THE ROLE OF PHYSICAL ACTIVITY ON BODY MASS INDEX AMONG MIDDLE AND HIGH SCHOOL CHILDREN

by

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ABSTRACT

CAROLINE WOLLNER HOHENSEE. The role of physical activity on body mass index among middle and high school children. (Under the direction of DR. MARY A. NIES)

Aims: The purpose of this study was to determine the association between amount of physical activity and body mass index (BMI) percentile among middle and high school aged children. *Background:* The epidemic of physical inactivity among youth has substantially contributed to the obesity epidemic. Both in-school and out-of-school environments need be considered when evaluating physical activity among children. *Data source:* Data were drawn from the Panel Study of Income Dynamics (PSID) Child Development Supplement, 2007. *Methods:* A cross-sectional design was employed to examine a sample of 1,306 children. The dependent variable was BMI percentile, while the independent variable was physical activity. Multinomial logistic regression model was used to assess the associations between physical activity and BMI percentile controlling for age, gender, race/ethnicity, parental income, participation in school lunch programs, and neighborhood safety. *Results:* After adjusting for covariates, children who engaged in low daily physical activity levels had 1.8 times the odds of being obese vs. normal weight than those who engaged in moderate levels (OR = 1.80, CI = 1.31, 2.48). Minority children and females exhibited higher odds of being obese in comparison to non-Hispanic white children. *Conclusions*: This study suggests that adherence to national physical activity guidelines in- and out-of-school may be effective in preventing obesity among children.

Keywords: Physical Activity, BMI, Children, and Secondary Data Analysis

DEDICATION

This dissertation is dedicated to my family. First, I would like to thank my parents for providing me with an education which will serve me throughout my life. For their sacrifices in doing so, I will be forever grateful. Next, I would like to thank my brother and sister-in-law, Peter and Tania Wollner, and my niece and nephew, Alexa and Luca, for their love and support over the years. I am deeply appreciative for all their help with my children which allowed me to study, as well as their smiles which enabled me to relax. I am forever grateful to our children, Kaya, Maximilian, and Oliver, for their unbelievable patience and cooperation during this process. I will never forget the times they quietly accompanied me to the University as infants and toddlers. Finally, I would like to thank my husband, Peter, for his unconditional love, support, encouragement, and sense of humor which has made this journey not only possible but enjoyable. Thank you.

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INTRODUCTION

The obesity epidemic among children is a major public health concern with rates tripling since the 1960s.[1] According to the Centers for Disease Control and Prevention, substantial improvements in the child obesity prevalence have not yet been seen. Therefore, additional research and improved interventions are essential in combating this alarming trend.

Although a substantial amount of research on physical activity and health has been published since 1995, gaps still exist.[2] In 2008, the Physical Activity Guidelines Advisory Committee (PAGAC) of the Department of Health and Human Services identified the following two key areas of future research which included: 1) determine the types and amounts of physical activity for youth that are needed to prevent the development of excessive adiposity during childhood and adolescence, and 2) because minority groups are an understudied population, it is essential to increase the number of studies with sufficient representation of at least one racial/ethnic minority. Thus, additional research is needed to study the effects of different amounts of physical activity on obesity using a large, nationally representative sample. Previous studies lack magnitude of sample, adequate minority representation, and consistency of findings.[2]

Child obesity

Childhood obesity has reached epidemic proportions in the United States and abroad.[3] Thirty one percent of children aged 2 through 19 years are overweight or obese, which is triple the prevalence in the 1960s.[4] Obesity rates are most striking when broken down by gender and ethnicity.[5] Among adolescent girls nationwide, non-Hispanic black

girls have the highest prevalence of obesity (28%), followed by Mexican American (20%) and non-Hispanic white (15%).[6] Prevalence among black girls is almost twice the rate for non-Hispanic white girls.

Body Mass Index

Body Mass Index (BMI) is a standard measure of weight status for individuals. It is calculated according to the following formulas[7]:

BMI (USA) = weight (lb)/height (in^2) x 703

BMI (Metric) = weight (kg)/height (m^2)

For children, BMI percentiles are constructed by plotting BMI values on an age and gender specific growth chart which results in a percentile value. A BMI below the 5^{th} percentile indicates a child is underweight. Children with a BMI greater than or equal to 5^{th} percentile and below the 85^{th} percentile are classified as normal weight. A BMI percentile at or greater than the 85^{th} percentile but less than 95^{th} percentile is defined as overweight and those at or above the 95^{th} percentile are obese.[8]

Physical Activity

Physical activity is "any bodily movement produced by skeletal muscles that results in energy expenditure."[9] The lack of physical activity among children has been identified as a primary mechanism responsible for their increased excess body weight.[5] Research has shown that children who are more sedentary, by watching TV and playing video games for example, have higher BMI and are also more likely to be overweight or obese[6.] On the other hand, children who are more physically active have been shown to be at lower risk of overweight and obesity.[10] Other factors contribute to childhood obesity

such as nutrition[11] and to a smaller extent medical and genetic conditions,[12] however, the primary focus of this investigation is physical activity.

Environment

Research has demonstrated that both school and after-school environments play a major role in the development of obesity among middle and high school children. [13] School physical education (PE) programs have the ability to reach most children daily. [14] However, they have not yet been shown to provide recommended levels of physical activity for students. Therefore, out-of-school opportunities play a vital role in enabling children to accumulate adequate amounts of physical activity.

School Physical Activity Policy and Guidelines

In 2004, Congress unanimously passed the Child Nutrition and WIC Reauthorization Act of 2004. This law, Public Law 108 – 265, required all schools participating in the National School Lunch Program to have local wellness policies by the summer of 2006. Wellness policies are required to have a physical activity element aimed at increasing levels based on national guidelines.

According to the National Association of School Boards, middle and high school children should receive 225 minutes of physical education weekly, half of which should involve participation in moderate to vigorous physical activity (MVPA). [15] Research has demonstrated that these recommendations are often not being met. Forty-four percent of high school students do not have PE class in an average week according to the 2009 Youth Risk Behavior Surveillance (YRBSS). [16]

Daily Physical Activity Policy and Guidelines

In 2008, the Department of Health and Human Services (DHHS) released *Physical Activity Guidelines for Americans* which recommends at least 60 minutes of daily physical activity for children and adolescents to promote health and prevent obesity among our youth. Most of the 60 minutes or more per day should consist of moderate to vigorous intensity aerobic physical activity and some should include vigorous intensity. [17] This represents the first official set of national guidelines for physical activity.

The DHHS recommendations support the national goals set forth in *Healthy People 2020.* One objective of this report, Objective PA-3, states the need to "increase the proportion of adolescents who meet current Federal physical activity guidelines for aerobic physical activity and for muscle-strengthening activity." [18] According to the 2009 YRBSS, only 18.4 percent of adolescents met current physical activity guidelines for aerobic physical activity. [19]

Consequences of obesity

The increasing rates of obesity among children are associated with major health consequences. The most common condition is cardiovascular disease, which involves high blood pressure, elevated cholesterol, and abnormal glucose tolerance. One study of 5-to 17 year olds demonstrated that 60% of overweight children had at least one of the risk factors for cardiovascular disease such as high blood pressure, elevated cholesterol, and Type 2 diabetes. [20] Other health conditions related to overweight that are equally serious include asthma, diabetes, cancers, orthopedic conditions, and cerebrovascular disease. [21, 22]

Social consequences of obesity are also problematic. Overweight and obese children are "targets of early and systematic social discrimination."[23] Furthermore, the effects of psychosocial stress can decrease self-esteem leading to lower academic performance and decreased social functioning.[24] These effects can persist into adulthood.[25]

Economic consequences have the potential to be devastating to the nation at three major levels: government, workforce, and individual. At the local, state and federal government level, the costs of health and welfare programs are directly related to increased obesity prevalence. [26] According to the Department of Health and Human Services, $117 billion dollars are spent by the US on obesity a year and this represents 83 cents of every health care dollar in America.[27] In the workplace; employers bear the costs of higher insurance premiums, absenteeism, and reduced productivity. At the individual level, economic costs other than those associated with health care costs include reduced earning power due to a declined capacity to find and keep jobs. This may be in part explained by discrimination of overweight persons. [23] The economic consequences of obesity are produced mostly by adults. However, most obese children become obese adults. [28]

Concluding Statement

In summary, child obesity is an avoidable disease affecting the quality of life for millions of children in the United States and globally. Daily physical activity among children and adolescents promotes a healthy body weight and body composition. Therefore, for health, social, and economic benefits, the promotion of physical activity is

desirable. Although a substantial amount of research on physical activity and health has been published since 1995, gaps still exist. [2] The obesity epidemic is in need of effective prevention and intervention efforts.

