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Do Physical Activity, Sedentary Behaviors, and Nutrition Affect Healthy Weight in Middle School Students in an Appalachian Community? Children's Health Opportunities Involving Coordinated Efforts in Schools (CHOICES) Project

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Do Physical Activity, Sedentary Behaviors, and Nutrition Affect Healthy Weight in Middle School Students in an Appalachian Community? Children's Health Opportunities Involving Coordinated Efforts in Schools (CHOICES) Project

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**Dissertation submitted to the
College of Physical Activity and Sport Sciences
at West Virginia University**

in partial fulfillment of the requirements for the degree of

**Doctor of Philosophy in
Kinesiology**

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**Morgantown, West Virginia
2016**

Keywords: physical activity, sedentary behaviors, nutrition, obesity, middle school

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ABSTRACT

Do Physical Activity, Sedentary Behaviors, and Nutrition Affect Healthy Weight in Middle School Students in Appalachian Community: Children's Health Opportunities Involving Coordinated Efforts in Schools (CHOICES) Project

Kibum Cho, M.S.

Background/Purpose: The study was a three-year, multi-component, school-based health programs implemented in two middle schools in an Appalachian county. The purpose of this study was to: (a) examine the association between healthy weight and physical activity, sedentary behavior, and nutrition and (b) explore predictors affecting changes in physical activity, sedentary behaviors, and nutrition. **Methods:** The sample consisted 1,620 subjects with 3,263 observations aged 11 to 16 years, who enrolled in the Children's Health Opportunities Involving Coordinated Efforts in Schools (CHOICES) Project in 2012-2014. Each subject was observed at least one time point. Two main analyses were conducted, a logistic regression and linear mixed model. All data were analyzed using the SAS program (version: 9.4). **Results:** Gender, Moderate to Vigorous Physical Activity (MVPA), and nutrition were associated with healthy weight, while grade, year, screen time were not associate with healthy weight. Boys increased time spent in physical activity over time while girls had no change in physical activity. Girls decreased screen time over time, while boys slightly increased screen time. Girls and boys decreased screen time as BMI percentile increased. Girls and boys increased school work (homework) as BMI percentile increased. None of the variables were significantly related to total consumption of vegetables and fruits. **Conclusion:** This study indicates the importance of Social Ecological Model (SEM) for assessment of obesity prevalence by emphasizing individual, interpersonal, organizational, and community level and it is recommended that school-based interventions and programming consider those levels to promote behavioral changes for adolescent health in the Appalachian region.

Dedications

To my family (wife and new baby) and parents whom I love with all my heart,

Youna Choi, James Zion Cho, Kwangsik Cho, and Soonok Cho

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CHAPTER 1

INTRODUCTION

The prevalence of obesity in adult and youth populations has held the attention of national and international researchers since the early twentieth century. Seminal work conducted by Joslin (1921) examined the weight status of diabetes patients and revealed a link between obesity and diabetes that remains constant today. Obesity and overweight have been identified as risk factors for not only diabetes, but other chronic health conditions such as cardiovascular diseases, cancers, and hypertension. In the United States, obesity rates of adults reached 35.8% in 2009-2010 (Flegal, Carroll, Kit, & Ogden, 2012) and 16.9% of children and adolescents in 2007-2008 (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010). The economic impact of rising obesity rates in both adult and youth populations was reported in 2009 to constitute 8.5-12.9% of U.S. healthcare costs (Finkelstein, Trogon, Cohen, & Dietz, 2009), which does not include indirect costs such as absenteeism, presentism, disability, and premature mortality (Hammond & Levine, 2010). Thus, researchers noted that obesity has become an important threat to public health (Doak, Visscher, Renders, & Seidell, 2006).

Studies have linked genetics, metabolism, poor nutrition, physical inactivity, and environment as known contributing factors to obesity (Jebb, 2004). Obesity is defined as body fat over a body fat standard (Flegal & Ogden, 2011) and is commonly measured using a calculation of weight and height which is referred to as Body Mass Index (BMI). The terms overweight and obese refer to classifications of a range of BMI values; for instance, BMI values of adults between 25.0 and 29.9 are classified as overweight, and values over 30.0 are classified as obese. Obesity rates of both men and women (≥ 18 years) in the U.S. have increased an average 0.37% every year from 1988 to 2010 in the U.S using National Health and Nutrition

Examination Survey (NHANES) data, resulting in changes of 24.9% to 35.4% prevalence of obesity in women and 19.9% to 34.6% prevalence of obesity in men (Ladabaum, Mannalithara, Myer, & Singh, 2014). The increased obesity rate in adults appears to be related to childhood and adolescent obesity. In fact, obesity in adolescents (12-19 years) in the U.S. has increased on average 0.5% every year from 1980 to 2012, resulting in 5% in 1980 to 21% in 2012 (Ogden, Carroll, Kit, & Flegal, 2014). Similarly, the obesity prevalence of children (6-11 years) has also increased on average 0.34% every year, resulting in 6.5% in 1980 to 19.6% in 2012 (Fryar, Carroll, & Ogden, 2012).

With the increases in child and adolescent obesity from 1980 to 2012, researchers have examined the adverse effects of obesity on psychosocial health (e.g., Ebbeling, Pawlak, & Ludwig, 2002). Children who are overweight have been reported to be more likely to have lower self-esteem and to report being targets of discrimination (Dietz, 1998). In addition, society's negative view toward those who are overweight and obese was described with such terms as ugly, mean, stupid, and lazy (Latner & Stunkard, 2003; Wardle, Volz, & Golding, 1995).

Obesity and overweight in children are associated with poor nutrition, inadequate physical activity, and excessive time spent in sedentary behaviors (Kraak, Liverman, & Koplan, 2005; McCambridge et al., 2006). Wang and Lobstein (2006) suggested dietary factors and food habits are of greatest significance in obesity in children and adolescents. Relative to dietary behaviors, sugar-sweetened beverage consumption has been linked to negative health outcomes such as incidence of obesity, diabetes and cardiovascular diseases (Malik, Schulze, & Hu, 2006). According to the 2010 National Youth Physical Activity and Nutrition Study, 65% of high school students in U.S. drank sugar-sweetened beverages (SSBs) at least once or more every day,

and 22% of them drank SSBs at least three times or more every day (Park, Blanck, Sherry, Brener, & O'Toole, 2012).

Regular participation in health-enhancing physical activity has been associated with obesity prevention and treatment in youth and adult populations. However, data suggested only 24.8% of youth aged 12 to 15 years engaged in the recommended 60 minutes of daily physical activity (Fakhouri et al., 2014). The Youth Risk Behavior Surveillance System (YRBSS) announced that across 41 states, 25.4% of youth aged 12 to 15 did not participate in at least 60 minutes of physical activity on all seven days (Kann et al., 2014). In West Virginia, state regulations for childcare facilities (children age birth to 13) met only 8.5% of the federal standards for physical activity and sedentary behaviors (CDC, 2014).

Sedentary behaviors, such as watching television, playing games, using computers, and sitting have been positively correlated with increased weight status in children and adults. According to Sallis et al. (1997), children ages 6-11 spent 7.1 hours a day in sedentary behaviors, while adolescents aged 16-19 spent 8.3 hours a day. The 2011 YRBSS report suggested that 31.1% and 32.4% of high school students in U.S. spend more than 2 hours watching television and playing computer games (Eaton et al., 2012). In West Virginia, 32.2% of high school students spend more than 3 hours playing computer games, and 31.2% spend more than 3 hours watching television per day, which is more than the national average (Eaton et al., 2012).

Although physical activity, nutrition, and sedentary behaviors have been associated with obesity, researchers speculate much greater complexity. Numerous theories and models have been developed and applied to research aimed to explore obesity prevention and treatment. The most commonly used models and theories in obesity prevention research include those that propose a self-contained explanation of behaviors, while others emphasize the individual,

interpersonal relationship, and social environments as contributing factors to behavior and behavior change. The theories include knowledge-attitude-behavior model (Bettinghaus, 1986), Health Belief Model (Janz & Becker, 1984), Social Cognitive Theory (SCT) (Bandura, 2001), Theory of Reasoned Action or Theory of Planned Behavior (Madden, Ellen, & Ajzen, 1992), Transtheoretical Model (Prochaska & Velicer, 1997), and Social Ecological Model (SEM) developed by Bronfenbrenner (1977). Among them, the Social Cognitive Theory and the Social Ecological Model appear to be the most popular frameworks for obesity prevention and intervention (Leroux, Moore, & Dubé, 2013; O'Dea & Eriksen, 2010). A well-documented example of a school-based intervention that was conceptualized around the Social Cognitive Theory is Planet Health (Gortmaker et al., 1999). Planet Health integrated four behavioral change concepts within middle school settings to promote students' health behaviors including: a) decreasing time in television viewing, b) increasing moderate or vigorous physical activity, c) reducing the consumption of fast-foods, and d) increasing consumption of fruits and vegetables (Gentile et al., 2004; U.S. Department of Health and Human Services, 2000).

Another framework that has informed the development of numerous obesity prevention and treatment initiatives is the Social Ecological Model. The Social Ecological Model emphasizes the influence and interplay of societal factors such as interpersonal, organizational, community, and policy have on individuals and has been used to examine the prevention of obesity (Lytle, 2009). Examining obesity from an ecological perspective suggests that one's weight status is affected by not only one's own decisions, but decisions of those around them, the environment, and even social norms. Given the impact that parents and guardians can have on a child's weight status and home environment, the Social Ecological Model informed the development of a resource for physicians to communicate with parents and guardians about

obesity prevention and treatment. The 5-2-1-0 guidelines is a nationwide health education marketing campaign that emphasizes specific behaviors including the consumption of five or more fruits and vegetables, two hours or less time spent in screen time, one or more hour of daily physical activity, and little to no consumption of sugar-sweetened beverages (Rogers et al., 2013).

Federal agencies, educational institutions and professional organizations (e.g., World Health Organization, American Academy of Pediatrics, American Heart Association, Center for Disease Control and Prevention, Society for Health and Physical Education America (SHAPE)–formerly National Association for Sport and Physical Education) have acknowledged the adverse effects of obesity and have issued recommendations for prevention and treatment, many of which include individual behavior change, and family and environmental components. School-based obesity interventions focus on school, family, community, and policy-related issues. In particular, the role of schools in low-income and rural settings that cannot provide enough recreation facilities (Hannon et al., 2006) is important because children in rural areas have 25% higher BMI than their metropolitan peers (Lutfiyya, Lipsky, Wisdom-Behounek, & Inpanbutr-Martinkus, 2007). The school environment can encourage students to make individual changes in areas such as emotional and mental health, and in academic achievement (Cohen, McCabe, Michelli, & Pickeral, 2009). School-based physical activity programs and interventions are viable strategies for improved child and adolescent health, and have been associated with decreases in drop-out rates, improved student self-esteem, and enhanced classroom environments (Mahar et al., 2006). In addition, one study revealed that many studies found that school-based physical activity interventions, decreased screen time, improved VO₂ max (Dobbins, Husson, DeCorby, & LaRocca, 2013), and reduced body weight (Gortmaker et al., 1999). The strengths

of school-based physical activity interventions helped schools improve their environments and educational curricula. Malik, Willett, and Hu (2013) suggested that schools can emphasize nutritional education, provide healthy school meals, and change vending machines contents to favor students' health by developing policy strategies. However, expensive equipment (Hesketh, Waters, Green, Salmon, & Williams, 2005), unsafe facilities for physical activities (Cohen et al., 2006) and low support from parents (Bauer, Nelson, Boutelle, & Neumark-Sztainer, 2008) are common barriers to implementing various types of school-based physical activity interventions.

Although much has been written about the complexity and causes and effects of obesity in adolescents throughout the United States, little is known about the effects of school-based multi-component approaches, such as physical activity, sedentary behavior, and nutrition to obesity treatment and prevention in adolescents, rural areas, especially mountainous areas. In fact, one meta-analysis of school-based interventions including physical activity, sedentary behavior, and nutrition revealed that only 4 (9.3%) of all 43 published studies used all three components in school-based intervention (Lavelle, Mackay, & Pell, 2012), while most studies only used a single or two components because multi-component approaches are time consuming and often complicated (Mariani et al., 2015). Particularly in school settings, regional limitations, such as unsafe sidewalk and lack of facilities, cause to obstruct the use of multi-component approaches for obesity prevention. This study focuses on a rural, Appalachian county. West Virginia is the second most rural state in the U.S. and the only state entirely classified as Appalachia (Alkadry, Wilson, & Nicholas, 2006). These features not only affect the individual development process, but decrease access to healthcare services affecting the quality of life (Chenoweth & Galliher, 2004). In addition, some studies found that people in rural areas met unique challenges that may cause prevalence of obesity, such as lack of physical education

classes, nutrition education, and sidewalks, exercise facilities, and food availability (Reed, Patterson, & Wasserman, 2011; Tai-Seale & Chandler, 2010). Therefore, the efforts for school-based obesity prevention in rural areas are important and should be studied. That is, additional study is needed to understand health behaviors for obesity prevention in school settings and develop targeted health messages for adolescents and their parents within the Appalachian region. This study will help expand existing results of school-based approaches for adolescents' obesity prevention in the Appalachian region.

Purpose of Study

The purpose of this study is (a) to examine the association between healthy weight and physical activity, sedentary behavior, and nutrition and (b) to explore predictors affecting changes in physical activity, sedentary behaviors, and nutrition across a three-year, multi-component, school-based health efforts.

Research Questions

The proposed study aims to examine the following questions:

1. Are physical activity, sedentary behavior, and nutrition in middle school students associated with BMI percentile?
2. Are changes in physical activity, sedentary behavior, and nutrition over time associated with changes in BMI percentile over time, controlling for grade and gender?

Significance of Study

One of strengths of this study can be characterized by multiple measurements. Multiple measurements include: (a) physical activity and sedentary behaviors are measured via the Three Day Physical Activity Recall (3DPAR); (b) nutrition is measured via the School Physical Activity and Nutrition (SPAN); and (c) obesity is measured via Body Mass Index (BMI). These measurements will help explore not only how nutritional factors (fruits and vegetables), physical activity factors (physical activity, moderate to vigorous physical activity, and PACER), and sedentary behavior factors (school work, eating/resting, and screen time) independently affect changes of BMI over a period of three years, but also how strongly those factors are intertwined across the time period.

Further, this study is based on a three-year, school-based multi components for middle school students in a rural, Appalachian county. The thirteen collection periods including baseline for three years helped find the changes in BMI, making it possible to explore what factors are strongly associated with changes in BMI. There have been considerable evidence to suggest that obesity prevention initiatives can change children's behaviors and weight over time; however, there has been far less evidence on which to judge the impact over the longer term (Jones et al., 2011). According to a systematic review of school-based obesity prevention (Lavelle et al., 2012), studies with investigation period over one year were only 10 (23.3%) from 1991 to 2010. Also, the same study revealed that 26 (60%) published studies were based in the primary school settings, which suggests that students at the secondary level are relatively less studied. Therefore, the current study will help expand knowledge about complicated relationships between obesity and obesity-related health risk behaviors, provide unique results for a rural, Appalachian-county,

and highlight some implications and strategies for future school-based interventions to reduce the high risk of poor health for middle school students.

Conceptual Framework

The conceptual framework for this study was based on the Social Ecological Model (SEM). SEM is used in general health promotion studies, and based on a broad paradigm that includes several different fields of research such as sociology, psychology, and public health, and was developed from 1960s (Sallis, Owen, & Fisher, 2008). SEM suggests five levels to explain health promotion interventions, and includes individual, interpersonal, organizational, community, and policy (McLeroy, Bibeau, Steckler, & Glanz, 1988). In particular, these five levels in SEM are used to emphasize and understand the issues of obesity (Lytle, 2009). This trend helped SEM become one of the popular models to explain obesity (Koplan, Liverman, & Kraak, 2005). The Nutrition and Physical Activity Program (Egger & Swinburn, 1997) designed to prevent obesity and other chronic diseases noted that the obesity prevention can be addressed by emphasizing SEM (Golden & Earp, 2012). Story, Neumark-Sztainer, and French (2002) also mentioned that the SEM is useful to explain obesity prevalence because there are five organized domains which can explain risk factors for obesity.

Five different levels in SEM have been studied to find effects on obesity. First, individual level to explain the prevalence of obesity has been emphasized by many previous studies (Kolodziejczyk et al., 2015; Lerdal et al., 2011; Lin, Huang, & French, 2004). They mentioned that individual level generally includes demographic characteristics (e.g. gender, race, age, and region) and one's knowledge and attitudes. For example, Ogden et al. (2014) revealed that Non-Hispanic Asians (19.5%) and non-Hispanic Whites (28.5%) showed lower obesity rate than Hispanics (38.9%) and non-Hispanic Blacks (35.2%). Children at low-income families have

limited opportunities for healthy foods and physical activity, so multifaceted interventions (e.g. policy changes and financial support) should be preceded for obesity prevention (Addy et al., 2004; Economos et al., 2001). Also, body image dissatisfaction caused overweight and obesity negatively (Saloumi & Plourde, 2010). Second, interpersonal level at SEM generally includes the interaction with friends and families. Harris and Neal (2009) found that only 23% of parents with obese child were concerned about their child's high BMI, so obese children are less likely to realize their health problem. Some studies revealed that family members who suffer from an obesity problem caused their children to be highly likely to increase obesity (Freeman et al., 2012; Pryor et al., 2011). Lindsay, Sussner, Kim, and Gortmaker (2006) found that parents can be an important role that their children pursue healthy eating by cooking at home. Third, the importance of organization factors in SEM was emphasized. Among organization factors, schools are an important place to affect adolescent obesity because 95% of adolescents are enrolled in school (CDC, 2013a). Foulk (2004) found that school nutrition, vending machines, and physical education classes are considered as factors causing adolescent obesity in schools. Drake et al. (2012) revealed that physical education classes were associated with increased physical activity and decreased obesity rate. Also, improved school nutrition is important for adolescents to reduce their body weight because adolescents consumed at least 19 to 50 percent of their total daily calories in schools (Gleason & Sutor, 2001). Therefore, Stone, McKenzie, Welk, and Booth (1998) said that school-based health interventions based on the five levels in SEM were continually developed and emphasized. Allensworth and Kolbe (1987) claimed that since the 1900's, school-based health interventions generally focused on health education, health service, and healthy school environment. The comprehensive school physical activity program (CSPAP), for example, used SEM framework for impacting students' health (McLeroy et al.,

1988). Application of a social ecological model in CSPAP enabled school-based health interventions to design school-based physical activity programs that emphasize the interrelation between individuals and their environments (Carson, Castelli, Beighle, & Erwin, 2014).

The last two factors in SEM are community and policy. Researchers may pay no attention to these factors for obesity prevention because these are broader and hard to measure. However, Zenk, Schulz, and Odoms-Young (2009) mentioned that environmental disparities, such as the availability and accessibility of healthful foods, may be an important issue to maintain body weight. Curry (2005) said that vehicle traffic and unsafe facilities in community affected physical activity, eating behaviors, and sedentary behaviors that contribute to obesity. Adding on to the importance of community factors, Frieden, Dietz, and Collins (2010) also emphasized that policy changes are necessary to prevent obesity and should be achieved from local to national levels. Specifically, there were relatively many fast food restaurants in low-income neighborhoods, so it potentially contributes to obesity (Thornton, Lamb, & Ball, 2016). Also, lack of policies and funding may be an obstacle to securing walkability that causes the time spent in physical activity negatively (Allender et al., 2009). Therefore, Brownell and Frieden (2009) pointed out that governments need to control food prices by decreasing healthy food prices and increasing unhealthy food prices.

As SEM emphasized the importance of five levels to explain health behaviors, this model is based on the assumption that influences on health behaviors interact across these five different levels (Glanz, Rimer, & Viswanath, 2008). Therefore, this study explored all levels except for policy level in SEM. Specifically, first, students went through the adolescent stage of development. During this stage, physical, cognitive, and social-emotional development were affected by interpersonal (e.g., teachers), and organizational (e.g., school-based programs) levels.

Second, teachers experienced professional development by enhancing PE curriculum. PE teachers managed PE classes and physical activity related programs in school. Third, after school PA programs were provided in year 2. After-School PA programs offered students' opportunities to build their interests and skills in areas such as: archery, mountain-biking, walking, slack-lining, Zumba, land-paddling and yoga. Fourth, PE curriculum enhancements were provided in year 2-3. PE curriculum enhancements developed standards-based health and physical education curricula and integrated culturally-relevant lifetime activities in PE. Fifth, school garden was provided in year 1-3. School garden was designed to allow students to learn by doing and explore nutritious options that might increase their awareness and promote healthy eating. Sixth, school-based health care was provided in year 1-3. Greenbrier County Schools has partnered with local medical practitioners and existing school-based health centers to provide support and resources for students and their families about obesity awareness and prevention, and facilitate goal-setting related to healthy lifestyle habits and decisions. Students within a specific BMI percentage are invited to participate in the one-on-one interactions with healthcare providers as well as programs designed to promote healthy eating and physical activity. However, the analysis for school-based health care component was not included in this study because this component was used for a small number of participants. Figure 1 introduced factors affecting obesity in an Appalachian region.

