting, laxative/diuretic or diet pill use) in the past week was nearly four times higher in males involved in a sport or activity where the participant felt that it was important to stay a certain weight and twice as high among females, compared to their peers who did not participate in a weight-related sport. Creatine use among male and female sports participants was estimated at 5.6% in a sample of high school student sports participants in New York [19]. The prevalence of anabolic steroid use among high school sports participants in the US was estimated at 1.6% among female sports participants and 2.5% among males involved in sports [3]**.** Other, potentially harmful substances are also available for purchase in nutrition stores and on the Internet with virtually no restrictions. This is troublesome, not only because of the short-term effects of many of these products, but also because of the potential for long-term usage and an increased likelihood of engaging in illegal weight-management strategies. Compared to non-participants, adolescents who were involved in high school sports were nearly 60% more likely to use dietary supplements in adulthood [20]. Furthermore, while use of performance-enhancing substances (PES) is much more frequent among youth than anabolic steroid use, legal PES use can serve as a gateway for future use of illegal substances. Consistent with this gateway theory, data from the National Longitudinal Study of Adolescent Health (Add Health) have indicated that young adults, aged 18-24 years, who used a legal performance-enhancing substance were 26 times more likely than non-users to report using an anabolic steroid [20].

There are a limited number of studies of the association between sports participation and weight-related perceptions, intentions, and behaviors among adolescents. Findings from these studies are inconsistent, and often based on small, non-representative samples. Thus, we have proposed a conceptual framework (Figure) to describe how sports participation may be associated with weight-management intentions and strategies. In this analysis, we examined direct associations between sports participation and perceived weight or body size, weight-related intentions, and weight-management strategies, physical activity, and television viewing. Specifically, we tested the associations between participation on at least one sports team (versus no participation) in the past 12 months and (1) perceived body size; (2) intentions to lose, gain, and maintain weight; (3) use of exercise, dieting, diet pills or powders, fasting, vomiting or laxatives, and combinations of these methods; (4) meeting recommendations for moderate, vigorous, and moderate-vigorous physical activity and television viewing; and (5) overweight and at-risk for overweight.

Methods

Youth Risk Behavior Survey (YRBS)

The YRBS is a survey administered by the CDC and completed by youth in grades 9-12 in classrooms at public, parochial, and private schools, selected from among all fifty states and the District of Columbia. The survey collects data on tobacco use; unhealthy dietary behaviors; inadequate physical activity; alcohol use; sexual behaviors and sexually transmitted infections; and behaviors that contribute to unintentional injuries and violence. Detailed sampling and administration methods for the YRBS have been published elsewhere [4, 21].

Questions selected for inclusion in this analysis were those pertaining to weight-related perceptions and intentions and weight-management strategies (Table 1). Participation in physical activity and TV viewing were also included, as there is evidence linking these two behaviors to the development of overweight in youth [22-25]. The test-retest reliability of the 1999 YRBS questionnaire was assessed and has been reported elsewhere [26]. The mean kappa was 0.50 for the dietary behavior items and 0.55 for the physical activity behaviors. Kappa for perceived overweight and trying to lose weight were 0.59 and 0.58, respectively. The kappa statistics for the various weight-management practices ranged from 0.40-0.57; thus all items used in this analysis had good reliability.

Self-reported height and weight were collected on the YRBS survey. Data from a validation study conducted among a convenience sample of youth in grades 9-12, have suggested a high correlation (r= 0.89) between BMI calculated from self-reported height and weight and BMI calculated from measured height and weight [27].

Sample and Exclusion Criteria

As noted above, Grades 9 through 12 of all regular public, Catholic, and other private schools, in all fifty states and the District of Columbia were included in the sampling frame (n=203). Of these, 159 schools participated (school response rate= 78%). Questionnaires were completed by 86% of the sample students (total response rate= 67%). After exclusions due to implausible height, weight, and BMI data and logical inconsistencies, 13,917 questionnaires were available for analysis. We further excluded participants who were missing height or weight (n=798), or missing any of the other variables being used in this analysis (n=1090), yielding a final analytic sample of 11,997 males and females.

Variable Specification and Statistical Analyses

Sports participants were defined as those males and females who reported playing on at least one sports team in the past year. Initially, there were five response options for perceived body size: (1) very underweight, (2) slightly underweight, (3) about right, (4) slightly overweight, (5) very overweight. These options were collapsed into the following three categories for analysis because there were small numbers of responses (<5%) in the very underweight (n=194) and very overweight (n=522) categories: (1) underweight, (2) about right, and (3) overweight.

Responses to items describing participation in vigorous physical activity, moderate physical activity, any activity, and television viewing were coded into a series of dichotomous variables representing those who did or did not meet each of the following recommendations: 20 minutes of vigorous activity on at least 3 days each week [28]; 30 minutes of moderate-intensity activity on most days of the week (≥ 5 days) [28]; 60 minutes of moderate-vigorously intense activity on most days of the week (≥ 5 days) [29, 30]; and fewer than two hours spent viewing television each day [14, 28]. Two more variables were created to describe: (1) whether each participant was meeting at least one of the current physical activity recommendation or not, and (2) whether each participant was meeting the TV viewing recommendation in addition to any of the physical activity recommendations.

Height and weight were used to calculate body mass index (BMI= weight/height^2, kg/m^2). Using age- and sex-specific percentiles [31], BMI was classified into the following 4 categories: underweight (< 5th percentile), normal (5-85th percentiles), at risk for overweight (85-95th percentiles), and overweight (≥ 95th percentile).

Prevalence estimates of participation on at least one sport team were reported by sex, race/ethnicity group (White, Black or African-American, Hispanic, and other), and grade level (grades 9 and 10 and grades 11 and 12) using the Surveyfreq procedure in SAS version 9.1 (SAS Institute, Cary, NC). The remaining analyses were stratified on sex because males and females have been shown to differ with regard to perceptions and behaviors related to physical activity and weight [3, 18, 32]. Prevalence estimates were obtained for perceived body size, weight management goal or intention, weight management behaviors, meeting physical activity and TV viewing recommendations, and BMI categories. In addition to individual weight-management behaviors (exercise only; diet only; fasting; using dietary supplement, such as diet pills or powders, and purging behaviors [vomiting and taking laxatives]), use of a combination of exercise and diet was also included in this analysis. Similarly, responses to the fasting, dietary supplements, and purging items were combined to create a variable describing the use of non-recommended weight management strategies. Simple logistic regression, using the Surveylogistic procedure to account for the complex sampling design, was conducted to examine associations between sport involvement (non-participants served as the referent group) and these measures. Multivariate logistic regression was then used to assess the relationships between sports participation and each of the following: perceived body size, weight-related intention, each weight-management behavior, and meeting activity and TV viewing recommendations. The models were adjusted for grade, race, and overweight status. Finally, to determine whether age, race, or overweight status modified any of the aforementioned relationships, the preceding analysis was repeated while stratifying on each these variables and sex in three separate models. Underweight participants were excluded from this sub-analysis, because the sample (n=242) was too small to yield stable estimates upon stratification by sex and other potential effect modifiers. Odds ratios were considered statistically significant if the 95% confidence interval did not include 1.

Results

Table 2 shows the distribution of demographic characteristics for the analytic sample. In brief, there was no difference in the proportion of males versus females, the majority of the sample was White (64.1%), and most of the participants were in grades 9 or 10 (54.0%). Among males, the proportion of sports participants was higher than that of non-participants. This was true of all race/ethnic groups. Non-participation was more common among Black and Hispanic females.

Males. In the unadjusted analysis (Table 3), males who perceived themselves as underweight (OR= 0.7, 95% CI= 0.6-0.9) or overweight (OR= 0.5, 95% CI= 0.4-0.6) had lower odds of being sports participants than males who thought their body size was “about right”. Male participants who reported an intention to gain weight, however, had higher odds of sports involvement compared to those who reported that they were not trying to do anything about their weight (OR= 1.8, 95% CI= 1.5-2.3). Sports participation was positively associated with using exercise as a weight-control method (OR= 1.2, 95% CI= 1.1-1.4), but inversely related to dieting (OR= 0.8, 95% CI= 0.7-0.9). Males who were reportedly meeting physical activity and TV viewing recommendations had higher odds of sports involvement (OR= 1.9, 95% CI= 1.6-2.2). Playing sports was inversely associated with overweight (OR= 0.4, 95% CI= 0.2-0.6), but there was no relationship between sports participation and being at risk for overweight.

In models adjusted for age, race, and BMI, all associations in males except the use of dieting as a weight-management strategy, remained statistically significant. With regard to the covariates themselves, in general, younger males (versus males over age 16) had higher odds of sports involvement. Black and Hispanic males had reduced odds of sports participation compared to White males, and overweight males had lower odds of participating in a sport than normal weight males. When included in the models containing perceived body size and weight-related intentions, overweight status was no longer associated with sports participation. Overweight status however, appeared to have a multiplicative effect on the association between sports participation and intention to gain weight among males (Appendix D1). The odds ratio for intention to gain weight among sports participants who were at risk for overweight or overweight compared to non-participants was 7.6 (95% CI= 3.9-14.9). In contrast, intention to gain weight was reported nearly twice as often by normal weight sports participants (compared to normal weight non-participants, OR= 1.7, 95% CI= 1.3-2.1). Age also modified the association between sports participation and intention to gain weight. The odds ratio describing involvement on a sports team for those intending to gain was 1.2 (95% CI= 0.9-1.78) for younger males and 2.3 (95% CI= 1.82-3.0) in older males.

Females. As with males, in the unadjusted analysis (Table 4), females who perceived themselves as overweight (OR= 0.7, 95% CI= 0.6-0.9) had lower odds of being involved in a sport. Female sports participation was also inversely associated with fasting for weight-control

(OR= 0.8, 95% CI= 0.7-0.9), but positively associated with the use of a combination of diet and exercise to manage one's weight (OR= 1.2, 95% CI= 1.1-1.4). Among females who were meeting physical activity and television viewing recommendations, sports participation was reported more frequently than among those who were not meeting these recommendations (OR= 2.8, 95% CI= 2.3-3.3). Conversely, sport involvement was inversely associated with being underweight (OR= 0.4, 95% CI= 0.3-0.7) or at risk for overweight (OR= 0.7, 95% CI= 0.5-0.8) and overweight (OR= 0.5, 95% CI= 0.4-0.6). In the models adjusted for age, race, and BMI, sports participation was no longer inversely associated with perceived overweight; all other associations remained significant. With regard to the three covariates, among females, sports involvement was associated with age, nonwhite race, and overweight status across the models. Compared to white females, black, Hispanic, and "other" females had lower odds of sports participation, as did females who were classified as overweight or at risk for overweight (compared to normal weight females). Overweight status also appeared to interact with meeting vigorous physical activity recommendations, such that the odds of being a sports participant were higher among normal weight females who were meeting the vigorous activity recommendations (OR= 4.4, 95% CI= 3.6-5.3) than females who were overweight or at risk for overweight and sufficiently active according to this recommendation (OR= 2.6, 95% CI= 2.0-3.5, Appendix D2).

Discussion

The initiation of many risky behaviors occurs during adolescence.[33] Participation in sport, a widespread activity in the United States, may further compound risk-taking behaviors.[3, 6, 34] Currently, there is little information regarding the association between health-related behaviors and sports participation. This analysis sought to describe weight-related perceptions, intentions, and behaviors among youth involved in sports compared to those who were not. In general, male and female sports involvement was inversely associated with underweight and overweight, and positively related to exercising to control weight, and meeting expert physical activity and television viewing recommendations. Participation in a sport was negatively associated with perceived underweight and positively associated with intention to gain weight among males, but not females. Fasting and being at risk of overweight were negatively associated with sports involvement in females, but not in males.

The findings that males who perceived themselves as underweight (versus "about right") had lower odds of being involved in a sport, but males who reported an intention to gain weight (versus do nothing about their weight) had increased odds of sports involvement raise the question of whether perception has any influence on weight intention among male sports participants. Understanding how perceived body size relates, if at all, to weight intention and other weight-related outcomes and behaviors in this population should be an area for future research. While these relationships have not been widely studied in adolescent sports participants, the following factors have been associated with weight-related perceptions, intentions, and management strategies among youth in the general population and may warrant further consideration among sport participants: social norms surrounding body size [11, 35], cultural norms specific to participation in a particular sport [36], internalization of body-size stereotypes in the media [17, 37] the receipt of advice to alter or maintain one's weight by teammates or coaches [36, 37], and a desire to enhance one's sports performance [36].

Our findings indicated that nearly one-fifth of the male sports participants in our sample were trying to gain weight despite the observation that less than 3% of males were underweight. We also showed evidence of an interaction between overweight status and intention to gain weight, with the odds of reporting an intention to gain weight being significantly higher among overweight male sports participants than normal weight sports participants when compared with their counterparts who did not play on any sports teams. This is suggestive of a discrepancy between recommended weight goals based on body mass and the participants' personal weight goals. We suspect that some boys may have interpreted this response option as wanting to gain muscle, but the YRBS questionnaire does not make this distinction. If the YRBS is revised in the future, it may be beneficial to distinguish between gaining weight and gaining muscle. Media, such as magazine and television advertisements and articles on body shape and increasing muscle mass, have been identified as important influencers of intentions to gain weight or muscle [17, 37]. In light of the observation that sports participation among males is associated with an increased desire to gain weight, it is also important to be aware of the weight-gaining strategies being used in this population in order to determine if unhealthy practices are being employed Future research should address this gap in the literature on youth sports participation; studies of this nature would provide information needed to determine if preventive measures, such as regulations and screenings, are needed to discourage the use of harmful substances to aid in the accrual of muscle. In particular, males involved in football, soccer, basketball, and hockey have been found to have a greater intention to gain weight than males who do not participate in these sports [16, 36]. It is likely that weight-related intentions are different among participants of weight-sensitive sports compared to those with no expectation of body size or weight. For instance, football players are often expected to have large, muscular builds, while runners are expected to have leaner frames. There may also be issues surrounding intentions to lose weight prior to competition among participants in sports that emphasize weight or weight classes. Unfortunately, these analyses did not incorporate information on the types of sport(s) the study participants were involved in. Future studies on this topic should address this limitation.

Among participants in our sample, 36% of male sports participants reported using at least one of the following methods to change or maintain their weight: exercise, dieting or reducing food intake or calories, using a diet pill or powder, fasting, vomiting, or laxative use. Males most often engaged in exercise to manage weight, followed by dieting. However, only the use of exercise as a weight-management strategy differed significantly between male sports participants and non-participants.

Females involved in sports also reported a higher prevalence of using diet and exercise to manage their weight than females who did not participate in sports; conversely, female sports participants reported fasting as a weight-management practice less often than non-participants.

The use of non-recommended practices (i.e., diet aids, fasting, laxative use, and vomiting) was higher among female sports participants (11%) than males who were involved in sport (6%). Although this estimate did not differ significantly between female sports participants and those who did not play sports, it is still an area worthy of further study in the general population as well as among youth involved in high school athletic programs. Because these methods are unhealthy and potentially harmful, continued care should be taken to discourage their use. There exists a unique opportunity to do this among sports participants, since there is generally frequent contact with physicians, dieticians, and coaches. Efforts should be made to educate participants about healthy ways to manage weight, such as diet and physical activity, and to monitor the use of non-recommended weight-change.

Participation in regular physical activity is recommended for optimal health in adolescents. It is thought that youth involved in sports participate in significant amounts of activity during training (practice) and competitions [3, 34, 38].We found that meeting at least one of the physical activity recommendations was more common in sports participants than non-participants, however only about one-half of males and two in five females involved in sports were meeting the most recent recommendation of 60 minutes of moderate-vigorous activity per day. This underscores the need to explore and implement creative ways to effectively increase regular activity in youth, in general. Though data from the YRBS do not allow for an analysis of this sort, it is also of interest to determine if sports participants are more active, apart from time spent in training activities and competitions.

There are other limitations that should be taken into account when considering these findings and conclusions. Because the YRBS survey is administered in schools, youth who are homeschooled are not included in this analysis. However, the percentage of the student population (grades K-12) being homeschooled in the United States is small (estimated at 2.2% in 2003) and national data indicate that there are no significant differences between homeschooled children and children who were enrolled in public or private schools with regard to sex, parental educational attainment, urbanicity, or region.[39] There are some differences between homeschooled youth and their peers enrolled in public and private schools with regard to ethnicity, the number of children in the household, the number of parents employed outside of the home, and annual household income.[39] Because the YRBS dataset does not include information on several of these sociodemographic characteristics, we are unable to make any inferences about the generalizability of these findings to youth who are homeschooled. Due to the cross-sectional nature of this study, we are unable to draw any conclusions with regard to the direction of the demonstrated associations. For example, we are unable to ascertain whether males want to gain weight because they play a sport or if males participate in a sport because they want to gain weight. In addition, although most of the items used in this analysis had suitable test-retest reliability, the items describing fasting and vomiting or laxative use had less than moderate test-retest reliability and should be interpreted with caution. In this population, which included sports participants, it is possible that the use of only height and weight may have lead to some misclassification of overweight status [40, 41]. Our findings regarding BMI status may have been biased if sports participants under-reported their weight or over-reported their height more than non-participants. This has not been tested in the YRBS population, and there are no studies available that suggest that this is a likely occurrence. Among males in particular, having a BMI greater than the 85th percentile may not be indicative of excess body fatness, but of high fat-free mass. This is probably less true in girls. A published report of the sensitivity and specificity of BMI when compared to percent body fat calculated via body density measured by air displacement plethysmography demonstrated that BMI was only 27% specific for overweight among male collegiate athletes and 67% specific among female collegiate athletes [42]. Finally, the YRBS questionnaire does not distinguish between intention to gain weight and intention to gain muscle, nor does it contain questions related to practices used to gain weight or muscle, such as protein supplementation or anabolic steroid use. While the use of anabolic steroids in this population is probably low, it is important to have national estimates of these behaviors from a monitoring standpoint.