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THE EFFECTS OF SCHOOL-BASED PHYSICAL ACTIVITY ON BMI AMONG MIDDLE AND HIGH SCHOOL CHILDREN

Introduction

Childhood obesity is a preventable disease affecting millions of youth in the United States and it has been declared a global epidemic by the World Health Organization.[1] According to the Youth Risk Behavior Surveillance Survey (YRBSS), 31.9% of children aged 2 through 19 years are overweight or obese, which is triple the prevalence in the 1960s.[2] The obesity rates have been shown to vary by gender and ethnicity.[3] Non-Hispanic black girls have the highest prevalence of obesity (28%), followed by Mexican American (20%) and non-Hispanic white (15%).[4] Non-Hispanic black girls exhibit approximately twice the prevalence for non-Hispanic white girls.

Physical Activity

According to the Council on School Health and the Council on Sports Medicine and Fitness, physical inactivity among youth is a primary mechanism underlying the rise in excess body weight among children.[5] Studies confirm that children who are moderately to vigorously physically active have a lower risk of becoming overweight and obese. [6] Nutrition[7] and to a lesser extent medical and genetic conditions[8] have also been shown to contribute to weight status among children; however this study is focused on the effects of physical activity.

The School Environment

The school environment plays a key role in providing physical activity for middle and high school children. First, school programs can influence the behavior of all children on a daily basis. According to the US Department of Education, 92% of high school aged children attend school and even more attend middle school. [9] The school environment is relatively controlled making it more amenable to intervention and policy change than a child's after-school or home environment. Research studies have shown that children who are physically active during the day in school are more likely to be physically active after school as well[10], increasing the potential impact of school physical activity programs. Research has also demonstrated that traditionally schooled children engage in more moderate to vigorous activity than those who are home-schooled.[11] Furthermore; most children do not meet recommended levels of physical activity outside of school.[12] For many reasons, the school environment is effective in the promotion of physical activity among children.

School-based physical activity and BMI percentile

Few studies of physical activity during school have investigated the relationship between amount of physical activity in-school and weight status among middle and high school students. [13] Most studies have focused on elementary school children or examined changes in duration or intensity of physical activity during short-term interventions.

A meta-analysis conducted by Kahn et al[14] identified twelve school-based physical activity programs that successfully increased reported or observed amount of time that children were being physically active in school, most of which occurred in

physical education (PE). However, the effects on BMI were minor and inconsistent. The majority of these studies were conducted on elementary schools and a few high schools. There were no reported studies in middle schools.

More recently Harris and colleagues[15] conducted a systematic review of the literature to determine the effects of school-based physical activity interventions on BMI in children. Meta-analysis of 18 studies involving 18,141 children revealed that BMI did not improve with physical activity interventions. Participants were primarily elementary school students.

Some research has been able to demonstrate a positive correlation between increased PE-related physical activity and lower BMI percentile among children. For example, Gonzalez-Suarez et al[16] research showed that schools with long-term physical activity interventions were effective in reducing the prevalence of obesity among students. However, most of these studies were multi-pronged interventions involving nutritional and education components, making the effect of physical activity on BMI difficult to decipher. Furthermore, it is unclear whether results were sustainable beyond the intervention period.

Overall, few studies have examined routine physical activity levels during school and its association with BMI percentile. The need for further research in this area is warranted and confirmed by the Department of Health and Human Services (DHHS) Physical Activity Guidelines Advisory Committee (PAGAC). [17] In 2008, they identified the following two key areas of future research which included: 1) Determine the types and amounts of physical activity for youth needed to prevent the development of

excessive adiposity during childhood and adolescence, and 2) Because minority groups are an understudied population, it is essential to increase the number of studies with sufficient representation of at least one racial/ethnic minority group.

Policy and National Guidelines

In response to the trends in childhood obesity and physical inactivity among youth, Congress unanimously passed the Child Nutrition and WIC Reauthorization Act of 2004 *(*Public Law 108 – 265), which was signed into law by President George W. Bush on June 30, 2004. This law required all school districts that participate in the National School Lunch Program to have local wellness policies by July 1, 2006. Wellness policies must include a physical activity component aimed at increasing levels based on national recommendations.

The National Association of School Boards recommends that students in middle and high school receive 225 minutes of physical education weekly. At least half of that time or approximately 112 minutes should be devoted to participation in moderate to vigorous physical activity (MVPA). [18] Despite efforts given, it seems that these recommendations are often not being met. According to the 2009 Youth Risk Behavior Surveillance System (YRBSS), 44% of high school students do not attend PE classes in an average week. [19]

School Lunch

The Child Nutrition and WIC Reauthorization Act of 2004 also requires schools to meet current national nutritional standards. According to the 2005 Dietary Guidelines for Americans, school nutrition programs must now offer more whole grains, less

sodium, and more fruits and vegetables.[20] However, studies have not shown participation in school lunch to be associated with improved health or lower weight status. One recent study looked specifically at the relationship between school meals and BMI. [21] Cross-sectional data from the School Nutrition Dietary Assessment Study of 2,228 students in grades 1 to 12 found no evidence that school lunch was associated with BMI. Another study revealed a positive association between children participation in the National School Lunch Program (NSLP) and child weight. [22] Children eligible for the NSLP had 4.5% higher probability of being overweight compared to children not eligible. No recently reported studies were found to have examined the association between eating lunch at school and BMI, regardless of participation in the National School Lunch Program, i.e. funding source.

Summary

The literature is inconsistent regarding whether meeting the national guidelines for PE-based physical activity guidelines decreases BMI percentile among middle children. Furthermore, few studies look at middle and high school children and use a large sample size with sufficient minority representation. This study uniquely contributes to the literature by examining the role of PE-based physical activity on BMI percentile among middle and high school aged children using a large, nationally representative sample (n=1,306). In particular, the following research question was addressed:

- Is meeting the national guidelines for PE-based physical activity associated with a lower BMI percentile among middle and high school students?

H_A: Meeting national guidelines for PE-based physical activity in school is associated with a lower BMI percentile for middle and high school children.

Conceptual Framework

This study was guided by the conceptual framework developed by Nies and Kershaw. [23] According to the model (See Figure 1), health outcomes are directly and indirectly affected by behavioral activity and contextual components. This model was adapted for this study to describe the association between physical activity and BMI percentile among children. In place of workplace, the environmental factor, the school environment was used. Income described parental income. In-school physical activity was the independent variable of primary interest.