Figure 1. Theoretical Model for Factors Affecting Obesity in an Appalachian Region

Key Terms

For the purpose of the proposed study the following terms are defined as:

Greenbrier CHOICES Project. A children's health opportunities involving coordinated efforts in schools project in Greenbrier County, West Virginia. The purpose of Greenbrier CHOICES Project was to develop, implement, and evaluate an integrated approach for adolescent health using complimentary intervention strategies and settings (schools, communities, and health care). The Greenbrier CHOICES Project had total 13 collection periods including a baseline from 2012 to 2014.

Overweight. An adult who has BMI between 25.0 and 29.9 (CDC, 2012a)

Obese. An adult who has BMI over 30.0 (CDC, 2012a)

Physical Activity. Human movements with energy expenditure such as walking, jogging, or running (Katzmarzyk et al., 2008).

School-Based Health Intervention. Programs, campaigns, classes, and policies, which encourage students not only to improve health-related knowledge about nutrition and well-being, but also promote physical activity (Morgan et al., 2014).

School Physical Activity and Nutrition (SPAN). This is a survey which addresses school physical activity and nutrition, and is based on School-Based Nutrition Monitoring (SBNM) questionnaire developed by Hoelscher, Day, Kelder, and Ward (2003). The purpose of this survey is to assess physical activity and eating behaviors in children and adolescents.

Sedentary Behaviors. Resting behaviors showing low energy expenditure (less than 1.5METs) including computer use, television viewing, sitting, reading, and school-work (Ainsworth et al., 2000).

Social Ecological Model. Based on ecological perspective developed by Urie Brofenbrenner, the social ecological model was developed by McLeroy et al. (1988). The main concept of this model is that individual behavior not only causes multiple domains of influence, but is caused by them.

3-Day Physical Activity Recall (3DPAR). This is a self-report developed by Pate, Ross, Dowda, Trost, and Sirard (2003), and based on the Previous Day Physical Activity Recall (PDPAR). The purpose of this report is for the subject to evaluate his or her the time spent in physical activity and type of physical activity in the last 3 days (one weekend and two weekdays).

CHAPTER 2

REVIEW OF THE LITERATURE

Childhood and Adolescent Obesity

Trend in Obesity. The development of industry, such as transportation and communication technology, affects human life, allowing us to reduce the need for physical labor and movements (Hallal et al., 2012). Conveniences provide people with time- and money-saving, but the effects do not directly benefit the function of the human body. In other words, while the quality of our lives continues to develop, the human body does not develop unless it is activated through bodily activities (Booth, Laye, Lees, Rector, & Thyfault, 2008).

The obesity problem is no longer an individual problem, but a global problem. The obesity epidemic increased in most developed countries from 1970 to 1990 (Sassi, Devaux, Cecchini, & Rusticelli, 2009), and many developing countries have also seen an increase in obesity prevalence since 1990 (Finucane et al., 2011). The World Health Organization (WHO) alerted that over 2 billion overweight people aged 15 years would exist, and 700 million obese people in the world would also exist by 2015 (WHO, 2010a). According to an update report on obesity by Organization for Economic Co-operation and Development (OECD) (2014), the obesity rate of adults in OECD countries was less than 10% until 1980, while the obesity rate of adults in 2012 was 18.4%. As a result of world trends in obesity, one noticeable fact was that the obesity rates of the United States, Australia, and England rapidly increased since the 1990s, while the increase of the obesity rates in other countries maintained a more stable pace. In fact, a recent study explained that in 2009-2010, the obesity rate of adults in U.S was 35.5-35.8% (Flegal et al., 2012). Although the obesity rate between the mid-2000's and 2010 was not significantly increased, the obesity rate in the United States is still highest in the world.

Olshansky et al. (2005) mentioned that the obesity problem can be one of the leading causes of decreased life expectancy, and there are no countries that are not in danger of an increased obesity problem.

The U.S. Government has collected and presented data to emphasize the seriousness of the obesity problem by using reliable national surveillances. The popular surveillances are Behavioral Risk Factor Surveillance System (BRFSS), National Health Interview Survey (NHIS), and National Health and Nutrition Examination Survey (NHANES) (Whitt-Glover, Taylor, Heath, & Macera, 2007) (Table 1). The resulting data on the obesity rate through these surveillances indicated a 26.8%-35.7% increase in 2008-2011, which shows similar results to data from worldwide organizations such as WHO or OECD.

Table 1

Introduction of National Surveillances

	BRFSS	NHIS	NHANES
Type of Survey	Telephone	Home-based interview	Combining interviews, physical examinations, and laboratory testing
Questions	Current health-related perceptions, behaviors, and socio-demographic questions	Chronic conditions, health behaviors, and health status questions	Socio-demographic, socio-economic, nutritional, and health behavior questions
Response Rate	53.3% in 2008	60.8% in 2010	72.6% (Interview) and 69.5% (Examination) in 2011-2012
Result	Adult aged 18 and older: 26.8% (BMI $\geq$ 30) in 2008	Adult aged 18 and older: 28% (BMI $\geq$ 30) in 2011	Adult aged 18 and older: 35.7% (BMI $\geq$ 30) in 2010

Specifically, based on the BRFSS in 2009-2010, Finkelstein et al. (2012) expected that obese people will comprise 51% of the entire population in the U.S. by 2030, calculated by using regression modeling based on explanatory variables such as the price of food market or individual-level variables affecting obesity prevalence. Compared to the result of BRFSS in 1990, 2000 and 2008, the currency of obesity in 2008 was much severer than in 1990, increasing from 11.1% to 26.8% ($BMI \geq 30$), and from 0.8% to 3.5% ($BMI \geq 40$) (Finkelstein et al., 2012). Based on BRFSS results, Prospective Studies Collaboration (2009) reported that the continuous increase of obesity rate, especially those who have over 40 BMI, will have a shorter life expectancy and higher medical costs for treatment, resulting in a low quality of life. 2011 NHIS report revealed that 34% of adults (≥ 18 years) were overweight and 28% were obese (Gu, Charles, Andrew, Ma, & Burchfiel, 2013). Also, the percentage of underweight women was more than twice the percentage of underweight men although the obesity rates of men and women were almost the same (Gu et al., 2013). Lastly, the result of the 2009-2010 NHANES report indicated that obese adults comprised 35.7% and obese children and adolescents, 16.9% (Flegal et al., 2012). The American Heart Association (2013a) analyzed data that indicated the obesity rate in male youth in 2010 increased by 5% compared to 2000, although there was no difference in female youth.

More seriously, the obesity rate in West Virginia (WV) was 33.5%, which is 8% higher than the nationwide average (Herath & Brown, 2013). In 2005, West Virginia's Healthy Lifestyle Act revealed the obesity rate (BMI equal to or greater than 95 percentile) in 2007-2009 comprised 18.5% of students in kindergarten, 22.1% of second graders, and 29.6% of fifth graders (Tomblin & Lewis, 2011). According to WV Coronary Artery Risk Detection in Appalachian Communities (CARDIAC) Project (2002-2006), the obesity rate ($BMI \geq 85$

percentile) of fifth graders in WV was 48.1%, and the obesity rate of children with overweight rose from kindergarten (35%) to second graders (37.8%) (Harris & Neal, 2009). In addition, the obesity rate (BMI equal to or greater than 95 percentile) of the eligible fifth grade population was an average of 28.3% from 1998 to 2012, which was similar to results (29.6%) reported in data from West Virginia's Healthy Lifestyle Act in 2007-2009.

The CDC announced that West Virginia is one of the states with the most obesity in the United States; it has a 35.5% obesity rate among children ages 10-17 (Eaton et al., 2012). According to West Virginia's and the United States BRFSS report, the obesity problem in West Virginia has been always more serious than the nationwide average since 1995 (Tomblin & Lewis, 2011). The high obesity rate in West Virginia causes serious adult diabetes and heart disease (Kung, Hoyert, Xu, & Murphy, 2008). Amarasinghe, Brown, D'Souza, and Borisova (2006) revealed that some variables causing obesity in West Virginia could be poor accessibility to food stores and gyms, lack of education, inconvenient public transportation, and low income. In addition, despite the high risk of obesity in West Virginia, two thirds of the population in West Virginia lives in rural areas residing wholly within Appalachia, making it difficult to access healthcare (Retrieved from <http://muafind.hrsa.gov/index.aspx>). This environmental barrier can be overcome by a state-wide network in the areas that allows for the sharing of information and cooperation between counties. Considering the regional limitations and lower income than other states, health surveys in West Virginia should be more developed and have an important value to provide appropriate interventions.

Consequences of Obesity. The terms overweight and obesity refer to increased amounts of body fat, generally measured by the body-mass index (BMI). Obesity is commonly associated with negative effects on health, economy, and social consequences, including discrimination (Wellman & Friedberg, 2002).

Impact on Global Health. Caloric imbalance is the main cause of being obese (Karnik & Kanekar, 2012). The popularity of processed food and the high prevalence of physical inactivity have caused a distinct growth of heart disease, various cancers and other health problems in all countries regardless of developed and developing status (Vucenik & Stains, 2012; Popkin, 2003). In addition, stress can cause increased food intake: thus, obesity is affected not only by imbalance between calorie intake and calories consumed, but also by psychological problems such as stress (Epel et al., 2004).

Obesity causes cardiovascular diseases and various mental health problems (Reilly et al., 2003). People who are obese and overweight have a high risk of hypertension, dyslipidemia, insulin resistance, and diabetes mellitus, compared to those of lower weight status (Poirier et al., 2006). Obesity is also associated with Type 2 diabetes. In fact, more than 80% of patients with Type 2 diabetes are also obese (Wild, Roglic, Green, Sicree, & King, 2004). Lastly, obesity is strongly related to mental health problems although obesity is not a direct psychological disease. In fact, obesity is generally referred as important stressor in people's life (Gundersen, Mahatmya, Garasky, & Lohman, 2011).

Many societies are faced with early mortality and morbidity linked to chronic diseases, due to the obesity epidemic. Nations need to address this concern by providing adequate public policies and health services, which require discretionary effort and resources that are often lacking or non-existent (Rokholm, Baker, & Sørensen, 2010).

Impact on Global Economy. Nguyen and El-Serag (2010) claimed that the obesity epidemic causes serious damage to economies due to healthcare costs, and will be one of the most crucial global issues during the next several decades. Furthermore, obesity imposes a considerable economic burden; billions of dollars every year are spent on health care costs, threatening the long-term viability of the global economy (Cawley, 2010; Yach, Stuckler, & Brownell, 2006). The McKinsey Global Institute (MGI) reported that obesity impact is \$2.0 trillion, or 2.8% of the whole global economy, which has a similar economic impact as smoking (Dobbs et al., 2014). The burden of healthcare in developing countries is serious. For example, people in Tanzania, a developing country, have had to spend 25% of individual income for healthcare (Neuhann, Warter-Neuhann, Lyaruu, & Msuya, 2002)

Both direct and indirect costs should be examined to determine total medical costs. Direct costs, which include prevention, diagnosis, and treatment in medical institutions (Friedman & Fanning, 2004), have the biggest impact on the economy (Hammond & Levine, 2010). The sum of \$75 billion was assessed as the additional medical costs of obesity every year in the U.S., constituting 4-7% of whole healthcare expenses (Finkelstein, Fiebelkorn, & Wang, 2004). This burden has caused 46% increased inpatient costs compared to healthcare costs of normal-weight people (Finkelstein et al., 2009). Many studies predicted that if obesity continues to increase as fast as it is now, society would suffer considerable indirect costs from obesity due to early retirement, resulting in higher costs than medical costs (Finkelstein, Dibonaventura, Burgess, & Hale, 2010; Trogon, Finkelstein, Hylands, Dellea, & Kamal-Bahl, 2008).

Another impact of obesity includes significant productivity costs. Hammond and Levine (2010) suggested that there are four different factors due to obesity that affect productivity negatively, including absenteeism, presenteeism, disability, and premature mortality. Another

indirect financial consequence of weight gain is additional airline fuel, calculated to be almost 300 million dollars in the year 2000 (Dannenberg, Burton, & Jackson, 2004).

Impact on Social Consequences. It is not easy to determine whether social and psychosocial variables have an impact on increased obesity because the previous research has depended on short-term studies (Scott, Melhorn, & Sakai, 2012). In recent years, however, some studies revealed that adults with low social support caused $\geq 10\%$ body mass index (BMI), and even growth in their waist circumferences (Kouvonen et al., 2011). This means that low social support affects potential variables which cause obesity, such as lack of information or eating excessively, resulting in negative effects on health. In addition, the discrimination caused by obesity at school, in the workplace, and even at home is one of the serious social problems. Many people tend to think that obese people are lazy, because having a beautiful, slim body is considered important in a competitive society, causing socially and psychologically large burdens to obese people (Wellman & Friedberg, 2002).

Psychosocial impacts caused by obesity generally include the realms of socioeconomic status, self-esteem, social support, and personal relationships with friends and family (Russell-Mayhew, McVey, Bardick, & Ireland, 2012). First, the association between obesity and socioeconomic status is complicated; one study found that it is not clear that there are differences between obesity prevalence and socioeconomic status (Zaninotto, Head, Stamatakis, Wardle, & Mindell, 2009). In addition, studies related to the effects of geographical neighborhood are also limited because it is not easy to gather data regarding participants' neighborhood conditions (Singh, Kogan, Van Dyck, & Siahpush, 2008). In contrast, an inverse relationship between self-esteem and obesity is relatively clear (Wang & Veugelers, 2008). Puhl and Latner (2007) found that there was a significant difference between obese and normal weight children in terms of

self-esteem. Despite the controversial relationship between obesity prevalence and psychosocial variables, if these psychosocial variables are formed as stressors, they will lead to increased weight gain (Cohen, 2005; Steptoe et al., 2002). For example, low income was related to higher risk of childhood overweight and obesity (Gundersen et al., 2011; O'Dea, Hoang, & Dibley, 2011). Also, obesity prevalence has caused negative emotional conditions such as worries, loneliness, and high-risk behaviors, which affect the quality for a healthy life (Tsiros et al., 2009) causing a high risk of suicide (Heneghan, Heinberg, Windover, Rogula, & Schauer, 2012). As mentioned above, psychosocial impacts caused by obesity are so complicated that approaches to deal with obesity should be discretely provided. In fact, the improvement of psychosocial outcomes was achieved by approaches that emphasized weight-neutral meaning a person does not gain or drop, rather than weight-loss (Bacon & Aphramor, 2011).

School-Based Health Interventions for Obesity Prevention. There have been many family-, school-, community-, and hospital-based interventions to deal with obesity problems (Karnik & Kanekar, 2012). Some studies examined interventions for obesity prevention, and observed that most interventions were school-based (Hollar et al., 2010). They mentioned that school-based health interventions not only are cost-effective, but can use both physical activity and nutritional interventions at the same place (Hollar et al., 2010). According to the systematic review of Brown and Summerbell (2009), there were 38 studies focusing on school-based interventions such as exercise, nutrition, and combined diet and exercise. Targets for health-related interventions generally focused on young students at schools because healthy conditions at a young age positively contribute to adult life (Branscum & Sharma, 2012). Sharma (2006) investigated school-based health interventions conducted between 1999 and 2004. He found that most of the interventions focused on the individual level for health promotion, rather than policy

changes. Also, half the interventions focused on both physical activity and eating behaviors, while 27% of interventions only focused on one component such as decreasing sweetened beverages, decreasing television viewing, or increasing physical activity. Through these school-based interventions, previous studies revealed that school-based physical activity interventions decreased screen time and improved VO2 max (Dobbins et al., 2013), as well as reducing body weight (Gortmaker et al., 1999).

One of the reasons to emphasize the importance of school-based health interventions is that schools can provide more varied equipment or resources such as gymnasiums and green spaces than any other facility (Branscum & Sharma, 2012). In addition, schools provide secured places. In fact, the importance of school-based physical activity intervention is not only explained by the health improvement for children and adolescents, but emphasized by positive contributions such as decreasing drop-out rates, higher self-esteem, and improved classroom environments (Mahar et al., 2006). However, in several developed countries, physical education classes in schools have decreased since 1990 (Knuth & Hallal, 2009). Also, only 4.2% of elementary schools in the United States encouraged all students to participate in daily physical education (Kann, Brener, & Wechsler, 2007). Although the purpose of schools is not only to improve students' health, the fact that the obesity issue causes a huge burden on society challenges schools to provide opportunities for preventing of obesity (Story, 1999). Resnicow (1993) also pointed out that most students aged 5 to 17 are enrolled in school, making it possible to follow students for over ten years although many parents still consider clinics to be institutions which monitor their children's health.

Most of school-based interventions to prevent obesity actively use school facilities such as school grounds. Students spend most of their time exercising on school grounds or in the

gymnasium during break time as well as lunch hour (Cradock, Melly, Allen, Morris, & Gortmaker, 2007). Therefore, studies emphasized providing both proper hard playgrounds and green areas because sports appropriate for hard courts and sports for green surfaces are different. Jones et al. (2010) found that playgrounds, such as the surface or slope of playgrounds, designed appropriately by each sport's characteristics increased moderate to vigorous physical activity (MVPA). The increased school facilities and equipment were also positively correlated with time spent in physical activity (Haug, Torsheim, Sallis, & Samdal, 2010). Especially, availability of game equipment during break time or lunch hour increased time spent in physical activity as well as MVPA (Haerens et al., 2007).

After school programs are one of the representative interventions for obesity prevention in school. Smith (2007) found that almost 6.6 million youth participate in after school programs and 22 million parents were interested in the programs. According to a meta-analysis analyzing studies published between 1980 and 2008, large numbers of studies recognized physical activity in schools as after school programs and they found that after school programs improved physical activity level as well as health-related aspects (Beets, Beighle, Erwin, & Huberty, 2009). Similarly, the popularity of school garden programs for obesity prevention is also growing because many previous studies found that health eating is strongly associated with obesity prevention as well as improved quality of life (Blair, 2009). Ratcliffe, Merrigan, Rogers, and Goldberg (2011) suggested several advantages of school garden programs. Specifically, schools can improve existing curriculum by integrating with nutrition, environmental studies, or physical education, making it possible for teachers to teach students effectively. Also, they mentioned that students can understand knowledge of healthy eating and nutrition more easily by experiencing

planting, nurturing, and harvesting fruits and vegetables in the school garden. This direct experience encourages students to increase healthy eating's interest.

Among school-based health interventions developed by Allensworth and Kolbe (1987), family and community linkages are also a noteworthy component. Family and community linkages include parental involvement, incorporating individuals (friends, teachers, and parents) in the students' environment, and incorporating environments (home, school, and community). Story (1999) said that the collaboration between school, parent, and community is essential for students in order to increase physical activity and change eating behaviors. He also said that the effects of school-based health intervention may be decreased if only intervention in school settings is emphasized. Interestingly, there was no difference in the amount of time spent in physical activity in school between overweight, obese, and even normal-weight children, meaning that the time difference for physical activity between them is caused by their families at home (Hunter, Steele, & Steele, 2008). Therefore, understanding the relationship between school, parent, and community can be a first step to using interventions for students effectively.

Lastly, the legislation addressing children and adolescents' health at schools is one of the effective interventions to prevent obesity. Direct or indirect forms can be included in the legislation. For example, schools can provide increased physical education classes and ample sport experiences based on direct legislation, they can not only encourage students to increase their health-related knowledge, but build environments to secure safety for after- and before-school physical activity programs recommended by indirect forms of legislation (Katzmarzyk et al., 2008).