Despite these limitations, this report provides national estimates of the prevalence of weight-related perceptions, intentions, and practices among high school sports participants and non-participants. We have also identified significant differences between these two groups with regard to weight perceptions and weight-management goals, highlighting the need for more studies aimed at understanding unique concerns and behaviors among youth sports participants, particularly weight-gaining intentions among older male sports participants. Given the extent of participation in sports among American high school students, it is also desirable to continue monitoring the use of recommended versus non-recommended weight-management practices in this population.

Figure 7.1 Conceptual framework describing the proposed relationship between sports participation and weight-management intention and strategies among high school students

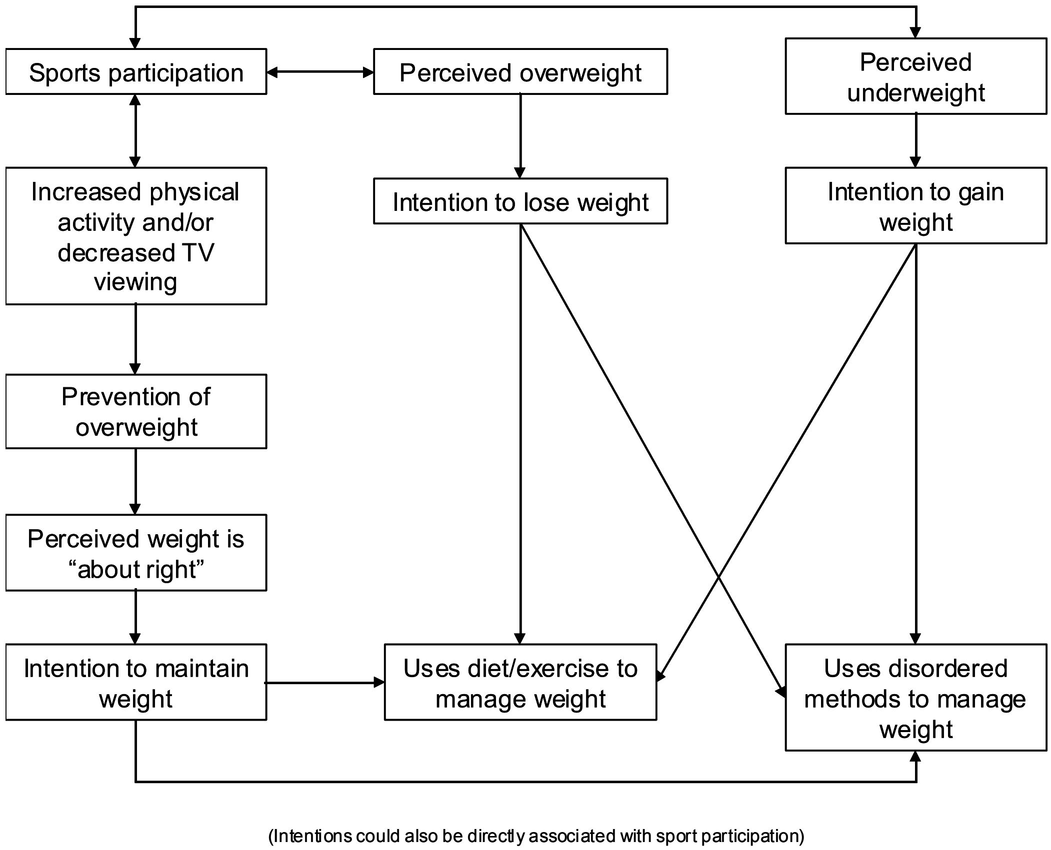

Table 7.1 Description of selected items and response options for the 2005 Youth Risk Behavior Survey and operational definitions and categories.

YRBS question	YRBS response options	Operational definitions and categories
How do you describe your weight?	1= very underweight 2= slightly underweight 3= about right 4= slightly overweight 5= very overweight	Perceived body size 1= underweight 2= about right (referent) 3= overweight
Which of the following are you trying to do about your weight?	1= lose weight 2= gain weight 3= stay the same weight 4= I am not trying to do anything about my weight	Weight-management goal 1= lose 2= gain 3= maintain 4= do nothing (referent)
During the past 30 days, did you exercise to lose weight or to keep from gaining weight?	1= yes 2= no	Exercise 0= no 1= yes
During the past 30 days, did you eat less food, fewer calories, or foods low in fat to lose weight or to keep from gaining weight?	1= yes 2= no	Diet 0= no 1= yes
During the past 30 days, did you go without eating for 24 hours or more (also called fasting) to lose weight or to keep from gaining weight?	1= yes 2= no	Fast 0= no 1= yes
During the past 30 days, did you take any diet pills, powders, or liquids without a doctor's advice to lose weight or to keep from gaining weight?	1= yes 2= no	Diet supplements 0= no 1= yes

Table 7.1 cont. Description of selected items and response options for the 2005 Youth Risk Behavior Survey and operational definitions and categories.

YRBS question	YRBS response options	Operational definitions and categories
During the past 30 days, did you vomit or take laxatives to lose weight or to keep from gaining weight?	1= yes 2= no	Purge 0= no 1= yes
On how many of the past 7 days did you exercise or participate in physical activity for at least 20 minutes that made you sweat and breathe hard, such as basketball, soccer, running, swimming laps, fast bicycling, fast dancing, or similar aerobic activities?	1= 0 days 2= 1 day 3= 2 days 4= 3 days 5= 4 days 6= 5 days 7= 6 days 8= 7 days	Meets vigorous activity recommendation 0= $<$ 3 days 1= $\geq$ 3 days
On how many of the past 7 days did you exercise or participate in physical activity for at least 30 minutes that did not make you sweat and breathe hard, such as fast walking, slow bicycling, skating, pushing a lawn mower, or mopping floors?	1= 0 days 2= 1 day 3= 2 days 4= 3 days 5= 4 days 6= 5 days 7= 6 days 8= 7 days	Meets moderate activity recommendation 0= $<$ 5 days 1= $\geq$ 5 days
During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?	1= 0 days 2= 1 day 3= 2 days 4= 3 days 5= 4 days 6= 5 days 7= 6 days 8= 7 days	Meets moderate-vigorous activity recommendation 0= $<$ 5 days 1= $\geq$ 5 days

Table 7.1 cont. Description of selected items and response options for the 2005 Youth Risk Behavior Survey and operational definitions and categories.

YRBS question	YRBS response options	Operational definitions and categories
On an average school day, how many hours do you watch TV?	1= I do not watch TV on an average school day 2= less than 1 hour per day 3= 1 hour per day 4= 2 hours per day 5= 3 hours per day 6= 4 hours per day 7= 5 or more hours per day	Meets TV viewing recommendation 0= ≥ 3 days 1 < 3 days
During the past 12 months, on how many sports teams did you play?	1= 0 teams 2= 1 team 3= 2 teams 4= 3 or more teams	Sports participation 0= 0 teams 1= ≥ 1 team

Table 7.2 Weighted prevalence estimates of sex, grade, and race/ethnicity by sports participation

	Entire Sample (n=11997)	Non-participant (n= 5492)	Sport participant (n= 6505)
Sex			
Male	50.2 (49.0-51.4)	37.7 (34.9-40.6)	62.3 (59.4-65.1)
Female	49.8 (48.6-51.0)	49.8 (47.0-52.6)	50.2 (47.4-53.0)
Race			
White, Non-Hispanic			
Male	32.4 (30.1-34.6)	38.1 (34.2-41.9)	61.9 (58.1-65.8)
Female	31.7 (29.2-34.1)	46.3 (42.4-50.2)	53.7 (49.8-57.6)
Black/African-American, Non-Hispanic			
Male	6.2 (4.8-7.6)	35.2 (31.3-39.1)	64.8 (60.9-68.7)
Female	6.9 (5.4-8.5)	56.8 (52.7-60.8)	43.2 (39.2-47.3)
Hispanic			
Male	7.4 (6.3-8.5)	37.4 (33.4-41.3)	62.6 (58.7-66.6)
Female	7.2 (6.2-8.2)	55.7 (51.8-59.6)	44.3 (40.4-48.2)
Other			
Male	4.2 (3.0-5.3)	39.5 (33.8-45.2)	60.5 (54.8-66.2)
Female	4.0 (2.8-5.2)	54.4 (48.8-59.9)	45.6 (40.1-51.2)
Grade			
All			
9-10	54.0 (52.5-55.5)	40.5 (37.6-43.3)	59.5 (56.7-62.4)
11-12	46.0 (44.5-47.5)	47.6 (45.0-50.1)	52.4 (49.9-55.0)
Grades 9-10			
Male	54.8 (53.0-56.6)	35.6 (32.0-39.2)	64.4 (60.8-68.0)
Female	53.1 (51.2-55.1)	45.6 (42.2-48.9)	54.4 (51.1-57.8)
Grades 11-12			
Male	45.2 (43.4-47.0)	46.8 (44.3-49.3)	53.2 (50.7-55.7)
Female	46.9 (44.9-48.8)	43.1 (40.6-45.5)	56.9 (54.5-59.4)

Values are percent (95% confidence interval).

Table 7.3 Weighted prevalence estimates and odds ratios for weight-related outcomes by sports participation among males

	No sport (unweighted n)	Percent, SE	≥ 1 sport (unweighted n)	Percent, SE	Unadjusted OR (95% CI) [1]	Adjusted OR (95% CI) [2]
Perceived body size						
About right	1127	49.9, 1.6	2165	62.4, 0.9	1.0	1.0
Underweight	420	18.6, 1.1	583	16.4, 0.9	0.7 (0.6-0.9)	0.8 (0.6-0.9)
Overweight	668	31.5, 1.4	740	21.2, 1.0	0.5 (0.4-0.6)	0.5 (0.4-0.7)
Weight-management goal						
Lose weight	774	35.1, 1.5	985	27.0, 1.1	0.9 (0.7-1.0)	0.9 (0.7-1.1)
Gain weight	469	20.0, 1.1	1125	31.4, 1,2	1.8 (1.5-2.3)	1.9 (1.5-2.4)
Maintain weight	455	20.9, 1.4	742	20.6, 0.9	1.1 (0.9-1.4)	1.1 (0.9-1.4)
Do nothing	517	24.1, 1.2	636	21.0, 1.0	1.0	1.0

Table 7.3 cont. Weighted prevalence estimates and odds ratios for weight-related outcomes by sports participation among males

	No sport (unweighted n)	Percent, SE	≥ 1 sport (unweighted n)	Percent, SE	Unadjusted OR (95% CI) [1]	Adjusted OR (95% CI) [2]
Weight-management behavior[3]						
Exercise	1138	49.6, 1.6	1935	55.1, 1.0	1.2 (1.1-1.4)	1.3 (1.2-1.5)
Diet	650	28.9, 1.5	878	24.6, 0.9	0.8 (0.7-0.9)	0.8 (0.7-1.0)
Fast	181	8.5, 0.8	252	6.4, 0.5	0.7 (0.6-1.0)	0.8 (0.6-1.0)
Diet supplements	86	3.6, 0.5	156	4.1, 0.4	1.1 (0.8-1.6)	1.2 (0.9-1.7)
Purge	52	2.2, 0.5	88	2.2, 0.4	0.9 (0.6-1.6)	1.0 (0.6-1.6)
Exercise + diet	543	24.6, 1.5	799	22.5, 0.9	0.8 (0.7-1.0)	1.0 (0.8-1.2)
Fast, diet supplement, or purge	241	10.4, 0.9	370	9.6, 0.7	0.9 (0.7-1.2)	1.0 (0.8-1.2)
Any method	1280	55.4, 1.4	2052	58.1, 1.0	1.1 (1.0-1.2)	1.2 (1.0-1.4)
Meets recommendation[4]						
Vigorous PA	1250	58.1, 1.3	2842	82.9, 1.0	3.5 (2.9-4.1)	3.4 (2.9-4.0)
Moderate PA	491	23.5, 1.3	1071	32.0, 1.1	1.5 (1.3-1.8)	1.5 (1.3-1.8)
MVPA	539	26.8, 1.2	1878	55.5, 1.5	3.4 (2.9-4.0)	3.4 (2.9-4.0)
TV viewing	1215	60.5, 1.7	2040	63.7, 1.6	1.1 (0.9-1.3)	1.2 (1.0-1.4)
Meets ≥ 1 PA	1408	65.5, 1.2	2972	86.4, 1.0	3.3 (2.8-4.0)	3.3 (2.8-3.9)
Meets ≥ 1 PA + TV	794	40.9, 1.6	1775	56.4, 1.6	1.9 (1.6-2.2)	1.9 (1.6-2.3)

Table 7.3 cont. Weighted prevalence estimates and odds ratios for weight-related outcomes by sports participation among males

	No sport (unweighted n)	Percent, SE	≥ 1 sport (unweighted n)	Percent, SE	Unadjusted OR (95% CI) [1]	Adjusted OR (95% CI) [2]
Body mass index						
Underweight	74	3.5, 0.5	54	1.3, 0.2	0.4 (0.2-0.6)	0.4 (0.2-0.6)
Normal	1385	61.9, 1.4	2313	68.4, 1.1	1.0	1.0
At risk for overweight	332	15.6, 1.0	562	16.0, 1.0	0.9 (0.7-1.2)	0.9 (0.7-1.1)
Overweight	424	19.1, 1.1	559	14.3. 0.7	0.7 (0.6-0.8)	0.7 (0.6-0.8)

n= 5703; PA= physical activity; [1] referent group= nonparticipation; [2] Adjusted for age/grade, race/ethnicity, and BMI (BMI was adjusted for age and race only); [3] referent group= did not engage in respective behavior to manage weight during the past 30 days; [4] referent group= did not meet recommendation, vigorous PA recommendation= 20 m/d on at least 3 days, moderate PA recommendation= 30 m/d on at least 5 days, MVPA recommendation= 60 m/d on at least 5 days, TV recommendation= ≤ 2 h/d

Table 7.4 Weighted prevalence estimates and odds ratios for weight-related outcomes by sports participation among females

	No sport (unweighted n)	Percent, SE	≥ 1 sport (unweighted n)	Percent, SE	Unadjusted OR (95% CI) [1]	Adjusted OR (95% CI) [2]
Perceived body size						
About right	1605	48.6, 1.0	1694	55.4, 1.6	1.0	1.0
Underweight	336	10.2, 0.7	283	9.3, 0.7	0.9 (0.7-1.1)	0.9 (0.7-1.1)
Overweight	1336	41.2, 1.2	1040	35.3, 1.3	0.7 (0.6-0.9)	1.0 (0.8-1.2)
Weight-management goal						
Lose weight	1963	61.4, 1.2	1836	62.7, 1.1	1.1 (0.8-1.3)	1.2 (1.0-1.6)
Gain weight	289	7.3, 0.6	175	4.6, 0.6	0.7 (0.5-1.1)	0.7 (0.5-1.0)
Maintain weight	530	16.3, 0.9	596	18.6, 0.8	1.2 (0.9-1.5)	1.2 (0.9-1.4)
Do nothing	495	15.0, 1.0	410	14.1, 0.8	1.0	1.0

Table 7.4 cont. Weighted prevalence estimates and odds ratios for weight-related outcomes by sports participation among females

	No sport (unweighted n)	Percent, SE	≥ 1 sport (unweighted n)	Percent, SE	Unadjusted OR (95% CI)[1]	Adjusted OR (95% CI)[2]
Weight-management behavior[3]						
Exercise	1946	61.2, 1.6	2214	74.2, 1.1	1.8 (0.5-2.1)	1.9 (1.6-2.3)
Diet	1699	55.4, 1.3	1614	55.0, 1.3	1.0 (0.8-1.1)	1.0 (0.9-1.2)
Fast	543	18.5, 1.0	479	15.4, 0.7	0.8 (0.7-0.9)	0.8 (0.7-0.9)
Diet supplements	252	8.3, 1.0	217	7.8, 0.8	0.9 (0.7-1.2)	1.0 (0.8-1.4)
Purge	180	5.9, 0.6	202	6.5, 0.5	1.1 (0.9-1.4)	1.2 (0.9-1.5)
Exercise + diet	1364	44.4, 1.4	1457	49.8, 1.3	1.2 (1.1-1.4)	1.3 (1.1-1.6)
Fast, diet supplement, or purge	730	24.1, 1.3	662	21.6, 0.9	0.8 (0.7-1.0)	0.9 (0.8-1.1)
Any method	2329	73.7, 1.2	2403	80.2, 1.1	1.4 (1.2-1.6)	1.6 (1.3-1.89
Meets recommendation[4]						
Vigorous PA	1284	39.8, 1.6	2122	72.5, 1.3	3.9 (3.3-4.6)	3.9 (3.3-4.5)
Moderate PA	581	18.1, 1.1	846	30.6, 1.1	2.0 (1.7-2.3)	2.0 (1.7-2.3)
MVPA	454	13.9, 1.0	1187	41.9, 1.7	4.5 (3.8-5.4)	4.3 (3.6-5.1)
TV viewing	1767	59.1, 1.4	1923	68.7, 1.5	1.5 (1.3-1.7)	1.4 (1.2-1.7)
Meets ≥ 1 PA	1576	48.7, 1.6	2271	77.1, 1.2	3.5 (2.9-4.2)	3.4 (2.9-4.1)
Meets ≥ 1 PA + TV	875	29.8, 1.5	1506	54.4, 1.8	2.8 (2.3-3.3)	2.7 (2.2-3.2)