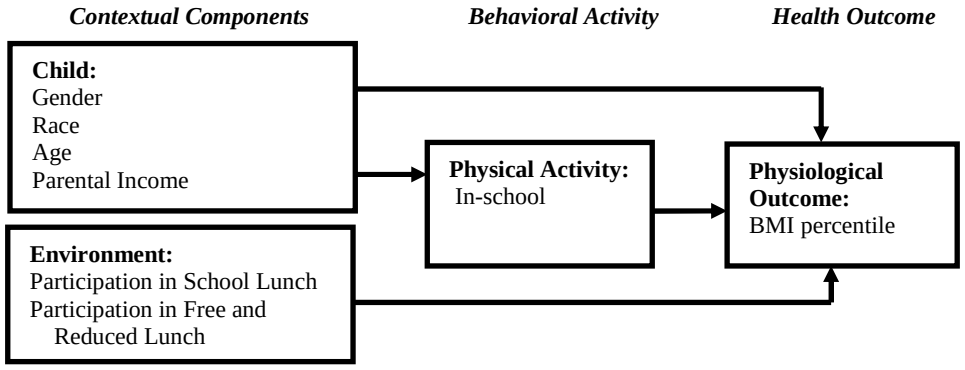


Figure 1: Conceptual Model

(Adapted from Nies and Kershaw, 2004)

Method

Sample

This study was based on a secondary data analysis of the Panel Study of Income Dynamics (PSID), Child Development Supplement (CDS). The PSID started in 1968 and is an ongoing, nationally representative prospective cohort study of the US population.

The initial sample consisted of two independent samples. The first was a cross-sectional, national sample based on multistage selection of the civilian non-institutional US population. It was an equal probability sample of households in the 48 contiguous states. The second was a national sample of low-income families conducted by the US Census Bureau. Together these make up the original 1968 PSID sample.

The Child Development Supplement was added to the PSID in 1997. All PSID households with children 12 years and under in 1997 were selected to participated in this survey. The CDS collects information on child development as well as community and school-based information. Data were collected in three waves: 1997 (CDS I), 2002 (CDS II), and 2007 (CDS III). Response rates were 88% in 1997, 91% in 2002, and 90% in 2007. Of the 2,907 children in the second wave, 1,250 children aged out of the study (turned 19 years or older) and 151 (10%) were lost to follow up.

This study sample was taken from the 2007 interview, CDS III (N=1,506). Children in this sample represented the following racial/ethnic groups: White non-Hispanic (n=616, 47.5%), Black non-Hispanic (519, 39.7%), Hispanic (105, 8.0%), and children of other racial/ethnic groups, including Asian, Pacific Islander, Native American, and Alaskan Native (n=63, 4.8%). Children for whom the dependent variable, BMI percentile, was not available were excluded, 66 (4%). An additional 134 (9%) were excluded because they were not in middle or high school. The final sample included 1,306 middle (n=577, 44%) and high school (n=729, 56%) children aged 11-18. Because some of these children resided in the same family unit (n=66), they were not truly independent. However, exclusion of these children did not alter the nature of the

relationships under study, thus they were retained in the final model. This secondary data analysis was approved by the University of North Carolina at Charlotte Institutional Review Board.

Three instruments were used to collect data used in this study: the primary caregiver child interview, the child interview, and the child assessment. The primary caregiver child interview gathered information about the child and his/her environment from his/her primary caregiver. The child interview surveyed the child directly and included an audio computer-assisted interview (ACASI) which was used for sensitive subjects including physical activity. Height and body weight information was collected during the child assessment. Interviews were conducted primarily in the child's home, or alternatively over the telephone.

Measures

Physical Activity

The primary independent variable in this study is PE-based physical activity. It was self-reported and collected through in-home interviews with children aged 11-18 years using an Audio Computer-Assisted Self-Interview (ACASI). In order to obtain a measure of *total* in-school physical activity, researchers in this study combined two CDS physical activity variables. The product of "the number of physical education (PE) classes per week" and the "number of minutes actually exercising during an average PE class" resulted in a new composite variable measuring "total minutes actually exercising during PE per week." Because the original CDS variable "number of minutes actually

exercising during an average PE class" was a categorical variable, the midpoint for each category was used in multiplication with number of PE classes per week.

Actual categories for physical activity in this study were defined as: No physical activity, low physical activity (<30 minutes per day or 1-209 minutes per week), and moderate physical activity (more than 30 minutes per day or 210+ minutes per week). Multiplicative interaction terms were created for physical activity and gender as well as for physical activity and age. However, these were not found to be statistically significant and were removed from the final analysis.

BMI percentile

The dependent variable in this study is BMI percentile, a measure of weight status for children. BMI is calculated according to the following formulas[24]:

BMI (USA) = weight (lb)/height (in^2) x 703

BMI (Metric) = weight (kg)/height (m^2)

BMI percentile categories used in this study were: underweight/normal, overweight, or obese. The underweight and normal weight categories were combined due to the small size of the underweight category (n=34, 2.6%). Other research studies on this topic confirmed this practice. [25]

Child height and weight were measured during the child assessment module of the CDS. Using a tape measure and rafter's square, height was directly measured by the interviewer while the child stood against a wall with shoes removed. A digital scale was used to measure weight with shoes removed. The same instruments were utilized to measure height and weight for all children and data were entered electronically. For 29

children, the child refused to be measured or there were physical limitations. In these instances the interviewer retrieved these values from the child's last doctor's visit.

Statistical Analyses

Estimates of current PE-based physical activity levels were assessed using descriptive analysis in SPSS, Version 19. Chi squared analysis was used to examine the relationship between BMI percentile and in-school physical activity levels, both categorical variables. Similar bivariate analyses were utilized to examine the relationship between BMI and demographic data. Statistical significance was determined by 95% confidence intervals and *p* values less than or equal to 0.05.

The relationship between physical activity and BMI percentile was examined using multinomial logistic regression. Because the outcome variable is ordered, the proportional odds assumption for use of the ordinal logistic regression model was assessed using the test of parallel lines. However, this test was significant ($p<.001$) indicating that slope coefficients were not equal and ordinal logistic regression was inappropriate. Therefore, analyses were conducted using the multinomial logistic regression model using the Nominal Regression function in SPSS, Version 19. BMI percentile for children (underweight/normal, overweight, or obese) was categorized as a nominal trichotomous outcome variable. PE-based physical activity was modeled as the predictor variable. Multinomial logistic regression models the probabilities of the different possible outcomes of the categorically distributed dependent variable given a set of independent variables. Odds ratios greater than one suggest that children had greater risk of being in a high BMI percentile category. Odds ratios less than one suggest that

children had lower risk of being in a high BMI percentile category. Both adjusted and unadjusted odds ratios were calculated for the dependent variable to determine the impact of the covariates. Odds ratios were adjusted for the following covariates, which were selected based on the conceptual framework guiding the study: age, gender, race/ethnicity, parental income, participation in school lunch, and participation in free and reduced lunch. Variables were assessed for multicollinearity by examining the variance inflation factor; there was no evidence of notable multicollinarity. To compensate for selection bias in the original PSID sample design as well as attrition between first and third waves of CDS (t=1997 and t=2007), analyses were weighted using the CDS-III Child Interview/Child sample weight variable.

Results

Bivariate analysis showed that two study variables differed significantly by gender: physical activity and school lunch (Table 1). First, more females (35.4%) than males (29.7%) did not participate in any PE-related physical activity in an average week $X^2(1, N = 1306) = 4.29$, $p = .03$. The number of children who get "some PE-related physical activity" was not statistically different between males (23.0%) and females 22.0% $X^2(1, N = 1306) = 0.21$, $p = .65$. Approximately 5% more males meet the national PE-related physical activity guidelines than females in middle and high schools nationwide. Secondly, the difference between genders for those who purchase hot lunch at school and those who do not was also statistically different. More male students (39.1%) buy lunch at school than female students (30.8%) $X^2(1, N = 1292) = 9.59$, $p = <.001$.