Physical Activity/Inactivity in Adolescents

Trends in Physical Activity/Inactivity. Physical activity is one of the most important solutions to overcome the obesity epidemic world-wide (Barreto, 2013) because it is an inexpensive and easily accessible solution to prevent obesity, while physical inactivity is one of the main reasons of death throughout the world (Kohl et al., 2012). Currently, one third of children and adolescents are physically inactive (Ekelund et al., 2012), and 58% of people in the world do not meet the physical activity guidelines which recommend spending 150 minutes with in moderate-intensity physical activity a week (U.S. Department of Health and Human Services, 2008a). In 2002, physical inactivity led to 1.2 million deaths (Brownson, Boehmer, & Luke, 2005), and currently leads to approximately 3.2 million deaths annually (Church et al., 2011), resulting in physical inactivity being the fourth leading risk factor for mortality (WHO, 2003). In fact, 6-10% of all deaths from non-communicable diseases (Das & Horton, 2012), 20% of cardiovascular diseases, and 10% of strokes (WHO, 2002) were caused by physical inactivity. According to one study dealing with physical inactivity in 76 countries, the prevalence (27.8%) of physical inactivity in most developed countries was much higher than the less developed countries (18.7%), and physical inactivity of women (23.7%) and elderly individuals were also much more prevalent than for men (18.9%) and young individuals (Dumith, Hallal, Reis, & Kohl III, 2011).

The U.S. government leads three representative surveillances for public health including the Behavioral Risk Factor Surveillance System (BRFSS), National Health Interview Survey (NHIS), and National Health and Nutrition Examination Survey (NHANES). According to these surveillances, those who participated in 150 minutes per week were 51.6% (CDC, 2013b). The other two surveillances also reported that those who are physically active were 30.2% (NHIS,

1998-2007) and 33.5% (NHANES, 1999-2006) (Li et al., 2012). The reason for the difference between surveillances is that each process and questionnaire for the surveillances were conducted differently. West Virginia is a unique state because most parts of this state are covered by the Appalachian Mountain. This regional characteristic causes environmental limitations for physical activity. According to WV Health Statistics Center (2011), people (n=2,100) in West Virginia (WV), who participated in 150 minutes per week, were only 43.0% while other states were average 51.6%. CDC (2012b) also reported that only 22.6% of adolescents in WV exercised 60 minutes per day with a moderate to vigorous intensity level. In this overall perspective, it is remarkable that the prevalence of physical inactivity (not participating in any physical activity for one week before an interview), reported by Youth Risk Behavior Surveillance System (YRBSS) in 2009, has decreased to 17.3% in 2009 since 24.3% of all students in the 2005 survey (Tomblin & Lewis, 2011). Recently, the WV Health Statistics Center (2012) showed that 31% of adults in WV had no physical activity or exercise, which was one of the highest states in the United States (national average: 23.5%). More specifically, 14.8% of persons aged 18-24 engaged in no physical activity, compared to 35.2% of those aged 55-64.

We know physical activity positively affects our bodies, while physical inactivity, which is sedentary behavior, negatively causes not only health conditions such as obesity and coronary heart diseases (Lee et al., 2012), but a decrease in cognitive function, and lower academic achievement among children and adolescents (Burkhalter & Hillman, 2011). The relationship between physical activity, physical inactivity, and sedentary behavior is a little unclear. First of all, physical activity and physical inactivity have an inverse relationship. Physical activity generally means human movements with energy expenditure, such as walking, jogging, or running. Physical inactivity means that one does not meet minimum physical activity guidelines

or requirements (Katzmarzyk et al., 2008). Physical inactivity and sedentary behavior are broadly similar. However, physical inactivity is mentioned as insufficient amounts of moderate-to-vigorous physical activity (MVPA) (Katz et al., 2011), while sedentary behaviors include, specific activities such as sleeping, playing computer games, or watching television, which are considered activities at a resting level (Pate, O'Neill, & Lobelo, 2008).

Physical activity is important for both adults and children, but physical activity for children may be emphasized more than adults because children's behaviors or attitudes for physical activity directly affect their future lives (Laguna et al., 2013). Therefore, the prevalence of physical inactivity throughout the world increases the need for developed policies and action plans for health. (Twisk, Kemper, & Mechelen, 1997). Kohl et al. (2012) said that 73% of countries have plans, interventions, and policies to improve the level of physical activity for people's health. Also, WHO emphasized the importance of school-based intervention, and considered the school curriculum, educational policy, and guidelines as key points to improve children and adolescents' health; WHO reported almost half of children and adolescents did not meet current guidelines for physical activity participation (WHO, 2004).

Harrison and Jones (2012) emphasized environmental changes to promote physical activity. One example of intervention associated with physical activity environment is the development of roads between schools and homes (Sluijs et al., 2011). They pointed out that road networks securing safety between school and home can encourage students to walk and use bicycles, resulting in promoting health as well as preventing environmental pollution. However, Ham, Martin, and Kohl (2008) found that only 16.2% of students aged 5 to 18 walked or biked to travel to their schools in 2001, compared to 42% in 1969. The reason showing low percentage of walking or biking during before and after school is that parents were uncertain about road safety

because of complex crossroads and narrow walkways (Timperio, Salmon, Telford, & Crawford, 2005). Therefore, schools and communities need to secure road safety as well as parents' traffic guidance for students to travel to their schools. As introduced above, walking is one of the popular examples used to promote physical activity. It is easy to do, is not interrupted by facilities or places, and is economical exercise (Monteiro et al., 2003). Although it is already known that walking is the most effective and convenient intervention for health, only 64.1% of adults walked for minimum 10 minutes every day (Hallal et al., 2012). Specifically, they reported that while adults in the Americas (66.9%) and Europe (66.8%) had at least 10-minute walk, adults in Africa were only 57%. These results mean that over one third of the adults in the world do not meet a 10-minute walk for per day. Active transportation is one of the easiest ways to achieve 10-minute walk for per day (Manson et al., 1999). In fact, the importance of active transportation has been emphasized when children and adolescents go to school and come home from school (McDonald, 2007). Some studies reported that active transportation to school was an effective way to reduce BMI and cardiovascular risk factors although removing factors which threaten the security of active transportation should be the first priority of schools and communities (Andersen, Lawlor, Cooper, Froberg, & Anderssen, 2009).

For promoting physical activity, several physical activity guidelines for children include:

- 1) Healthy People 2010 (U.S. Department of Health and Human Services, 2000), which suggests that childhood and adolescents should participate in vigorous physical activity at least three or more days per week with a minimum of 20 minutes per occasion,
- 2) The 2008 Physical Activity Guideline for Americans, which recommends that time spent doing physical activity with moderate and vigorous intensity should be at least 150 minutes a week, and doing muscle-strengthening activities should be at least 2 days a week for adults (Carlson, Fulton, Schoenborn,

& Loustalot, 2010), 3) Healthy People 2020, which mentioned that at least an hour of daily aerobic activity is recommended for adolescents (U.S. Department of Health and Human Services, and Office of Disease Prevention and Health Promotion, 2012), and 4) the CDC (2011a), which also announces that children and adolescents should spend an hour a day in physical activity.

To evaluate physical activity guidelines, related questionnaires have been developed. Most questionnaires before the 1990s only measured physical activity during leisure time or at school or in the workplace. These questionnaires could not exactly estimate daily physical activity because each movement has different types and intensities of physical activity (Hagströmer, Oja, & Sjöström, 2006). However, the technology for physical activity assessment, as well as the importance of health, have developed sedentary behavior, and nutrition assessment tools since 1990s (Vanhees et al., 2005). In the late 1990s, an International Consensus Group developed the international physical activity questionnaire (IPAQ) to measure physical activity worldwide, and the validity and reliability of the questionnaire throughout 12 countries was assessed (Booth et al., 2003). The IPAQ is a self-report, is divided into two forms (short and long), for people aged 15 to 69 as the target population, and includes questions about physical activity and sitting time. The only difference between two forms is the number of questions (short: 7, long: 27) (IPAQ Research Committee, 2005). The reason why the IPAQ is more valuable is that researchers was able to first start measuring global patterns of physical activity and sedentary behaviors (Bauman et al., 2011). The three day physical activity recall (3DPAR) is more specific questionnaire which can measure physical activities performed for the past three days (Weston, Petosa, & Pate, 1997). The 3DPAR was developed by Pate et al., (2003) and includes: 59 activities such as homework, basketball, eating, and sleeping; 4 different intensities

such as rest, light, moderate, and vigorous; and 34 blocks of time (30 minutes per block) from 7 a.m. to midnight. The 3DPAR is a self-report instrument, so students record what they did during the three days prior to reporting (one weekend and two weekdays) (Stanley, Boshoff, & Dollman, 2007). Unlike self-report instruments such as questionnaires, technological developments generate more objective and observable instruments through computer or video (Tudor-Locke, Ainsworth, Thompson, & Matthews, 2002). Accelerometers are one of the instruments to use technologies, and make it possible to measure the frequency, duration, and intensity of physical activity more objectively, as well as remove recall bias that is the limitation of self-report instruments (Chen, Chou, Yu, & Cheng, 2008). Although accelerometers are widely used because of their ability to gather and monitor physical activity objectively, they are relatively expensive and require technical skills to manage, update, and analyze (Tudor-Locke & Myers, 2001). Pedometers can be considered as an alternative to accelerometers. Pedometers are much less expensive than accelerometers and can be used simply, though they cannot measure intensity and type of physical activity (Tudor-Locke et al., 2002). The accuracy of the pedometer to explain physical activity has already been proved by many studies (Bassett et al., 1996; Hendelman, Miller, Baggett, Debold., & Freedson, 2000), so researchers can use either the accelerometer or pedometer to monitor physical activity according to financial or environmental situations.

Sedentary Behaviors in Adolescents

Trends in Sedentary Behaviors. With technology advancing at a fast rate, industrial automation and mechanization decrease physical labor and increase office work, resulting in a proliferation of sedentary behaviors (Lanningham-Foster, Nysse, & Levine, 2003). Hallal et al. (2012) reported 41.5% of adults in the world spent 4 or more hours sitting for a day. Specifically,

adults in Europe (64.1%) and the Americas (55.2%) spent 4 or more hours sitting for a day, while adults in Southeast Asia spent 23.8%. Sedentary behaviors are generally defined as low energy expenditure (≤ 1.5 METs: desk work, light housework, or washing clothes) or lack of physical activity (Sedentary Behavior Research Network, 2012). Sedentary behaviors include all behaviors at the level of rest, such as: computer/video games, sitting, reading, watching television, sleeping, or driving a car (Owen, Healy, Mathews, & Dunstan, 2010). However, sedentary behaviors are not the opposite of physical activity because sedentary behaviors are determined by the intensity of behaviors (Katzmarzyk et al., 2008).

As many studies reported, people in the United States spend much time in sedentary behaviors. Although the Bar-On et al. (2001) recommends children aged 2 years and older spend less than 2 hours per day on screening time, approximately half the children in the United States spend more than 2 hours watching television per day (Council on Communications and Media, 2011). Specifically, children aged 6-11 spent 7.1 hours in sedentary behaviors, while adolescents aged 16-19 spent 8.3 hours (Sallis et al., 1997). This result indicated that the time spent in sedentary behaviors increased as children got older. The 2011 Youth Risk Behavior Surveillance System (YRBSS) announced that high school students in the U.S. spend more than 2 hours daily watching television and playing computer games, 31.1% and 32.4%, respectively (Eaton et al., 2012). This result means that one third of high school student spend considerable time with computer and television at home after school. The American Academic of Pediatrics (AAP) emphasizes that the children's parents can play an important role in reducing sedentary behaviors such as screen time and computer use because most sedentary behaviors occur at home (Council on Communications and Media, 2011).

West Virginia is one state where people spend much more time in sedentary behaviors than people in other states. The 2011 Youth Risk Behavior Survey showed that 32.2% of high school students in West Virginia spent more than 3 hours playing computer games, and 31.2% of them spent more than 3 hours watching television per day, while the national average for playing computer games and watching television was each 28.8% and 29.5%, lower than in West Virginia (Eaton et al., 2012). In addition, the National Resource Center for Health and Safety in Child Care and Early Education (2013) found that of childcare facilities in West Virginia state childcare facilities, only 8.5% met standards for physical activity and sedentary behaviors, recommended by several associations such as the American Public Health Association.

Sedentary behaviors are not a minor problem because sedentary behaviors in the United States have had a negative effect on social and health problems (Owen et al., 2010). For example, time spent in sedentary behaviors is associated with a level of depression and low satisfaction with life (Rhodes, Mark, & Temmel, 2012). 5.9% of all deaths could even be explained by sedentary behaviors such as sitting time, which means that this result is relatively higher than deaths caused by obesity (5%) (Chau et al., 2013). Of sedentary behaviors, television viewing has been the most studied behavior, followed by sitting and computer/video games (Rhodes et al., 2012). Specifically, time spent viewing television is strongly related to increased BMI (Danner, 2008), and is associated with a lower than recommended levels of physical activity (Sugiyama, Healy, Dunstan, Salmon, & Owen, 2008).

Recently, many studies based on the ecological framework suggest strategies or interventions to reduce time spent in sedentary behaviors. Healy et al. (2008) found that the relationship between sedentary behaviors and light-intensity physical activity was negatively correlated, suggesting that the best way to discourage sedentary behaviors may be to recommend

light-intensity physical activity. In addition, sit-stand workstations for workers results in reduction in sitting time (Pronk, Katz, Lowry, & Payfer, 2012). Most studies for interventions to decrease sedentary behaviors have focused more on childhood and adolescents than adults (Salmon, Tremblay, Marshall, & Hume, 2011). The prevalence of a sedentary lifestyle on children and adolescents is globally increasing because childhood and adolescents are generally sensitive to the latest trends and fashions, so that they sit at the computer and television to obtain social information (Kautiainen, Koivusilta, Lintonen, Virtanen, & Rimpela, 2005). School-based interventions can also be effective. Educational messages or curricula about turning off television or improving physical activity may be a good approach to prevent childhood obesity (Robinson, 1999).

Nutrition in Adolescents

Trends in Nutrition. National Health and Nutrition Examination Survey (NHANES) announced that energy intake increased 168 kcal/d for men, and 335 kcal/d for women, between 1971 and 2000 (Hill, Wyatt, & Peters, 2012). The increased energy intake means the change of dietary patterns. Dietary patterns have been rapidly changing for the past few decades in the world; the changes include increased intake of fat, sugar, and edible oil (Popkin, 2001). For example, sweetener consumption showed 74kcal/d increase between 1962 and 2000 (Popkin & Nielsen, 2003). Western-style fast food is considered nutrition which causes obesity, diabetes, and cardiovascular diseases (Pan, Malik, & Hu, 2012). CDC (2012b) showed that 71.9% of adolescents in West Virginia had fruit consumption including 100% fruit juice less than twice a week, and 34.5 of them drank sweetened beverages at least one or more times for a day. These eating behaviors in West Virginia led to its designation as one of the top unhealthy states in the United States (Pan et al., 2012). According to 2010 Dietary Guidelines for Americans, the

recommendation is to eat 5 to 13 servings of fruits and vegetables per day, and to avoid soft drinks.

Sugar-Sweetened Beverages (SSB) consumption is the strongest and the most serious issue to have a negative influence on health such as obesity, diabetes and cardiovascular diseases (Malik et al., 2006). It is hard to find non-SSB around us because SSB can include soda, sweetened waters and teas, sports and energy drinks, and fruit juice (not 100% juice), which are substantial contributors to calorie intake (Reedy & Krebs-Smith, 2010). In fact, Block (2004) mentioned that SSB consumption for both children and adults has shown a 500% increase between 1947 and 1999, and overtook milk consumption in the late 1990s. The age group which most frequently drinks SSB is adolescents aged 12-19 years. 70% of boys and 60% of girls drink SSB every day (Ogden, Kit, Carroll, & Park, 2012). Another result revealed that 65% of high school students in U.S. drank SSB at least once or more every day, and even 22% of adolescents drank SSB three times or more every day (Park et al., 2012).

According to CDC, 79% of middle and high schools in 27 states of U.S. offer school vending machines which sell sugar-sweetened beverages (SSB) (Kann, Grunbaum, McKenna, Wechsler, & Galuska, 2005). In addition, School Health Profiles 2010 (Brener et al., 2011) showed that over 50% of schools in West Virginia still permitted advertising and promotion of poor nutritional foods such as fast foods or sweetened beverages. Staten et al. (2005) mentioned that simply eliminating or decreasing the vending machines in schools may be the solution to decrease SSB, but it is not easy for schools to follow the solution because the profits from the vending machines are generally used to provide food service, club activities, or school events such as graduation ceremonies. For these reasons, school policies have improved, showing the

removal of vending machines and the prohibition of unhealthy foods in the school cafeteria, as well as offering nutrition education (Lucarelli et al., 2014).

Generally, poor eating behaviors in children and adolescents are influenced by their homes, schools, and communities (Glanz, Sallis, Saelens, & Frank, 2005). For example, students' accessibility to healthy foods at home affected less fat intake (Zive et al., 1998) and more fruits and vegetables consumption (Larson et al., 2008). However, many studies emphasized the importance of schools for good eating habits because 54% of students in U.S. ate school breakfast or lunch in 2004 (United States Department of Agriculture, 2007). Specifically, 47% of the calories required for a day are generally consumed during school hours (Briefel & Wilson, 2009). According to Hider (2001), one third of studies collecting data on environment-based interventions to reduce energy intake were school-based, which mean that schools are an important place for affecting children. Swinburn, Caterson, Seidell, and James (2004) introduced several elements to contribute to the school food environment: school food policies, teacher and staff training, offering recommendations for school food and drink choices, and health education. Among these elements, policy changes at school settings are considered as one of the important interventions to deal with the prevalence of obesity (Gostin, 2007). For example, a total of 34 states received legislation to restrict sale of foods and beverages based on Federal Government regulation (Jaime & Lock, 2009), so soda sales in high schools were steadily decreased from 53.6% in 2006–07 to 25.3% in 2010–11 (Terry-McElrath, Johnston, & O'Malley, 2012). West Virginia passed one of the most competitive foods standards laws in 1993. The standards emphasized not only the restriction of food or drinks that contains 40% or more sugar by weight, but the restriction of the increased vending machines and school events (Mello, Pomeranz, & Moran, 2008). West Virginia now prohibits the sale of soft drinks through vending machines,

school stores, or onsite fundraisers during the school day in areas accessible to students in elementary and middle or junior high schools. During the school day, these schools are permitted to sell only “healthy beverages,” defined as water, 100 percent fruit and vegetable juice, low-fat milk, and other juice beverages with at least 20 percent real juice. For high schools that permit the sale of soft drinks, the law also requires that “healthy beverages” must account for at least 50 percent of the total beverages offered and must be located near the vending machines containing soft drinks.

Food environments around a school are as important as schools to determine health behaviors. For example, Davis and Carpenter (2009) found that students ate less healthy food if fast-food restaurants were around the school. Schools cannot control the number of fast-food restaurants outside of schools. The barriers for students to obtain healthy foods were choice, price, time, and accessibility (McKinley et al., 2005). Before schools provide healthy foods in school canteens, they should encourage students to increase recognition of healthy foods. Installing and managing school gardens can be a good example to promote changing nutritional perception (Morris, Neustadter, & Zidenberg-Cherr, 2001). According to Morris and Zidenberg-Cherr (2002), nutritional education using school gardens increased students’ preference for vegetables and fruits, resulting in promoting fruit and vegetable intake. However, expensive equipment (Hesketh et al., 2005), unsafe facilities for physical activities (Cohen et al., 2006) and low support from parents (Baue, Yang, & Austin, 2004) were critical barriers to implementing school-based physical activity interventions. Additionally, the development of mass media has worsened eating behaviors in children and adolescents. Kotz and Story (1994) revealed that half of the advertisements such as television and radio were related to foods which are high in calories, salt, and sugar. Through the advertisements, young children were more

likely to acquire poor eating behaviors and wrong nutritional knowledge (Signorielli & Staples, 1997).

These poor school and home environments which increase the SSBs consumption have rapidly increased in the past few decades, particularly due to the access and affordability of sugar-sweetened beverages at fast-food restaurants (Han-Markey et al., 2012). Fast food intake is a key contributor to explain the prevalence of obesity because fast food mostly has poor quality nutrition, high calories, and much sodium (O'Donnell, Hoerr, Mendoza, & Goh, 2008). There are almost 38,000 fast food restaurants such as KFC and McDonalds throughout the world, contributing in no small part to the consumption of sodas which increased 12.6% between 1997 and 2007 (Pan et al., 2012). Even worse, the frequent fast-food restaurant visits with friends make students' health worse by drinking SSB at the restaurants (Wiecha, Finkelstein, Troped, Fragala, & Peterson, 2006). Individual eating behaviors such as fast-food restaurant visits are generally formed by friends because children's and adolescents' friendships play an important role in forming health behaviors (Gifford-Smith, Dodge, Dishion, & McCord, 2005). The reason the role of friends in adolescents cannot be overlooked is that lifelong eating patterns are formed during adolescence (Ilich & Brownbill, 2010). Fast food intake is also affected by the family dinner which is associated with healthy eating patterns (Gillman et al., 2000). Taveras et al. (2005) said that there was the positive relationship between eating family dinner and low fat intake because family members are able to become interested in other members' foods, resulting in their pursuing healthier foods as compared to habits of those eating alone.