Table 7.4 cont. Weighted prevalence estimates and odds ratios for weight-related outcomes by sports participation among females

	No sport (unweighted n)	Percent, SE	≥ 1 sport (unweighted n)	Percent, SE	Unadjusted OR (95% CI) [1]	Adjusted OR (95% CI) [2]
Body mass index						
Underweight	71	2.6, 0.4	43	1.3, 0.2	0.4 (0.3-0.7)	0.4 (0.3-0.7)
Normal	2155	67.0, 1.2	2299	77.9, 1.1	1.0	1.0
At risk for overweight	594	17.3, 1.0	453	13.9, 1.0	0.7 (0.6-0.9)	0.7 (0.6-0.9)
Overweight	457	13.0, 0.9	222	6.9, 0.6	0.5 (0.4-0.6)	0.5 (0.4-0.6)

n= 6294; PA= physical activity; [1] referent group= nonparticipation; [2] Adjusted for age/grade, race/ethnicity, and BMI (BMI was adjusted for age and race only); [3] referent group= = did not engage in respective behavior to manage weight during the past 30 days; [4] referent group= did not meet recommendation, vigorous PA recommendation= 20 m/d on at least 3 days, moderate PA recommendation= 30 m/d on at least 5 days, MVPA recommendation= 60 m/d on at least 5 days, TV recommendation= ≤ 2 h/d

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Chapter 8

Correlates of weight-management intentions and practices among high school sports participants in Muscogee County, Georgia

Abstract

Adolescents who participate in sports may be at an increased risk of engaging in unhealthy weight-control practices. Factors related to these practices are not well characterized among youth involved in sport. This study described the importance of receiving weight-related advice from an adult or peer and both perceived and measured body size with regard to weight-related intentions and practices. During sports-related pre-participation screenings in Muscogee County, Georgia in 2006, 801 students (ages 13-18, 73.2% inclusion rate) completed a 5-item survey assessing their intentions to lose, gain, or maintain weight. Other items included the receipt of advice to change or maintain their weight from a peer and/or adult, perceived weight (underweight, about right, overweight), the use of various weight-management behaviors, and the number of sports teams they had been a member of in the past year. Body mass index (BMI) was calculated using measured height and weight. Receiving peer or adult advice was associated with all intentions among males, e.g., receiving weight-related advice from a peer or adult (vs. receiving no advice) was associated with a seven-fold (95% CI= 2.6-20.8) increased odds of having an intention to gain weight. Among females, receipt of advice from both a peer and adult was associated with intention to lose (OR= 2.8, 95% CI= 1.1-7.2) or maintain weight (OR= 3.2, 95% CI= 1.5-6.9). Perceived overweight mediated the association between receipt of peer/adult advice and weight-loss intention among females. Among females in particular, the development of weight intentions is a complex process requiring youth to weigh the relative importance of their own perceptions and advice from peers or adults within the context of actual body size.

Introduction

A majority of American adolescents have an intention to lose or gain weight.[1] Weight-change intentions are associated with participation in weight-related behaviors. For instance, intention to lose weight has been associated with restrictive eating behaviors among adolescents.[2] Restrictive food behavior among adolescents has also been linked to the development of disordered eating behaviors and ironically, weight gain.[3, 4] This is one example of why it is important to identify correlates of weight-related intentions among youth. Studies show that youth involved in sports that emphasize weight are more likely to engage in these disordered eating behaviors than those who are not involved in such sports.[5, 6] This finding and the pervasiveness of involvement in sport in American society underscores the importance of identifying factors related to weight-related behaviors in this population.

Sports participants are a unique subset of the adolescent population that has been shown to have unique concerns with regard to weight-related perceptions and intentions.[7-9] Reports of trying to lose weight, feeling overweight, and self-induced vomiting were more common among adolescents involved in sports compared to those who were not. Additionally, findings from the preceding analysis in this dissertation indicate that a higher proportion of male sports participants have an intention to gain weight than males in the general population. Weight-gain intention has been linked to the use of dietary supplements, such as creatine, which are widely available to people of all ages.[2, 10-12] In addition to the potential for adverse side effects in youth, the use of supplements to gain weight may increase the likelihood of engaging in the use of illegal substances, such as anabolic steroids.[13, 14] Unfortunately limited research is available describing correlates of supplement use or any other non-recommended weight-management practices among sports participants, making it difficult to form salient health messages to address the use of these non-recommended methods to manage weight in this population.

Developmental theory offers some insight into some of the factors that may influence weight-related intentions and behaviors among youth. Adolescence is a time when peer influence begins to supersede that of parents.[15] In the case of sports participants, they have to negotiate relationships with their teammates as well as their peers who are not involved in sports. Additionally, coaches may also exert some influence on the attitudes and behaviors of sports participants.[12, 16-19] Thus, youth involved in sport have the complex task of weighing weight-related advice of parents, peers, and coaches along with their own personal ideals and perceptions.

To date, there have been no studies that have sought to examine the relative importance of receiving weight-related advice from an adult or peer and perceived body size, with regard to weight-related intentions and practices among sports participants. The primary objective of this analysis is to describe these associations, while also considering the influence of measured BMI, age, and the extent of sports participation, i.e., the number of sports teams of which an individual is a member. It has been suggested that overweight youth who do not perceive themselves as overweight are not likely to engage in practices to achieve a healthy weight.[20] It is of particular interest to understand if perceived weight mediates potential associations between weight-related intentions and measured weight status and receiving weight-related advice among sports

<u>Methods</u>

Data Collection

High School students in Muscogee County, Georgia who were interested in participating on a school-based sports team were invited to attend a sport-related health screening conducted at a local high school by volunteers and staff of the Hughston Sports Medicine Foundation in July 2006. During the screening, each participant's height was measured to the nearest centimeter, using a free-standing stadiometer, and weight was measured to the nearest pound using a portable electronic scale, while the participant wore gym shorts and a lightweight t-shirt.

A 5-item questionnaire designed by the authors was completed during the screening (Table 1). This questionnaire was designed to assess weight-related intentions and perceptions, and receipt of advice from a significant other (i.e., peer, parent, coach) to lose, gain, or maintain their weight. The items used to capture intention to lose, gain, and maintain weight and perceived body size were taken from current Youth Risk Behavior Survey (YRBS) items. The YRBS is a survey administered by the Centers for Disease Control and Prevention (CDC) and completed by youth in grades 9-12 in classrooms at selected schools. The survey collects self-reported data on tobacco use, unhealthy dietary behaviors, inadequate physical activity, alcohol use, sexual behaviors and sexually transmitted infections, and behaviors that contribute to unintentional injuries and violence.[1] Each of the YRBS items selected for inclusion in the Muscogee study had moderate reliability.[21] Information of the validity of these items, however, is lacking. Internal consistency of perceived body size and weight-management intentions are briefly described in this analysis.

The weight-loss strategy question was also based on a YRBS item, but was modified to include two additional response options addressing weight-gaining behaviors: eat more food, more calories, or foods high in fat; and take performance enhancing products, such as creatine or protein. The advice item, “In the past 12 months, have any of the following people suggested that you lose weight, gain weight, or maintain weight to improve your sports performance?”, was created for this study by the researchers; reliability and validity data are not available for this item. Sport team participation, age, and grade level were also self-reported by each participant.

Staff and volunteers of the Hughston Sports Medicine Foundation were responsible for data collection and obtaining Informed Consent from the participants’ parents. This study was approved by the Hughston Foundation’s Institutional Review Board in Columbus, Georgia.

Muscogee County Sample

Of the 1003 Muscogee County high school students who completed questionnaires, 197 were excluded due to being younger than 13 years (n=126) or older than 18 years of age (n=3), missing height or weight measurements (n=2), being underweight (defined as BMI < 5^{th} percentile, n=6),[22] incomplete questionnaires (n=33), or reporting that they had not participated on any sports team in the past 12 months (n=27). Five females who reported an intention to gain weight were also excluded from analysis due to instability of statistical estimates when these females were included. The final sample included 801 participants, 586 (73.2%) of whom were male.

YRBS National and Georgia Samples

Weighted prevalence estimates of weight intentions, weight-management behaviors, overweight, and sociodemographic characteristics were obtained using the 2005 national and Georgia state YRBS surveys for the purpose of comparison with the Muscogee County sample. Data from the national study consisted of 13,917 surveys; 1755 surveys were completed in the Georgia sample. Both samples were limited to participants who reported playing a sport in the past 12 months and who had complete data on weight intention, perceived body size, weight-management behaviors, height, weight, sex, and age or grade level (national data, n=6992; Georgia data, n=917).

Variable Specification

The outcome measures were weight-related intention (lose, gain, or maintain versus do nothing) and weight-management strategy (exercise, reduce/increase calories [diet only], use diet aids/PEPs [supplements], fasting/vomiting/laxative use [disordered] versus do nothing).

One of the main exposure variables was receipt of advice to lose, gain, or maintain weight (peer or adult only, but not both; or peer and adult both versus no advice). The number of participants who reported receiving advice from an adult only was small (n=23), consequently the category of adult advice alone was combined with the category of peer advice alone to represent advice from one source only.

The remaining exposure variables were perceived body size (underweight or overweight versus about right); BMI (at risk for overweight or overweight versus healthy weight); and number of sports teams involved in (two or three versus one). BMI was calculated using the standard formula, weight/height^2 (kg/m^2) and further classified into the following categories, based on age- and sex-specific percentiles published by the CDC in 2000: healthy (BMI >15th

percentile to <85th percentile), at risk for overweight (BMI from the 85th to the 94th percentile), and overweight (BMI ≥95th percentile).[24]

Statistical Analyses

All analyses were conducted in SAS version 9.1 (SAS Institute, Cary, NC) and were stratified by sex. First, the Surveyfreq procedure was used to obtain weighted prevalence estimates and 95% confidence intervals of relevant items from the national and Georgia YRBS data sets (www.cdc.gov/yrbs), which were subsequently compared to the Muscogee county data. To assess, agreement between perceived body size and measured BMI, crosstabs of these two variables were examined. To evaluate how youth interpreted differences in the response options of maintain and do nothing for weight-management intention, we compared measured BMI, perceived body size, weight-management strategy, and grade level among participants who reported an intention to maintain weight vs. do nothing.

Polytomous logistic regression analyses were conducted to assess the relationships between weight intention and each of the following independent variables: advice, perceived body size, BMI, and number of sports teams. Multivariate models were then examined to determine the independent associations between weight intentions (lose, gain, and maintain versus do nothing) and each exposure variable, while adjusting for age and the other exposures.

A mediating-effects approach, using age-adjusted logistic regression models, was applied to determine whether the associations between weight intention and advice and weight intention and BMI were mediated by perceived body size.[23] This was done in four steps, each controlled for age: (1) The association between perceived body size and weight intention was tested for significance, (2) The association between advice and perceived body size was tested for significance, (3) the association between intention and advice was tested for significance, and (4) a multivariate model regressing intention onto both advice and perceived body size, was tested to determine the significance of each of these. If mediation were present, advice would be significantly associated with intention in the third step, but not in the multivariate model (step 4).

A parallel approach was used to test the presence of mediation between intention (outcome), BMI (exposure), and perception of body weight (mediator), with BMI replacing advice in each model.

Simple logistic regression analysis was utilized to assess the bivariate relationships between weight-management strategy (exercise and/or diet, supplements, and disordered behaviors versus not engaging in these strategies) and each of the following independent variables individually: intention, advice, perceived body size, BMI, and number of sports teams. Logistic regression was then used to determine the independent associations between weight-management strategy and each exposure variable, while adjusting for age and the other exposures. The number of females who reported using dietary supplements or disordered eating practices was too small to yield meaningful finding. Thus, only correlates of diet and/or exercise were assessed in females. The significance level was set to $p<0.05$ for all analyses.

Results

In our sample, the most frequent weight intention among males was an intention to gain weight (39.4%); the most frequent weight intention among females was an intention to lose weight (38.6%, Appendices E1 and E2). A greater proportion of males (18.4%) than females (3.3%) perceived their body size to be underweight, while greater proportions of females perceived their body size to be overweight or about right. Based upon their BMI, males in this sample were classified as overweight more often than females. Based on their responses, the proportion of males who engaged in all of the weight-management methods studied, except exercise and reduced calories, was higher than that of females.

Our sample differed considerably from sports participants in the Georgia and national YRBS datasets. In general, males and females in our sample were also younger than participants in the national and state samples. Compared to both YRBS samples, a lower proportion of males and females in our sample reported an intention to lose weight, but the proportion of participants who reported that they were trying to maintain their weight or gain weight was higher in our sample. While the distribution (pattern) of perceived body size differed between female participants in our sample and the national sample, there were no differences between our sample and the Georgia state sample. Participants in our sample were heavier; the prevalence of overweight among males in our sample (32.6%) was more than twice as high as that of participants in the national (14.4%) and state (14.4%) samples. This finding was similar among females with regard to the national sample (15.3% versus 7.2%). When compared to participants in the national and Georgia state samples, males and females in our sample reported participating in only one sport more often and participating in three or more sports less often. Prevalence estimates of using various weight-management methods were higher among males in our sample than in the national and state samples; among females in our sample the prevalence of using diet aids was higher than the state and national prevalence estimates and reports of purging behaviors were also higher than in the national sample.

The Spearman correlation coefficient describing the association between perceived body size and measured BMI was 0.50 (95% CI= 0.45-0.55); there were no difference in estimates between males (r, 95% CI= 0.53, 0.47-0.62) and females (r, 95% CI= 0.59, 0.53-0.69). Examination of the percent agreement between perceived body size and measured BMI, however, indicated that females' perceptions of their body sizes were more consistent with measured BMI than that of males (Appendix E3). For example, 84% (95% CI= 84.1-94.6) of normal weight (i.e., BMI <85^{th} percentile for age and sex) females perceived their body size to be "about right" compared to 67.1% (95% CI= 61.4-72.7) of normal weight males. Similarly, 84.8% (95% CI= 72.6-97.1) of overweight females perceived their body size as overweight compared to only 50.8% (95% CI= 43.7-57.9) of overweight males.

We identified differences in the distributions of BMI and weight-management strategies among males who reported an intention to maintain weight compared to those who responded they were not trying to do anything about their weight (Appendix E4). Males with an intention to maintain weight were less likely to be normal weight (%, 95% CI= 31.9, 29.4-39.6) and more likely to be overweight (%, 95% CI= 38.2, 30.3-46.1) than those who were not trying to do anything about their weight (normal weight: %, 95% CI= 57.8, 48.3-67.4; overweight: %, 95% CI= 16.7, 9.4-23.9). Males reporting an intention to maintain their weight vs. do nothing were also more likely to use diet (eat more or less), exercise, and disordered behavior (fasting, vomiting, laxative use). Among females, however, measured BMI did not differ significantly between those with an intention to lose weight vs. do nothing. A greater proportion of females with weight maintenance intentions, used diet (%, 95% CI= 50.0, 37.9-62.1) or exercise (%, 95% CI= 67.9, 74.3-92.3) as a weight-management strategy than those who were not trying to do anything about their weight (diet: %, 95% CI= 25.8, 15.2-36.3; overweight: %, 95% CI= 39.4, 27.6-51.2). Distributions of perceived body size and grade level did not differ by weight-related intention among males and females.

In multivariate analyses (Table 2), among males, intention to lose weight (versus intention to do nothing) was significantly associated with receiving advice from a either a peer or adult but not both (OR= 10.6, 95% CI= 2.9-39.2), perceived overweight (OR= 46.5, 95% CI= 12.3-175.3), and having a BMI classified as being at risk for overweight (OR= 3.8, 95% CI= 1.2-12.2), or overweight (OR= 11.4, 95% CI= 3.7-35.0) in the adjusted model. Intention to gain weight among males was significantly associated with receiving advice from either a peer or adult but not both (OR= 7.3, 95% CI= 2.6-20.8), receiving both peer and adult advice (OR= 3.2, 95% CI= 1.8-5.5), and perceived underweight (OR= 8.0, 95% CI= 3.5-18.5) in the adjusted model. Intention to maintain weight among males was associated with receiving advice from a peer or adult but not both (OR= 3.3, 95% CI= 1.1-10.2), receiving advice from both a peer and adult (OR= 2.4, 95% CI= 1.4-4.3), and having a BMI classified as being at risk for overweight (OR= 1.9, 95% CI= 1.02-3.7) or overweight (OR= 3.2, 95% CI= 1.6-6.7) in the adjusted model.

Among females (Table 3), intention to lose weight was associated with receiving both peer and adult advice (versus receiving no advice; OR= 2.8, 95% CI= 1.1-7.2) rather than with receiving advice from either a peer or an adult but not both, as in males. The remaining results were similar to those for males, but intention to maintain weight only associated with receiving both peer and adult weight-related advice (versus receiving no advice, OR= 3.2, 95% CI= 1.5-6.9).

As receiving weight-related advice and measured body size were significantly associated with weight intentions among males and females, the relationship between these variables was further explored for the presence of mediation by perceived body size. Results of the steps of the mediation analysis are presented in Table 7.5 of the Appendix. Among males, advice was not associated with perceived body size, so perceived body size could not act as a mediator between advice and weight intention. Among females, perceived overweight was not associated with intention to maintain weight, so it could not act as a mediator between advice and intention to maintain weight. The prevalence of perceived underweight was very low (n=7/215) among females, making it difficult to obtain stable estimates when perceived body size was treated as the dependent variable. Thus, only perceived overweight was tested in the mediation model. All four conditions were met for perceived overweight to mediate the association between receiving either peer or adult advice and intention to lose weight: peer or adult advice was associated with intention to lose weight (OR= 8.6, 95% CI= 2.5-29.0), advice was also associated with perceived overweight (OR= 10.3, 95% CI= 3.6-29.2), perceived overweight was associated with intention to lose weight (OR=49.2, 95% CI= 11.2-215.8), and when intention to lose weight was regressed upon peer or adult advice with perceived overweight in the model, the odds ratio for advice was reduced from a significant odds ratio of 8.6 to a non-significant odds ratio of 3.2 (95% CI= 0.7-14.6).