Bivariate analysis also revealed that BMI percentile differed significantly for African American middle and high school children, $X^2(2, N = 1303) = 19.77$, $p < .001$. Almost twenty nine percent of African American children were obese in comparison to about 19% of non-Hispanic white children. They also experienced higher rates of overweight than non-Hispanic white children (18.5% vs. 14.4%). More African American children did not have any PE-based physical activity (6.2 vs. 3.7%) and slightly less met the national guidelines for weekly PE-based physical activity (48.6% vs. 51.6%) in comparison to non-Hispanic white children. More African American children (36%) eat a school lunch, regardless of whether or not they participate in the Federal free or reduced school lunch program, than non-Hispanic white children (28%). Both participation in Federal free and reduced lunch program, $X^2(3, N = 1303) = 247.37$, $p < .001$, and eating a lunch offered at school, $X^2(3, N = 1303) = 29.47$, $p < .001$, were shown to vary significantly by race/ethnicity.

The final multinomial logistic regression model (Table 2) showed that children who engaged in no PE-based physical activity had approximately 1.6 times the odds of being obese vs. normal weight than those who met the national guidelines for weekly PE-based physical activity (OR = 1.58, CI = 1.14, 2.20), after adjusting for covariates. Age, gender, race/ethnicity, and parental income did not contribute significantly to predicting BMI percentile in this model, however were retained in the final model. Both eating lunch at school and participation in the federal free and reduced lunch program were found to be statistically significant predictors of obesity. Children who ate a school lunch at least three days a week were found to have had about 1.7 times the odds of being obese

than normal weight (OR = 1.68, C I = 1.13, 2.49). Children who participated in the federal free and reduced lunch program had almost twice the odds of being obese versus normal weight as those who did not participate in the federal free and reduced lunch program (OR = 1.99, CI = 1.29, 3.07).

Discussion

The hypothesis that meeting national guidelines for PE-based physical activity in school was associated with higher odds of having normal BMI was supported when comparing obese children to normal weight children. Children who had no physical activity during PE were much more likely to be obese than normal weight in comparison to those who met the national requirements. However, the same effect was not seen for children getting "some physical activity but less than 112 minutes per week." This finding supports the link between duration of weekly PE-based physical activity and BMI percentile among children. That is, low amounts of weekly physical activity are not sufficient in mitigating excess adiposity in children.

The results of this study suggest that half of children are meeting the required levels of physical activity in school and half are not. Of those who are not, 32.5% are not engaging in any physical activity in PE and 22.5% are getting some physical activity but less than the recommended levels. These estimates are much higher than those reported by the School Health Policies and Programs Study of 2006 that found only 7.9% of middle school students and even less (2.1%) of high school students meet nationally required levels of PE-related physical activity. [26] This may be due in part to the difference in survey respondents, unit of analysis, and year of data collection. The CDS surveyed

children directly in 2007, while the SHPPA surveyed school administrators about school-wide practices in 2006. It is conceivable that some increases in physical activity may have occurred in the Fall of 2007 since physical activity requirements based on the Child Nutrition and WIC Reauthorization Act of 2004 were to have been implemented at that time.

This study found that 32.5% of middle and high school are not getting any PE-based physical activity. However, the 2009 YRBBS estimates that 44% of high school students do not. [19] Given that middle school students typically attend PE more often than high school students and because we looked at a combined sample of middle and high school students, it is not surprising that this study had a lower non-participation rate for weekly PE class.

The findings from this study also illustrate importance of school-based nutrition when evaluating BMI percentile for adolescents. Children who ate lunch offered by the school, regardless of funding source, were much more likely to be obese than normal weight. One study confirmed the link between weight status and participation in the National School Lunch Program which found a positive relationship with child weight. [24] However, no studies were found that examine the relationship between eating a school lunch, regardless of funding source, and obesity. Though the Child Nutrition and WIC Reauthorization Act of 2004 has required schools who participate in the National School Lunch program to improve the quality of meals offered at schools, substantial improvements may have not yet been detected by this study.

As much more African American children were shown to participate in free or reduced school lunch or buy a hot lunch at school, this may partially explain the higher proportion of African American children who are obese. This finding also indicates that the hot lunches offered by schools are not as nutritionally balanced as they should be.

This study has several limitations. Working with a large data set allows only the use of variables already collected. Additional variables of interest cannot be added. Also, missing data in a secondary data analysis can only be estimated or excluded from analysis, not regenerated. The following variables in this study contained missing values: Age (n=2, 0.2%), race/ethnicity (n=3, 0.3%), and children who purchased a school lunch (n=14, 1.1%). Overall, cross-sectional data cannot determine cause and effect.

Limitations involving the primary predictor variable, physical activity, should be noted. First, only PE related physical activity data was examined. Information about recess or lunchtime at school was not assessed in this study. Some children not engaging in PE-related physical activity may be engaging in physical activity during recess or lunch periods. Additionally there is some discrepancy between the national guideline which recommends 112 minutes of MVPA and the CDS which collects information on minutes of physical education where students are “actually exercising or playing sports.” The CDS does not specify that activity be moderate to vigorous, but in this study it was assumed to be equivalent. This may have resulted in an overestimation of children who met the national guidelines. Non-differential misclassification may be a problem when collecting physical activity data, as interviews ask participants to remember past events. Gathering self-reported data on physical activity duration and frequency may also be a

cognitive challenge for children. Social desirability may be a concern as physical activity is likely to be over-estimated, though audio computer assisted self interview was used in an effort to minimize this effect.

The precision of the outcome variable, BMI percentile, is of some concern. It is known to underestimate overweight in tall individuals and overestimate overweight in short individuals and those with high lean body mass, e.g. athletes. Use of accelerometers can be more precise, yet requires more resources. Overall, BMI percentile is a good indicator of obesity, which is easy to use and cost effective for large national research studies such as the CDS. However, future studies should consider using more comprehensive data for physical activity such as time-use dairies, accelerometers, or direct observation over time to capture more information about the intensity, frequency, and duration of PE-based physical activity.

Findings from this study could be generalized to other middle and high school children of similar ages (10 to 18 years) in the United States. The CDS collected data on a large sample of children located in various parts of the country which were demographically representative of the population. Data were from 2007, and thus relatively recently collected.

Study Significance

This study fills a gap in the literature in that few studies have examined the relationship between amount of PE-based physical activity in schools and BMI percentile. Even fewer studies examine this relationship among middle and high school children. Overall, the DHHS has called on researchers to determine the amounts of

physical activity for youth that are necessary to prevent child obesity using samples which have sufficient minority representation.[17] This study uses a large sample (N=1,306) and has adequate minority participation, using sample weights to reflect the population.

In summary, this study suggests that the current requirement of 112 minutes per week of MVPA may be effective in reducing obesity among middle and high school children. Those who do not accumulate this level of weekly physical activity in PE are much more likely to be obese. This study also suggests that eating a school lunch may contribute to obesity among middle and high school children, regardless of funding source. Future research is needed to continue monitoring the levels of PE-based physical activity as well as its effect on BMI percentile, hence monitoring the long term effects of the Child Nutrition and WIC Reauthorization Act of 2004. Additional research is needed to confirm the association between school lunch participation and BMI percentile and monitor progress in this area.