Relationship between Health Outcomes and Obesity

Relationship between Physical Activity/Inactivity and Obesity. Physical activity is necessary for the normal growth of children. Many studies have emphasized the importance of physical activity because it helps prevent obesity and reduce high risks of cardiovascular diseases in children (Powell, Thompson, Caspersen, & Kendrick, 1987) and have revealed several findings: boys spent more time in physical activity than girls (Sherman & Ruiz, 2001) and obese and overweight children spent less time in physical activity and more time in sedentary behaviors than normal-weight counterparts (Janssen et al., 2005). It is clear that physical activity is positively associated with health, so recent physical activity guidelines specifically focus on time spent in physical activities, as well as frequency and intensity. For example, 2008 Physical Activity Guidelines for Americans recommended that youth participate in at least an hour of physical activity daily by following physical activities: an hour a day of moderate to vigorous intensity aerobic physical activity; an hour of muscle-strengthening physical activity on at least 3 days of the week; and an hour of bone-strengthening physical activity on at least 3 days a week. Despite nationally known guidelines, rapidly changing environments and limited school facilities contribute to the reduction of physical activities, resulting in obesity (U.S. Department of Health and Human services, 2008b).

Physical activity is mainly considered as one important factor causing obesity and has been studied for decades by researchers although the relationship between physical activity and energy expenditure directly affecting the development of obesity is still unclear (Cordain, Gotshall, Eaton, & Eaton, 1998; DeLany, Kelley, Hames, Jakicic, & Goodpaster, 2014; Reilly et al., 2004). For example, Maffeis, Zaffanello, Pinelli, and Schutz (1996) found that obese children (BMI > 97th percentile) spent 100 minutes a day less being physically active than non-obese

children. Laurson et al. (2008) found that children who did not meet physical activity recommendations were three or four times more likely to be overweight than children of normal weight. DeLany, Kelley, Hames, Jakicic, and Goodpaster (2013) found that individuals who spent less time in MVPA decreased energy expenditure and gained more weight than normal groups. Hughes, Henderson, Ortiz-Rodriguez, Artinou, and Reilly (2006) used accelerometers to measure physical activity level, and found that total activity time (counts/min.) in obese children (BMI > 98th percentile) was less 80 counts/min. than non-obese children. In contrast, Goran, Reynolds, and Lindquist (1999) found that the relationship between physical activity and obesity in cross-sectional design has been unclear because the amount of body fat is continually changing during the growing process. Also, the common assessments used for physical activity measurements are based on subjective forms (e.g., self-report and logs), which can have potential limitations affecting results. For this reason, Gazzaniga and Burns (1993) found that obese adolescents were more active than their counterparts. Also, some studies in cross-sectional design showed various results by gender: BMI was negatively related to physical activity in only boys (Ekelund et al., 2005) and only girls (Klein-Platat et al., 2005). Even so, some studies were interested in level of physical activity in family members, rather than the children themselves. For example, Fogelholm, Nuutinen, Pasanen, Myöhänen, and Säätelä (1999) found that high level of physical activity in a family positively influences their children's activity, resulting in preventing obesity because family members can be a good models to encourage their children to be active. These mixed results mean that researchers have to consider not only physical activity type, intensity, and time, but biological and social influences such as family background, simultaneously (H. Prentice-Dunn & S. Prentice-Dunn, 2012).

Relationship between Sedentary Behaviors and Obesity. Sedentary behaviors have been increasingly studied and are considered as an important risk factor for adolescent obesity. In particular, increased sedentary behaviors among children continued after they reach adolescence (Matthews et al., 2008). Robinson (1999) revealed that physical activity level was not increased after sedentary behavior decreased, which means that sedentary behaviors can be an independent factor in causing obesity. Many studies found that there was a positive correlation between sedentary behaviors such as screen time and obesity. For example, Sonnevile and Gortmaker (2008) found that an hour increase in television viewing increased 106 kcal per hour in total energy intake in adolescents. Specifically, Anderson, Economos, and Must (2008) found that overweight children spent more than 2 hours on screen time. Mitchell, Pate, Beets, and Nader (2013) observed that increased time spent in sedentary behaviors was associated with considerable increases in BMI from ages 9 to 15 years. In a birth cohort study from New Zealand (Hancox, Milne, & Poulton, 2004), researchers found that when children from ages 5 to 15 years spent additional an hour screen time per day, BMI was increased by 0.5 units at age 26 years. Graf et al. (2004) revealed that obese children spent 30% more time on screen time than other children. Also, Hu, Li, Colditz, Willett, & Manson (2003) found that those who spent over 40 hours per week in sitting were associated with increased BMI. Interestingly, Oliver, Schluter, Rush, Schofield, and Paterson (2011) found that watching television every day was associated with increased BMI, but the time spent in watching television was not related to BMI. Also, Davison, Marshall, and Birch (2006) found that there was no significant relationship between television viewing and BMI, but there was significant difference between them when the data were analyzed longitudinally. For such studies, some studies showed mixed results or a weak relationship between sedentary behaviors and obesity. Aires et al. (2010) used an

accelerometer to measure sedentary behaviors and found that there was no difference between overweight and other children. Kautiainen et al. (2005) found a weak relationship between increased time spent in playing computer and BMI. Therefore, Marshall, Biddle, Gorely, Cameron, and Murdey (2004) mentioned that sedentary behaviors are multifaceted and may not be accurately measured by one sedentary behavior such as television viewing.

Relationship between Nutrition and Obesity. Nutritional issues such as dietary factors and food habits are among the important factors relating to obesity in children and adolescents (Wang & Lobstein, 2006). In particular, the relationship between Sugar-Sweetened Beverages (SSB) consumption and weight gain has been studied. Ariza, Chen, Binns, and Christoffel (2004) found that 37% of non-obese children consumed soda at least one time a day, while 67% of obese children consumed soda at least one time a day. Giammattei, Blix, Marshak, Wollitzer, and Pettitt (2003) found that children who consumed soda more than 3 times a day had 4.4% more body fat than their counterparts. Woodward-Lopez, Kao, and Ritchie (2011) analyzed 56 observational studies and found that about 75% of all studies (longitudinal and cross-sectional) revealed the positive relationship between SSB and obesity. One longitudinal study conducted by Mozaffarian, Hao, Rimm, Willett, and Hu (2011) investigated 120,000 people for 20 years. They revealed that those who increased SSB consumption gained an extra pound every 4 years on average. Ludwig, Peterson, and Gortmaker (2001) found that the risk of being overweight increased 1.6 times for each additional SSB a day.

However, some studies still pointed out that the relationship between fruits/vegetables consumption and obesity remain unclear. Wang, Ge, and Popkin (2003) found that only one fourth of longitudinal studies showed inverse association between fruit/vegetable consumption and obesity. Gibson (2008) also found no significant association between BMI and SSB. Dietary

behaviors are multifaceted like sedentary behaviors, so it is hard to evaluate the association between BMI and dietary behaviors accurately. In particular, self-evaluation for measuring dietary behaviors is generally used, so more accurate evaluation systems to measure dietary behaviors should be developed and applied.

Relationship between Multi-Component and Obesity. The relationship between health behaviors and obesity has been studied a lot although personal characteristics (e.g., gender, age, or region) in each study were differently examined. In particular, physical activity, sedentary behaviors, and nutrition for behavior changes were emphasized by studies that focused on obesity prevention because there is good evidence that these behaviors are strongly associated with obesity and formed in the early life stages (Sanchez et al., 2007). Besides, many adolescents do not meet recommendations for physical activity, sedentary behaviors, and nutrition, so the importance of multiple health behaviors is continually growing (Hardy et al., 2012). Various studies examined combined patterns between physical activity, sedentary behaviors, and nutrition. Prochaska, Spring, and Nigg (2008) mentioned that interventions using multiple health behaviors may be more cost-effective and maximize the effect on obesity prevention. National Heart, Lung, and Blood Institute (2012) emphasized that a combination of increased physical activity, reduced sedentary behaviors, and improved eating behaviors should be required to decrease the risk of cardiovascular diseases as well as obesity. For example, sedentary-snacking pattern increased the risk of obesity (Gubbels et al., 2012) and high level of physical activity with healthy diet decreased the risk of obesity (Lioret, Touvier, Lafay, Volatier, & Maire, 2008). Iannotti and Wang (2013) found that students who meet recommendations for physical activity and sedentary behaviors consumed more vegetables and fruits than other students who do not meet recommendations. However, Leech, McNaughton, and Timperio (2014) revealed that

compared with studies using single intervention, studies dealing with multiple health interventions led to inconsistent findings and found that results varied due to age, gender, or personal characteristics. In fact, Iannotti and Wang (2013) mentioned that health minorities can be the potential contribution of obesity, affecting healthy patterns of physical activity, sedentary behaviors, and nutrition regardless of the effect of health-related interventions. Furthermore, there was also evidence that many studies using multiple health interventions assessed only one measure (e.g., minutes of physical activity) of each behavior, so it was hard to clearly determine the relationship between health behaviors and obesity (Yannakoulia, Ntalla, Papoutsakis, Farmaki, & Dedoussis, 2010).

All things considered, previous studies revealed that the factors affecting obesity may be different for different gender, age, areas, and investigation period, so various types of school-based obesity prevention studies have been documenting.

CHAPTER 3

METHODS

This study was based on the data of the Greenbrier CHOICES (Children's Health Opportunities Involving Coordinated Efforts in Schools) Project, funded by the Carol M. White Physical Education Program (PEP) grant from U.S. Department of Education in 2011. Using three-year data of physical activity, sedentary, and nutrition behaviors of adolescents in two middle schools from southern West Virginia, the current study examined: (a) the association between healthy weight (5th to less than the 85th BMI percentile) and physical activity, sedentary and nutrition behaviors and (b) whether physical activity, sedentary, and nutrition behaviors were affected by changes in adolescents' BMI across the three-year, multi-component, school-based efforts. Data for the Greenbrier CHOICES Project (2012-2014) were collected per collection period from over 300 middle school students aged 10 through 16. This chapter includes a description of the Greenbrier CHOICES Project, setting and sampling, data collection, instrumentation and variables, and methods of analysis for the current study.

Description of the Greenbrier CHOICES Project

Schools provide numerous opportunities for students to achieve health-related recommendations regarding amounts of physical activity and healthy eating (CDC, 2011b). In particular, reasons why many studies have recommended school-based interventions as the best place because students spend a lot of time in schools, the interventions in school settings are cost-effective, and it is easier to receive permission from students' parents than in out-of-school settings (Karnik & Kanekar, 2012). In addition, school-based interventions can be applied consistently, making it possible for schools to not only develop interventions based on the

changes of student behavior, but to overcome environmental barriers inside and outside of schools (Kriemler et al., 2011).

The purpose of Greenbrier CHOICES Project was to develop, implement, and evaluate an integrated approach for adolescent health using complimentary intervention strategies and settings (schools, communities, and health care). The Greenbrier CHOICES Project had a total of 13 data collection periods including a baseline from 2012 to 2014. This project team measured progress toward adolescents' physical activity, nutrition, and health-related fitness using multiple methods such as seven-day, 24 hours a day pedometer, 3 Day Physical Activity Recall (3DPAR), School Physical Activity and Nutrition (SPAN), and Progressive Cardiovascular Endurance Run (PACER). However, the data acquired seven-day pedometer was not used in this study because the project team recognized that students did not comply with the guideline. For example, there were missing data during seven days, so it was not enough to receive reliable data from students. Also, it failed to control pedometer wear after school.

The school component focused on the development of a standards-based, middle school curriculum in health and physical education (PE) that included frequent opportunities for PA before, during, and after school (see Appendix A). The community component complimented school health and PE through the identification of available resources, formation of collaborative partnerships, and initiation of joint-access agreements regarding facility and equipment use. The health care component provided a mechanism for monitoring risk of chronic disease and provided families with prevention and treatment strategies according to standardized national protocol. This study is used as a secondary data analysis in Greenbrier CHOICES Project.

Setting and Sampling

The setting of the Greenbrier CHOICES Project included two middle schools from Greenbrier County in West Virginia. Greenbrier County is the second largest county in West Virginia by geographic area. Over 5,000 children in this county are enrolled in public schools. Although agriculture has been a main industry in this county, some population growth and industrial development are causing significant changes (West Virginia Department of Agriculture, 2014). Figure 2 indicates Greenbrier County in WV where there are two middle schools for the Greenbrier CHOICES Project in 2012-2014.

Figure 2. Greenbrier County in West Virginia (Retrieved from <http://wvpublic.org/post/truck-explodes-greenbrier-county>)

Participants for the Greenbrier CHOICES Project were recruited from the two public middle schools in Greenbrier County, West Virginia. Approximately 30% of the eligible participants were randomly selected each collection period from a master list for the Greenbrier CHOICES Project. A total of 1,864 10-16 year-old adolescents participated in the Greenbrier CHOICES Project, with a total of 4,621 observations in 2012-2014. Among the 1,864 students, there were 1,620 students (86.9%), with a total of 3,263 observation, who provided at least one piece of information (e.g., BMI, PA, sedentary behavior, or nutrition behavior), while 195 students (10.5%) did not provide any information and 49 (2.6%) students provided incorrect

information (e.g., out of range answers). Table 2 shows the number of participants included in this study.

Table 2

Number of Participants for This Study in 2012-2014

School year														
Year 1					Year 2					Year 3				Total
Collection	1	2**	3	4	5	6**	7	8	9	10**	11	12	13	
Period														
Date	2/22	3/21	4/08	5/09	9/27	10/07	02/13	3/20	4/17	9/25	11/20	3/27	4/09	
	/12	/12	/12	/12	/12	/12	/13	/13	/13	/13	/13	/14	/14	
Observation	364	364	364	360	368	313	356	356	352	355	349	360	360	4621
Valid Obs	272	283	215	144	47	213	276	305	291	314	295	298	310	3263
														1620*

Note. * Primary case (Unique Adolescents), ** BMI done on all children, assigned to collection periods 2, 6, and 10

Data Collection

The data used for this study were collected during 2012-2014 school years. If selected, adolescents in each grade level (6, 7, and 8th grade) gathered in the school gym for evaluation at the appointed time. Students filled in the School Physical Activity and Nutrition Questionnaire (SPAN) survey under Greenbrier CHOICES Project members' supervision. Those who finished the SPAN then filled in the 3 Day Physical Activity Recall (3DPAR). The school teacher and Greenbrier CHOICES Project members not only encouraged students to finish the 3DPAR, and helped them fill in the 3DPAR correctly. After students completed SPAN and 3DPAR, about 10-15 students completed the 20 meter PACER test under controlled conditions which was developed by Fitnessgram and the Cooper Institute. Peer students observed and recorded the PACER laps conducted. During the PACER test, school teachers and instructors did not actively intervene in the test.

Instruments and Variables

Instruments. The 3 Day Physical Activity Recall (3DPAR), School Physical Activity and Nutrition Questionnaire (SPAN), and Progressive Cardiovascular Endurance Run (PACER) were used to measure physical activity, sedentary, and nutrition behaviors at multiple time points. Table 3 specifically shows variables and instruments for this study.

Table 3

Instruments and Variables

Construct	Concept	Instrument	Variables
Health Behaviors	Physical Activity	3-Day Physical Activity Recall (3DPAR)	Total minutes spent in PA and MVPA: -Minutes spent in lifestyle activities -Minutes spent in aerobic activities -Minutes spent in aerobic sports -Minutes spent in muscular activities -Minutes spent in flexibility activities
		Progressive Cardiovascular Endurance Run (PACER)	Total laps for 20-meter distance
	Sedentary Behaviors	3-Day Physical Activity Recall (3DPAR)	Total minutes spent in Sedentary Behaviors: -Minutes spent in school(home)work: -Minutes spent in video or computer -Minutes spent in eating and resting
Health Outcome	Nutrition	School Physical Activity and Nutrition (SPAN)	Total servings of fruits and vegetables:
	Obesity	CARDIAC school-based health screening	BMI Percentile Healthy Weight (5 th percentile to less than the 85 th percentile)
	Demographics	WVEIS school database	Gender Grade
Adolescents' Characteristics	Personal Information	Greenbrier CHOICES data	Year

3 Day Physical Activity Recall. The 3DPAR is a self-report developed by Pate et al. (2003), and based on the Previous Day Physical Activity Recall (PDPAR) (Weston et al., 1997). The PDPAR includes 59 activities, 4 different intensities, and 34 blocks of time (30 minutes per block) from 7am to midnight. The 3DPAR (Pate et al., 2003) added 11 activities based on the PDPAR. The 3DPAR was developed by 3DPAR Fitness Activitygram (The Cooper Institute, 2010) and included: 30 activities, 4 different intensities, and 32 blocks of time from 7 a.m. to 11 p.m. The new 3DPAR has collapsed activities into certain groupings to reduce length and redundancy. Table 4 represents the comparison between the PDPAR, 3DPAR, and 3DPAR Fitness Activitygram. This study used 3DPAR Fitness Activitygram for measuring physical activity and sedentary behavior.

Table 4

Comparison between the PDPAR, 3DPAR, and 3DPAR Fitness Activitygram

	PDPAR	3DPAR	3DPAR Fitness Activitygram
The number of activities	59	70	30
The number of blocks	34 (7am-midnight)	34 (7am-midnight)	32 (7am-11pm)
The number of intensities	4 (Light, Moderate, Hard, Very Hard)	4 (Light, Moderate, Hard, Very Hard)	4 (Rest, Light, Moderate, Vigorous)

For accurate measurement, each day was segmented into 32 30-minute time blocks, and performed activities were grouped into 30 categories (25 physical activities, 5 sedentary behaviors). Specifically, the 3DPAR was divided into two steps. Step 1 was to determine the primary activity students participated in during each 30-minute interval. Among 30 different

activities, students entered the related number in the Activity column. Step 2 was to circle an intensity level that best describes how hard the activity felt in the intensity column (Rest: "Resting", such as sleeping; Light: "Easy"; Moderate: "Not too tiring"; Vigorous: "Very tiring") (see Appendix B).

Progressive Cardiovascular Endurance Run. The PACER test, a 20-meter shuttle run, developed by the Cooper Institute (2010) was used to measure aerobic capacity. The 20-meter PACER is an aerobic capacity test within the Fitnessgram's™ battery of physical fitness tests. Fitnessgram™ is a valid and reliable assessment to determine muscle fitness, aerobic capacity, and body composition (Welk, Morrow, & Falls, 2002). The PACER is scored by the number of completed laps. Completed PACER laps are recorded by an observer on designed scoring sheets. A single score is assigned to participants based upon the number of PACER laps completed (see Appendix C). The recorded score is the total number of laps completed by participants.

School Physical Activity and Nutrition Questionnaire. The SPAN is a self-report which addresses school physical activity and nutrition, and is based on School-Based Nutrition Monitoring (SBNM) questionnaire developed by Hoelscher et al. (2003). The SPAN choice options were modified by the Greenbrier CHOICES Project team in year 2, and included 16 questions: 11 nutrition-related questions, 3 physical activity-related questions, and 2 sedentary behavior-related questions (see Appendix D). Five of the questions in the SPAN were used for the current study (Table 5).

Table 5

SPAN Questions in this study

Category	Questions	Response Options
Vegetables/ Fruits	1. How many times did you eat any orange vegetables like carrots, squash, or sweet potatoes?	
	2. How many times did you eat a salad made with lettuce, or any green vegetables like spinach, green beans, broccoli, or other greens?	a) 0 time b) 1 time
	3. How many times did you eat any other vegetables like peppers, tomatoes, zucchini, asparagus, cabbage, cauliflower, cucumbers, mushrooms, eggplant, celery or artichokes?	c) 2 times d) 3 times e) 4 or more times
	4. How many times did you eat fruit?	
	5. How many times did you drink 100% fruit juice?	

Variables. Physical activity, sedentary behaviors, nutrition, obesity, and adolescents' characteristics were main variables for this study.

Physical Activity. As measured by the 3DPAR, *physical activity* was defined as total minutes spent in physical activities in the category of 3DPAR. The activities included lifestyle activity, aerobic activity, aerobic sport, muscular activity, and flexibility activity. According to intensity level, this study included total time in physical activity well as in MVPA. To obtain the total minutes of PA, the time spent for three days in those activities was summed. Then, the average minutes per day were calculated and included: the hours spent during school days and the hours spent during non-school days. Recommendations from the Physical Activity Guidelines Advisory Committee (2008), and WHO (2010b) are 60 minutes of MVPA daily. Possible range for total hours per day spent in physical activity was 0 to 16 because the 3DPAR instrument only included 16 hours (7am to 11pm).