With regard to perceived body size mediating the effect of BMI upon weight intention (Appendix, Table 7.6), among males, the three preliminary conditions for mediation (i.e., that BMI is associated with intention, that BMI is associated with perceived body size, and that perceived body size is associated with intention) were only met in one case. When BMI was classified as overweight, when perception of body size was overweight, and when the intention was to lose weight, perception of overweight partially mediated the association between BMI and intention to lose weight. Having a BMI classified as overweight was associated with intention to lose weight (OR= 54.7, 95% CI= 20.2-147.9), having a BMI classified as overweight was associated with perceived overweight (OR= 44.4, 95% CI= 17.1-113.4), perceived overweight was associated with intention to lose weight (OR=102.7, 95% CI= 27.8-353.8), and when intention to lose weight was regressed upon both BMI classified as overweight and perception of overweight, the odds ratio of BMI decreased from 54.7 to 15.2 (95% CI= 5.2-44.6), although it remained significant. Among females, the three preliminary conditions for mediation (i.e., that BMI is associated with intention, that BMI is associated with perceived body size, and that perceived body size is associated with intention) were met in two cases. When perception of body size was overweight and the intention was to lose weight, then both when BMI was classified as at risk for overweight and when it was classified as overweight, perception of overweight partially mediated the association between BMI and intention to lose weight. In the first model, having a BMI classified as at-risk for overweight was associated with intention to lose weight (OR= 12.2, 95% CI= 4.6-32.4), having a BMI classified as at-risk for overweight was associated with perceived overweight (OR= 12.4, 95% CI= 4.9-31.5), perceived overweight was associated with intention to lose weight (OR= 49.2, 95% CI= 11.2-215.8), and when intention to lose weight was regressed upon both BMI classified as at-risk for overweight and perception of overweight, the odds ratio of BMI decreased from 12.2 to 6.8 (95% CI= 2.4-19.5), although it remained significant. In the second circumstance, having a BMI classified as overweight was associated with intention to lose weight (OR= 93.3, 95% CI= 11.8-737.8), having a BMI classified as overweight was associated with perceived overweight (OR= 104.4, 95% CI= 30.2-360.9), perceived overweight was associated with intention to lose weight (OR=49.2, 95% CI= 11.2-215.8), and when intention to lose weight was regressed upon both BMI classified as overweight and perception of overweight, the odds ratio of BMI decreased from 93.3 to 20.8 (95% CI= 2.3-184.5), although it remained significant.

When correlates of weight-management strategies were assessed in multivariate models (Tables 4 and 5), weight intention, receiving advice from either a peer or an adult but not both, and receiving advice from both a peer and adult were consistently associated with the use of exercise and/or diet among both males and females. Among males only, being classified as at-risk for overweight was associated with the use of diet and/or exercise as a weight management strategy (OR= 2.3, 95% CI= 1.2-4.3). Perceived body size and number of sports teams were not associated with these strategies in males or females. Among males, both dietary supplement use (diet aids and performance enhancing products) and disordered eating behaviors were associated with receiving weight-related advice from either a peer or adult only and with receiving advice from both. Intention to lose weight was also associated with disordered eating behaviors among males (OR= 3.4, 95% CI= 1.4-8.1), as was perceived overweight (OR= 0.4, 95% CI= 0.2-0.9). Due to the small number of females reporting the use of supplements or disordered eating behaviors, only exercise and modified diet were assessed in logistic regression models.

Discussion

Few studies have sought to identify factors related to weight intentions and weight-management strategies among youth sports participants. In our study of these factors, several significant relationships emerged. Receiving weight-related advice from a peer or adult was associated with weight intention among males and females. Among females, when compared to not receiving any weight-related advice, receiving advice from both peers and adults was a more powerful correlate of intentions to lose or maintain weight than receiving advice from only one source. Conversely, receiving advice from either a peer or adult was sufficient to influence weight-change intentions (loss and gain) among males, and more effective than advice from both. There are similarities between these observations and those reported by McCabe and Ricciardelli[24] from a prospective study of parental, peer, and media influences on body image and strategies to change weight or muscle among Australian adolescents. The authors reported that, among males and females, parental influences were significantly associated with strategies to lose weight and gain muscle. Peer influences were also related to muscle-gaining behaviors among males and females. In the present study, it appears that peer advice is of greater influence among males with regard to weight-loss intention. The opposite was true of females in this study – only both peer and adult advice was associated with intention to lose weight. Differences in these findings could stem from differences in the study populations and methodology. Our sample consisted of American youth who self-identified as sports participants, but the sample used in the study of McCabe and Ricciardelli[24] most likely contained both sports participants and non-participants. It is also unclear whether their analysis was adjusted for personal factors, such as the participant's own perceptions of their body size and their actual or measured weight, which are important in shaping weight-related intentions in youth.

In our study, both perceived overweight and a BMI classified as at risk for overweight or overweight were associated with increased weight-loss intention in males and females. Intentions to gain and maintain weight among males, however, appear to be differentially influenced by perceived and measured body size; measured overweight was associated with a desire to maintain weight, but perceived underweight was associated with increased intention to gain weight. This is an interesting finding that authors of at least one other study have reported, but with regard to weight-loss intention.[25] Why perceived and measured body sizes are differentially related to weight intention is not well understood. Perhaps, societal pressures are greater among male sports participant to have larger (more muscular) bodies.[26, 27] Exposure to media images reflecting "ideal" body shapes may also affect this relationship, by influencing perceived social norms regarding what a desirable body shape/size is for a young man. Field et al.[10] have reported increased muscle- or weight-gaining behavior among boys who read men's, fashion, or health fitness magazines. There is also evidence of increased concern with weight among boys who reported making an effort to look like male figures in the media.[28] This finding may also be driven by participants involved in certain sports that emphasize a larger body size. Whatever the mechanism, it appears both perceived and measured body size are important factors related to weight intentions among young sports participants.

In addition to the relative importance of perceived and measured body size, we were also interested in how these factors relate to each other and, ultimately, to weight intention. Our findings suggest that perceived overweight partially mediates the association between weight-loss intention and overweight in male and female sports participants. Perceived overweight also mediates the relationship between female intention to lose weight and receiving weight-related advice from a peer or adult. The development of a weight-loss intention, particularly among females, appears to be a rather complex process, requiring youth to weight the relative importance of their own perceptions and advice from peers and adults within the context of reality (i.e., their actual body size). Based on these findings, it seems that perceived weight is key to affecting the weight-change intentions of youth sport participants. The effectiveness of educational programs, counseling sessions, or interventions aimed at changing weight intentions in this population could possibly benefit if participant weight perception is taken into account.

Unfortunately, receiving incorrect or misguided advice could also contribute to developing an unhealthy weight perception or body image, and possibly inappropriate weight goals or engagement in potentially harmful or extreme weight-management behaviors.

In this study, supplement use and disordered weight-management behaviors, like fasting and vomiting, were consistently associated with perceived body size among females and with peer and adult advice among both males and females. These relationships remained significant, even after adjustment for overweight status, weight intention, and age. Societal norms and personal ideals about the "perfect" body color individuals' perceptions of their own body-size/shape. Furthermore, awareness and internalization of media stereotypes are related to weight-change intentions and behaviors among youth.[10, 29, 30] In the absence of readily available and approachable information and supervision from legitimate sources, youth may resort to their peers and/or various media (e.g., health and fitness magazines, television) for guidance regarding appropriate weight goals and healthy weight-management practices. Among adolescent sports participants, we suspect that this problem may be compounded by desire to be more competitive, highlighting one of the negative aspects of youth sports participation. Within the context of sports programs, however, we believe there is opportunity to provide a forum for discussion of weight-related concerns, to educate youth about setting and achieving realistic weight goals, and to model and encourage positive health behaviors.

There are a number of limitations in our study, including a lack of data on body composition. Though height and weight were measured, in this population of sports participants, it is possible that the use of only height and weight may have led to some misclassification of overweight status and affected some of our findings.[31, 32] In males, it is possible that participants who were classified as overweight, but did not perceive themselves as such, actually did have a high fat-free mass relative to excess body fatness. We speculate that this may be less true in girls. The questionnaire also failed to distinguish between an intention to gain muscle versus weight. This will be an important distinction to make in future studies of this topic, particularly among females. We were unable to adjust analyses for sports type because there was too little variability to distinguish differences in weight-related intentions and behaviors among participants of varying sports. The greater prevalence of the various weight-management strategies in our sample compared to the YRBS data was surprising. However, the overall patterns (distributions) of the variables were similar. Our sample was also composed largely of male football players, and the prevalence of supplementation, e.g., creatine, has been estimated as high as 47% in a sample of Wisconsin high school football players.[12] In addition, at least one other study has observed similar rates of weight change behavior among youth athletes in the southeastern United States.[33] We cannot, however, rule out the possibility that this is due to some measurement error, as the reliability and validity of some items is unknown. However, several of the questionnaire items have been previously used and have adequate reliability.[21]

This study provides new evidence in support of the influence of receiving weight-related advice from peers and adults on weight goals and weight-management behaviors of youth sports participants. Weight-change intentions and behaviors may be also differentially influenced by perceived body size and BMI in this group. These findings, taken together, support the increased availability of nutritional counseling staff to participants in school and community sports programs. Future studies should include more comprehensive information on weight-gaining intentions and strategies among female sports participants.

Figure 8.1 Conceptual framework describing the proposed relation of receiving weight-related advice, perceived body size, and measured body size to weight-management intentions and behaviors

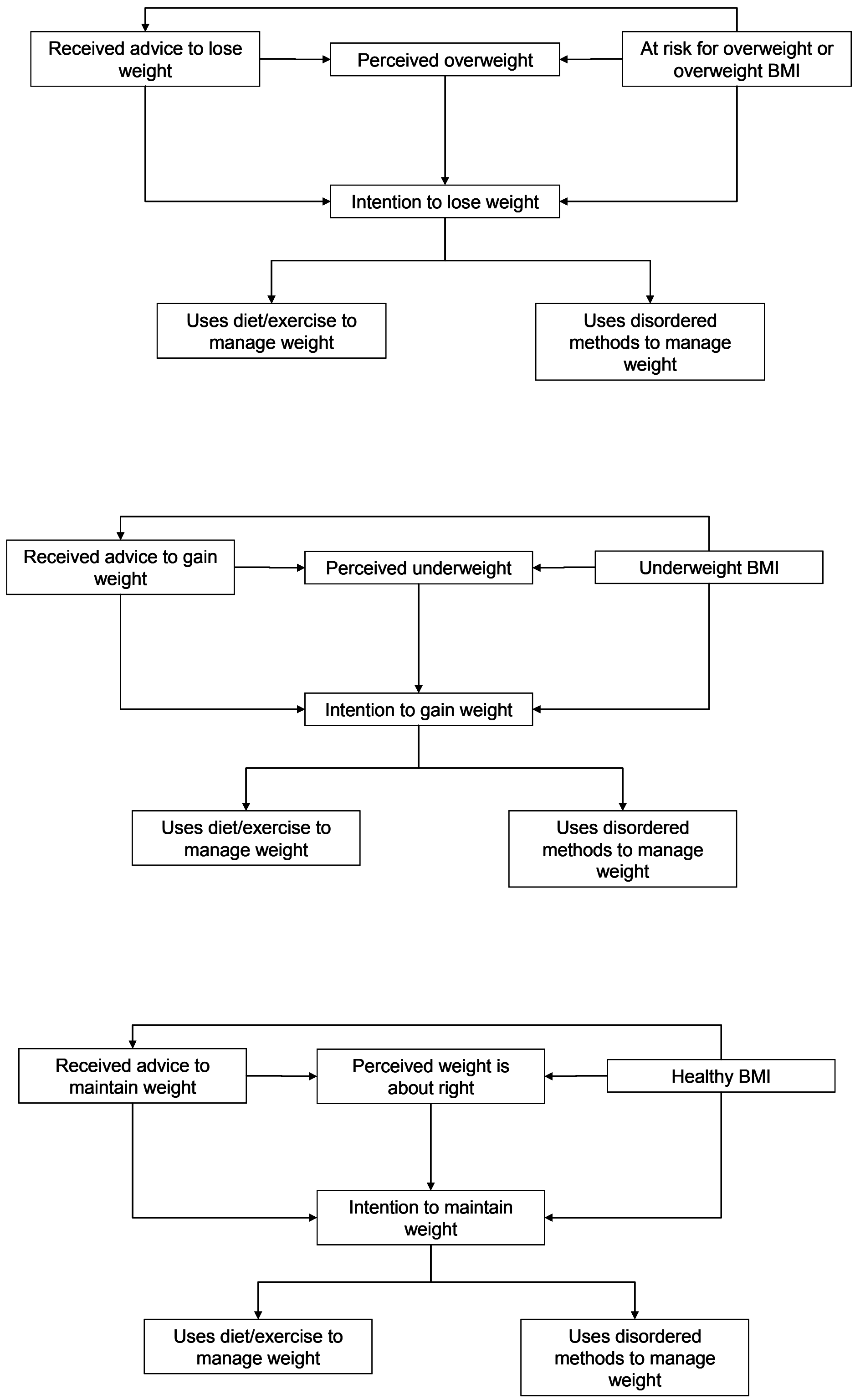

Table 8.1 Description of exposure variables, questions, and response options used for analysis

Variable	Question	Response Options	Operational definitions
Advice	In the past 12 months, have any of the following people suggested that you lose weight, gain weight, or maintain (keep from gaining or losing) weight to improve your sports performance? Please check all that apply.	A friend, a teammate, my parent(s), my coach, a doctor, other (please list), no one has suggested that I lose weight, gain weight, or maintain weight to improve my sports performance	No one (referent) peer or adult peer + adult
Intention	Which of the following are you trying to do about your weight?	Lose weight, gain weight, maintain weight, I am not trying to do anything about my weight	Do nothing (referent) lose, gain, maintain
Perceived body size	How do you describe your weight?	Very underweight, slightly underweight, about the right weight, slightly overweight, very overweight	About right (referent), underweight, overweight

Table 8.1 cont. Description of exposure variables, questions, and response options used for analysis

Variable	Question	Response Options	Operational definitions
Strategy	During the past 30 days did you do any of the following to lose weight, gain weight, or maintain weight? Please check all that apply.	Exercise; eat less food, fewer calories, or foods low in fat; eat more food, more calories, or foods high in fat; go without eating for 24 hours or more (also called fasting); take any diet pills, diet powders, or diet liquids without a doctor's advice; take performance enhancing products (PEPs), such as creatine or protein, without a doctor's advice; vomit or take laxatives; I did not do any of the above	Exercise and/or diet supplements (diet aids or PEPs) disordered (fasting, vomiting, or laxatives)
Sports team participation	During the past 12 months, on what sports teams did you play? Include any teams run by your school or community groups. Please check all that apply.	Baseball, basketball, cheerleading, cross-county running, football, golf, , lacrosse, soccer, softball, swimming, tennis, track and field, volleyball, wrestling, other, I did not play any sports in the past 12 months	1 team (referent) 2 teams, 3 or more teams

Table 8.2 Results of logistic regression analysis describing intention (versus do nothing) among male sports participants

	Percent (se)	Unadjusted Odds Ratio (95% CI)	Adjusted[1] Odds Ratio (95% CI)
Lose weight, n= 109			
Advice			
None	31.2 (4.4)	1.0	1.0
Peer or Adult	19.3 (3.8)	6.8 (2.3-19.7)	10.6 (2.9-39.2)
Peer + Adult	49.5 (4.8)	2.1 (1.2-3.7)	1.6 (0.7-3.7)
Perceived body size			
About right	22.9 (4.0)	1.0	1.0
Underweight	1.8 (1.3)	1.0 (0.2-5.4)	1.6 (0.3-8.6)
Overweight	75.2 (4.1)	100.6 (29.3-245.5)	46.5 (12.3-175.3)
Body mass index			
Healthy	5.5 (2.2)	1.0	1.0
At risk for overweight	10.1 (2.9)	4.2 (1.4-12.4)	3.8 (1.2-12.2)
Overweight	84.4 (3.5)	53.2 (19.8-142.7)	11.4 (3.7-35.0)
Number of sports teams			
1 team	68.8 (4.4)	1.0	1.0
2 teams	22.9 (4.0)	0.5 (0.3-0.99)	0.6 (0.3-1.5)
3 or more teams	8.3 (2.6)	0.6 (0.2-1.6)	1.2 (0.4-3.9)

Table 8.2 cont. Results of logistic regression analysis describing intention (versus do nothing) among male sports participants

	Percent (se)	Unadjusted Odds Ratio (95% CI)	Adjusted[1] Odds Ratio (95% CI)
Gain weight, n= 231			
Advice			
None	23.8 (2.8)	1.0	1.0
Peer or Adult	16.5 (2.4)	7.6 (2.8-20.7)	7.3 (2.6-20.8)
Peer + Adult	59.7 (3.2)	3.3 (2.0-5.5)	3.2 (1.8-5.5)
Perceived body size			
About right	57.1 (3.3)	1.0	1.0
Underweight	39.8 (3.2)	9.2 (4.1-20.7)	8.0 (3.5-18.5)
Overweight	3.0 (1.1)	1.6 (0.4-6.4)	2.2 (0.5-9.5)
Body mass index			
Healthy	66.2 (3.1)	1.0	1.0
At risk for overweight	22.1 (2.7)	0.8 (0.4-1.3)	0.8 (0.5-1.6)
Overweight	11.7 (2.1)	0.6 (0.3-1.2)	0.6 (0.3-1.3)
Number of sports teams			
1 team	48.0 (3.3)	1.0	1.0
2 teams	34.6 (3.1)	1.1 (0.7-1.9)	0.9 (0.5-1.7)
3 or more teams	17.3 (2.5)	1.8 (0.9-3.8)	1.7 (0.7-3.7)

Table 8.2 cont. Results of logistic regression analysis describing intention (versus do nothing) among male sports participants

	Percent (se)	Unadjusted Odds Ratio (95% CI)	Adjusted[1] Odds Ratio (95% CI)
Maintain weight, n= 144			
Advice			
None	29.2 (3.8)	1.0	1.0
Peer or Adult	9.0 (2.4)	3.4 (1.1-10.3)	3.3 (1.1-10.2)
Peer + Adult	61.8 (4.0)	2.8 (1.6-4.8)	2.4 (1.4-4.3)
Perceived body size			
About right	84.7 (3.0)	1.0	1.0
Underweight	4.9 (1.8)	0.7 (0.2-2.2)	0.9 (0.3-2.7)
Overweight	10.4 (2.5)	3.8 (1.1-13.4)	2.4 (0.6-9.2)
Body mass index			
Healthy	31.9 (3.9)	1.0	1.0
At risk for overweight	29.9 (3.8)	2.1 (1.1-3.9)	1.9 (1.0-3.7)
Overweight	38.2 (4.0)	4.1 (2.1-8.1)	3.2 (1.6-6.7)
Number of sports teams			
1 team	50.0 (4.2)	1.0	1.0
2 teams	29.9 (3.4)	0.9 (0.5-1.7)	1.0 (0.5-1.8)
3 or more teams	20.1 (3.3)	2.0 (0.9-4.4)	2.2 (1.0-4.9)

n= 586
[1]Adjusted for advice, perceived body size, body mass index, number of sports teams, and age.