TABLES

Table 1: Demographic Characteristics of the 2007 CDS sample stratified by gender

Variable	Whole sample (% of total)	Males (% within gender)	Females (% within gender)	Test statistic[b]
Sample size	1306	660 (50.5%)	646 (49.5%)	
BMI percentile				
Normal/Underweight	785 (60.1%)	399 (60.5%)	386 (59.8%)	X^2 = .67(1), p=.79
Overweight	216 (16.5%)	96 (14.5%)	120 (18.6%)	X^2 = .39(1), p=.53
Obese	305 (23.4%)	165 (25.0%)	140 (21.7%)	X^2 = .49(1), p=.48
PE-based physical activity[c]				
None	425 (32.5%)	196 (29.7%)	229 (35.4%)	X^2 = 4.29(1), p=.03
Some (<112 min/week)	294 (22.5%)	152 (23.0%)	142 (22.0%)	X^2 = .21(1), p=.65
Meets national requirement (≥ 112 min/week)	587 (45.0%)	312 (47.3%)	275 (42.6%)	X^2 = 2.9(1), p=.09
Age (mean years)[e]	14.28	14.4 (SD=1.93)	14.1 (SD=2.09)	X^2 = 28.25(1), p=<.001
Race/ethnicity[f]				
White (Non-Hispanic)	616 (47.5%)	311 (47.3%)	305 (47.3%)	X^2 = .00(1), p=.99
Black (Non-Hispanic)	519 (39.7%)	258 (39.2%)	261 (40.5%)	X^2 = .21(1), p=.64
Hispanic	105 (8.0%)	54 (8.2%)	51 (7.9%)	X^2 = .39(1), p=.84
Other	63 (4.8%)	35 (5.3%)	28 (4.3%)	X^2 = .67(1), p=.41
Parental Income (median)[d]	48,125	47,655	49,000	*U test*, p=.79
School Lunch				
Buys hot lunch at school	452 (35.0%)	255 (39.1%)	197 (30.8%)	X^2 = 9.59(1), p=<.001
Does not	840 (65.0%)	398 (60.9%)	442 (69.2%)	X^2 = 9.59(1), p=<.001
Free/Reduced Lunch				
Receives free or reduced lunch at school	514 (39.4%)	258 (39.1%)	256 (39.6%)	X^2 = .04(1), p=.84
Does not	792 (60.6%)	402 (60.9%)	390 (60.4%)	X^2 = .04(1), p=.84

[a]Data Source: Panel Study of Income Dynamics Child Development Supplement, 2007

[b]Chi squared (df), or Mann-Whitney U test of difference in values between males and females

[c]PE-based physical activity categories are based on the current national guidelines for PE-based physical activity for middle and high school students (National Association of School Boards)

[d]American dollars

[e] Age had 2 cases (0.2%) with missing values which were excluded from analysis.

[f] Race/ethnicity (n=1303) had 3 cases (0.3%) with missing values which were excluded from analysis.

[g] School Lunch (n=1292) had 14 cases (1.0%) with missing values which were excluded from analysis.

Table 2: Multinomial Logistic Regression Analyses of PE-based Physical Activity and Body Mass Index (BMI) percentile of the Child Development Supplement 2007 sample aged 11-18 years

	BMI percentile					
	Normal weight [c] (reference group) (BMI: <85th percentile)		**Overweight** (BMI: 85th to < 95th percentile)		**Obese** (BMI: ≥ 95th percentile)	
	Unadjusted OR (95%CI)	Adjusted OR (95%CI)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)
PE-based Physical Activity [b]						
None vs. Meets Guidelines	1.00	1.00	0.94 (0.66-0.33)	0.99 (0.69-1.45)	1.38* (1.02-1.87)	1.58** (1.14-2.20
Some vs. Meets Guidelines	1.00	1.00	0.77 (0.51-1.15)	0.73 (0.48-1.10)	1.22 (0.87-1.71)	1.19 (0.83-1.69)
Race/ethnicity						
African American vs. White	1.00	1.00	1.17 (0.78-1.77)	1.24 (0.78-1.96)	1.93***(1.35-2.75)	1.44 (0.96-2.16)
Hispanic vs. White	1.00	1.00	1.36 (0.76-2.45)	1.32 (0.71-2.44)	1.64* (1.01-2.65)	1.43 (0.85-2.40)
Other vs. White	1.00	1.00	1.49 (0.79-2.84)	1.46 (0.72-2.95)	0.46 (0.20-1.05)	0.49 (0.21-1.14)
Gender						
Female vs. Male	1.00	1.00	1.28 (0.95-1.74)	1.28 (0.94-1.74)	0.87 (0.67-1.14)	0.86 (0.66-1.14)
Age (years)						
11-18	1.00	1.00	0.95 (0.88-1.03)	0.94 (0.87-1.03)	0.98 (0.92-1.05)	0.96 (0.89-1.03)
Parental Income ($) [d]						
Below poverty threshold vs. high	1.00	1.00	1.42* (1.02-1.97)	0.99 (0.57-1.76)	1.69*** (1.27-2.25)	1.65 (0.96-2.84)
Low vs. high	1.00	1.00	1.01 (0.77-1.57)	0.83 (0.49-1.42)	1.01 (0.74-1.38)	1.20 (0.71-2.04)
Middle vs. high	1.00	1.00	0.75 (0.49-1.15)	0.69 (0.41-1.19)	1.05 (0.75-1.48)	1.68 (1.02-2.76)
Upper Middle vs. high	1.00	1.00	0.75 (0.45-1.23)	0.71 (0.40-1.30)	0.90 (0.60-1.35)	1.53 (0.88-2.66)
School Lunch						
Yes vs. No	1.00	1.00	1.06 (0.77-1.45)	1.40 (0.92-2.14)	0.97 (0.73-1.28)	1.68** (1.13-2.49)
Free/reduced Lunch						
Yes vs. No	1.00	1.00	1.33 (0.97-1.82)	1.54 (0.97-2.46)	1.81***(1.37-2.38)	1.99** (1.29-3.07)

[a] Data Source: Panel Study of Income Dynamics Child Development Supplement, 2007

[b] PE-based physical activity levels are based on national recommendations endorsed by the National Association of School Boards for middle and high school children. "Meets guidelines" = 112 + minutes per week and "Some" = <112 minutes per week.

[c] The Normal weight category (n=785) includes 34 underweight children (2.6%).

[d] Poverty threshold based on 2006 U.S. Census Bureau Data for families of 5-6 persons in household. Income categories were defined as: Below the poverty threshold (>25,000), Low income (25,000-49,999), Middle income (50,000-74,999), Upper middle income (75,000-99,999), and High income (100,000+).

*p<0.05, **p<0.01, ***p<0.00

JOURNAL ARTICLE II

PHYSICAL ACTIVITY AND BMI : EVIDENCE FROM THE PANEL STUDY OF INCOME DYNAMICS CHILD DEVELOPMENT SUPPLEMENT 2007

Child Obesity

The prevalence of child obesity has received increasing national attention. The rate of childhood obesity over the last 50 years has tripled reaching epidemic proportions.[1]

Obesity in children is defined as body mass index (BMI) equal to or greater than the 95% percentile, while overweight is defined as the 85th to less than or equal to the 95th percentile.[2] Based on these age and gender specific weight ranges, approximately 18% of children aged 10-18 are obese. [3] When overweight is also considered, the prevalence is considerably greater. The Youth Risk Behavior Surveillance Survey (YRBSS) results identified 31.9% of children aged 2 through 19 years as overweight or obese.[3] When stratified by gender and ethnicity, non-Hispanic black girls have the highest prevalence of obesity (28%).[1]

Direct measures of body fat composition including underwater weighing, magnetic resonance imaging, computed axial tomography, and dual-energy radiograph absorptiometry provide accurate measurement of total body fat mass. However, the measurement techniques are expensive and complex.[4] Indirect measures that are easily obtained and more frequently used in large research studies include height and weight measurement, waist circumference, skinfold thickness, and body mass index (BMI). Of these, the most convenient is BMI which has been shown to correlate well with the more

precise measures of adiposity.[5] BMI is calculated by dividing weight by height as follows: [6]

BMI (USA) = weight (lb)/height (in^2) x 703

BMI (Metric) = weight (kg)/height (m^2)

Physical activity

Physical activity is "any bodily movement produced by skeletal muscles that results in energy expenditure,"[7] According to the Council on School Health and the Council on Sports Medicine and Fitness, lack of physical activity among youth is a primary mechanism underlying the rise in excess body weight among children.[5] Studies have confirmed that children who engage in more sedentary activities such as watching TV and playing video games have higher body mass index (BMI) and are more likely to be overweight or obese.[8] Alternatively children who engage in moderate to vigorous activity, have been shown to be at lower risk of overweight and obesity.[9]

Moderate to vigorous-intensity physical activity is defined by the Centers for Disease Control and Prevention (CDC) on a scale relative to a child's individual capacity. Moderate-intensity physical activity is usually a 5 or 6 on a scale of 0 to 10, while vigorous-intensity is a 7 or 8. Examples of moderate physical activity include: walking briskly, bicycling slowly (less than 10 miles per hour), playing tennis (doubles), and general gardening. Vigorous physical activity includes: jogging or running, swimming laps, hiking uphill, or heavy gardening (continuously digging or hoeing).[10]

Environment: School and Neighborhood

Both school and after-school environments play a critical role for physical activity participation among middle and high school children. The school system is an efficient vehicle for providing physical activity instruction and programs because they reach most children and adolescents daily.[11] However, schools do not provide sufficient physical activity for students to achieve recommended levels. Therefore, out-of-school opportunities are essential in enabling children to accumulate the recommended amounts of physical activity.