The PACER test was also used to support physical activity. The PACER test consisted of running a 20-meter shuttle run with 1-minute paced stages at an initial running speed of

8.5km/h with an increasing speed of 0.5km/h per stage (Leger, Mercier, Gadoury, & Lambert, 1988). For ease in administration, it is acceptable to count the first miss (not making it to the line by the beep).

Sedentary Behaviors. As measured by the 3DPAR, *sedentary behaviors* were defined as total minutes spent in non-activity, and were summed time of three activities in 3DPAR which include: schoolwork, homework, or reading; computer games or TV/videos; and eating, resting, listening to music, riding bus. As one of the sedentary behaviors, sleeping time in 3DPAR was removed because the 3DPAR only included time range between 7am and 11pm, so it could not measure correctly unless participants slept before 11pm on wake up after 7am. The possible range for total hours per day spent in sedentary behaviors was 0 to 16.

Nutrition. As measured by the SPAN questionnaire, *nutrition* was defined as the total servings of fruits and vegetables reported within the past day. Participants were asked to respond to the following 5 questions: “How many times did you eat any orange vegetables like carrots, squash, or sweet potatoes?”, “How many times did you eat a salad made with lettuce, or any green vegetables like spinach, green beans, broccoli, or other greens?”, “How many times did you eat any other vegetables like peppers, tomatoes, zucchini, asparagus, cabbage, cauliflower, cucumbers, mushrooms, eggplant, celery or artichokes?”, “How many times did you eat fruit?”, and “How many times did you drink 100% fruit juice?”. As indicated by Table 6, participants responded by circling an answer from 0 to 5 times. However, the answer choices in the 2012 SPAN were between “0-1 time,” “2 times,” “3 times,” “4 times,” and “5 or more times.”, while the answer in 2013-2014 SPAN was selected between “0 time,” “1 times,” “2 times,” “3 times,” and “4 or more times.” Therefore, coding for each answer was adjusted by experts (Table 6). Recommendations from the 2010 Dietary Guidelines for Americans (U.S.

Department of Agriculture and U.S. Department of Health and Human Services, 2010) and CDC (2005) are 5 servings of fruits and vegetables daily for healthy eating. The possible range for nutrition was 2.5 to 27.5.

Table 6

Adjusted Answer for Nutrition Questions in SPAN

2012		2013-2014	
Original Answer	Adjusted Answer	Original Answer	Adjusted Answer
0-1 times	0.5 times	0 time	0.5 times
2 times	2 times	1 time	0.5 times
3 times	3 times	2 times	2 times
4 times	4 times	3 times	3 times
5 or more times	5.5 times	4 or more times	4.5 times

Obesity. For research question 1, the healthy weight variable categorized by BMI percentile was used to explain relationship between physical activity, sedentary, and nutrition behaviors. For research question 2, the BMI percentile variable was used to explain changes in physical activity, sedentary, and nutrition behaviors over time associated with changes over time. Although determining health problems caused by the excess weight needs additional assessments such as skinfold thickness measurements, family history, or eating behaviors, the results of BMI can predict people's potential health problems (Garrow & Webster, 1985).

Therefore, BMI for this study was used as the prediction of possible weight problems such as physical activity, sedentary behavior, and nutrition for students. BMI is generally defined as measurement to determine possible weight problems (Mei et al., 2002). BMI measurements for this study were provided from WV Coronary Artery Risk Detection in Appalachian Communities (CARDIAC) school-based health screening and measured as weight (kg) divided by squared height (meters). Based on individual BMI, BMI percentiles were used for this study

because not only does the amount of body fat differ between genders, but amount of body fat changes with age. Therefore, BMI percentiles were calculated by CDC BMI-for-age growth charts (CDC, 2009) after BMI is measured. Based on BMI percentile, this study used the categorized BMI groups suggested by CDC (2015) (Table 7).

Table 7

Categorized BMI groups

Weight Status Category	Percentile Range
Underweight	Less than the 5 th percentile
Healthy Weight	5 th percentile to less than the 85 th percentile
Overweight	85 th percentile to less than the 95 th percentile
Obese	Equal to or greater than the 95 th percentile

Note. Data for categorized BMI groups from CDC (2015)

Adolescents' Characteristics. Three characteristics were considered for this variable, and included demographics and personal information. Gender and grade were collected from individuals through self-report. As for gender, boys were coded as "M" and girls as "F". Similarly, as for grade, 6th grade was coded as "6", 7th grade as "7", and 8th grade as "8". Also, time (year) was included as personal information variable. If collection period was ranged from 1 to 4, it was coded as "1", collection period from 5 to 9 as "2", collection period from 10 to 13 as "3".

Methods of Analysis

Howell (2013) suggested types of data, differences versus relationships, and number of groups or variables as three standards to select appropriate statistical procedures. Considering these standards and all assumptions, this study had two main research analyses: a logistic

regression and linear mixed model. All data were analyzed using the SAS program (version: 9.4).

This study was based on a planned missing data design (PMDD) to reduce missing data by randomly selecting 30% of participants in master list each collection period. PMDDs have become more universal in recent years (Plamer & Royall, 2010). The purpose of using this design is to decrease missing not at random (MNAR), by allowing missing completely at random (MCAR) or missing at random (MAR) assumptions to stay true (Baraldi & Enders, 2010). This design did not require any students to complete all evaluation periods. Participants who opted out of the Greenbrier CHOICES Project during collection periods were removed from the master list for the next collection period. Since the data for this study included total 13 collection periods in 2012-2014, there were some participants who were entering or leaving the targeted middle schools during 13 collection periods. Therefore, the data for each participant could range from one to eight times of participation because of the use of PMDDs. In other words, PMDDs do not require all students to complete all measures.

The analysis section is divided into 2 sections that outline the statistical analyses used in each research question. Descriptive statistics, such as mean and standard deviation of continuous variables, and frequency and percentage of dichotomous variables, were provided. Table 8 represents predictors, outcomes, and type of analysis used for each research question.

Table 8

Summary of Analyses by Research Question

Research question	Predictors	Outcomes	Type of analysis
Question 1	Physical activity, sedentary behaviors, nutrition, and personal information	Healthy weight	Logistic regression
Question 2	BMI percentiles and personal information	Physical activity, sedentary behaviors, and nutrition	Linear mixed model

Research Question 1: Are physical activity, sedentary, and nutrition behaviors in middle school students associated with BMI?

Logistic Regression was used to explain the relationship between variables for research question 1 in this study. The purpose of logistic regression is to measure the probability that a particular event will occur through the relationship between independent and dependent variables. The dependent variable should be binary (e.g., meeting or not meeting guideline) or ordinal (e.g., extreme, normal, or light). Logistic regression is generally used in many application areas such as health-related research (Healy, 2006). Logistic regression is recommended when assumptions are violated (Healy, 2006). Compared to other analyses, logistic regression is less restrictive in terms of required assumptions. Although normal distribution and homogeneity of variance are not required (Anderson, 1982), three assumptions are required and were met; dependent variable is on a dichotomous scale; variables have independence of observations and have mutually exhaustive category; and the Hosmer-Lemeshow test is performed to assess the model fit. The model used in this study was acceptable because a p-value was greater than 0.05.

Specifically, logistic regression was used to determine whether a statistically significant relationship existed between independent variables (physical activity, sedentary behavior, and

nutrition) and the dependent variable (healthy weight) after controlling for the influence of covariates (gender, grade, and year). If healthy weight was met, it was coded to 1. If the requirement was not met, it was coded to 0. As a dependent variable, healthy weight was defined as BMI from 5th percentile to less than the 85th percentile provided from CDC (2015). Independent variables are physical activity (total minutes spent in MVPA), sedentary behavior (total minutes spent in screen time), and nutrition (total servings of fruits and vegetables). For this research question, the first observation of each participant was selected. Therefore, the number of participants for this research question is 1,620 middle school students who had at least one or more opt-in of Greenbrier CHOICES project between 2012 and 2014 (Table 2).

Research Question 2: Are changes in physical activity, sedentary behavior, and nutrition over time associated with changes in BMI percentile over time controlling for grade and gender?

Linear mixed model (LMM) was another analysis technique for research question 2 in this study. LMM develops the linear model, and includes random effects as well as fixed effects in the linear predictors (McCulloch & Neuhaus, 2001). LMM is generally used for the physical, biological and social sciences (Ghodsypour & O'Brien, 1998), and is also useful in longitudinal studies where repeated measurements are made on the same statistical units (Laird, 1988). LMM includes continuous outcome variables (e.g., physical activity, sedentary behavior, and nutrition) in which residuals are normally distributed.

One advantage of LMM is that it allows for subjects with unequal measurements over time, so this model is appropriate for this study with missing data. Missing data are a common problem in a longitudinal study because of randomly selected participants or refusal to fill out surveys. Although missing data is not a rare problem, it can lead to biased statistical inferences. Therefore, it is important to suggest the appropriate method to deal with missing data. Dropping

missing values by using listwise or pairwise may be not preferred because these techniques decrease sample size. This study is based on planned missing data design, which allow two types [missing completely at random (MCAR) and missing at random (MAR)] of missing data. Missing data techniques based on planned missing data design are Full Information Maximum Likelihood (FIML) (Enders, 2001), Restricted Maximum Likelihood (REML) (Thompson & Sharp, 1999), Ignorable Likelihood (IL) (Little & Raghunathan, 1999), and Multiple Imputation (MI). These techniques for the fitting of linear mixed models can improve the power of lost data, reduce error inflation, and avoid bias (Graham, 2009). This study used REML, which is the most common method of estimating covariance parameters (Gurka, 2006). REML is one of the most common methods, especially as alternative to maximum likelihood (ML), to deal with missing data (MAR and MCAR) in mixed model treating time (Hox & Roberts, 2011). In addition, the REML can deal with the bias from the ML which cannot account for the degrees of freedom lost by the fixed effects (West, Welch, & Galecki, 2014). The Best Linear Unbiased Prediction (BLUP) was also used for the estimation of random effects. The use of LMM with BLUP function is distinguished from conventional linear model provides the ability to estimate random effects. Therefore, BLUP is not only a technique to estimate random effects, but is unbiased and has minimal mean squared errors (Robinson, 1991).

LMM is a statistical technique that is developed from a standard regression model. A standard regression model assumes that a continuous outcome variable Y can be analyzed by one or more predictor variables of X (equation 1).

$$Y = X\beta + e \text{ (Equation 1),}$$

where Y is a dependent variable for a subject, X is an independent variable for a subject, β is a regression coefficient for independent variable X , and e is an error for a subject (Nelder &

Wedderburn, 1972). The error term e not only is assumed to be independent and to vary randomly, but follows normal distribution with mean of $[N(0, \sigma^2)]$. However, longitudinal data violate the independence assumption for error variance because observations within a subject are correlated over time. Therefore, a linear mixed model breaks the error term based on equation (1) by forming random effects in addition to the fixed effects β . Finally, equation (2) based on equation (1) can be suggested:

$$Y = X\beta + Z\gamma + e^* \text{ (Equation 2),}$$

where Y , $X\beta$, $Z\gamma$, and e denotes respectively the n -dimensional response vector, the fixed components (X : $n \times p_0$ fixed effects design matrix and β : p_0 -dimensional vector of fixed effects parameters), random components (Z : $n \times m$ random effects design matrix and γ : m -dimensional random effects vectors), and the error term (Verbeke & Molenderghs, 2009). For this study with longitudinal data, a typical Z covariate would be each subject. In other words, an effect of subject (correlation over time) clarifies part of the variability of Y . However, this subject effect is considered as random because subjects are a sample randomly selected from all possible subjects, and each individual subject effect is not the research interest. Thus, subject effect is to be adjusted in LMM.

$$Y = \beta_0 + X\beta^* + Z\gamma^* + e^{**} \text{ (Equation 3),}$$

where $\beta_0 + X\beta^*$ means a fixed effect (β_0 : intercept of population) and $Z\gamma^* + e^{**}$ means a random effect. Fixed effects are the independent covariates (e.g., BMI) in LMM, and are population slopes for a set of considered covariates, while the random effects are quantitative variable whose levels are randomly sampled from individual experimental units in outcome and in changes over time (Gelman, 2005). For this research question, fixed effects were BMI, gender, and grade, while a random effect was the year. Random effects were used to model between-

subject variation and the correlation generated by this variation. Among two forms of LMMs, random intercept and slope models explain subjects having different slopes (e.g., not all students had the same year point). Thus, equation (3) was used for research question 2.

LMM assumes that the covariance structure is correctly specified. The structure of the covariance matrix is employed to determine the assumptions about the repeated measures error covariance, with different assumptions influencing the calculation of estimates, and generally includes autoregressive [AR (1)], compound symmetry (CS), unstructured (UN), toeplitz (TOEP), etc. According to Littell, Stroup, Milliken, Wolfinger, & Schabenberger (2006), it is recommended that determining the appropriate structure of covariance should be conducted before conducting LMM, and the determination can be found by comparing the Akaike Information Criterion (AIC) (Akaike, 1974), and Schwarz Bayesian Criterion (BIC) (Schwarz, 1978) values as information criteria for model selection. Both criteria are based on various assumptions and asymptotic approximations. AIC means a model is considered to be closer to the truth, while BIC means that a model is considered to be more likely to be the true model. Also, the penalty for additional parameters is more in BIC than AIC. Generally, the most common structure of the covariance is UN, and BIC is more preferred than AIC as information criteria for model selection. The current study fitted models repeatedly using AR, CS, UN, and TOEP covariance structure. Then fit statistics were measured and we found that UN was the most appropriate covariance structure in this model because UN had the lowest BIC. Finally, the results shown in this study came from UN covariance structure.

The three key assumptions for the standard linear mixed model are suggested (Gelman & Hill, 2006; Tabachnick & Fidell, 2013), and were examined to ensure satisfaction of assumptions. The assumptions include: 1) linearity for each variable, 2) absence of collinearity,

and 3) homoscedasticity of the error. The changes in physical activity, sedentary behavior, and nutrition were measured using the MIXED procedures of SAS (version 9.4).

Among 1,620 students with 3,263 observations, 668 students with 668 observations were removed because the students who participated only once were not available for analysis of linear mixed model. Therefore, a total 952 students who had participated two or more times with 2,595 observations were selected for this research question.

CHAPTER 4

RESULTS

Description of Population

There were 3,263 observations for this study. Among them, the first valid data for each subject was used for the description of population because 3,263 observations included same subjects repeatedly. Therefore, a total of 1,620 students who provided BMI and at least one piece of information (e.g., BMI, physical activity, sedentary behavior, or nutrition behavior) at two middle schools were used for the description of population. These participants comprised 51 percent girls and 49 percent boys. 37 percent were 6th grade, 33 percent were 7th grade, and 30 percent 8th grade. Lastly, participants in Eastern Greenbrier middle school were 74 percent and participants in Western Greenbrier middle school were 26 percent (Table 9).

Table 9

Gender, Grade, and School of the Sample

	N	%
Gender		
Girls	833	51.4
Boys	787	48.6
Grade		
6 th	602	37.2
7 th	533	32.9
8 th	485	29.9
School		
Eastern Greenbrier	1196	73.8
Western Greenbrier	424	26.2

About 34% of subjects were gathered in Year 1, 29% of subjects in Year 2, and 39% of subjects in Year 3 (Table 10). The total number of subjects between collection periods greatly differed because the first valid data of each subject were randomly included at least collection period. That is, the data for the description of the population only included the first valid data point of each subject, not all observations.

Table 10

Frequency and Percentage at Each Collection Period

		N (1,620)	%
Year1	Collection Period 1	173	10.7
	Collection Period 2	174	10.8
	Collection Period 3	128	7.9
	Collection Period 4	72	4.4
	Total (Year 1)	547	33.8
Year2	Collection Period 5	23	1.4
	Collection Period 6	69	4.3
	Collection Period 7	134	8.3
	Collection Period 8	78	4.8
	Collection Period 9	134	8.1
	Total (Year 2)	438	28.9
Year3	Collection Period 10	152	9.4
	Collection Period 11	142	8.8
	Collection Period 12	168	10.4
	Collection Period 13	173	10.7
	Total (Year 3)	635	39.3

Physical characteristics of the sample are presented in Table 11. The average age was 13.08 ± 1 year old. The mean BMI percentile was approximately the 70th percentage for both girls and boys. Based on individual BMI percentile, the healthy weight (BMI 5th percentile to less than the 85th percentile) was approximately 57 percent for girls and 51 percent for boys. Although the average of BMI for girls and boys did not differ, the percentage of healthy weight between girls (57.07%) and boys (50.98%) was different.

Table 11

Physical Characteristics of the Sample

	Total (n=1,620)		Girls (n=833)	Boys (n=787)
	Mean (SD)	Min-Max	Mean (SD)	Mean (SD)
Age (yrs)	13.08 (.98)	10.66-16.22	12.99 (.95)	13.18 (1)
Height (inches)	62.48 (3.73)	51-72.75	62.01 (3.13)	62.95 (4.21)
Weight (lb)	127.51 (36.91)	66-329	126.43 (34.78)	128.59 (38.98)
BMI (kg/m ²)	22.75 (5.37)	15.07-45.56	22.97 (5.53)	22.52 (5.2)
BMI Percentile	70.98 (27.38)	2.23-99.82	71.23 (25.75)	70.71 (28.99)
Healthy Weight (%)	54.03%		57.07%	50.98%

Means and standard deviations of physical activity, sedentary behaviors, and nutrition by gender are presented in Table 12. Boys spent 15-20 minutes more in daily physical activity than girls. The average of total minutes in MVPA showed 20-25 minutes difference between gender (boys > girls) regardless of whether it was on a weekday or weekend. Also, although girls had a higher average of total minutes in sedentary behaviors, boys spent 30-40 minutes more on screen time. Girls and boys both consumed fruits and vegetables approximately 6-7 times a day.

Table 12

Physical Activity, Sedentary Behaviors, and Nutrition at Gender (N=1,620)

	Girls (n=833)	Boys (n=787)
	Mean (SD)	Mean (SD)
Physical Activity (hour/day)		
Total PA	4.86 (2.93)	5.13 (3.39)
Weekday	4.28 (3.23)	4.56 (3.67)
Weekend	6.32 (3.58)	6.56 (4.11)
Total MVPA	2.02 (1.9)	2.38 (2.28)
Weekday	1.76 (1.94)	2.03 (2.28)
Weekend	2.66 (2.74)	3.25 (3.31)
PACER Laps	19.52(12.22)	29.52(19.11)
Sedentary Behaviors (hour/day)		
Total SD	8.98 (3.03)	8.71 (3.57)
School(Home)-Work	4.62 (2.32)	4.37 (2.55)
Computer/TV	1.1 (1.33)	1.68 (2.01)
Eating/Resting	2.39 (1.85)	1.93 (1.81)
Other	.87 (1.33)	.74 (1.39)
Nutrition (consumption/day)		
Total Fruits/Vegetables	6.02 (3.64)	6.76 (4.22)
Orange Vegetables	.87 (.92)	.97 (.99)
Salad	.94 (.89)	1.02 (1.07)
Other Vegetables	1.12 (1.07)	1.28 (1.26)
Fruit	1.9 (1.36)	2.05 (1.53)
100% Fruit Juice	1.22 (1.2)	1.46 (1.47)

Means and standard deviation of physical activity, sedentary behaviors, and nutrition by grade are presented in Table 13. The average of total minutes in physical activity did not differ

between 6th, 7th, and 8th grade, while the average of total hours in moderate-vigorous physical activity decreased as students got older (6th: 2.38 hours; 8th: 2.12 hours). The average of total hours in sedentary behaviors was no different between each grade (6th: 8.79 hours; 8th: 8.91 hours). Among sedentary behaviors, time spent in screen time increased as students got older (6th: 1.29 hours; 8th: 1.43 hours). However, time spent in eating/resting decreased as students got older (6th: 2.23 hours; 8th: 2.06 hours). In nutrition, total consumption of vegetables and fruits did not differ between 6th, 7th, and 8th grade.

Means and standard deviation of physical activity, sedentary behaviors, and nutrition at each time point (year) are presented in Table 14. The average of total hours in physical activity increased from year 1 (4.87 hours) to year 3 (5 hours) and the average of total hours in MVPA also increased from year 1 (1.67 hours) to year 3 (2.45 hours). Both the average of total minutes in physical activity and in MVPA increased from year 1 to year 3. In particular, the average of total minutes in physical activity and in MVPA for the weekend rapidly from year 1 to year 3 (PA: 50-60 mins; MVPA: 100-110 mins). In contrast, the average of total minutes in sedentary behaviors showed no difference between years 1, 2, and 3. In nutrition, total consumption of vegetables and fruits decreased from year 1 (7.93 times) to year 3 (5.53 times).