Table 8.3 Results of logistic regression analysis describing intention (versus do nothing) among female sports participants

	Percent (se)	Unadjusted Odds Ratio (95% CI)	Adjusted[1] Odds Ratio (95% CI)
Lose weight, n= 83			
Advice			
None	24.1 (4.7)	1.0	1.0
Peer or Adult	21.7 (4.5)	8.3 (2.5-28.0)	2.0 (0.4-10.0)
Peer + Adult	54.2 (5.5)	3.3 (1.6-6.9)	2.8 (1.1-7.2)
Perceived body size			
About right	37.3 (5.3)	1.0	1.0
Underweight	1.2 (1.2)	0.5 (0.05-4.5)	0.4 (0.04-4.5)
Overweight	61.4 (5.3)	49.3 (11.3-216.3)	17.4 (3.4-91.5)
Body mass index			
Healthy	26.5 (4.8)	1.0	1.0
At risk for overweight	36.1 (5.3)	11.3 (4.3-29.4)	6.4 (2.2-19.0)
Overweight	37.3 (5.3)	81.7 (10.5-635.1)	16.1 (1.6-158.7)
Number of sports teams			
1 team	60.2 (5.4)	1.0	1.0
2 teams	28.9 (5.0)	0.7 (0.3-1.4)	0.6 (0.2-1.7)
3 or more teams	10.8 (3.4)	0.8 (0.3-2.2)	0.9 (0.2-3.7)

Table 8.3 cont. Results of logistic regression analysis describing intention (versus do nothing) among female sports participants

	Percent (se)	Unadjusted Odds Ratio (95% CI)	Adjusted[1] Odds Ratio (95% CI)
Maintain weight, n= 66			
Advice			
None	31.8 (5.7)	1.0	1.0
Peer or Adult	3.0 (2.1)	0.9 (0.1-5.2)	0.6 (0.1-3.6)
Peer + Adult	65.2 (5.9)	3.0 (1.5-6.3)	3.2 (1.5-6.9)
Perceived body size			
About right	90.9 (3.5)	1.0	1.0
Underweight	3.0 (2.1)	0.5 (1.0-2.8)	0.3 (0.05-1.9)
Overweight	6.1 (2.9)	2.0 (0.3-11.3)	2.4 (0.4-15.8)
Body Mass Index			
Healthy	78.8 (5.0)	1.0	1.0
At risk for overweight	19.7 (4.9)	2.1 (0.8-5.6)	2.0 (0.7-5.6)
Overweight	1.5 (1.5)	1.1 (0.07-18.3)	0.7 (0.04-12.8)
Number of sports teams			
1 team	59.1 (6.1)	1.0	1.0
2 teams	25.8 (5.4)	0.6 (0.3-1.3)	0.6 (0.2-1.3)
3 or more teams	15.1 (4.4)	1.1 (0.4-3.1)	0.9 (0.3-2.7)

n= 215
[1]Adjusted for advice, perceived body size, body mass index, number of sports teams, and age.

Table 8.4 Prevalence and odds ratio for weight-management behavior among male sports participants

	Percent (se)	Unadjusted Odds Ratio (95% CI)	Adjusted[1] Odds Ratio (95% CI)
Diet and/or Exercise, n= 486			
Intention			
Lose	21.0 (1.8)	5.6 (3.1-10.2)	4.4 (1.4-13.3)
Gain	42.2 (2.2)	3.6 (2.2-5.8)	5.5 (2.9-10.7)
Maintain	24.9 (2.0)	4.0 (2.3-6.8)	2.9 (1.5-5.6)
Do Nothing	11.9 (1.5)	1.0	1.0
Advice			
None	27.0 (2.0)	1.0	1.0
Peer or Adult	14.0 (1.6)	3.2 (1.5-7.0)	2.2 (1.0-5.0)
Peer + Adult	59.3 (2.2)	3.5 (2.2-5.7)	3.1 (1.8-5.1)
Perceived body size			
About right	60.5 (2.2)	1.0	1.0
Underweight	18.7 (1.8)	1.3 (0.8-2.1)	0.9 (0.4-1.8)
Overweight	20.8 (1.8)	2.1 (1.3-3.4)	2.6 (0.8-8.1)
Body mass index			
Healthy	41.6 (2.2)	1.0	1.0
At risk for overweight	23.3 (1.9)	1.4 (0.7-1.7)	2.3 (1.2-4.3)
Overweight	35.2 (2.2)	2.1 (1.4-3.1)	1.5 (0.7-3.0)
Number of sports teams			
1 team	54.9 (2.3)	1.0	1.0
2 teams	30.5 (2.1)	0.9 (0.6-1.3)	0.7 (0.4-1.3)
3 or more teams	14.6 (1.6)	0.8 (0.5-1.2)	0.6 (0.3-1.2)

Table 8.4 cont. Prevalence and odds ratio for weight-management behavior among male sports participants

	Percent (se)	Unadjusted Odds Ratio (95% CI)	Adjusted[1] Odds Ratio (95% CI)
Supplement, n= 215			
Intention			
Lose	19.1 (2.7)	2.2 (1.2-4.0)	2.1 (0.9-4.7)
Gain	45.6 (3.4)	2.7 (1.6-4.6)	1.5 (0.8-2.7)
Maintain	25.1 (3.0)	2.2 (1.2-3.9)	1.6 (0.8-3.0)
Do Nothing	10.2 (2.1)	1.0	1.0
Advice			
None	12.1 (2.2)	1.0	1.0
Peer or Adult	17.7 (2.6)	6.0 (3.3-11.0)	5.6 (3.0-10.5)
Peer + Adult	70.2 (3.1)	5.4 (3.4-8.6)	5.1 (3.2-8.3)
Perceived body size			
About right	23.3 (2.9)	1.0	1.0
Underweight	60.0 (3.3)	1.6 (1.0-2.5)	1.4 (0.8-2.4)
Overweight	16.7 (2.5)	0.9 (0.1-1.5)	0.8 (0.4-1.6)
Body mass index			
Healthy	46.0 (3.4)	1.0	1.0
At risk for overweight	21.9 (2.8)	0.9 (0.6-1.4)	1.0 (0.6-1.7)
Overweight	32.1 (3.2)	0.9 (0.6-1.4)	0.8 (0.5-1.5)
Number of sports teams			
1 team	55.8 (3.4)	1.0	1.0
2 teams	26.0 (3.0)	0.7 (0.5-1.0)	0.6 (0.4-0.9)
3 or more teams	18.1 (2.6)	1.3 (0.8-2.0)	1.1 (0.7-1.9)

Table 8.4 cont. Prevalence and odds ratio for weight-management behavior among male sports participants

	Percent (se)	Unadjusted Odds Ratio (95% CI)	Adjusted[1] Odds Ratio (95% CI)
Disordered Behaviors, n= 192			
Intention			
Lose	22.4 (3.0)	2.4 (1.3-4.3)	3.4 (1.4-8.1)
Gain	35.9 (3.5)	1.5 (0.9-2.7)	1.0 (0.5-1.9)
Maintain	30.2 (3.3)	2.4 (1.4-4.4)	1.8 (0.9-3.5)
Do Nothing	11.5 (2.3)	1.0	1.0
Advice			
None	10.4 (2.2)	1.0	1.0
Peer or Adult	13.0 (2.4)	4.0 (2.1-7.8)	3.9 (1.9-7.7)
Peer + Adult	76.6 (3.1)	6.9 (4.2-11.6)	7.2 (4.2-12.2)
Perceived body size			
About right	64.1 (3.5)	1.0	1.0
Underweight	18.2 (2.8)	1.0 (0.6-1.5)	1.1 (0.7-2.0)
Overweight	17.7 (2.8)	0.9 (0.6-1.5)	0.4 (0.2-0.9)
Body mass index			
Healthy	41.7 (3.6)	1.0	1.0
At risk for overweight	21.3 (3.0)	1.0 (0.7-1.6)	1.0 (0.6-1.6)
Overweight	37.0 (3.5)	1.4 (0.9-2.0)	1.1 (0.6-1.9)
Number of sports teams			
1 team	55.7 (3.6)	1.0	1.0
2 teams	25.5 (3.2)	0.7 (0.5-1.1)	0.7 (0.5-1.1)
3 or more teams	18.8 (2.8)	1.3 (0.8-2.1)	1.3 (0.8-2.3)

n= 586
[1]Adjusted for advice, perceived body size, body mass index, number of sports teams, and age; reference= do nothing

Table 8.5 Prevalence and odds ratio for weight-management behavior among female sports participants

	Percent (se)	Unadjusted Odds Ratio (95% CI)	Adjusted[1] Odds Ratio (95% CI)
Diet + Exercise, n= 156			
Intention			
Lose	48.1 (4.0)	7.1 (3.4-14.7)	7.8 (2.4-25.1)
Maintain	35.3 (3.8)	2.9 (1.4-6.0)	7.0 (3.0-16.6)
Do Nothing	16.7 (3.0)	1.0	1.0
Advice			
None	26.9 (3.6)	1.0	1.0
Peer or Adult	14.1 (2.8)	9.4 (2.1-42.9)	5.8 (1.1-31.1)
Peer + Adult	59.0 (3.9)	3.8 (2.0-7.2)	2.6 (1.2-5.6)
Perceived body size			
About right	64.7 (3.8)	1.0	1.0
Underweight	2.6 (1.3)	0.5 (0.1-2.7)	0.8 (0.1-4.9)
Overweight	32.7 (3.8)	3.3 (1.7-6.4)	0.8 (0.2-3.3)
Body mass index			
Healthy	53.2 (4.0)	1.0	1.0
At risk for overweight	26.9 (3.6)	3.1 (1.6-6.1)	1.6 (0.6-4.5)
Overweight	19.9 (3.2)	5.0 (2.1-11.8)	2.9 (0.5-18.3)
Number of sports teams			
1 team	58.3 (3.9)	1.0	1.0
2 teams	28.9 (3.6)	0.7 (0.4-1.3)	1.1 (0.5-2.5)
3 or more teams	12.8 (2.7)	1.1 (0.5-2.6)	1.2 (0.4-3.8)

n= 215
[1]Adjusted for advice, perceived body size, body mass index, number of sports teams, and age; reference= do nothing

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Chapter 9

Conclusions

The prevalence of overweight in the United States has reached 17% among children and adolescents.[1] As a result, there has been an increase in media attention on body size among youth, possibly resulting in an increased awareness of body size among youth themselves. Morbidities associated with overweight have also increased among children and young adults. Increased participation in physical activity and limited time spent in sedentary activities have been suggested as mechanisms to curb the accrual of excess body weight and adverse changes in cardiovascular disease risk factors during childhood and adolescence. The objectives of the present work were to assess the relation of physical activity and television viewing to health measures and behaviors among male and female adolescents. Specifically, we examined associations between physical activity and changes in adiposity, systolic and diastolic blood pressures, and blood lipids. We proposed a definition of weight maintenance and tested its association with changes in blood pressure and blood lipids. Finally, we described differences in sports participants and non-participants with regard to weight-related perceptions, intentions, and behaviors in a nationally representative sample. Correlates of these behaviors were also described.

We did not observe associations between physical activity and changes in BMI percentile, percent body fat, blood pressure, or blood lipids among male and female children and adolescents (Figure 9.1). While amounts of physical activity were similar across categories of BMI maintenance, loss, and gain, weight maintenance (by our proposed definition of within 4.2 BMI percentile units) was inversely associated with the rate of change in systolic blood pressure and diastolic blood pressure among males and females. Weight gain was positively associated with changes in the cardiovascular disease risk factor summary score and inversely associated with changes in HDL. While this underscores the need to prevent rapid increases in weight among children and adolescents, this definition may not have merit beyond this study population. Additional studies are needed to validate the proposed definition in other populations.

With regard to television viewing, we noted associations between television viewing and increases in BMI percentile and percent body fat among males and females who reported watching at least two hours of television per day compared to those watching less than one hour per day. We also observed steeper increases in LDL-cholesterol among participants who viewed between TV viewing of two or more hours per day compared to less than one hour each day. These findings suggest that reducing time spent in sedentary pursuits, TV viewing in particular, has a greater impact than physical activity on healthy weight maintenance among youth.

In our analyses, greater proportions of male and female sports participants than non-participants met the Dietary Guidelines (2005) physical activity recommendation of at least 60 minutes per day of moderate-vigorous physical activity. Compared to non-participants, a larger proportion of female sports participants also met the recommendation to watch fewer than 2 hours of television each day. Intention to gain weight and the use of exercise as a weight-management strategy were more common among male sports participants than non-participants. Among females, reports of both exercise alone and a combination of diet and exercise to manage weight were more common among sports participants than non-participants. Fasting was also less prevalent among females who participated in sports than among those who did not. The prevalence of other disordered eating behaviors (i.e., self-induced vomiting and the use of diet aids or laxatives to manage weight) were 9.7% and 10.4% among male sports participants and non-participants, respectively; estimates were higher among female sports participants (21.7%) and non-participants (24.6%). This suggests that disordered eating practices to manage weight are no more common among sports participants than youth in the general population. An intention to gain weight, however, was reported more often by male sports participants than non-participants. The Youth Risk Behavior Survey does not include questions about specific weight-gaining strategies, so we were unable to describe weight-gaining behaviors, such as dietary supplement and steroid use in this nationally representative sample.

In a convenience sample of sports participants in Georgia, however, we were able to include questions about weight management strategies, as well as about the receipt of weight-management advice. More than 40% of male sports participants in this sample indicated they had either increased their food/calorie intake or used a performance-enhancing product within the 30 days preceding the questionnaire as a strategy to enhance their sports performance. Furthermore, receiving advice from either a peer or adult to change or maintain their weight was associated with increased odds of weight-gaining intention and the use of dietary supplements among males. Among females, weight-loss and weight-maintenance intentions were influenced by the receipt of advice from both a peer and adult to change or maintain their weight. Among males and females, perceived weight appeared to have a greater influence on weight-management intentions than measured BMI. Among females, in particular, perceived overweight mediated the associations between weight-loss intention and receiving weight-related advice from a peer, and between weight-loss intention and measured overweight. For both genders, receipt of advice from an adult, in addition to peers, was associated with intention to maintain weight.

Though we did not observe any associations between physical activity and changes in BMI and percent body fat during childhood and adolescence, we support the continued recommendation of participation in physical activity in childhood for a number of reasons. There is a large body of evidence that suggests a relation between childhood physical activity and childhood health in areas other than weight-control, such as bone health.[2] We acknowledge the use of a 24-hour recall questionnaire to measure physical activity as a limitation of this study, and suggest that future studies use more objective and reliable instruments to capture child and adolescent activity. Support is, however, provided for the recommendation that youth limit time spent in sedentary behaviors, namely television viewing, by the relation of TV viewing to adverse changes in BMI percentile, percent body fat, and LDL-cholesterol.

One mechanism for decreasing time spent watching television among youth may be through the promotion of involvement in sports. Our findings indicate that television viewing recommendations were met by a greater proportion of females involved in sports than females who were not. The prevalence of disordered eating behaviors was similar among sports participants and non-participants, and among females, fasting was actually less prevalent among sports participants than non-participants. This supports the idea that involvement in youth sports is a positive behavior, which has been associated with higher grades[3, 4] and better self-concept[4, 5] among youth.

Organized sports programs provide a unique opportunity to educate youth about healthy body size and composition and ways to achieve and maintain a healthy weight, while also addressing inaccurate weight perceptions.[6] Our findings suggested that receiving advice from adults in addition to peers was associated with the intention to maintain weight. Additional research is needed to describe factors that influence weight perceptions among youth involved in sport and among youth in the general population. Based on our findings, perceived weight is especially important in developing a weight-loss intention. Others have noted that youth who do not perceive themselves as overweight are unlikely to engage in practices, such as physical activity, to achieve a healthy weight.