While both schools and after-school environments are important, research shows that age influences where children accumulate the majority of their physical activity. Gidlow et al found that primary school children accumulate higher levels of physical activity in school than children in secondary school.[12] Another study revealed that most physical activity among adolescents occurs after school in organized and structured programs such as sports and dance teams or lessons.[13]

Physical activity and BMI percentile

An inverse relationship between physical activity and BMI percentile seems logical, yet the evidence is still equivocal. While some research found this relationship to be significant, such as Suter and Hawes,[14] other studies, also using questionnaire data to measure physical activity, have found no evidence of a relationship.[15,16] According a 2008 report issued by the Physical Activity Guidelines Advisory Committee (PAGAC) of the Department of Health and Human Services, the literature has been inconsistent and more studies are needed to determine the types and amounts of physical activity required

to prevent obesity among children.[16] Furthermore, because minority groups are disproportionately affected by obesity and understudied, more research involving minority children is warranted.

National guidelines

The U.S. Department of Health and Human Services (DHHS) *Physical Activity Guidelines for Americans* recommends at least 60 minutes of daily physical activity for children and adolescents, most of which should consist of moderate to vigorous aerobic physical activity.[17] *Healthy People 2020* states the need to increase the number of children who meet Federal physical activity guidelines.[18] According to the 2009 Youth Risk Behavior Surveillance Survey, only 18.4 percent of adolescents met current physical activity guidelines for aerobic physical activity.[19]

Significance and Hypothesis

Despite the numerous research studies conducted on physical activity and health in the past 15 years, gaps still exist. [16] The Department of Health and Human Services (DHHS) Physical Activity Guidelines Advisory Committee (PAGAC) recently identified two key areas of future research: 1) Determine the types and amounts of physical activity for youth needed to prevent the development of excessive adiposity during childhood and adolescence, and 2) Because minority groups are an understudied population, it is essential to increase the number of studies with sufficient representation of at least one racial/ethnic minority group. This study incorporated both PAGAC items by examining the association between amount of physical activity and BMI percentile using a large, nationally representative sample (n=1,306) with substantial minority representation.

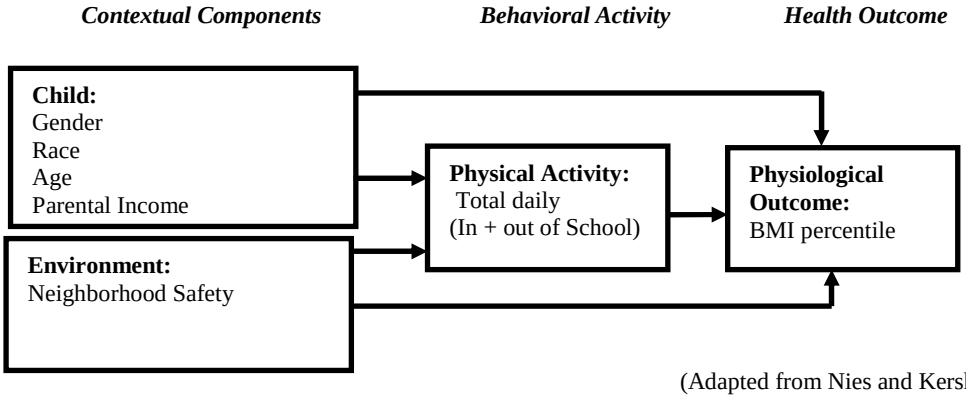
Previous research consists mainly of smaller samples with insufficient minority representation. Specifically, the following research question was addressed:

- Is there an association between the amount of daily physical activity and BMI percentile among middle and high school students?

H_A: Middle and high school children with more daily physical activity than others (less than 30 minutes or more/day) will be more likely to have normal weight.

Conceptual Model

The conceptual model developed by Nies and Kershaw (See Figure 2) was used to guide this research study. [20] The model states that health outcomes are a function of behavioral activity and contextual components. A modification of the model was used to describe the nature of children's health outcomes in this study. In place of the workplace, neighborhood was considered as the main environmental factor. With respect to host characteristics, income consisted of the parental income. Physical activity was the behavioral outcome of interest in this study.



(Adapted from Nies and Kershaw, 2004)

Figure 2: Conceptual Model

Method

Sample

A secondary data analysis of the Panel Study of Income Dynamics (PSID) Child Development Supplement (CDS) was used in this study. [21] The PSID started in 1968 and is an ongoing, nationally representative prospective cohort study of the US population conducted by the Institute for Social Research, University of Michigan. The original sample which included 4,800 families in 1968 grew to include over 7,000 families in 2001.

In 1997 the Child Development Supplement was added to the PSID. All PSID households with children aged 0 to 12 years were selected for inclusion in the CDS. This survey collected information on child development, community, and school characteristics. The CDS collected data in 1997, 2002, and 2007. High response rates were maintained for all three data collection years: 88% (1997), 91% (2002), and 90% (2007).

For this study, the sample was drawn from the 2007 interview, CDS III (N=1,506). Sixty-six children (4%) for whom BMI data was not available were excluded. A small amount of children were omitted from the sample because they were in elementary school or college (n=134, 9%). These children have different in-school physical activity guidelines from the majority of the sample, middle or high school students. The final sample consisted of 1,306 middle and high school children aged 11-18. Some children in the sample (n=66) were from the same family and therefore not

truly independent. Even so their exclusion did not change the nature of the relationship, therefore they were retained in the analysis model.

G* power 3.0.10 was used to calculate power using sample size, a significance level of .05 and an effect size of .20-.35 for t tests, correlations, and multinomial logistic regression.[22] Effect size was determined based on Cohen's effect size conventions. The sample size for this study (N=1,306) far exceeded the minimum requirement calculated.

Interviews were conducted primarily in person in home or otherwise over the telephone for children and primary care givers separately. Audio computer-assisted interview (ACASI) was used to facilitate the child interview.

Measures

Physical Activity

The primary independent variable in this study is total weekly physical activity. In order to obtain this value, three CDS physical activity variables were re-coded and combined so that the following two variables were created: "in-school physical activity" and "out-of-school physical activity," each measuring minutes per week. The sum of these two new variables formed the independent variable "total minutes of weekly physical activity."

The physical activity categories in this study were defined as follows: No physical activity, low physical activity (<30 minutes per day or 1-209 minutes per week), and moderate physical activity ($\geq$ 30 minutes per day or 210+ minutes per week). Two multiplicative interaction terms were created for physical activity: physical activity and

age as well as physical activity and gender. These were removed from the final model as they were not statistically significant.