Table 13

Physical Activity, Sedentary Behaviors, and Nutrition at Grade

	6 th (n=602)	7 th (n=533)	8 th (n=485)
	Mean (SD)	Mean (SD)	Mean (SD)
Physical Activity (hour/day)			
Total PA	5.06 (3.13)	4.96 (3.17)	4.93 (3.2)
Weekday	4.44 (3.47)	4.4 (3.44)	4.4 (3.43)
Weekend	6.62 (3.69)	6.38 (3.91)	6.26 (3.93)
Total MVPA	2.38 (2.11)	2.04 (1.97)	2.12 (2.2)
Weekday	1.97 (2.12)	1.8 (2.04)	1.88 (2.17)
Weekend	3.39 (3.08)	2.64 (2.77)	2.72 (3.21)
PACER Laps	24.66 (14.97)	24.32 (16.87)	25.31 (19.64)
Sedentary Behaviors (hour/day)			
Total SD	8.79 (3.27)	8.91 (3.28)	8.87 (3.35)
School(Home)-Work	4.44 (2.46)	4.55 (2.35)	4.53 (2.5)
Computer/TV	1.29 (1.56)	1.41 (1.84)	1.43 (1.75)
Eating/Resting	2.23 (1.88)	2.2 (1.85)	2.06 (1.8)
Other	.82 (1.42)	.75 (1.21)	.85 (1.44)
Nutrition (consumption/day)			
Total Fruits/Vegetables	6.51 (4.02)	6.29 (3.76)	6.29 (4.05)
Orange Vegetables	.9 (.94)	.91 (.95)	.94 (.98)
Salad	.96 (.97)	.96 (.95)	1.02 (1.02)
Other Vegetables	1.22 (1.19)	1.17 (1.12)	1.18 (1.18)
Fruit	2.04 (1.5)	1.99 (1.44)	1.87 (1.38)
100% Fruit Juice	1.39 (1.43)	1.3 (1.28)	1.3 (1.27)

Table 14

Physical Activity, Sedentary Behaviors, and Nutrition at Year

	Year 1 (n=547)	Year 2 (n=438)	Year 3 (n=635)
	Mean (SD)	Mean (SD)	Mean (SD)
Physical Activity (hour/day)			
Total PA	4.87 (2.89)	5.12 (3.38)	5 (3.23)
Weekday	4.48 (3.1)	4.49 (3.66)	4.31 (3.57)
Weekend	5.85 (3.78)	6.7 (4.06)	6.74 (3.7)
Total MVPA	1.67 (1.88)	2.43 (2.17)	2.45 (2.14)
Weekday	1.63 (1.98)	2.05 (2.22)	2 (2.13)
Weekend	1.79 (2.44)	3.39 (3.19)	3.59 (3.11)
PACER Laps	26.12 (15.71)	22.92 (16.83)	24.81 (17.59)
Sedentary Behaviors (hour/day)			
Total SD	8.82 (3.21)	8.75 (3.34)	8.94 (3.35)
School/Home-Work	4.44 (2.48)	4.29 (2.45)	4.67 (2.38)
Computer/TV	1.5 (1.73)	1.38 (1.71)	1.27 (1.69)
Eating/Resting	1.96 (1.72)	2.3 (1.94)	2.27 (1.87)
Other	.92 (1.3)	.79 (1.45)	.73 (1.34)
Nutrition (consumption/day)			
Total Fruits/Vegetables	7.93 (4.27)	5.63 (3.55)	5.53 (3.48)
Orange Vegetables	1.11 (1.13)	.84 (.89)	.79 (.79)
Salad	1.19 (1.1)	.88 (.93)	.86 (.86)
Other Vegetables	1.5 (1.34)	1 (1.02)	1.05 (1.03)
Fruit	2.35 (1.46)	1.76 (1.43)	1.79 (1.37)
100% Fruit Juice	1.79 (1.53)	1.17 (1.18)	1.04 (1.13)

Table 15 represents number of observations on the activity log in 3DPAR. The total minutes spent in lifestyle activities such as housework or walking were 2 hours and 51 minutes, while 37 minutes were spent on muscular activity, 23 minutes on aerobic activity, and 24

minutes on flexibility activity. Among physical activity types, 1 hour and 5 minutes spent in aerobic sports such as field sport (baseball, softball, football, or soccer) were the highest.

Table 15

Activity Log in 3DPAR (7am to 11pm)

	N	%	Mins per day
Lifestyle Activity			
Walking, bicycling, or skateboarding for transportation	8350	6.72	65
Housework or yard work	4389	3.53	34
Playing active games or dancing	2978	2.4	23
Work- active job	2212	1.78	17
Other	4213	3.39	32
Total	22142	17.83	171
Aerobic Activity			
Aerobic dance activity	598	0.48	5
Aerobic gym equipment	348	0.28	3
Aerobic activity	1098	0.88	8
Aerobic activity in physical education	298	0.24	2
Other	628	0.51	5
Total	2970	2.39	23
Aerobic Sport			
Field sports	4328	3.48	33
Court sports	2149	1.73	17
Racket sports	236	0.19	2
Sports during physical education	745	0.6	6
Other	977	0.79	7
Total	8435	6.79	65

Muscular Activity			
Gymnastics, cheer, dance or drill teams	1493	1.2	11
Track and field sports	1223	0.98	10
Weightlifting or calisthenics	759	0.61	6
Wrestling or martial arts	385	0.31	3
Other	918	0.74	7
Total	4778	3.85	37
Flexibility Activity			
Martial arts	308	0.25	2
Stretching	1050	0.85	8
Yoga	398	0.32	3
Ballet	308	0.25	2
Other	1094	0.88	8
Total	3158	2.54	24
Rest			
Schoolwork, homework, or reading	31908	25.69	246
Computer games or TV/videos	10566	8.51	82
Eating, resting, listening to music, riding bus	16729	13.47	129
Sleeping	16131	12.99	125
Other	7394	5.95	57
Total	82728	66.6	639

Pearson correlations among the variables of physical activity (MVPA), sedentary behaviors (television/computer), nutrition (vegetable and fruit), and BMI percentile are shown in Table 16. The variables of BMI percentile and PACER laps were negatively correlated ($r = -.25$, $p < .001$). The time in MVPA was positively correlated with PACER laps ($r = .2$, $p < .001$), while it was negatively correlated with time in television/computer ($r = -.29$, $p < .001$). Also, the

variables of PACER laps were positively correlated with the consumption of vegetables and fruits ($r = .14, p < .001$).

Table 16

Correlation Coefficients for Relationships between BMI Percentile, Physical activity, Sedentary Behaviors, and Nutrition Factors

Variables	1	2	3	4	5
1. BMI Percentile	—	-.01	-.25**	-.14	-.05
2. MVPA		—	.2**	-.29**	-.05
3. PACER Laps			—	-.1	.14**
4. Television/Computer				—	-.06
5. Fruit/Vegetable					—

Note. ** $p < .001$ level (2-tailed)

Summary of Major Findings. This study provides some meaningful results through description of the population. First of all, the proportion of healthy weight in adolescents was 54%. Healthy weight is defined as BMI 5th percentile to less than the 85th percentile (CDC, 2015). This study revealed that 57% of girls were in the category of healthy weight, while boys were 51%.

This study found a difference between gender, year, and grade in terms of physical activity, sedentary behaviors, and nutrition. First of all, a gender difference for health behaviors was found in this study. The basic finding was that boys (5.13 hours/day) spent more time in physical activity than girls (4.86 hours/day), while girls (8.98 hours/day) spent more time in sedentary behavior than boys (8.71 hours/day). The gender difference was caused by school (home) work and eating/resting in sedentary behaviors, and physical activity. That is, regardless

of weekday or weekend, boys spent more time in physical activity than girls. In addition, sedentary behaviors each gender prefers are clearly different and can be explained by lifestyles. For example, girls spent more time in school (home) work (4.62 hours/day) and eating/resting (2.39 hours/day) than boys (school work: 4.37 and eating/resting: 1.93 hours/day), while boys spent more time on screen time than girls. Also, the PACER score for boys (29.52 laps) was higher than for girls (19.52 laps), and PACER scores increased as students grew older due to the differences (e.g., weight and height changes) in physical abilities (6th: 24.66; 8th: 25.31 laps). Lastly, boys (6.76 times) consumed more fruits and vegetables than girls (6.02 times) although the proportion of healthy weight in girls was higher than boys.

Differences in students' grade in school regarding health behaviors were found in this study. Although the result did not show a significant difference between graders, the average of total hours in sedentary behaviors in 7th (8.91 hours) and 8th (8.87 hours) graders was relatively higher than 6th graders (8.79 hours). This may mean that it is more difficult for higher graders to meet recommendations for health. In fact, the obesity rate caused by unhealthy behaviors (e.g., sedentary behavior) generally increased as individuals grew older. According to Ogden et al. (2016), children aged 6 to 11 years showed 17.5% obesity rate, but adolescents aged 12 to 19 years had 20.5%, which shows a 3% gap between children and adolescents. Lastly, this study found yearly differences for health behaviors. The most interesting result was that the average of total hours in physical activity had no difference between year 1 (4.87 hours) and year 3 (5 hours), while the average of total hours in MVPA increased from year 1 (1.67 hours) to year 3 (2.45 hours). It may mean that physical activity programs provided by Greenbrier CHOICES Project focused on the increase of MVPA rather than the increase of physical activity.

This study analyzed activity log of 3 Day Physical Activity Recall (3DPAR) and found that lifestyle activities (2 hours and 51 minutes) were the longest time period spent per day in the physical activity categories, while flexibility activities (24 minutes) and aerobic activities (23 minutes) were the shortest time spent per day. This results means that students spent considerable time in lifestyle activities (walking and bicycling for transportation: 65minutes; housework: 34 minutes). In contrast, time spent in aerobic activity, big muscle activity, and flexibility activity recommended by many institutions was relatively lower than lifestyle activities. Therefore, creative physical activities during housework and transportation need to be developed. In fact, American Heart Association (2013b) emphasized physical activities around the house and provided ways to be physically active at home.

This study found some relationship between BMI percentile and health behaviors through Pearson correlation. First of all, time in MVPA was negatively correlated with time in television/computer ($r = -.29, p < .001$). That is, as previous studies have emphasized, time spent in MVPA can have a good influence on decreased screen time and improved health (e.g., cardiovascular health and diabetes). Also, this study found the importance of PACER laps. First, BMI percentile and PACER laps variable were negatively correlated ($r = -.25, p < .001$). That is, those who are in healthy weight are highly likely to have more PACER laps than other BMI groups. Second, PACER laps variable was positively correlated with the consumption of vegetables and fruits ($r = .14, p < .001$) and MVPA ($r = .2, p < .001$). The positive relationship between PACER score and health behaviors has an important meaning in schools. Compared with skinfold thickness and BMI measures, PACER test can be effectively used by teachers as a reliable and noninvasive measurement to turn out changes in BMI (Le Masurier & Corbin, 2012). In addition, PACER test can be motivation of students to achieve good records, is an easy

test to perform anytime, and can be managed by only one teacher, while normal measurements to estimate obesity often require additional resources, professionals, and time. Therefore, schools may need to provide PACER protocols, training programs for teachers, and appropriate places for students to perform PACER test by themselves.

Research Question 1

Question 1 was “Are physical activity, sedentary behavior, and nutrition in middle school students associated with BMI percentile?” Total 1,620 students who provided BMI and at least one piece of information (e.g., BMI, physical activity, sedentary behavior, or nutrition behavior) at two middle schools were used for this research question.

Logistic Regression to Predict the Odds of Healthy Weight. Logistic regression was conducted to determine whether MVPA, sedentary behaviors (screen time), and nutrition predicted healthy (vs. not healthy) weight as categorized by CDC controlling for gender and grade. The omnibus test of model coefficients measured the improved predictive power achieved by the regression equation once the independent variables had been added. The test results indicated that the chi-square was highly significant (chi-square= 3.84, $df= 8$, $p< .001$). The overall fit of the model was conducted using the Hosmer and Lemeshow goodness-of-fit test. The test result indicated that a chi-square value of 3.84 ($p = .87$), which meant that the final model of logistic regression was a good fit with the data.

The logistic regression of relationship between physical activity, sedentary behaviors, nutrition, and healthy weight was conducted (Table 17). Gender (OR= 1.59, 95% $CI= 1-2.52$, $p= .05$) was slightly associated with healthy weight, meaning that girls are 1.59 more times likely to be healthy weight than boys. Interestingly, total consumption of vegetables and fruits (OR= 1.06, 95% $CI= 1-1.25$, $p= .05$) was slightly associated with healthy weight, meaning that the

odds of a participant who consume one additional vegetables and fruits a day are 1.06 more times likely to be in healthy weight, with a 95% CI of 1 to 1.25. Lastly, MVPA (OR= 1.06, 95% CI= 1-1.12, $p = .04$) was associated with healthy weight, meaning that the odds of a participant who spend one additional hour in MVPA are 1.06 more times likely to be in healthy weight, with a 95% CI of 1 to 1.12. Other predictors (grade, year, and screen time) were not associated with healthy weight.

Table 17

Logistic Regression Predicting Healthy Weight

Predictor	<i>B</i>	<i>SE</i>	Wald	<i>p</i>	Odds Ratio	95% <i>CI</i> for Odds Ratio	
						Lower	Upper
Gender (Girls)	.46	.24	3.82	.05*	1.59	1	2.52
Grade	.17	.14	.14	.23	1.19	.9	1.57
Year	.1	.13	.5	.48	1.1	.85	1.42
MVPA	.11	.06	4.06	.04*	1.06	1	1.12
Screen Time	.11	.07	2.4	.12	1.12	.97	1.29
Fruits/Vegetables	.06	.03	3.85	.05*	1.06	1	1.25
(Constant)	-2.23	1.16	3.73	.05	.11		
Model summary							
Final step	-2 Log likelihood			Cox & Snell R Square		Nagelkerke R Square	
	432.39			.04		.05	

Note. * $p \leq .05$

Research Question 2

Question 2 was “Are changes in physical activity, sedentary behaviors, and nutrition associated with changes in BMI percentile over time?” Among 1,620 students with 3,263

observations, 668 students with 668 observations were removed from the analysis of liner mixed model. Therefore, a total of 952 students with 2,595 observations who had participated two or more times were used for this research question.

Linear Mixed Model to Determine Changes in Dependent Variables over time. A linear mixed model was conducted to determine changes in physical activity, sedentary behavior, and nutrition associated with changes in BMI percentile over time, controlling for gender and grade. A linear mixed model is a type of hierarchical model that develops the linear regression model. It includes fixed effects (e.g., gender and BMI percentile) and random effects (e.g., year) for a continuous outcome (e.g., physical activity, sedentary behaviors, and nutrition). The changes in physical activity, sedentary behavior, and nutrition were evaluated using a linear mixed model as implemented in the MIXED procedure of SAS (version 9.4) with a restricted maximum likely estimation (REML). Fixed effects were gender, and BMI, while the random effect was year.

Different covariance structures (i.e. CS, AR, and UN) were used, and UN was determined to be the best structure for this question due to the lowest BIC among other covariance structures. Based on the results of covariance parameter estimates for each outcome variable, random slopes in physical activity and sedentary behaviors were removed because the random effects of intercept and slope were not significant.

Three important assumptions for linear mixed model were measured prior to analysis. First, the residual plots for four predictors (physical activity, sedentary behavior, and nutrition) showed a curve, meeting the assumption of linearity. Second, predictor variables should not be highly correlated (< 0.9) to meet the multicollinearity assumption. This study included relationships between three predictors (i.e. gender, year, and BMI percentile), which were not

highly correlated. Third, predictors met the assumption of homoscedasticity although some predictors were skewed, especially sedentary behavior. However, in general, residual plots looked acceptable. All tables that reflect physical activity, sedentary behaviors, and nutrition are shown, but all figures (3-10) are in Appendix E.

Changes of Physical Activity. The final BIC was 2,749 for total physical activity time, and 2,367 for moderate-vigorous time. The analysis was done using linear mixed model (Proc Mixed). Time spent in physical activity was significantly associated with the interaction between gender and year (estimate=1.96, $p=.03$) (Table 18); boys increased time spent in physical activity over time while girls had no change in physical activity over time (Figure 3 in Appendix E).

Table 18

Predictors of Physical Activity

Outcome: Total PA time			MVPA time		
BIC: 2749, Chi-Square: 1.55			BIC: 2367, Chi-Square: 0		
	Estimate	SE		Estimate	SE
Intercept	6.72	1.48	Intercept	1.91	1.03
Gender(boys)	-2.63	2.07	Gender(boys)	.53	1.44
Year	-.97	.62	Year	.07	.43
BMI_P	-.02	.02	BMI_P	<.01	.01
Gender×Year*	1.96	.88	Gender×Year	.03	.61
Gender×BMI_P	.03	.03	Gender×BMI_P	-.01	.02
Year×BMI_P	.01	<.01	Year×BMI_P	<.01	<.01
Gender×Year× BMI_P*	-.024	.01	Gender×Year× BMI_P	<.01	<.01

Note. * $p < .05$

Also, time spent in physical activity was significantly associated with another interaction between gender, year, and BMI percentile (estimate=-.02, $p=.05$); girls in the healthy weight category decreased time spent in physical activity over time while boys in same category increased over time (Figure 4 in Appendix E); girls in the obese category increased time spent in physical activity over time while boys in the same category decreased over time (Figure 5 in Appendix E). However, none of the variables were significantly related to time spent in moderate-vigorous physical activity over time (Table 18).

Changes of Sedentary Behaviors. For a better model fit, random slopes were removed, and final the BIC was 2,796 for time in sedentary behaviors. The analysis was done using linear mixed model (Proc Mixed). None of the variables were significantly related to total time spent in sedentary behaviors (Table 19).

Table 19

Predictors of Sedentary Behaviors (Total SD Time)

Outcome: Total SD Time		
BIC: 2796, Chi-Square: 1.47		
	Estimate	SE
Intercept	7.18	1.54
Gender(boys)	.81	2.16
Year	1.04	.65
BMI_P	.02	.02
Gender×Year	-1.38	.92
Gender×BMI_P	-.01	.03
Year×BMI_P	-.01	<.01
Gender×Year×BMI_P	.02	.01

There are three types of sedentary behaviors: schoolwork, screen time, and eating. Screen time was significantly associated with gender, the interaction between gender and year, the interaction between gender and BMI percentile, and the interaction between gender, year, and BMI percentile (Table 20). Specifically, boys had more time in screen time (estimate= 3.16, $p < .01$). Girls decreased screen time over time while boys slightly increased screen time over time (estimate= -1.22, $p < .01$) (Figure 6 in Appendix E). Also, girls showed a greater decrease in hours of screen time than boys as BMI percentile increased (estimate= -.04, $p < .01$) (Figure 7 in Appendix E). Girls in overweight and obese category increased over time while boys in overweight and obese category decreased over time (estimate= .02, $p < .01$) (Figure 8 and 9 in Appendix E).

Table 20

Predictors of Sedentary Behaviors (Screen Time)

Screen Time		
BIC: 2044, Chi-Square: 3.94*		
	Estimate	SE
Intercept	.32	.75
Gender(boys)**	3.16	1.05
Year	.4	.31
BMI_P	.01	.01
Gender×Year**	-1.22	.44
Gender×BMI_P**	-.04	.01
Year×BMI_P	<-.01	<.01
Gender×Year×BMI_P**	.02	<.01

Note. * $p < .05$, ** $p < .01$

School work (homework) was significantly associated with BMI percentile (Table 21); boys and girls increased school work (homework) as BMI percentile increased (estimate= .03, $p=.04$) (Figure 10 in Appendix E).

Table 21

Predictors of Sedentary Behaviors (School Work and Eating Time)

School Work			Eating Time		
BIC: 2452, Chi-Square: 0.53			BIC: 2128, Chi-Square: 2.89		
	Estimate	SE		Estimate	SE
Intercept	2.41	1.11	Intercept	1.96	.81
Gender(boys)	-.81	1.56	Gender(boys)	.1	1.14
Year	.8	.47	Year	.44	.34
BMI_P*	.03	.02	BMI_P	-.01	.01
Gender×Year	<.01	.66	Gender×Year	-.59	.48
Gender×BMI_P	<.01	.02	Gender×BMI_P	<.01	.02
Year×BMI_P	-.01	<.01	Year×BMI_P	<.01	<.01
Gender×Year× BMI_P	<.01	<.01	Gender×Year× BMI_P	<.01	<.01

Note. * $p < .05$

Changes of Nutrition. Nutrition included total consumption of vegetables and fruits. This study found that none of the variables were significantly related to total consumption of vegetables and fruits (Table 22).