In light of the current childhood overweight epidemic, it is important for young people to learn not only how to achieve a healthy weight, but also how to maintain it. In addition to the definitions of weight maintenance suggested in this dissertation, there is only one other published definition of weight maintenance for use in children and adolescents.[7] These definitions need to be validated in other samples and revised, if necessary. Researchers must take care to consider natural changes in height and weight that accompany growth and development when studying the stability of weight in children and adolescents. Future definitions of weight maintenance might also include a more direct measure of adiposity to increase applicability to youth who are more muscular, e.g. sports participants.

The main limitations of the analyses presented in this body of work were weaknesses in the measurement of the variables under consideration. For instance, annual changes in blood pressure and blood lipids are expected to be small among children and adolescents, making it difficult to detect meaningful associations between physical activity and CVD risk factor. Experimental studies with sufficient power to detect the impact of physical activity on biologic measures are needed. Using an objective measure of physical activity and TV viewing would have strengthened these analyses. We could not determine the relative impact of physical activity versus TV viewing on any of the outcomes of interest because we could not quantify the amount of error associated with either measure. It is possible that the estimates obtained for TV viewing were subject to less error than estimates of physical activity as a result of additional probing that was conducted to gather valid data on TV viewing. Future studies should employ objective measures of these behaviors, whenever possible. A major limitation of the sports participation analyses was the use of several items that had not been previously validated; this is of particular importance because the sensitive nature of some of the items (e.g., using disordered behaviors to manage one's weight) increases the risk of information bias related to social desirability. The use of items that have been tested for reliability and validity is of utmost importance to the integrity of the scientific findings.

Within the context of existing research, the findings presented here, and limitations of the present study, implementing efforts to reduce television viewing should continue to be a public health priority. Large samples are needed to investigate differences in the relationships between physical activity and changes in various disease risk factors among young participants of differing sexes and/or maturation stage. This is due, in part, to the large amount of variability in physical activity among youth. Further improvements in the tools and methods available for use, including the use of reliable and valid objective measures of physical activity as a standard practice, will ultimately help provide sound guidance to public health professionals in their effort to turn the tide of rising obesity in the United States.

Figure 9.1 Summary of findings: Project HeartBeat!, Youth Risk Behavior Survey national data (2005, and Muscogee County, Georgia (2005)

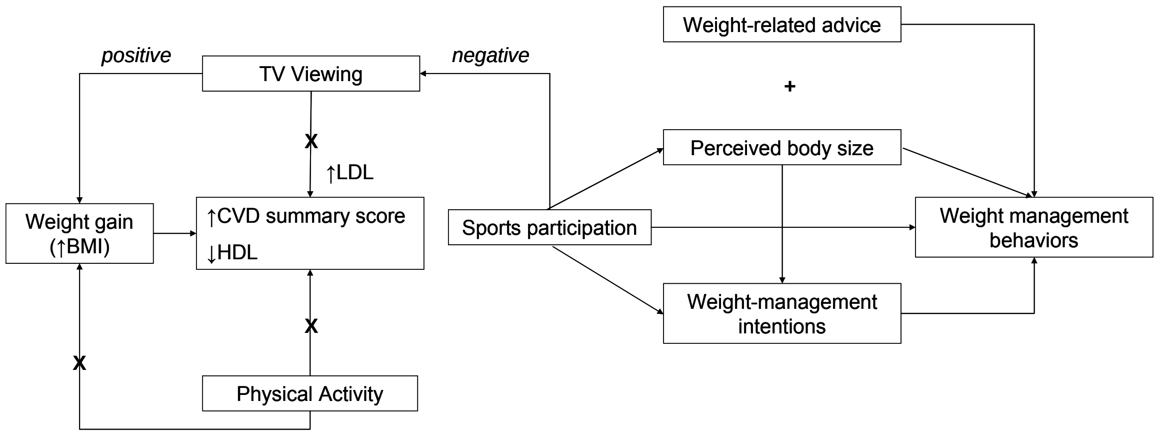

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Figure A.1 Questionnaire used to assess weight perception and weight-management goals and intention among sports participants in Muscogee County

This survey is about weight goals. It has been developed to learn more about student weight goals and the things they do to meet these goals. The information you provide will increase knowledge about student weight goals and practices.

The answers you give will be kept private. No one will know what you write. No names will ever be reported. Answer the questions based on what you really do and be sure to read every question.

Completing the survey is voluntary. Whether or not you answer the questions will not affect whether or not you will be able to participate in the sports program you are trying out for.

Thank you very much for your help!

Name ___________________________ Date of Birth_______________________

1. In the past 12 months, have any of the following people suggested that you lose weight, gain weight, or maintain (keep from gaining or losing) weight to improve your sports performance? Please check all that apply.

	Suggested I lose weight	Suggested I gain weight	Suggested I maintain weight
1. A Friend	❒	❒	❒
2. A Teammate	❒	❒	❒
3. My Parent(s)	❒	❒	❒
4. My Coach	❒	❒	❒
5. A Doctor	❒	❒	❒
6. Other (please list) ____________________	❒	❒	❒
7. No one has suggested that I lose weight, gain weight, or keep from gaining or losing weight to improve my sports performance		❒	

2. Which of the following are you trying to do about your weight?
   - ❒ Lose weight
   - ❒ Gain weight
   - ❒ Maintain weight (keep from gaining or losing weight)
   - ❒ I am not trying to do anything about my weight

3. How do you describe your weight?
   - ❒ Very underweight
   - ❒ Slightly underweight
   - ❒ About the right weight
   - ❒ Slightly overweight
   - ❒ Very overweight

4. During the past 30 days did you do any of the following to lose weight, gain weight, or maintain (keep from gaining or losing) weight? Please check all that apply.

	To lose weight	To gain weight	To maintain weight
1. Exercise	❐	❐	❐
2. Eat **less** food, **fewer** calories, or foods **low** in fat	❐	❐	❐
3. Eat **more** food, **more** calories, or foods **high** in fat	❐	❐	❐
4. Go without eating for 24 hours or more (also called fasting)	❐	❐	❐
5. Take any diet pills, diet powders, or diet liquids without a doctor's advice	❐	❐	❐
6. Take performance enhancing products, such as creatine or protein, without a doctor's advice	❐	❐	❐
7. Vomit or take laxatives	❐	❐	❐
8. I did not do any of the above		❐	

5. During the past 12 months, on what sports teams did you play? Include any teams run by your school or community groups. Please check all that apply.
   - ❐ Baseball
   - ❐ Basketball
   - ❐ Cheerleading
   - ❐ Cross-country running
   - ❐ Diving
   - ❐ Football
   - ❐ Fencing
   - ❐ Golf
   - ❐ Gymnastics
   - ❐ Hockey
   - ❐ Lacrosse
   - ❐ Marksmanship/Riflery
   - ❐ Soccer
   - ❐ Softball
   - ❐ Swimming
   - ❐ Tennis
   - ❐ Track and Field
   - ❐ Volleyball
   - ❐ Water Polo
   - ❐ Wrestling
   - ❐ Other ____________________________________
   - ❐ Other ____________________________________
   - ❐ I did not play any sports in the past 12 months

Table B.1 NCEP and NHBPEP criteria for borderline high and high blood pressure and blood lipids

<table>
<tr><th>CVD risk factor</th><th>Normal</th><th>Borderline high</th><th>High</th></tr>
<tr><td>Systolic blood pressure, mm Hg</td><td rowspan="2">< 90^{th} percentile for sex, age, and height</td><td rowspan="2">$90\text{-}94.9^{th}$ percentile for sex, age, and height</td><td rowspan="2">≥ 95^{th} percentile for age, sex, and height</td></tr>
<tr><td>Diastolic blood pressure, mm Hg</td></tr>
<tr><td>Total cholesterol, mg/dl</td><td>< 170</td><td>170-199</td><td>≥ 200</td></tr>
<tr><td>HDL, mg/dl</td><td>≥ 35</td><td>--</td><td>< 35[1]</td></tr>
<tr><td>Triglycerides, mg/dl[2]</td><td>≤ 110</td><td>--</td><td>> 110</td></tr>
</table>

[1] low HDL; [2]Reference: Cook S et al., Arch Prediatr Adolesc Med 2003; 157: 821-827

Figure B.2 Receiver operator curve describing the sensitivity and specificity of changes in BMI, BMI percentile, and percent body fat for predicting adverse changes in the cardiovascular disease risk factor summary score: Project HeartBeat!

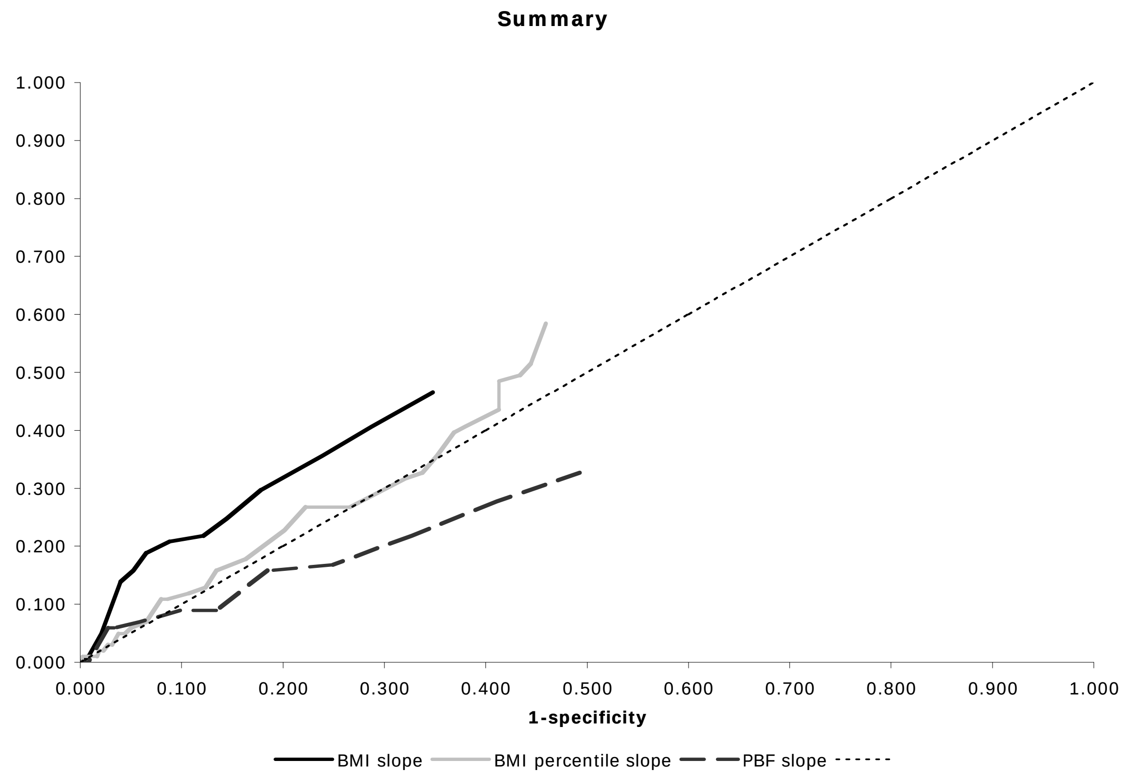


Figure B.2 Receiver operator curve describing the sensitivity and specificity of changes in BMI, BMI percentile, and percent body fat for predicting adverse changes in HDL cholesterol: Project HeartBeat!

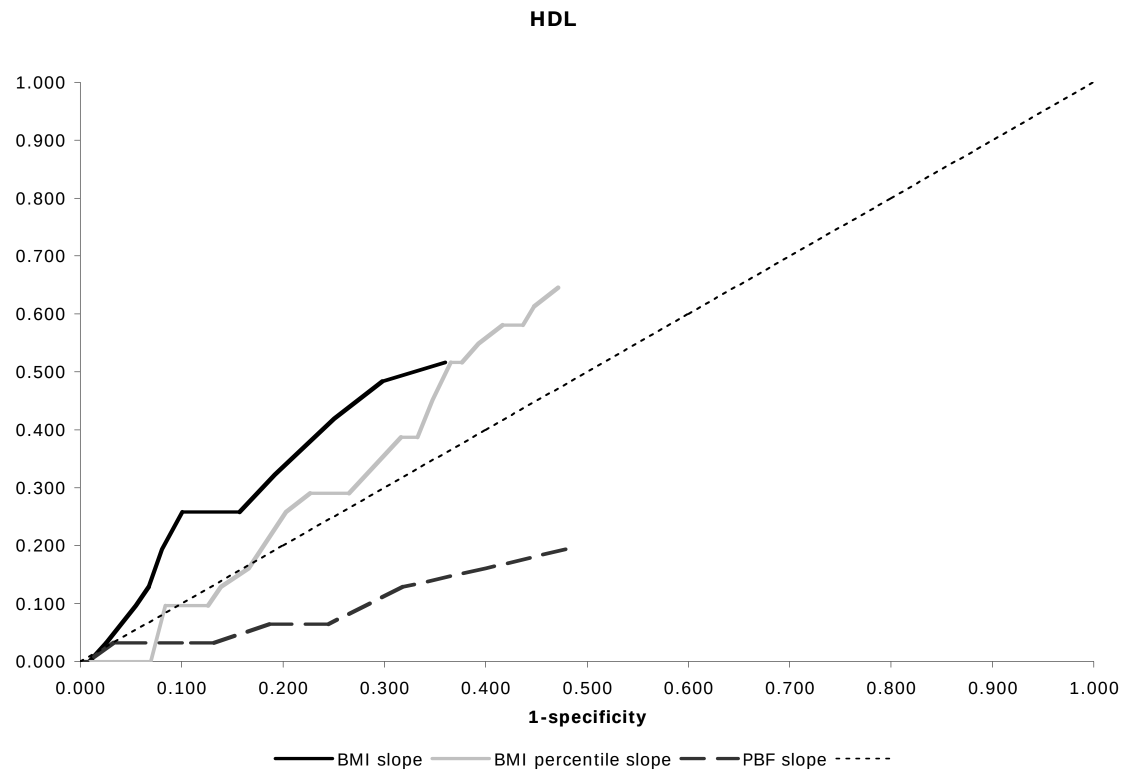
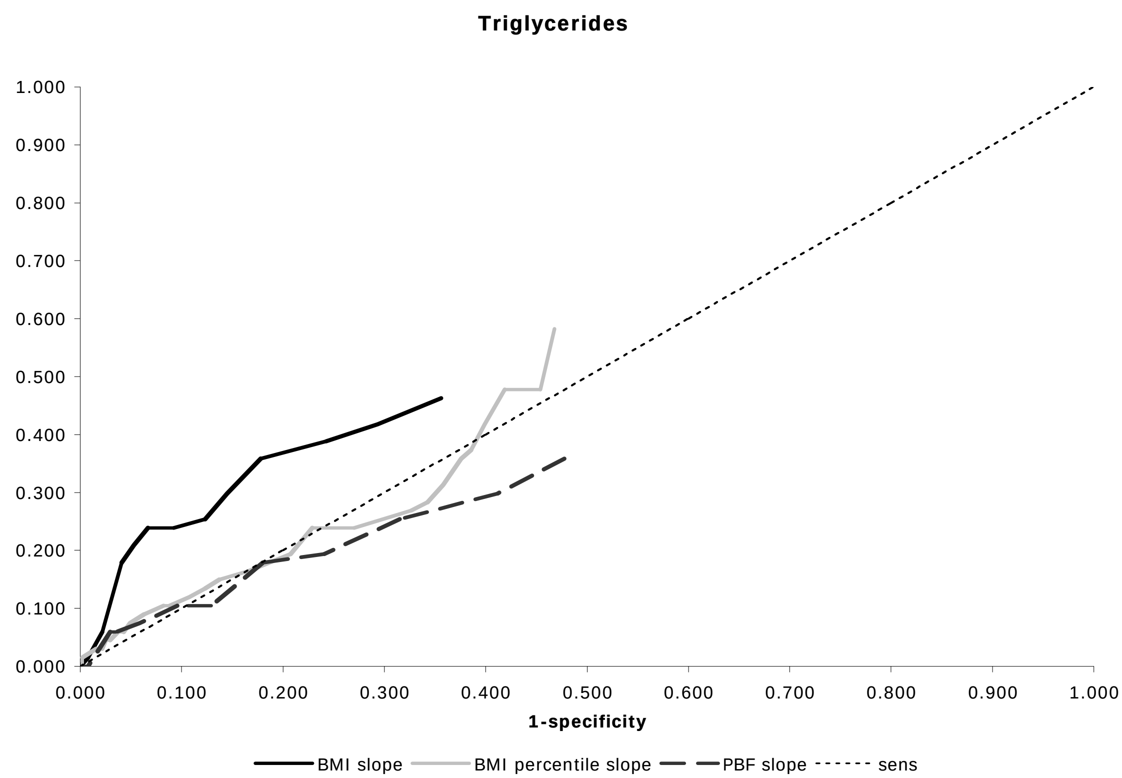


Figure B.3 Receiver operator curve describing the sensitivity and specificity of changes in BMI, BMI percentile, and percent body fat for predicting adverse changes in triglycerides: Project HeartBeat!



APPENDIX C

Table C.1 Correlations between MVPA, TV viewing, and potential covariates: Project HeartBeat!