BMI percentile

The dependent variable for this study was BMI percentile which varies with age and gender. BMI percentile is calculated by plotting BMI on an age and gender specific growth chart resulting in a percentile value. Children with a BMI below the 5th percentile are classified as underweight. Those with a BMI greater than or equal to 5th percentile but below the 85th percentile are considered normal weight. Children with a BMI at or greater than the 85th percentile but less than 95th percentile are overweight and those at or above the 95th percentile are categorized as obese. [23] BMI percentile for children was categorized as underweight/normal, overweight, or obese. The combination of underweight and normal weight was based on the small size of the underweight category, 34 (2.6%), as well as literature in this area.[24]

Child height and weight were measured during the child assessment module of the CDS. Using a tape measure and rafter's square, height was directly measured by the interviewer while the child stood against a wall with shoes removed. A digital scale was used to measure weight with shoes removed. The same measurement process was utilized for all children and data were entered electronically. For 29 children, the child refused to be measured or there were physical limitations. In these instances the interviewer retrieved these values from the child's last doctor's visit.

Statistical Analyses

Analyses were performed using SPSS, Version 19 (SPSS Inc., Chicago, IL). Statistical significance was determined using 95% confidence intervals and *p* values less than or equal to 0.05. The relationship between BMI percentile and physical activity was examined using Chi squared analysis. Additional bivariate relationships were examined between BMI percentile and demographic and environmental variables.

Due to the ordered nature of the outcome variable, the use ordinal logistic regression model was assessed in investigating the association between BMI percentile and physical activity. However, because the test of parallel lines was significant ($p = .03$), indicating unequal slope coefficients, this analyses type was found to be inappropriate. Therefore, analyses were conducted using the multinomial logistic regression model using the Nominal Regression function in SPSS, Version 19 (SPSS Inc., Chicago, IL). BMI percentile (underweight/normal, overweight, or obese) was modeled as a trichotomous nominal outcome variable, while physical activity was the predictor variable. Adjusted and unadjusted odds ratios were calculated for this model to examine the influence of covariates: age, gender, race/ethnicity, parental income, and neighborhood safety. These covariates were selected based on the conceptual model. Odds ratios greater than one suggest that individuals were at a greater risk of experiencing increased BMI percentile that may result in an increased level of BMI percentile category, while odds ratios less than one suggest that individuals were at lower risk of increasing to the next higher level of BMI percentile category. Multicollinearity was assessed using the variance inflation factor (VIF) value, which were below 1.51 for

all variables. Sample weights were provided by the CDS III data set and were utilized to compensate for selection bias in the original PSID sample design as well as attrition between 1997 and 2007.

Results

As shown in Table 1, bivariate analysis revealed that BMI percentile differed significantly for those children engaging in “less than 30 minutes a day” of physical activity, $X^2(2, N = 1306) = 14.59$, $p = .001$ and those engaging in “30 minutes or more physical activity”, $X^2(2, N = 1306) = 15.91$, $p < .001$. Children who participated in 30 minutes or more physical activity daily had the least prevalence of obesity (20.4%) versus those who had less than 30 minutes daily (24.8%) or none (26.4%).

Bivariate analysis also showed that BMI percentile was significantly associated with the racial category African American $X^2(2, N = 1303) = 19.77$, $p < .001$. More African American children were obese (28.7% vs. 19.3%) and overweight (18.5% vs. 14.4%) than non-Hispanic white children. These findings are consistent with the literature. Slightly fewer African American adolescents engaged in moderate physical activity, i.e. 30 minutes or more daily, (48.6% vs. 51.6%) and more engaged in no physical activity daily on average (6.2 vs. 3.7%) when compared to non-Hispanic white children. BMI percentile also differed significantly by the neighborhood safety category “dangerous” $X^2(2, N = 1001) = 7.41$, $p = .03$. Children in dangerous neighborhoods, based on that it was “somewhat to very dangerous to walk around in their neighborhood after dark,” are more likely to be obese (31.8% vs. 22.4%) or overweight (18.2% vs. 15.7%) than those who live in safer neighborhoods. Four times more African American

children (20.4%) than non-Hispanic white children (5.0%) live in a “dangerous” neighborhood.

The multinomial logistic regression model (Table 2) revealed that BMI percentile differed significantly by total weekly physical activity as well as by gender, when adjusted for covariates: race/ethnicity, age, parental income, and neighborhood safety. First, children who engaged in low daily physical activity levels (1-29 minutes per day) had approximately 1.8 times the odds of being obese vs. normal weight than those who engaged in moderate levels of physical activity (30 minutes or more per day) (OR = 1.80, CI = 1.31, 2.48). Next, female middle and high school students had almost 1.5 times the odds of being overweight than normal weight in comparison to males (OR = 1.49, CI = 1.04, 2.13). Age, race/ethnicity, parental income, and neighborhood safety level did not contribute significantly to predicting BMI percentile in the final multivariate model.

Discussion

The hypothesis that more daily physical activity level is associated with a lower BMI percentile was supported in this study. Many more children engaging in low levels of physical activity were obese in comparison to those who engaged in moderate levels. This suggests that accumulation of at least 30 minutes may contribute to lower adiposity levels among middle and high school aged children. We also found evidence that obesity prevalence differed by racial/ethnic category as well as gender. Specifically, African American children and females exhibited the highest rates of obesity. While this is consistent with previous studies, research indicates that complex cultural factors need to be considered in investigating this phenomenon among African American girls[25].

Overall these data suggest that female minority children engage in low levels of physical activity daily and are at highest risk of obesity. However, because obesity prevalence among the highest physical activity group was still 20.4%, it seems that physical activity alone cannot prevent the development of excess adiposity in children. Other individual and environmental factors should be taken into consideration when developing child obesity policy, programs, and interventions. Although some covariates were not found to be statistically significant (age, parental income, and neighborhood safety), they were retained in the final analytical model due to their relevance to the conceptual model.

This study contained some limitations that should be noted. First, cross-sectional data cannot determine causation between physical activity levels and weight status. Next, working with a large data set allows only the use of those variables previously collected. Missing data cannot be re-generated, only estimated. Three variables contained missing values: Age (n=2, 0.2%), race/ethnicity (n=3, 0.3%), and neighborhood safety (305, 23.4%). While most variables did not contain missing values or had very few, neighborhood safety had a large percentage of missing data. This can be explained mostly by that fact that only students ages 12 and older were surveyed regarding neighborhood safety.

The outcome variable, BMI percentile, is limited in its capacity to identify excess adiposity. First, it is known to underestimate overweight in tall individuals and overestimate overweight in short individuals and those with high lean body mass. [26] Also, the WHO has developed new growth curves based on optimal growth which indicate that

our current growth curves are underestimating obesity and overestimating underweight overall.[27] Next, BMI percentile changes with age for children and adolescents and is associated with changes in normal growth and maturation. [28] As a result, it is difficult to partition physical activity effects from those expected with growth and maturation.

The primary independent variable of interest may have been underestimated. "Total minutes of weekly physical activity" was calculated by adding together CDS variables "in-school physical activity" and "out of school physical activity." However, for the "in school" variable, only physical education- related physical activity data is accounted for. Information about recess time or lunchtime activity during school was not captured in this data set. This would underestimate the amount of in-school physical activity measured, resulting in an underestimated "total weekly physical activity."

The out-of-school physical activity variable may also contribute to an underestimation of the "total weekly physical activity" measured. Outside of school, children are asked, "How many days a week do you get at least 30 minutes of vigorous activity?" Instances of physically active for less than 30 minutes are not captured, nor are moderate levels. As a result, the potential underestimation of both in-school and out-of-school physical activity may have produced a lower than actual amount of "total weekly physical activity." This would explain why no children in this study achieved the national recommendation of 60 minutes physical activity per day.

Overall, non-differential misclassification may be a problem when collecting physical activity data, as interviews ask participants to remember past events. Gathering self-reported data on physical activity duration and frequency may also be a cognitive

challenge for children. Social desirability, or the over-reporting of favorable behavior, may also be a concern. In this case, children may have over-reported amount of daily physical activity, though audio computer assisted self-interview were used in an effort to minimize this effect. Finally, the estimates for prevalence of physical activity among 10-18 year old children did not consider regional location or urban versus rural living. Previous studies have shown that physical activity is lowest in the South and among urban children. [29]

This study used a large, nationally representative sample from a relatively recently conducted survey. Additionally, sample weights were utilized to adjust for some potential selection bias and account for minor attrition from 1997-2007. Therefore, the results of this study may be generalized to all middle and high school children across the United States.