Table 22

Predictors of Nutrition

Outcome: Nutrition		
BIC: 3122, Chi-Square: 13.07**		
	Estimate	SE
Intercept	6.49	1.78
Gender(boys)	.36	2.58
Year	-.74	.74
BMI_P	.03	.02
Gender×Year	.66	1.07
Gender×BMI_P	<.01	.03
Year×BMI_P	<-.01	.01
Gender×Year×BMI_P	<-.01	.01

Note. ** $p < .01$

CHAPTER 5

DISCUSSION

This study examined: (a) the relationship between BMI percentile and health behaviors (physical activity, sedentary behaviors, and nutrition) and (b) changes in three health behaviors over time associated with changes in BMI percentile over time when controlled for covariates of grade and gender. A Social Ecological Model (SEM) perspective provided the conceptual framework for this study. Using the SEM as a framework helped to explore the significant interactions between targeted health behaviors and gender, year, and BMI percentile by including individual, interpersonal, organizational, and community levels.

Obesity is multi-faceted issue and it is necessary to emphasize various levels of SEM simultaneously (Sallis et al., 2008). Designated levels of the SEM served to explore factors in the community level (distinct culture, different school environments, and regional characteristics) for research question 1, and in individual (the adolescent stage of development), interpersonal (teacher) and organizational level (after school PA program, PE curriculum revision, school garden, and healthcare) for research question 2. This chapter includes discussion of the findings, limitations, and suggestions for future studies.

Exploring Individual Health Behaviors through the Lens of Community Level Influencers

The relationship between physical activity (MVPA), sedentary behaviors (screen time), and nutrition (vegetables and fruits), and healthy weight was conducted using logistic regression. From an ecological perspective, community influences foster the cultural and social expectations of those living and interacting within the community. The social norms of communities can have influence on what opportunities are available and perceived to have value (Emmons, 2000; Sallis et al., 2008). A community is described as a larger societal construct comprised, in varying

combinations, of the three smaller tiers of the SEM, and may be defined geographically, culturally, or by other common characteristics (CDC, 2013c). With this in mind, the unique contextual factors reflected at the community level can have inter-generational and population-level impact. Thus, cultural health expectations, perceived environmental facilitators and barriers, health infrastructure, and so forth can extend beyond the individual and be perpetuated as social/cultural norms of individuals living within a community (Sallis, Floyd, Rodríguez, & Saelens, 2012). The Appalachian region has been documented to have unique contextual factors that both facilitate and hinder positive health behaviors in children and adults alike. Providing the participants within this study are adolescent residents of the Appalachian region, it can be speculated that they may have been influenced by the community level factors, such as social and cultural norms and perspectives of those living within rural Appalachia. Therefore, this study looks to the community level factors and regional features to help extrapolate and understand the findings from the current study relative to adolescent health behaviors and healthy weight.

There are unique situations student face in Appalachian communities: First, the Appalachian region is reflective of a very unique and distinct culture and lifestyle that is characterized by isolation and familism (Lewis & Billings, 1997). The rich Appalachian culture has been preserved across generations due in large part to the geographic isolation from large urban and metropolitan areas, which has contributed to limited access to health services and infrastructure within rural areas. Also, traditions caused by the value of family and inter-generational interactions and living off the land exist in the Appalachian region (Coleman, Ganong, Clark, & Madsen, 1989). Also, rural Appalachia is covered by mountains and has documented unstable weather. Considering the mountainous landscape and narrow and windy roads, travel from remote rural towns can be difficult and treacherous at different times of the

year. These characteristics in community level are not generally changed over time. Therefore, the unique contextual features of rural Appalachia will assist in the discussion of adolescent health behaviors presented in this study.

Although this study showed a small association between gender and healthy weight, the data indicated that more girls participants were within the healthy weight category than their boys counterparts ($OR=1.59, p=.05$). Previous studies supported these results, specifically according to NHANES 2009-2010, about 30% of adolescent girls and 33% of adolescent boys were classified as overweight or obese (Flegal et al., 2012). However, other studies presented no difference between BMI percentile and gender, and in some instances, there were reversed results. For example, Sardinha et al. (2016) presented that BMI was not different between boys (19.9 kg/m^2) and girls (20 kg/m^2) aged 8 to 17. Saxena, Ambler, Cole, and Majeed (2004) mentioned that girls were more overweight than boys aged 2-20 years (24% and 22% respectively).

Physical Activity. Among the health behaviors of interest, physical activity and nutrition predictors were associated with healthy weight. Specifically, MVPA was more likely to result in healthy weight within this sample ($OR=1.06, p=.04$). Similar results can be found in previous studies (DeLany et al., 2014; Reilly et al., 2004). DeLany et al. (2013) found that individuals who spent less time in physical activity decreased their energy expenditure, resulting in weight gain. The Physical Activity Guidelines Advisory Committee (2008) and the World Health Organization (WHO, 2010b) recommend at least 60 minutes of MVPA most days of the week. Based on the present study, participants adhered to the physical activity guidelines of 60-minutes per day, however differences across grade level were observed. For instance, time spent engaged in MVPA per day was reported to be less in 8th grade participants as compared to 6th grade

participants (2.12 hr/day and 2.38 hr/day respectively). This finding is consistent with previous research that has demonstrated declines in self-reported physical activity across adolescence (Caspersen, Pereira, & Curran, 2000).

Physical activity levels of those living within the Appalachian region has been documented to be lower than those living outside of the region (Swanson, Schoenberg, Erwin, & Davis, 2013). Factors that contribute to these low levels of physical activity include regional characteristics such as limited access to PA facilities and programming, a lack of walkable communities, and unpredictable weather due to the mountainous terrain (Martin et al., 2005; Sloane et al., 2006). Findings from this study build upon previous work that indicate positive relationships between participation in physical activity (MVPA) and healthy weight. A result from this study indicated that the most time spent in physical activity was reported within the lifestyle physical activity category (e.g., housework and transportation). This may suggest that it is difficult for students to spend time in other types of physical activity (e.g., aerobic or muscular activity) outside the school day, thus validating the need for physical activity-related programming and initiatives for adolescents within this region. Efforts at the community level may include changes that capitalize on existing infrastructure and environments where physical activity programming could be offered, such as schools (e.g., gymnasiums, tracks, or playing fields), community parks, and recreation spaces. Therefore, joint-use agreements which allow community-wide use of school facilities may be important (Swanson et al., 2013). For example, schools allow parents with their children to use the closest school's facilities (e.g., tracks or playing fields) after school hours and during the weekends. This opportunity, which expands physical activity in school, helps students increase aerobic or muscular activities recommended by many educational institutions during the school day. Additionally, considering the remote

location of many residents in rural Appalachia and extensive travel time to get to and from school, physical programming within the school day (before, during, or after) would allow all students to engage in health-enhancing programming. Those living in the Appalachian region have a lack of sharing information and limited opportunities for social interaction due to slow-speed Internet service (Strover & Mun, 2006) and houses far away from a school. In fact, some areas in the eastern and western regions of the county had uncovered or unstable internet services. Therefore, attractive guide books for physical activity available around the house may be realistic interventions to increase MVPA. For example, Gulley and Boggs (2014) recommended that writing exercise diaries may be a good intervention to increase physical activity for adolescents in the Appalachian region. Also, motivational messages via a cell phone which are provided by health professionals can increase self-efficacy, resulting in improving physical activity (Richardson, 2013). Lastly, culturally relevant lifelong physical activities such as a small-game hunting, fishing, and folk dance may be more appealing to adolescents in the Appalachian region (Kruger et al., 2012) than health-enhancing physical activities. Gulley (2011) suggested that Appalachian youth lack self-motivation necessary to engage in physical activity.

Sedentary Behavior. Unlike the physical activity variable of MVPA, the sedentary behavior variable of screen time was not associated with healthy weight. Basically, participants who spent more time in sedentary behaviors were likely to be classified as overweight or obese (Hancox et al., 2004; Hu et al., 2003; Mitchell et al., 2013). Yet, some studies found no relationship between sedentary behaviors and weight status (Davison et al., 2006; Oliver et al., 2011). These studies indicate that measuring time spent in sedentary behaviors should be longitudinal rather than cross-sectional to account for physical condition, weather, examination period, and even interscholastic sport seasons that can interfere with representative measures of

sedentary behavior patterns. In this study, only the first row of data was selected for each participant and therefore represented a cross-sectional data set to examine these variables. Fulton et al. (2009) suggested that some health disparities experienced by children in Appalachia may be associated with the lack of physical activity facilities and insufficient physical activity that contribute to increased sedentary behavior and screen time at home. Regardless of healthy or unhealthy weight, most students in the Appalachian region may spend much time in television or computer, whether it is deliberate or not (Hortz, Stevents, Holden, and Petosa, 2009). For example, lack of street lights and the sun going down earlier may lead students to return to home early after school hours. In fact, this study indicated that 53% of participants spent at least two hours in television/computer games a day, which was 6% higher than national average (Sisson et al., 2009). That is, regional characteristics may increase sedentary behaviors regardless of healthy weight.

Nutrition. Results from this study indicated that total consumption of vegetables and fruits positively affected healthy weight ($OR=1.06$, $p=.05$), however there was a small association between nutrition and healthy weight. This finding supported the conclusions of some previous studies. For example, Bertolia et al. (2015) found that increased consumption of fruits and vegetables produced weight changes of -0.25 lb. (vegetables) and -0.53 lb. (fruits) per daily serving over four years. Azagba and Sharaf (2012) revealed that the association between consumption of vegetables and fruits and BMI was negatively correlated, so they concluded that increased consumption of vegetables and fruits may be an effective strategy to lose weight. From a community-level perspective, Hortz et al. (2009) found that poor nutrition was one of the main factors affecting obesity in the Appalachian region. CDC (2012b) showed that 71.9% of adolescents in West Virginia consumed fruit fewer than two times per week less than twice a

week. Residents in the Appalachian region tend to prefer meats, biscuits, and fried foods to vegetables and fruits because of lack of high-quality grocery stores, affordable dollar menus, limited time to cook at home, and many fast-food restaurants (Bovell-Benjamin, Hathorn, Ibrahim, Gichuhi, & Bromfield, 2009; Brown and Wenrich, 2012; Sohn, 2001; Webber & Quintiliani, 2011). In fact, fast-food restaurants could be easily seen around the two middle schools where the study took place.

To some extent, residents in the Appalachian region experience physical isolation and poor living conditions, which can contribute to limited-knowledge of nutrition information, access to fresh foods, and healthy cooking and food preparation practices. However, Quandt, Popyach, and Dewalt (1994) suggested that residents in Appalachia are familiar with family gardening and food preservation, which have continued to be important characteristics of Appalachian-culture. Therefore, farm-to-school programs may be a good intervention for Appalachian adolescents. It connects schools with fresh, local food grown by family farmers. Through partnerships between a school and family, family farmers can provide students with information about vegetables and fruits. In addition, students have an opportunity to buy family farmers' products at an affordable price, making it possible for their parents to cook with fresh products at home.

Exploring Changes in Individual Health Behaviors Over Time through the Lens of Interpersonal and Organizational Level Influences

Individual health behavior has been documented by researchers as being highly influenced by interacting social and environmental constructs (Glanz et al., 2008). The SEM places the individual in the center of the model with multiple levels of social influence surrounding and extending beyond the center. As the model describes, individual beliefs,

behaviors, and attitudes are continually shaped and influenced by the interactive nature of the individual and the surrounding social constructs. This study attempted to measure predictive changes in adolescent health behaviors over time. Using the SEM as a framework to explore the documented effects, this study looked to the three innermost levels within the model (individual, interpersonal, and organization) to help contextualize and extrapolate the findings. The selection of the three levels was based upon the context of the intervention that was imposed upon the organization and interpersonal levels across a three-year period. This study has not attempted to document direct effects of the intervention components, however it remains difficult to separate the adolescent participant data collected and analyzed from the organizational changes occurring as a function of Greenbrier CHOICES. Therefore, this section discusses the significant results from the linear mixed model analysis alongside the intervention components as a way to connect and explain how changes over time may be associated with developmental factors and interacting social influencers.

Change in Individual Level Over Time. The individual level within the SEM is based on the assumption that an individual's beliefs, behaviors, and attitudes are continually shaped and developed based upon interactive effects of their surrounding social influences. Additionally, the physical, cognitive, and emotional developmental phases that individuals experience, particularly during early and mid-adolescence, can be instructive in understanding health behavior changes over time. However, it is not easy to determine what changes through growth can be linked to health behaviors because there are many possible factors within the individual level.

This study included participants 11-16 years of age which classifies them at the early and middle stages of adolescence. These stages of adolescent development may affect the changes in

health behaviors (physical activity, sedentary behaviors, and nutrition). For example, during these stages, boys show tremendous physical growth and the gap in physical abilities may begin to widen. In fact, our result found that boys in the obese group decreased time spent in physical activity and increased sedentary behaviors across the intervention; while boys in other BMI groups increased time spent in physical activity and decreased sedentary behaviors. For this reason, obese boys may lose interest in being active, while healthy boys may gain confidence in being active. Therefore, schools may need to develop physical activity programs for obese group.

Interestingly, the result for girls within the healthy weight category trended in the same pattern as boys in the obese group (i.e., decreased physical activity and increased sedentary behaviors). Girls in early and middle stages of adolescence reportedly develop self-esteem and are affected by physical self-concept (Siegel, Yancey, Aneshensel, & Schuler, 1999).

Interestingly, the poor physical self-concept (body image) and self-esteem resulted in being inactive due to low motivation for physical activity (Strickland, 2004). Therefore, schools may need to develop factors such as physical activity programs difficulty or interest which affects low motivation and encourage students to join an exercise group or class with friends.

Change in Interpersonal Level Over Time. At the interpersonal level, formal and informal social support systems that can affect students' health behaviors, including teachers, parents, and friends. This study considered teachers as a main role in interpersonal level even though some students may be affected by their parents or friends because adolescents tend to depend on their past experiences and personal characteristics when they want to pursue health behaviors, so it is critical for teachers to provide the right information about health behaviors (Moreland, Raup-Krieger, Hecht, & Miller-Day, 2013). Also, Moreland et al. (2013) found that living in a small community often contributes to students' development of strong relationship

with teachers or coaches who advise against risky behaviors. In some cases, PE teachers spend more time with students than other teachers because of their involvement in extracurricular activities such as sports, clubs, and after school programs. For this reason, the role of the PE teacher may serve as an important factor in creating and promoting health and physical activity opportunities for adolescents before, during, and after school within the Appalachian region.

As part of the intervention, the PE teachers developed the PE curriculum and delivered some of the after school programs. A primary goal of the curricular revisions was to provide students with opportunities to engage in high levels of MVPA and experience culturally-and geographically-relevant lifetime activities that they could enjoy participating in outside of the school day. However, this study found that none of the variables (gender, year, and BMI) were significantly related to MVPA. The U.S. Department of Health and Human Services (USDHHS) (2010) suggested that students engage in MVPA during at least 50% of physical education classes. Compared with light intensity physical activity, MVPA can effectively promote cardiovascular endurance, muscle, and bone strength, making it possible to maximize motor and psychological development (Strong et al, 2005). However, time devoted to class management, attendance checks, and non-teaching functions can decrease academic learning time in Physical Education (Jago et al, 2009). Based on the recommendations of USDHHS (2010) to increase MVPA, the study suggested that teachers should implement a well-designed PE content that applies to school as well as home. In this study, the teachers focused on PE curriculum enhancements and after school PA programs that not only promoted skill development, but also encouraged participation in the new lifestyle physical activities within the community and outside the school environment.

Therefore, schools may provide teachers with related training and supervision so they can develop economical and effective tools to implement MVPA at school as well as home. For example, trainings can include ways to reduce classroom management and transitions, instructional strategies to provide appropriate feedback, and professional development opportunities to improve instructional skills by using physical activity programs such as the Coordinated Approach to Child Health (CATCH) and Sports, Play, and Active Recreation for Kids (SPARK) programs (McKenzie et al., 2003; Sallis, et al., 1997). These programs were effective to increase students' physical activity levels as well as teachers' knowledge about physical activities (McKenzie et al., 1996; Stone et al., 1998).

Change in Organizational Level Over Time. This study considered the school as the main component in the organizational level and was based on the assumption that students spend considerable time in school and receive most information from school. Schools can provide students with nutrition and physical activity knowledge and help them make better personal choices by including after school PA programs, PE curriculum revisions, school gardens, and school-based health care in this study. Deschesnes, Martin, and Hill (2003) mentioned that changes in the school environment can improve students' health. Further, Sallis and colleagues (2012) noted that without modifications to the school environment, attempts to impact the obesity levels in children will be ineffective. Based on this premise, organizational changes within the school environment were a primary focus of the intervention and were designed with the intent of improving adolescent health behaviors. Organizational changes that were made to the school environment across the intervention included the addition of after school PA programs, revisions to the physical education curriculum, and the development of school gardens.

First, after school PA programs allowed students to build their interests and skills in archery, mountain-biking, walking, slack-lining, Zumba, land-paddling, and yoga for across 5-weeks period (see Appendix A). According to a meta-analysis on school-based health interventions, 16 of the 24 studies showed statistically significant effects on the reduction of screen time (-25 minutes/day) when interventions included some aspect of after school programming (Friedrich, Polet, Schuch, & Wagner, 2014). Interestingly, a notable result from the current study was that there were no changes in physical activity reported by girls whereas, boys reported increased time spent in physical activity over time. This result may be explained by time spent for a day. This study indicated that girls spent 11.7% in aerobic activity, aerobic sport, and muscular activity for a day, while boys spent 14.3%. Most after school PA programs for this study were related to active exercise which emphasizes MVPA, so the gender difference of changes in physical activity over time may be because boys prefer active exercise, while girls prefer static exercise. In fact, this study found that girls spent more than twice boys in stretching. Thus, practitioners and researchers may need to consider both active and static exercise to promote motivation for physical activity when developing after school PA programs. Also, this study found that the interaction between gender and BMI percentile was significantly associated with changes over time in screen time. Specifically, both girls and boys decreased time spent on screen time as BMI percentile increased. Although gender was not a primary variable in this study, this finding was interesting because screen time was negatively associated with BMI percentile. However, considering screen time as a predictive variable to obesity is a controversial topic. Anderson et al. (2008) found that overweight children spent more than two hours per day on screen time, but other studies revealed that there was no significant relationship between television viewing and BMI (Aires et al., 2010; Davison et al., 2006; Mitchell et al., 2013). This

study also found that BMI percentile was not correlated with screen time. An explanation of this may be other factors which are not possible to measure. The factors may affect the negative relationship between screen time and BMI percentile stronger than after school PA programs, PE curriculum revisions, and school garden programs. In fact, Huang, Gao, Hannon, Shultz, Newton, and Jenson (2012) mentioned that school-based programs alone cannot solve the problems caused by chronic sedentary behaviors. Therefore, schools may need to promote various school-based PA programs as well as collaborate with parents to decrease their child's sedentary behaviors at home.

Second, PE curriculum revisions were performed by PE teachers. They collaborated with their students to select new units and equipment needed to address the identified areas of improvement. The enhanced PE curriculum focuses on lifetime physical activities rather than traditional sports, and has the potential to evoke a love for physical activity that extends beyond skill performance. One of the main goals in this work was to increase the level of MVPA. However, none of the variables (gender, year, and BMI) were significantly related to MVPA over time. It may be hard for adolescents to meet physical activity recommendations promoted by PE curriculum revisions. The actual time spent in MVPA is small although individuals participate in physical activities or sports with moderate to vigorous intensity. Luke, Dugas, Durazo-Arvizu, Cao, and Cooper (2011) revealed that more than 75% of adults lasted only one minute in bouts of vigorous activity, and 35 minutes in moderate activity. They also revealed that only 0.3% of them met 60 minutes with MVPA when they used 10-minute blocks in self-report. Therefore, from an organizational level perspective, PE curriculum revisions may need to include sports or programming that can consistently resulted in MVPA during classes by using modified games or rules.