	All (n=460)	Males (n=224)	Females (n=236)	Blacks (n=75)	Non-blacks (n=385)
MVPA					
Baseline summary score	0.03	0.10	-0.05	0.06	0.02
Baseline SBP, mm Hg	0.02	0.02	-0.01	0.20	-0.02
Baseline DBP, mm Hg	-0.02	0.02	-0.08	0.09	-0.04
Baseline triglycerides, mg/dl	-0.04	0.01	-0.08	-0.01	-0.07
Baseline LDL, mg/dl	0.03	0.03	0.04	-0.07	0.05
Baseline HDL, mg/dl	-0.001	-0.11	0.10	0.11	-0.02
Δ BMI percentile	0.03	0.07	0.04	0.06	0.05
Δ Height, m	0.11*	-0.05	0.21*	0.15	0.11*
Sex	-0.16*	--	--	-0.18	-0.15*
Pubertal stage	-0.11*	0.05	0.22*	-0.10	-0.10*
Race	-0.13*	0.09	-0.15*	--	--
Caloric intake, kcal/d	0.05	0.11	-0.06	0.06	0.03
TV viewing					
Baseline summary score	0.11	0.11	0.11	0.06	0.13*
Baseline SBP, mm Hg	0.07	0.13	-0.01	0.13	0.06
Baseline DBP, mm Hg	-0.01	-0.04	0.02	-0.27*	0.04
Baseline triglycerides, mg/dl	0.04	0.05	0.04	0.19	0.03
Baseline LDL, mg/dl	0.06	0.04	0.08	0.09	0.06
Baseline HDL, mg/dl	0.09	-0.03	-0.14*	-0.04	-0.10*
Δ BMI percentile	0.08	0.10	0.09	0.02	0.07
Δ Height, m	0.05	0.13*	-0.02	0.28*	0.01
Sex	-0.05	--	--	0.09	-0.09
Pubertal stage	0.15*	0.17*	0.13*	0.25*	0.12*
Race	0.08	0.006	0.15*	--	--
Caloric intake, kcal/d	0.01	-0.01	0.02	0.06	0.01

*correlation coefficient significant at $p<0.05$

Table D.1 Results of stratified logistic regression analyses to test the presence of effect modification by BMI, age, and race among males: Youth Risk Behavior Survey, 2005

	Adjusted OR (95% CI), n= 5575							
	BMI[1]		**Age**[2]		**Race**[3]			
	Normal BMI (n=3698)	At risk for overweight/ Overweight (n=1877)	Age < 16 (n=1606)	Age ≥ 16 (n=3969)	White (n=2655)	Black (n=1263)	Hispanic (n=1243)	Other (n=414)
Perceived body size								
About right	REFERENCE GROUP							
Underweight	0.8 (0.6-1.0)	0.5 (0.2-1.0)	0.8 (0.6-1.2)	0.7 (0.6-0.9)	0.8 (0.6-1.0)	0.6 (0.4-1.0)	1.1 (0.6-1.9)	0.5 (0.2-1.1)
Overweight	0.6 (0.4-0.8)	0.5 (0.3-0.6)	0.5 (0.4-0.7)	0.5 (0.4-0.7)	0.5 (0.4-0.7)	0.5 (0.3-0.9)	0.8 (0.5-1.1)	0.3 (0.2-0.6)
Weight-management goal								
Do nothing	REFERENCE GROUP							
Lose weight	0.9 (0.7-1.2)	0.9 (0.7-1.3)	0.7 (0.5-1.0)	1.0 (0.8-1.3)	0.9 (0.7-1.2)	0.9 (0.6-1.6)	0.9 (0.6-1.2)	0.7 (0.4-1.2)
Gain weight	1.7 (1.3-2.1)	7.6 (3.9-14.9)	1.2 (0.9-1.78)	2.3 (1.82-3.0)	2.2 (1.6-3.0)	1.9 (1.2-2.9)	1.4 (1.0-2.0)	1.4 (0.6-3.0)
Maintain weight	1.1 (0.8-1.4)	1.2 (0.8-1.7)	1.0 (0.7-1.6)	1.2 (0.9-1.6)	1.1 (0.8-1.5)	1.2 (0.8-1.7)	1.2 (0.7-2.0)	1.0 (0.4-2.1)

Table D.1 cont. Results of stratified logistic regression analyses to test the presence of effect modification by BMI, age, and race among males: Youth Risk Behavior Survey, 2005

	Adjusted OR (95% CI), n= 5575							
	BMI[1]		**Age**[2]		**Race**[3]			
	Normal BMI (n=3698)	At risk for overweight/ Overweight (n=1877)	Age < 16 (n=1606)	Age ≥ 16 (n=3969)	White (n=2655)	Black (n=1263)	Hispanic (n=1243)	Other (n=414)
Weight-management behavior[4]								
Exercise	1.2 (1.1-1.5)	1.5 (1.1-2.0)	1.4 (1.1-1.8)	1.3 (1.1-1.6)	1.5 (1.2-1.8)	1.0 (0.7-1.3)	1.4 (1.1-1.9)	1.1 (0.6-2.0)
Diet	0.9 (0.7-1.1)	0.8 (0.6-1.0)	0.8 (0.5-1.1)	0.9 (0.7-1.1)	0.8 (0.7-1.1)	0.6 (0.4-0.99)	0.9 (0.6-1.3)	1.0 (0.7-1.7)
Fast	0.7 (0.5-0.9)	0.9 (0.6-1.3)	0.8 (0.5-1.2)	0.8 (0.5-1.1)	0.8 (0.5-1.1)	0.9 (0.5-1.4)	1.0 (0.5-1.7)	0.5 (0.3-1.0)
Diet supplements	1.3 (0.9-2.1)	1.0 (0.6-1.7)	0.9 0.5-1.7)	1.4 (1.0-2.1)	1.1 (0.7-1.7)	2.8 (1.2-6.8)	1.6 (0.8-3.2)	0.6 (0.2-1.4)
Purge	1.2 (0.6-2.3)	0.7 (0.3-1.4)	0.8 (0.3-2.0)	1.1 (0.6-1.8)	0.7 (0.3-1.5)	1.0 (0.5-2.1)	2.0 (0.5-7.0)	1.8 (0.6-5.2)
Exercise + diet	1.0 (0.8-1.3)	0.9 (0.6-1.2)	0.8 (0.6-1.1)	1.1 (0.8-1.3)	0.9 (0.7-1.2)	0.9 (0.6-1.3)	0.9 (0.6-1.4)	1.2 (0.6-2.1)
Fast, diet supplements, or purge	1.0 (0.7-1.3)	0.9 (0.6-1.3)	0.9 (0.6-1.3)	1.0 (0.7-1.4)	1.0 (0.7-1.4)	0.9 (0.6-1.4)	1.0 (0.6-1.7)	0.8 (0.4-1.4)
Any method	1.1 (1.0-1.3)	1.3 (0.9-1.7)	1.3 (1.0-1.7)	1.1 (0.9-1.4)	1.3 (1.0-1.6)	0.8 (0.5-1.1)	1.4 (1.1-1.9)	0.9 (0.5-1.6)

Table D.1 cont. Results of stratified logistic regression analyses to test the presence of effect modification by BMI, age, and race among males: Youth Risk Behavior Survey, 2005

	Adjusted OR (95% CI), n= 5575							
	BMI[1]		**Age**[2]		**Race**[3]			
	Normal BMI (n=3698)	At risk for overweight/ Overweight (n=1877)	Age < 16 (n=1606)	Age ≥ 16 (n=3969)	White (n=2655)	Black (n=1263)	Hispanic (n=1243)	Other (n=414)
Meets recommendation[4]								
Vigorous PA (20 min/d on ≥3 d/wk)	2.9 (2.5-3.5)	4.7 (3.2-6.8)	2.5 (1.8-3.5)	3.9 (3.1-4.9)	3.6 (3.0-4.4)	3.6 (2.6-5.0)	2.1 (1.5-3.0)	4.1 (1.8-9.5)
Moderate PA (30 min/d on ≥5 d/wk)	1.4 (1.2-1.6)	1.9 (1.4-2.6)	1.5 (1.0-2.1)	1.6 (1.3-1.8)	1.4 (1.1-1.7)	2.2 (1.5-3.4)	1.9 (1.4-2.7)	1.5 (0.8-2.6)
MVPA (60 min/d on ≥5 d/wk)	3.1 (2.5-3.8)	4.2 (3.1-5.6)	3.6 (2.7-5.0)	3.3 (2.9-3.9)	3.4 (2.9-4.2)	3.2 (2.0-5.0)	3.8 (2.6-5.6)	2.6 (1.7-4.9)
TV viewing	1.0 (0.8-1.3)	1.1 (0.9-1.5)	1.1 (0.7-1.5)	1.1 (0.9-1.3)	1.1 (0.8-1.4)	0.8 (0.5-1.1)	1.2 (0.8-1.7)	1.2 (0.8-1.9)
Meets any PA recommendation	2.9 (2.4-3.5)	4.1 (2.8-5.9)	2.6 (1.9-3.5)	3.7 (2.9-4.6)	3.4 (2.8-4.2)	3.4 (2.4-4.8)	2.3 (1.6-3.3)	3.9 (1.7-9.2)
Meets PA + TV recommendations	1.4 (1.1-1.8)	1.9 (1.4-2.6)	1.3 (0.9-1.9)	1.7 (1.3-2.1)	1.6 (1.2-2.0)	1.1 (0.7-1.8)	1.5 (1.0-2.3)	1.9 (1.1-3.3)

[1] Adjusted for age and race/ethnicity; [2] Adjusted for BMI and race/ethnicity; [3] Adjusted for age and BMI; [4] reference group= no; PA= physical activity

Table D.2 Results of stratified logistic regression analyses to test the presence of effect modification by BMI, age, and race among females: Youth Risk Behavior Survey, 2005

	OR (95% CI), n= 6180							
	BMI[1]		**Age**[2]		**Race**[3]			
	Normal BMI (n=4454)	At risk for overweight/ Overweight (n=1726)	Age < 16 (n=2023)	Age ≥ 16 (n=4157)	White (n=2753)	Black (n=1501)	Hispanic (n=1507)	Other (n=419)
Perceived body size								
About right	REFERENCE GROUP							
Underweight	0.9 (0.9-1.1)	1.1 (0.6-2.3)	1.0 (0.7-1.5)	0.8 (0.6-1.0)	0.8 (0.6-1.1)	0.8 (0.5-1.3)	1.5 (1.0-2.3)	1.0 (0.4-2.0)
Overweight	1.0 (0.8-1.3)	0.9 (0.6-1.3)	1.1 (0.8-1.5)	0.9 (0.7-1.2)	0.9 (0.7-1.2)	1.2 (0.8-1.8)	1.0 (0.7-1.4)	1.1 (0.7-1.9)
Weight-management goal								
Do nothing	REFERENCE GROUP							
Lose weight	0.7 (0.5-1.0)	2.4 (0.6-10.1)	0.7 (0.4-1.3)	0.8 (0.5-1.2)	0.7 (0.4-1.2)	0.8 (0.4-1.6)	1.0 (0.6-1.9)	0.5 (0.1-2.2)
Gain weight	1.1 (0.9-1.3)	1.9 (1.0-3.8)	1.0 (0.7-1.4)	1.2 (0.9-1.7)	1.0 (0.8-1.3)	1.2 (0.7-2.0)	1.4 (0.9-2.3)	1.8 (0.8-4.4)
Maintain weight	1.2 (0.9-1.5)	1.6 (0.9-2.9)	1.0 (0.7-1.4)	1.4 (1.1-1.8)	1.3 (1.0-1.7)	1.2 (0.7-2.0)	1.1 (0.7-1.6)	1.3 (0.7-2.7)

Table D.2 cont. Results of stratified logistic regression analyses to test the presence of effect modification by BMI, age, and race among females: Youth Risk Behavior Survey, 2005

	OR (95% CI), n= 6180							
	BMI[1]		**Age**[2]		**Race**[3]			
	Normal BMI (n=4454)	At risk for overweight/ Overweight (n=1726)	Age < 16 (n=2023)	Age ≥ 16 (n=4157)	White (n=2753)	Black (n=1501)	Hispanic (n=1507)	Other (n=419)
Weight-management behavior[4]								
Exercise	2.0 (1.6-2.4)	1.7 (1.3-2.4)	1.5 (1.2-2.0)	2.2 (1.8-2.8)	1.9 (1.5-2.3)	1.9 (1.4-2.6)	2.0 (1.6-2.5)	2.6 (1.3-5.2)
Diet	1.0 (0.9-1.2)	1.0 (0.7-1.4)	1.0 (0.8-1.2)	1.1 (0.9-1.3)	0.9 (0.8-1.1)	1.3 (1.0-1.8)	1.1 (0.8-1.5)	1.4 (0.9-2.4)
Fast	0.8 (0.7-1.0)	0.8 (0.6-1.1)	0.7 (0.5-1.0)	0.9 (0.7-1.1)	0.7 (0.6-0.9)	1.3 (0.8-2.0)	0.8 (0.6-1.0)	1.1 (0.7-1.9)
Diet supplements	1.0 (0.6-1.4)	1.1 (0.8-1.6)	1.1 (0.7-1.9)	1.0 (0.7-1.4)	0.9 (0.7-1.4)	1.9 (0.8-4.3)	1.2 (0.7-2.0)	0.9 (0.3-2.6)
Purge	1.1 (0.8-1.4)	1.2 (0.8-1.8)	0.9 (0.7-1.3)	1.3 (0.9-1.7)	1.1 (0.8-1.5)	1.7 (0.8-3.6)	1.0 (0.7-1.5)	1.1 (0.4-3.0)
Exercise + diet	1.3 (1.1-1.6)	1.2 (0.9-1.7)	1.2 (1.0-1.5)	1.4 (1.1-1.7)	1.2 (1.0-1.5)	1.4 (1.1-1.9)	1.5 (1.1-2.0)	2.1 (1.1-3.9)
Fast, diet supplements, or purge	0.8 (0.7-1.1)	1.0 (0.8-1.4)	0.8 (0.6-1.1)	0.9 (0.7-1.1)	0.8 (0.7-1.0)	1.5 (1.0-2.3)	0.8 (0.7-1.0)	1.2 (0.7-1.9)
Any method	1.6 (1.3-1.9)	1.3 (0.9-1.9)	1.2 (1.0-1.5)	1.8 (1.4-2.3)	1.5 (1.2-1.9)	1.9 (1.4-2.6)	1.5 (1.0-2.1)	1.6 (0.8-3.2)

Table D.2 cont. Results of stratified logistic regression analyses to test the presence of effect modification by BMI, age, and race among females: Youth Risk Behavior Survey, 2005

	OR (95% CI), n= 6180							
	BMI[1]		**Age**[2]		**Race**[3]			
	Normal BMI (n=4454)	At risk for overweight/ Overweight (n=1726)	Age < 16 (n=2023)	Age ≥ 16 (n=4157)	White (n=2753)	Black (n=1501)	Hispanic (n=1507)	Other (n=419)
Meets recommendation[4]								
Vigorous PA (20 min/d on ≥3 d/wk)	4.4 (3.6-5.3)	2.6 (2.0-3.5)	3.9 (2.9-5.3)	3.8 (3.1-4.6)	3.9 (3.2-4.9)	4.0 (3.0-5.4)	3.6 (2.5-5.2)	3.2 (1.8-5.5)
Moderate PA (30 min/d on ≥5 d/wk)	1.9 (1.6-2.3)	2.0 (1.6-2.6)	2.0 (1.6-2.6)	1.9 (1.5-2.4)	2.0 (1.6-2.5)	1.6 (1.1-2.2)	2.1 (1.5-2.8)	2.0 (1.2-3.3)
MVPA (60 min/d on ≥5 d/wk)	4.9 (4.1-5.8)	3.0 (2.1-4.3)	4.7 (3.7-5.9)	4.0 (3.2-5.1)	4.4 (3.6-5.5)	4.6 (3.3-6.5)	3.3 (2.4-4.6)	4.5 (2.5-8.3)
TV viewing	1.4 (1.1-1.7)	1.1 (0.9-1.5)	1.2 (0.9-1.6)	1.4 (1.1-1.7)	1.3 (1.1-1.7)	1.1 (0.7-1.6)	1.6 (1.2-2.1)	1.1 (0.7-1.9)
Meets any PA recommendation	3.7 (3.0-4.5)	2.7 (2.1-3.4)	3.5 (2.6-4.8)	3.3 (2.7-4.1)	3.4 (2.7-4.3)	3.7 (2.8-4.9)	3.8 (2.8-5.2)	2.5 (1.4-4.5)
Meets PA + TV recommendations	2.4 (2.0-2.8)	1.9 (1.3-2.8)	1.9 (1.5-2.4)	2.5 (2.0-3.0)	2.2 (1.8-2.7)	3.0 (1.8-5.1)	2.6 (1.9-3.7)	2.0 (1.0-3.7)

[1] Adjusted for age and race/ethnicity; [2] Adjusted for BMI and race/ethnicity; [3] Adjusted for age and BMI; [4] reference group= no; PA= physical activity

APPENDIX E

Table E.1 Prevalence of age, grade, weight-change intention, body weight perception, body mass index, sports team, and weight-management behaviors among male Muscogee County survey and 2005 Youth Risk Behavior Survey Georgia state and national sports participants