Study Significance and Implications for Future Research

It is essential to consider both school and after school environments when evaluating daily physical activity levels for children and adolescents. Both are important sources of physical activity. While this study shows that weekly physical activity levels were associated with obesity, more detailed measures of physical activity duration, frequency, and intensity would allow better understanding of the relationship between BMI percentile and physical activity among children and adolescents. This is evidenced by Rowlands and colleagues in a meta-analysis investigating the effect of type of physical activity measure on the relationship between physical activity and BMI. They

found that the size of the relationship depends on the activity measure used with observation and motion counters being superior to survey data.[30]

In sum, the obesity epidemic is in need of effective comprehensive prevention and intervention efforts. For health, social, and economic benefits, the promotion of physical activity is desirable and needed. Although a substantial amount of research on physical activity and health has been published since 1995, gaps in the literature remain.[16] This study incorporated two key areas recommended for future research: 1) determining the amount of physical activity needed to prevent excessive adiposity during childhood and adolescence and 2) inclusion of sufficient minority representation in physical activity research. Future research in this area is needed to better capture physical activity quantity and intensity in an average week using a large sample with sufficient minority representation.

TABLES

Table 1: Characteristics of CDS children by gender aged 10-18 years in 2007

Variable	Total sample (% of total)	Males (% within gender)	Females (% within gender)	Test statistic[b]
Sample size	1306	660 (50.5%)	646 (49.5%)	
BMI percentile				
Normal/Underweight	785 (60.1%)	399 (60.5%)	386 (59.8%)	X^2 = .67(1), p=.79
Overweight	216 (16.5%)	96 (14.5%)	120 (18.6%)	X^2 = .39(1), p=.53
Obese	305 (23.4%)	165 (25.0%)	140 (21.7%)	X^2 = .49(1), p=.48
Physical activity[c]				
None	62 (4.7%)	30 (4.5%)	32 (5.0%)	X^2 =.12 (1), p=.73
<30 min/day	574 (44.0%)	258 (39.1%)	316 (48.9%)	X^2 =12.79(1), p=<.001
> 30 min/day	670 (51.3%)	372 (56.4%)	298 (46.1%)	X^2 =13.69 (1), p=<.001
Age (mean years)[e]	14.28	14.4 (SD=1.93)	14.1 (SD=2.09)	X^2 = 28.25(1), p=<.001
Race/ethnicity[f]				
White (Non-Hispanic)	616 (47.5%)	311 (47.3%)	305 (47.3%)	X^2 = .00(1), p=.99
Black (Non-Hispanic)	519 (39.7%)	258 (39.2%)	261 (40.5%)	X^2 = .21(1), p=.64
Hispanic	105 (8.0%)	54 (8.2%)	51 (7.9%)	X^2 = .39(1), p=.84
Other	63 (4.8%)	35 (5.3%)	28 (4.3%)	X^2 = .67(1), p=.41
Parental Income (median)[d]	48,125	47,655	49,000	*U test*, p=.79
Neighborhood Safety[g]				
Completely safe	343 (34.3%)	178 (34.8%)	165 (33.7%)	X^2 =.34(1), p=.56
Fairly safe	526 (52.5%)	267 (52.1%)	259 (53.0%)	X^2 =.07(1), p=.80
Dangerous	132 (13.2%)	67 (13.1%)	65 (13.3%)	X^2 =.01(1), p=.92

[a]Data Source: Panel Study of Income Dynamics Child Development Supplement, 2007
[b]Chi squared (df), or Mann-Whitney U test of difference in values between males and females
[c] Physical activity categories are measured as the weekly equivalent of : None (0 minutes/week), Less than 30 minutes/day (1-209 minutes/week), and More than 30 minutes/day (210 + minutes/week).
[d]American dollars
[e] Age had 2 cases (0.2%) with missing values which were excluded from analysis.
[f] Race/ethnicity (n=1303) had 3 cases (0.3%) with missing values which were excluded from analysis.
[g] Neighborhood Safety (n=1,001) had 305 cases (23.4%).with missing values excluded from analysis.

Table 2: Multinomial logistic regression model of total daily physical activity and body mass index (BMI) percentile for CDS children aged 11-18 years in 2007

	BMI percentile					
	Normal weight [b] (reference group) (BMI: <85th percentile)		**Overweight** (BMI: 85th to < 95th percentile)		**Obese** (BMI: ≥ 95th percentile)	
	Unadjusted OR (95%CI)	Adjusted OR (95%CI)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)
Physical Activity						
None vs. ≥ 30 min/day	1.00	1.00	0.76 (0.35-1.67)	0.74 (0.29-1.88)	1.42 (0.77-2.64)	1.23 (0.58-2.62)
<30 min/day vs. ≥ 30 min/day	1.00	1.00	1.01 (0.74-1.38)	0.85 (0.59-1.23)	1.72***(1.31-2.26)	1.80*** (1.31-2.48)
Race/ethnicity						
African American vs. White	1.00	1.00	1.61* (1.16-2.23)	1.03 (0.61-1.74)	1.86*** (1.40-2.48)	1.55* (0.99-2.43)
Hispanic vs. White	1.00	1.00	1.34 (0.75-2.42)	1.27 (0.60-2.67)	1.77* (1.09-2.88)	1.79* (1.00-3.21)
Other vs. White	1.00	1.00	1.53 (0.80-2.92)	1.24 (0.54-2.86)	0.57 (0.25-1.31)	0.45 (0.17-1.21)
Gender						
Female vs. Male	1.00	1.00	1.29 (0.96-1.75)	1.49*(1.04-2.13)	0.88 (0.67-1.14)	0.83 (0.61-1.13)
Age (years)						
11 – 18	1.00	1.00	0.99 (0.99-1.00)	0.97 (0.89-1.06)	0.99 (0.99-1.01)	0.98 (0.90-1.05)
Parental Income ($) [c]						
Below poverty threshold vs. high income	1.00	1.00	1.42 (0.92-2.19)	1.20 (0.66-2.17)	2.85*** (1.84-4.41)	2.02* (1.17-3.49)
Low vs. high	1.00	1.00	1.18 (0.75-1.86)	1.22 (0.69-2.17)	1.98** (1.25-3.13)	1.36 (0.78-2.38)
Middle vs. high	1.00	1.00	0.87 (0.52-1.45)	0.89 (0.48-1.66)	2.05** (1.27-3.31)	1.60 (0.92-2.80)
Upper Middle vs. high	1.00	1.00	0.85 (0.48-1.51)	0.91 (0.46-1.80)	1.79* (1.05-3.05)	1.49 (0.80-2.76)
Neighborhood Safety						
Fairly safe vs. Safe	1.00	1.00	0.97 (0.66-1.42)	0.89 (0.60-1.31)	1.21 (0.86-1.70)	1.08 (0.76-1.54)
Dangerous vs. Safe	1.00	1.00	1.41 (0.81-2.45)	1.25 (0.70-2.25)	1.97** (1.23-3.16)	1.43 (0.86-2.37)

[a] Data Source: Panel Study of Income Dynamics Child Development Supplement, 2007

[b] The Normal weight category (n=785) includes 34 underweight children (2.6%).

[c] Poverty threshold based on 2006 U.S. Census Bureau Data for families of 5-6 persons in household. Income categories were defined as: below the poverty threshold (>25,000), low income (25,000-49,999), middle income (50,000-74,999), upper middle income (75,000-99,999), and high income (100,000+).

*p<0.05, **p<0.01, ***p<0.001

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