The third component introduced within the organizational level was the school garden managed by an AmericaCorp employee and designed to allow students to learn by doing and explore nutritious options that might increase awareness and promote healthy eating. Healthy recipes were prepared and taste-tested in Health and in Enrichment classes and students frequently participated in cooking classes. Often times they were taught to take their favorite recipes and make them in a more healthful or nutritious way. School garden programs have been emphasized to increase students' vegetables and fruits consumption and preferences because school garden programs are very effective intervention to improve knowledge of nutrition, importance of health, as well as consumption of vegetables and fruits (Langellotto & Gupta, 2012). According to Hollar et al. (2010), school-based intervention programs, including school gardens have observed decreased weight and blood pressure in participants. Ratcliffe et al. (2011) found that school garden programs increased total consumption of vegetables, and concluded that the increased availability of vegetables through school garden programs may increase total consumption of vegetables at home.

Despite this organizational change focusing on nutrition and healthy eating, this study found that none of the variables (gender, year, and BMI) were significantly associated with total consumption of vegetables and fruits over time. However, total consumption of vegetables and fruits was positively associated with healthy weight. This result may be caused by unclear evaluation tools to verify the effectiveness of school garden program. In fact, CDC (2012c) found that it is difficult to accurately measure calories consumed and volume of food eaten. For this reason, studies have presented contradictory results. According to Ledoux, Hingle, and Branowski (2010), they analyzed seven longitudinal studies emphasizing the relationship between fruits and vegetables and obesity, of which three revealed negative relationships and

four showed mixed results or no difference. Also, Ledoux et al. (2010) mentioned that multiple behavioral changes (i.e. parental eating behaviors or school garden program) may contribute to the unclear relationship between consumption of vegetables and fruits and obesity. Therefore, this study may suggest that schools need to set clear criteria for the evaluation of school garden programs, so they need to decide whether calories consumed should be measured or volume of food eaten should be measured to determine the effectiveness of school garden program.

In addition to three organizational level changes, this study found that BMI percentile was associated with time spent in school work, specifically homework over time. That is, both girls and boys increased BMI percentile as homework increased. Some studies did not recognize homework as one of the sedentary behaviors (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008; Pate et al, 2008) and mainly included watching television and playing video/computer games. However, the U.S. Department of Health (2010) considers homework as one of the sedentary behaviors and referred to homework as productive sedentary behavior. Feldman, Barnett, Shrier, Rossignol, and Abenhaim, (2003) mentioned that productive sedentary behaviors were not associated with obesity, compared with other leisure-time sedentary behaviors (e.g., watching TV and playing computer). Although the relationship between leisure-time sedentary behaviors and productive sedentary behaviors was not documented (Sisson et al., 2009), this study may conclude that homework can be included as one of the major sedentary behaviors in the Appalachian region and too much time spending homework may affect obesity negatively.

CONCLUSION

Findings from this study emphasized the importance of physical activity, sedentary behaviors, and nutrition for obesity prevention, and were characterized as a comprehensive, three-year, rural area, middle school-based study with large sample. This is the study to examine the relationship between health behaviors and obesity of middle school students in the Appalachian region. From an ecological perspective, the relationship between adolescent obesity and health behaviors was explained by: (a) individual level (stages of adolescent development), (b) interpersonal level (teachers), (c) organizational level (after school PA program, PE curriculum revisions, and school garden), and (d) community level (regional characteristics and distinct cultures). These four levels in SEM facilitated explanation about the obesity prevalence in the Appalachian region and revealed several important results. First, MVPA was more likely to result in healthy weight within this sample, especially time spent in MVPA was reported to be less in 8th graders as compared to 6th graders. Interventions or programming to prevent students from decreasing physical activity across adolescence may be needed. This study also indicated that the most time spent in physical activity was reported within the lifestyle physical activity category (e.g., housework and transportation), so the importance of community-wide use of school facilities, attractive guide books for physical activity available around the house, motivational messages via a cell phone, and culturally relevant lifelong physical activities could be emphasized. Second, this study indicated that total consumption of vegetables and fruits positively affected healthy weight. Residents in Appalachia are familiar with family gardening and food preservation, which has continued to be an important characteristics of Appalachian-culture. Farm-to-school program may be a good intervention for Appalachian adolescents. Third, this study indicated that girls were reported to have no changes in physical activity over time, but

girls in healthy weight category decreased time spent in physical activity. The poor physical self-concept (body image) and self-esteem may result in being inactive due to low motivation for physical activity. Therefore, schools may need to develop factors such as physical activity programs difficulty or interest which affects low motivation and encourage students to join an exercise group or class with friends.

Fourth, there were no changes in physical activity reported by girls whereas, boys reported increased time spent in physical activity over time. The gender difference of changes in physical activity over time may be because boys prefer active exercise, while girls prefer static exercise. Thus, practitioners and researchers may need to consider both active and static exercise to promote motivation for physical activity when developing after school PA programs.

Fifth, this study found that both girls and boys increased BMI percentile as homework increased. Although the relationship between leisure-time sedentary behaviors and productive sedentary behaviors was not documented, this study may conclude that homework can be included as one of the major sedentary behaviors in the Appalachian region and too much time spending homework may affect obesity negatively.

All things considered, this study indicates the importance of Social Ecological Model (SEM) for assessment of obesity prevalence by emphasizing individual, interpersonal, organizational, and community level and it is recommended that school-based interventions and programming consider those levels to promote behavioral changes for adolescent health in the Appalachian region.

LIMITATIONS

This study has several limitations. First, BMI measurement was not conducted every collection period while measurements for outcomes (physical activity, sedentary behaviors, and nutrition) were conducted every collection period. That is, participants measured their BMI at collection periods 2 (year 1), 6 (year 2), and 10 (year 3), which means that BMI was measured once a year. Therefore, there was a time interval between BMI measurement and other outcomes for up to 6 months.

Second, the PACER test was run by adolescents in a ‘volunteer-based’ setting which meant their efforts may not have truly reflected their cardiovascular fitness, and confounding factors (that were not measured) are degree of peer influence, amotivation (lack of motivation), and assessment fatigue (data collection windows punctuated every other month due to mandated schedule).

Third, the sample consisted of middle school students (6th to 8th grades) in West Virginia and heavily Caucasian population (approximately 90%). That is, it is not a representative sample of US adolescents. Therefore, it is not appropriate for generalization to US populations.

RECOMMENDATION FOR FURTHER RESEARCH

From the results of this study, several recommendations for future studies are suggested. First, PACER record may be an indicator for students' healthy or unhealthy behaviors. This study found PACER record was positively correlated with physical activity and nutrition, and negatively correlated with sedentary behaviors. The results mean that health behaviors may be reliably measured by fitness tests. Therefore, further research is needed to reveal whether other physical fitness tests such as sit-up can also be an indicator for healthy behaviors.

Second, students spent much time in lifestyle activity in this study. This activity generally includes housework and transportation. Students, who spent much time in this activity, are likely not to meet an intensity level recommended by PA guidelines because most lifestyle activities generally has light intensity. Therefore, further research is needed to develop interventions to transfer lifestyle activity to moderate-vigorous lifestyle activities.

Third, much time spent in productive sedentary behavior (e.g., school work) affected obesity in this study. However, it is still unclear how various purposes of sedentary behaviors affect obesity. For example, online-based education using online materials or social media is developing rapidly, so simply measuring time spent in computer use without confirming the purpose of use may lead to inaccurate results. Therefore, further research is needed to develop surveys to measure sedentary behaviors that include the detailed purposes (e.g., computer use for online education) rather than traditional sedentary behaviors (e.g., computer use).

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Appendix A
After School Programming Calendar in Greenbrier CHOICES Project

Data	School	
Collection	Eastern	Western
Y1(BL)		
Y1(2)		
Y1(3)		
Y1(4)		
Y1(5)		
Y2(6)	-After School Mt. Biking (10days) -After School Zumba (13days) -After School Gardening & Healthy Cooking (2days) -After School Gladiator Training (3days)	-Before School Walking (6 days) -After School Mt. Biking (12days) -After School Gardening & Healthy Cooking (4days) -After School Zumba (7days)
Y2(7)	-After School Gladiator Training (4days) -After School Gardening & Healthy Cooking (2days)	-After School Mt. Biking (4days) -After School Gardening & Healthy Cooking (1days)
Y2(8)	-After School Gardening & Healthy Cooking (3days)	-After School Gardening & Healthy Cooking (2days)
Y2(9)	-After School Gardening & Healthy Cooking (6days)	-After School Gardening & Healthy Cooking (7days)
Y3(10)		
Y3(11)		
Y3(12)		
Y3(13)		

Appendix B

Greenbrier CHOICES Activitygram Activity Log

Instructions: Use the charts below to track your physical activity across the past three (3) days. You must include two (2) school days, and one (1) weekend day. Follow these steps to complete the charts:

STEP 1: Determine the primary activity you did during each 30-minute interval using the list of activities at the side of the page and enter the related number in the Activity column. **Be sure there is a number in each row on all three sheets.**

STEP 2: Circle an intensity level that best describes how hard the activity felt in the Intensity column (Rest: "Resting", such as sleeping; Light: "Easy"; Moderate: "Not too tiring"; Vigorous: "Very tiring").

IMPORTANT: If you fill in activity numbers that are from the **Resting** category (#26, 27, 28, 29, 30) the only thing that should be circled in the Intensity column is Rest.

Here is a sample of a completed log sheet. Notice how there is a day of the week circled, an activity number written in each row, and an intensity level circled in each row.

Greenbrier CHOICES Activitygram Record Day 1 Log – <u>Weekend Day</u>					
Name: _____		Grade in School: _____		School: _____	
Day of the Week (circle one):		SATURDAY		SUNDAY	
TIME OF DAY	STEP 1 Activity Number	STEP 2 Intensity			
		Rest	Light	Moderate	Vigorous
Morning					
7:00 AM	28	☐	L	M	V
7:30	28	☐	L	M	V
8:00	28	☐	L	M	V
8:30	26	☐	L	M	V
9:00	28	☐	L	M	V
9:30	28	☐	L	M	V
10:00	26	☐	L	M	V
10:30	26	☐	L	M	V
11:00	26	☐	L	M	V
11:30	26	☐	L	M	V
Afternoon					
12:00 PM	26	☐	L	M	V
12:30	26	☐	L	M	V
1:00	14	R	L	☐	V
1:30	14	R	L	☐	V
2:00	26	☐	L	M	V
2:30	26	☐	L	M	V
3:00	26	☐	L	M	V
3:30	11	R	L	M	☐
4:00	11	R	L	M	☐
4:30	28	☐	L	M	V
Evening					
5:00	28	☐	L	M	V
5:30	28	☐	L	M	V
6:00	3	☐	L	M	V
6:30	3	☐	L	M	V
7:00	26	☐	L	M	V
7:30	26	☐	L	M	V
8:00	26	☐	L	M	V
8:30	28	☐	L	M	V
9:00	28	☐	L	M	V
9:30	29	☐	L	M	V
10:00	29	☐	L	M	V
10:30	29	☐	L	M	V

Lifestyle activity- "Activities that I do as part of my normal day"

(1) Walking, bicycling, or skateboarding for transportation
 (2) Housework or yard work (chores, cleaning room, mowing lawn)
 (3) Playing active games or dancing
 (4) Work – active job
 (5) Other

Aerobic activity- "Activities that I do for aerobic fitness"

(6) Aerobic dance activity
 (7) Aerobic gym equipment (stair climber, treadmill, etc.)
 (8) Aerobic activity (bicycling, running, skating, etc.)
 (9) Aerobic activity in physical education
 (10) Other

Aerobic sport- "Activities that I do for sport and recreation"

(11) Field sports (baseball, softball, football, soccer, etc.)
 (12) Court sports (basketball, volleyball, hockey, etc.)
 (13) Racket sports (tennis, racquetball, etc.)
 (14) Sports during physical education
 (15) Other

Muscular activity- "Activities that I do for muscular fitness"

(16) Gymnastics, cheer, dance or drill teams
 (17) Track and field sports (jumping, throwing, etc.)
 (18) Weightlifting or calisthenics (push-ups, sit-ups, etc.)
 (19) Wrestling or martial arts (karate, aikido)
 (20) Other

Flexibility activity- "Activities that I do for flexibility and fun"

(21) Martial arts (Tai Chi)
 (22) Stretching
 (23) Yoga
 (24) Ballet
 (25) Other

Rest- "Things I do when I am not active"

(26) School-work, home-work, or reading
 (27) Computer games or TV/videos
 (28) Eating, resting, listening to music, riding bus
 (29) Sleeping
 (30) Other

Name: _____ Grade in School: _____ School: _____

Day of the Week (circle one): MON TUE WEN THR FRI SAT SUN

TIME OF DAY	STEP 1 Activity Number	STEP 2 Intensity			
		Rest	Light	Moderate	Vigorous

Morning		Rest	Light	Moderate	Vigorous
7:00 AM		R	L	M	V
7:30		R	L	M	V
8:00		R	L	M	V
8:30		R	L	M	V
9:00		R	L	M	V
9:30		R	L	M	V
10:00		R	L	M	V
10:30		R	L	M	V
11:00		R	L	M	V
11:30		R	L	M	V
Afternoon					
12:00 PM		R	L	M	V
12:30		R	L	M	V
1:00		R	L	M	V
1:30		R	L	M	V
2:00		R	L	M	V
2:30		R	L	M	V
3:00		R	L	M	V
3:30		R	L	M	V
4:00		R	L	M	V
4:30		R	L	M	V
Evening					
5:00		R	L	M	V
5:30		R	L	M	V
6:00		R	L	M	V
6:30		R	L	M	V
7:00		R	L	M	V
7:30		R	L	M	V
8:00		R	L	M	V
8:30		R	L	M	V
9:00		R	L	M	V
9:30		R	L	M	V
10:00		R	L	M	V
10:30		R	L	M	V

Lifestyle activity- “Activities that I do as part of my normal day”

- 1.Walking, bicycling, or skateboarding for transportation
- 2.Housework or yard work (chores, cleaning room, mowing lawn)
- 3.Playing active games or dancing
- 4.Work – active job
- 5.Other

Aerobic activity- “Activities that I do for aerobic fitness”

- 6.Aerobic dance activity
- 7.Aerobic gym equipment (stair climber, treadmill, etc.)
- 8.Aerobic activity (bicycling, running, skating, etc.)
- 9.Aerobic activity in physical education
- 10.Other

Aerobic sport- “Activities that I do for sport and recreation”

- 11.Field sports (baseball, softball, football, soccer, etc.)
- 12.Court sports (basketball, volleyball, hockey, etc.)
- 13.Racket sports (tennis, racquetball, etc.)
- 14.Sports during physical education
- 15.Other

Muscular activity- “Activities that I do for muscular fitness”

- 16.Gymnastics, cheer, dance or drill teams
- 17.Track and field sports (jumping, throwing, etc.)
- 18.Weightlifting or calisthenics (push-ups, sit-ups, etc.)
- 19.Wrestling or martial arts (karate, aikido)
- 20.Other

Flexibility activity- “Activities that I do for flexibility and fun”

- 21.Martial arts (Tai Chi)
- 22.Stretching
- 23.Yoga
- 24.Ballet
- 25.Other

Rest- “Things I do when I am not active”

- 26.School-work, home-work, or reading
- 27.Computer games or TV/videos
- 28.Eating, resting, listening to music, riding bus, car, dirt bike, ATV
- 29.Sleeping
- 30.Other

Sample Activities within each Activity Category

Lifestyle Activity- "Activities I do as part of my normal day"

Aerobic Activity- "Activities I do for aerobic fitness"

Aerobic Sport- "Activities I do for sport and recreation"

Muscular Activity- "Activities I do for muscular fitness"

Flexibility Activity- "Activities I do for flexibility and fun"

Rest- "Things I do when I'm not active"

Appendix C
The PACER Individual Score Sheet

Score-keeper: _____ Group: _____ Date: _____

Laps (20-meter lengths)

<i>Min</i>	<i>Laps</i>													
1	1	2	3	4	5	6	7							
2	8	9	10	11	12	13	14	15						
3	16	17	18	19	20	21	22	23						
4	24	25	26	27	28	29	30	31	32					
5	33	34	35	36	37	38	39	40	41					
6	42	43	44	45	46	47	48	49	50	51				
7	52	53	54	55	56	57	58	59	60	61				
8	62	63	64	65	66	67	68	69	70	71	72			
9	73	74	75	76	77	78	79	80	81	82	83			
10	84	85	86	87	88	89	90	91	92	93	94			
11	95	96	97	98	99	100	101	102	103	104	105	106		
12	107	108	109	110	111	112	113	114	115	116	117	118		
13	119	120	121	122	123	124	125	126	127	128	129	130	131	
14	132	133	134	135	136	137	138	139	140	141	142	142	144	
15	145	146	147	148	149	150	151	152	153	154	155	156	157	

Lane	Student name	Laps completed

Appendix D
School Physical Activity and Nutrition Survey

Instructions: Using a #2 pencil fill in the bubbles for the following information: 1) Last and First Name; 2) Birthdate; and 3) Identification Number (get this from the Evaluation Team Member).

Indicate your responses to the following questions on the blue scantron sheet.

1. **Yesterday**, how many times did you drink any kind of milk? (INCLUDE chocolate or other flavored milk, milk on cereal, and drinks made with milk.)
 - a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - e) 4 or more times

2. **Yesterday**, how many times did you eat any starchy vegetables like potatoes, corn, or peas? (DO NOT COUNT French fries or chips.)
 - a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - a) 4 or more times

3. **Yesterday**, how many times did you eat any orange vegetables like carrots, squash, or sweet potatoes?
 - a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - e) 4 or more times

4. **Yesterday**, how many times did you eat a salad made with lettuce, or any green vegetables like spinach, green beans, broccoli, or other greens?
 - a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - e) 4 or more times

5. **Yesterday**, how many times did you eat any other vegetables like peppers, tomatoes, zucchini, asparagus, cabbage, cauliflower, cucumbers, mushrooms, eggplant, celery or artichokes?
 - a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - e) 4 or more times
6. **Yesterday**, how many times did you eat fruit? Fruits are all fresh, frozen, canned, or dried fruits. (DO NOT COUNT juice.)
 - a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - e) 4 or more times
7. **Yesterday**, how many times did you drink fruit juice? Fruit juice is a 100% juice drink like orange juice, apple juice, or grape juice. (DO NOT COUNT punch, Kool-Aid®, sports drinks, and other fruit-flavored drinks.)
 - a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - e) 4 or more times
8. **Yesterday**, how many times did you drink any punch, Kool-Aid®, sports drinks, or other fruit-flavored drinks? (DO NOT COUNT 100% fruit juice.)
 - a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - e) 4 or more times
9. **Yesterday**, how many times did you drink any regular (NOT diet) sodas or soft drinks?
 - a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - e) 4 or more times

10. **Yesterday**, how many times did you drink any diet sodas or soft drinks?
- a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - e) 4 or more times
11. **Yesterday**, how many times did you drink a bottle or glass of water? (INCLUDE sparkling or any other water drink that has 0 calories.)
- a) 0 times
 - b) 1 time
 - c) 2 times
 - d) 3 times
 - e) 4 or more times
12. During the past 7 days, on how many days were you physically active for a total of **at least 60 minutes per day**? (Add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time.)
- a) 0 days
 - b) 1-2 days
 - c) 3-4 days
 - d) 5-6 days
 - e) 7 days
13. On an average school day, how many hours do you watch TV?
- a) I do not watch TV on an average school day
 - b) Less than 1 hour per day
 - c) 1-2 hours per day
 - d) 3-4 hours per day
 - e) 5 or more hours per day
14. On an average school day, how many hours do you play video or computer games or use a computer for something that is not school work? (Include activities such as Xbox, PlayStation, Nintendo DS, iPod touch, Facebook, and the Internet.)
- a) I do not play video or computer games or use a computer for something that is not school work
 - b) Less than 1 hour per day
 - c) 1-2 hours per day
 - d) 3-4 hours per day

e) 5 or more hours per day

15. In an average week when you are in school, on how many days do you go to physical education (PE) classes?

- a) 0 days
- b) 1-2 days
- c) 3-4 days
- d) 5-6 days
- e) 7 days

16. During the past 12 months, on how many sports teams did you play? (Count any teams run by your school or community groups.)

- a) 0 teams
- b) 1 team
- c) 2 teams
- d) 3 or more teams

Appendix E
Figures (3 to 10) from Research Question 2

Figure 3. Total PA Time and Year by Gender

Figure 4. Total PA Time, Year, and BMI Percentile by Girls

Figure 5. Total PA Time, Year, and BMI Percentile by Boys

Figure 6. Total Screen Time and Year by Gender

Figure 7. Total Screen Time and BMI Percentile by Gender

Figure 8. Total Screen Time, Year, and BMI Percentile by Girls

Figure 9. Total Screen Time, Year, and BMI Percentile by Boys

Figure 10. Total School Work and BMI Percentile by Gender