	Muscogee (n=586)	Georgia YRBS (n= 497)	National YRBS (n=3757)
Age			
13	16.7 (13.9-19.9)	0.2 (0.0-0.4)	0.2 (0.0-0.4)
14	18.6 (15.7-22.0)	10.1 (7.1-13.1)	10.6 (9.0-12.2)
15	21.8 (18.6-25.3)	27.0 (22.8-31.2)	26.6 (24.6-28.7)
16	24.4 (21.1-28.0)	31.7 (27.4-36.0)	26.4(24.7-28.1)
17	14.7 (12.1-17.8)	18.8 (15.4-22.1)	22.5 (21.1-23.9)
18	3.8 (2.5-5.7)	12.2 (9.2-15.2)	13.7 (12.2-15.3)
Grade			
8	13.8 (11.1-17.0)	--	--
9	19.0 (16.0-22.4)	34.3 (29.9-38.6)	30.0 (27.5-32.5)
10	22.6 (19.4-26.2)	29.8 (25.8-33.7)	26.9 (24.6-29.2)
11	20.5 (17.4-24.0)	20.3 (16.9-23.8)	22.9 (20.8-25.0)
12	20.7 (17.6-24.2)	15.6 (12.4-18.8)	20.1 (18.4-21.7)
Ungraded or Other	3.6 (2.2-5.5)	0	0.03 (0.00-0.07)
Intention			
Do nothing	17.4 (14.5-20.7)	17.7 (14.1-21.4)	20.9 (18.8-23.0)
Lose weight	18.6 (15.7-22.0)	27.5 (23.3-31.7)	27.1 (25.0-29.3)
Gain weight	39.4 (35.5-43.4)	35.2 (30.8-39.6)	30.8 (28.4-33.3)
Maintain weight	24.6 (21.3-28.2)	19.5 (15.8-23.2)	21.1 (19.4-22.8)
Perception (%)			
About right	63.3 (59.3-67.1)	62.9 (58.3-67.5)	62.5 (60.6-64.5)
Underweight	18.4 (15.5-21.7)	17.2 (13.6-20.8)	16.3 (14.5-18.1)
Overweight	18.3 (15.4-21.6)	19.9 (16.1-23.6)	21.1 (19.2-23.1)
Body mass index (%)			
Healthy weight	45.0 (41.0-49.0)	68.8 (64.5-73.2)	69.3 (67.1-71.5)
At risk for overweight	22.3 (19.1-25.8)	16.8 (13.2-20.3)	16.3 (14.3-18.3)
Overweight	32.6 (28.9-36.5)	14.4 (11.2-17.6)	14.4 (13.1-15.7)

Table E.1 cont. Prevalence of age, grade, weight-change intention, body weight perception, body mass index, sports team, and weight-management behaviors among male Muscogee County survey and 2005 Youth Risk Behavior Survey Georgia state and national sports participants

	Muscogee (n=586)	Georgia YRBS (n= 497)	National YRBS (n=3757)
Number of sports teams (%)			
1 team	53.6 (49.6-57.6)	40.7 (36.2-45.3)	40.4 (37.3-43.6)
2 teams	31.2 (27.6-35.1)	32.7 (28.3-37.2)	29.0 (26.8-31.2)
3 or more teams	15.2 (12.5-18.3)	26.5 (22.5-30.6)	30.5 (27.3-33.8)
Strategy (%)			
Exercise	79.2 (75.7-82.3)	49.4 (45.8-55.2)	55.3 (53.4-57.3)
Reduce calories	54.4 (50.4-58.4)	23.7 (19.6-27.7)	25.3 (23.3-27.2)
Increase calories	56.3 (52.3-60.3)	--	--
Use diet aids	28.2 (24.7-32.0)	5.8 (3.5-8.1)	4.3 (3.4-5.3)
Use PEPs	33.8 (30.1-37.7)	--	--
Fasting	32.2 (28.5-36.1)	7.4 (4.9-9.9)	6.7 (5.6-7.8)
Purging	21.8 (18.6-25.3)	3.8 (2.0-5.6)	2.4 (1.6-3.2)

Values are percent (95% confidence interval).

Table E.2 Prevalence of age, grade, weight-change intention, body weight perception, body mass index, sports team, and weight-management behaviors among female Muscogee County survey and 2005 Youth Risk Behavior Survey Georgia state and national sports participants

	Muscogee (n=215)	Georgia YRBS (n=420)	National YRBS (n=3235)
Age			
13	11.2 (7.6-16.1)	0	0.04 (0.00-0.10)
14	23.3 (18.1-29.4)	8.9 (4.6-13.3)	12.7 (11.0-14.5)
15	23.3 (18.1-29.4)	31.1 (22.5-39.8)	30.3 (28.5-32.1)
16	14.6 (10.5-19.9)	27.7 (20.4-35.0)	25.3 (23.4-27.1)
17	16.7 (12.3-22.3)	21.2 (14.6-27.8)	21.2 (19.4-23.0)
18	0.9 (0.2-3.3)	11.0 (4.4-17.6)	10.4 (9.1-11.6)
Grade			
8	6.5 (3.7-10.9)	--	--
9	22.9 (17.8-29.0)	31.8 (17.4-46.2)	31.9 (29.7-34.2)
10	26.2 (20.8-32.5)	28.0 (16.6-39.4)	26.6 (24.8-28.4)
11	24.8 (19.5-31.0)	22.3 (15.2-29.3)	23.0 (21.2-24.7)
12	18.2 (13.6-23.9)	17.9 (7.6-28.2)	18.4 (16.5-20.3)
Ungraded or Other	1.9 (0.6-5.0)	0	0.07 (0.00-0.21)
Intention (%)			
Do nothing	30.7 (24.9-37.2)	13.8 (9.4-18.2)	13.5 (11.9-15.2)
Lose weight	38.6 (32.3-45.3)	59.5 (54.9-64.0)	63.1 (60.9-65.3)
Gain weight	--	5.9 (3.4-8.3)	4.9 (3.7-6.1)
Maintain weight	30.7 (24.9-37.2)	20.8 (17.5-24.1)	18.4 (16.8-20.0)
Perception (%)			
About right	70.2 (63.8-75.9)	62.2 (57.0-67.5)	54.8 (51.4-58.2)
Underweight	3.3 (1.6-6.6)	8.5 (4.8-12.3)	9.5 (7.8-11.1)
Overweight	26.5 (21.1-32.8)	29.2 (24.4-33.9)	35.7 (33.0-38.4)
Body mass index (%)			
Healthy weight	61.4 (54.7-67.7)	80.5 (76.2-84.8)	78.6 (76.3-81.0)
At risk for overweight	23.3 (18.1-29.4)	10.4 (6.8-14.0)	14.2 (12.1-16.2)
Overweight	15.3 (11.1-20.7)	9.1 (5.8-12.3)	7.2 (6.1-8.3)

Table E.2 cont. Prevalence of age, grade, weight-change intention, body weight perception, body mass index, sports team, and weight-management behaviors among female Muscogee County survey and 2005 Youth Risk Behavior Survey Georgia state and national sports participants

	Muscogee (n=215)	Georgia YRBS (n=420)	National YRBS (n=3235)
Number of sports teams (%)			
1 team	57.2 (50.5-63.6)	54.0 (49.6-58.4)	49.1 (45.8-52.5)
2 teams	30.2 (24.5-36.6)	28.8 (23.0-34.7)	30.0 (27.6-32.3)
3 or more teams	12.6 (8.8-17.7)	17.1 (12.4-21.9)	20.9 (17.6-24.2)
Strategy (%)			
Exercise	71.2 (64.8-76.8)	76.9 (72.3-81.4)	74.1 (71.8-76.4)
Reduce calories	50.2 (43.6-56.8)	49.9 (44.1-55.8)	55.1 (52.8-57.5)
Increase calories	29.3 (23.6-35.7)	--	--
Use diet aids	15.8 (11.5-21.3)	7.5 (5.1-10.0)	7.7 (6.2-9.3)
Use PEPs	13.5 (9.6-18.7)	--	--
Fasting	20.5 (15.6-26.4)	13.5 (8.9-18.1)	15.4 (14.0-16.9)
Purging	12.6 (8.8-17.7)	6.7 (2.9-10.5)	6.4 (5.4-7.4)

Values are percent (95% confidence interval).

Table E.3 Distribution of perceived body size within categories of BMI among males and females: Muscogee County

Males	BMI (n=801)			
Perceived body size	Normal	At risk for overweight	Overweight	*Total*
Underweight	31.1 (25.5, 36.6)	14.5 (8.5, 20.5)	3.7 (1.0, 6.3)	*108*
About right	67.1 (61.4, 72.7)	81.7 (75.1, 88.3)	45.6 (38.5, 52.6)	*371*
Overweight	1.9 (0.3, 3.5)	3.8 (0.5, 7.1)	50.8 (43.7, 57.9)	*107*
Total	*264*	*131*	*191*	*586*
Females	BMI			
Perceived body size	Normal	At risk for overweight	Overweight	*Total*
Underweight	4.6 (1.0, 8.1)	2.0 (0, 5.9)	0	*7*
About right	89.4 (84.1, 94.6)	56.0 (42.2, 69.8)	15.2 (2.9, 27.4)	*151*
Overweight	6.1 (2.0, 10.1)	42.0 (28.3, 55.7)	84.8 (72.6, 97.1)	*57*
Total	*132*	*50*	*33*	*215*

Values are percent (95% confidence interval).

Table E.4 Characterization of intentions to "maintain weight" and "do nothing": Muscogee County

	Males		Females	
	Do nothing	Maintain	Do nothing	Maintain
Males, n	102	144	66	66
BMI				
Normal weight	57.8 (48.3, 67.4)	31.9 (24.3, 39.6)	87.9 (80.0, 95.8)	78.8 (68.9, 88.7)
At risk for overweight	25.5 (17.0, 34.0)	29.9 (22.4, 37.3)	10.6 (3.2, 18.0)	19.7 (10.1, 29.3)
Overweight	16.7 (9.4, 23.9)	38.2 (30.3, 46.1)	1.5 (0, 4.5)	1.5 (0, 4.5)
Perceived body size				
Underweight	6.9 (2.0, 11.8)	4.9 (1.4, 8.4)	6.1 (0.3, 11.8)	3.0 (0, 7.2)
About right	90.2 (84.4, 96.0)	84.7 (78.8, 90.6)	90.9 (84.0, 97.9)	90.9 (84.0, 97.9)
Overweight	2.9 (0, 6.2)	10.4 (5.4, 15.4)	3.0 (0, 7.2)	6.1 (0.3, 11.8)
Strategy				
Diet	36.3 (26.9, 45.6)	70.1 (62.7, 77.6)	25.8 (15.2, 36.3)	50.0 (37.9, 62.1)
Exercise	56.9 (47.3, 66.5)	83.9 (77.2, 89.4)	39.4 (27.6, 51.2)	67.9 (74.3, 92.3)
Supplement	21.6 (13.6, 29.6)	37.5 (29.6, 45.4)	10.6 (3.2, 18.0)	18.2 (8.9, 27.5)
Disordered	21.6 (13.6, 29.6)	40.3 (32.3, 48.3)	12.1 (4.3, 20.0)	19.7 (10.1, 29.3)
Grade				
Other	27.5 (18.8, 36.1)	20.8 (14.2, 27.5)	9.1 (2.2, 16.0)	10.6 (3.2, 18.0)
9	19.6 (11.9, 27.3)	21.5 (14.8, 28.2)	15.4 (6.5, 23.8)	27.3 (16.5, 38.0)
10	19.6 (11.9, 27.3)	23.6 (16.7, 30.6)	33.9 (22.0, 44.7)	21.2 (11.4, 31.1)
11	12.8 (6.3, 19.2)	13.9 (8.2, 19.5)	21.5 (11.4, 31.1)	24.2 (13.9, 34.6)
12	20.6 (12.7, 28.4)	20.1 (13.6, 26.7)	20.0 (10.1, 29.3)	16.7 (7.7, 25.7)

Values are percent (95% confidence interval); Disordered= fasting, vomiting, and/or laxative use

Table E.5 Tests of mediating effects of perceived body size on the association between intention and advice among male and female sports participants: Muscogee County

Intent	Sex	Level of Advice	Level of Perception	Intention= Advice	Perception= Advice	Intention= Perception	Intenton= Advice +Perception**
Lose	Male	Peer or Adult	Overweight	6.7 (2.3-19.6)	1.1 (0.5-2.2)	102.7 (27.8-353.8)	12.1 (3.4-42.4)
			Underweight	6.7 (2.3-19.6)	1.6 (0.8-3.1)	1.0 (0.2-5.3)	12.1 (3.4-42.4)
		Peer + adult	Overweight	2.0 (1.1-3.7)	1.0 (0.6-1.6)	102.7 (27.8-353.8)	2.1 (0.9-4.5)
			Underweight	2.0 (1.1-3.7)	1.3 (0.8-2.2)	1.0 (0.2-5.3)	2.1 (0.9-4.5)
Lose	Female	Peer or Adult	Overweight	8.6 (2.5-29.0)	10.3 (3.6-29.2)	49.2 (11.2-215.8)	3.2 (0.7-14.6)
		Peer + adult	Overweight	3.3 (1.6-6.9)	1.7 (0.8-3.6)	49.2 (11.2-215.8)	3.5 (1.4-8.5)
Gain	Male	Peer or Adult	Overweight	7.4 (2.7-20.3)	1.1 (0.5-2.2)	1.7 (0.4-6.7)	7.2 (2.6-20.6)
			Underweight	7.4 (2.7-20.3)	1.6 (0.8-3.1)	8.8 (3.9-20.0)	7.2 (2.6-20.6)
		Peer + adult	Overweight	3.2 (1.9-5.3)	1.0 (0.6-1.6)	1.7 (0.4-6.7)	3.2 (1.8-5.5)
			Underweight	3.2 (1.9-5.3)	1.3 (0.8-2.2)	8.8 (3.9-20.0)	3.2 (1.8-5.5)
Maintain	Male	Peer or Adult	Overweight	3.4 (1.1-10.2)	1.1 (0.5-2.2)	3.8 (1.1-13.6)	3.5 (1.2-10.7)
			Underweight	3.4 (1.1-10.2)	1.6 (0.8-3.1)	0.7 (0.2-2.2)	3.5 (1.2-10.7)
		Peer + adult	Overweight	2.8 (1.6-4.7)	1.0 (0.6-1.6)	3.8 (1.1-13.6)	2.8 (1.6-4.8)
			Underweight	2.8 (1.6-4.7)	1.3 (0.8-2.2)	0.7 (0.2-2.2)	2.8 (1.6-4.8)
Maintain	Female	Peer or Adult	Overweight	0.9 (0.1-5.1)	10.3 (3.6-29.2)	2.0 (0.3-11.4)	0.8 (0.1-4.6)
		Peer + adult	Overweight	3.0 (1.5-6.3)	1.7 (0.8-3.6)	2.0 (0.3-11.4)	3.3 (1.6-6.9)

n= 801; Values are odds ratios (95% confidence intervals); All models were adjusted for age; *Models describing perceived underweight among girls were unstable and were excluded from this analysis due to an insufficient number of girls (n=7) who perceived themselves as underweight; ** Odds ratio and confidence interval reported is for Advice

Table E.6 Tests of mediating effects of perceived body size on the association between intention and BMI among male and female sports participants: Muscogee County

Intent	Sex	Level of BMI	Level of Perception	Intention= BMI	Perception= BMI	Intention= Perception	Intention= BMI + Perception**
Lose	Male	At-risk	Overweight	4.2 (1.4-12.6)	1.7 (0.5-6.0)	102.7 (27.8-353.8)	3.9 (1.2-12.3)
			Underweight	4.2 (1.4-12.6)	0.4 (0.2-0.6)	1.0 (0.2-5.3)	3.9 (1.2-12.3)
		Overweight	Overweight	54.7 (20.2-147.9)	44.0 (17.1-113.4)	102.7 (27.8-353.8)	15.2 (5.2-44.6)
			Underweight	54.7 (20.2-147.9)	0.2 (0.07-0.3)	1.0 (0.2-5.3)	15.2 (5.2-44.6)
Lose	Female	At-risk	Overweight	12.2 (4.6-32.4)	12.4 (4.9-31.5)	49.2 (11.2-215.8)	6.8 (2.4-19.5)
		Overweight	Overweight	93.3 (11.8-737.8)	104.4 (30.2-360.9)	49.2 (11.2-215.8)	20.8 (2.3-184.5)
Gain	Male	At-risk	Overweight	0.7 (0.4-1.3)	1.7 (0.5-6.0)	1.7 (0.4-6.7)	0.9 (0.5-1.5)
			Underweight	0.7 (0.4-1.3)	0.4 (0.2-0.6))	8.8 (3.9-20.0)	0.9 (0.5-1.5)
		Overweight	Overweight	0.5 (0.3-1.0)	44.0 (17.1-113.4)	1.7 (0.4-6.7)	0.8 (0.4-1.7)
			Underweight	0.5 (0.3-1.0)	0.2 (0.07-0.3)	8.8 (3.9-20.0)	0.8 (0.4-1.7)
Maintain	Male	At-risk	Overweight	2.1 (1.1-3.9)	1.7 (0.5-6.0)	3.8 (1.1-13.6)	2.1 (1.1-3.9)
			Underweight	2.1 (1.1-3.9)	0.4 (0.2-0.6)	0.7 (0.2-2.2)	2.1 (1.1-3.9)
		Overweight	Overweight	4.1 (2.1-8.0)	44.0 (17.1-113.4)	3.8 (1.1-13.6)	3.9 (1.9-8.0)
			Underweight	4.1 (2.1-8.0)	0.2 (0.07-0.3)	0.7 (0.2-2.2)	3.9 (1.9-8.0)
Maintain	Female	At-risk	Overweight	2.0 (0.7-5.5)	12.4 (4.9-31.5)	2.0 (0.3-11.4)	1.9 (0.7-5.3)
		Overweight	Overweight	1.1 (0.07-18.0)	104.4 (30.2-360.9)	2.0 (0.3-11.4)	0.8 (0.05-14.8)

n= 801; Values are odds ratios (95% confidence intervals); All models were adjusted for age; *Models describing perceived underweight among girls were unstable and were excluded from this analysis due to an insufficient number of girls (n=7) who perceived themselves as underweight; ** Odds ratio and confidence interval reported is for Advice