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Preliminary assessment of a school-based healthy lifestyle program among rural children.

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PRELIMINARY ASSESSMENT OF A SCHOOL-BASED HEALTHY LIFESTYLE

PROGRAM AMONG RURAL CHILDREN

By

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A Thesis Approved on

April 15, 2013

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DEDICATION

This thesis is dedicated to

my parents who have provided me unconditional love and invaluable support,

and my husband, Fujun Wen, who encouraged me to explore.

ACKNOWLEDGEMENTS

ABSTRACT

PRELIMINARY ASSESSMENT OF A SCHOOL-BASED HEALTHY LIFESTYLE

PROGRAM AMONG RURAL CHILDREN

Jiying Ling

April 15, 2013

Introduction: Childhood obesity has become a national public health crisis in
America. Physical inactivity and unhealthy eating behavior may contribute to childhood
obesity. School-based programs focusing on healthy lifestyles play a promising role in
preventing and controlling childhood obesity.

Purpose: To assess the preliminary effects of a school-based program on physical
activity and eating behavior among rural children.

Methods: A quasi-experimental study design with repeated measures
(intervention group only) was utilized. Children from kindergarten to fifth grade in four
rural elementary schools in Kentucky participated in the study. A variety of strategies
were implemented to obtain four goals: (1) improving physical activity level, (2)
improving health and nutrition education, (3) promoting family/community involvement
through Family Fitness Fun Nights, and (4) realigning school's wellness policy with
HealthierUS School Challenge. Physical activity was assessed by pedometer logs of step
counts (4 consecutive days), while fruits and vegetables consumption were assessed by a
previous day recall survey. Data were collected in January (baseline), February (t1),

March (t2), April (t3) and May (t4) of 2010. Repeated measures ANOVA and mixed-effects regression models were used.

   Results: A total of 1,508 children, 814 boys and 679 girls (15 missing sex), participated in this study. The program had significant effects on increasing the percentage of children meeting nutrition (14.8% vs. 25.9%, $p < 0.01$) and physical activity recommendations (1.4% vs. 5.0%, $p < 0.01$). There were significant main effects of school, time, sex and grade on physical activity and eating behavior. The effects of the program on physical activity and eating behavior depended on school, grade and age of the children. Children's physical activity level was positively correlated with their grade level. Generally, there was an increasing linear trend of physical activity and an increasing quadratic trend of eating behavior over time.

   Conclusions: The school-based healthy lifestyle program had beneficial effects on improving healthy behaviors among children. Further studies are needed to assess the long-term health effects and cost-effectiveness of this program.

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CHAPTER 1

INTRODUCTION

Childhood Obesity

Childhood obesity has become a public health crisis in the United States (U.S.), with significant geographic, sex, age and ethnic disparities (Ogden, 2010). Results from the National Health and Nutrition Examination Survey (NHANES) indicate that between 1963 and 2008, childhood obesity rates have tripled, and obesity rates are disproportionately high among children aged 6 to 11 years old (Ogden, 2010). Today, nearly one in three children in the U.S. is overweight or obese (American Heart Association, 2012). In Kentucky, nearly 40% of children are overweight or obese (Alliance for a Healthier Generation, 2011). Current evidence suggests that the prevalence of childhood obesity is likely to remain on the rise, and it has been estimated that by the year 2030, more than 60% of American children and nearly 90% of American adults will become overweight or obese (Y. Wang, Beydoun, Liang, Caballero, & Kumanyika, 2008). Obesity has very serious influences on children's health, and it is associated with a range of adverse metabolic and cardiovascular conditions (C. L. Williams et al., 2002), poor self-esteem (F. Wang & Veugelers, 2008), an increased likelihood of being obese in adulthood (Y. Wang et al., 2008), and increasing health care costs (G. Wang & Dietz, 2002). Thus, effective programs on preventing and controlling childhood obesity are urgently needed.

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Statement of Problem

Obesity is a global epidemic and has a rising trend among children (Lobstein, Baur, Uauy, & Iaso International Obesity TaskForce, 2004). Obesity not only affects children's physical and psychological health, but also influences subsequent adult health as obese children typically remain obese as adults (Reilly et al., 2003).

Short Term Effects

Short-term effects of childhood obesity can be categorized into psychological and cognitive consequences and the development of cardiovascular risk factors in childhood. Evidence has concluded that obese children are more likely to experience psychological problems than non-obese children (Reilly et al., 2003). Specifically, obese children tend to have lower self-esteem than non-obese children by demonstrating significantly higher rates of sadness, loneliness and nervousness (Strauss, 2000). As a result, obese children are more likely to engage in high-risk behaviors such as smoking or consuming alcohol. In addition, obese children tend to have lower visuospatial organization, that is, the visual perception of spatial relationships among objects, and lower general mental ability, compared to normal-weight children (Li, Dai, Jackson, & Zhang, 2008).

A literature review concluded that childhood overweight and obesity was significantly associated with poorer academic performance (Taras & Potts-Datema, 2005). However, some researchers suggest that obesity is only a marker instead of a causal factor of poorer academic performance. In other words, childhood obesity is significantly correlated with poorer academic performance, but not significantly correlated with poorer academic performance after controlling socioeconomic status and parents' education level (Datar, Sturm, & Magnabosco, 2004; Judge & Jahns, 2007;

Veldwijk et al., 2012). Further researches are needed to clarify the relationship between childhood obesity and academic performance.

Results from previous studies have consistently supported that childhood obesity is correlated with cardiovascular risk factors – hypertension, dyslipidemia, abnormalities in left ventricular mass and/or function, abnormalities in endothelial function, and hyperinsulinemia/insulin resistance (Reilly, 2005). Expert committee reports and reviews have recommended that childhood obesity should be considered as an important component of cardiovascular risk (C. L. Williams et al., 2002).

Long Term Effects

Childhood obesity not only has short-term effects, but also has long-term effects as the current generation of obese children becomes adults. It has been estimated that two in three children born after 2000 will suffer from obesity-related health problems such as cardiovascular disease, diabetes, hypertension, cancer, gall bladder disease, osteoarthritis, endocrine disorders and asthma at some point in their life (Lobstein et al., 2004). Evidence indicates that more than 70% of obese children will become obese adults (Reilly et al., 2003). As a result of the persistence of obesity, the current American generation might have a shorter life expectancy than their parents (Olshansky et al., 2005).

The economic costs of childhood obesity are especially evident in health care expenditures (G. Wang & Dietz, 2002; Y. Wang et al., 2008). Obesity-associated annual hospital costs increased from $35 million during 1979-1981 to $127 million during 1997-1999 (G. Wang & Dietz, 2002). The direct health care costs of childhood obesity include $14.1 billion of prescription drug, emergency room and outpatient costs, and $237.6

million of inpatient costs per year (Trasande & Chatterjee, 2009; Trasande, Liu, Fryer, & Weitzman, 2009). Much larger costs are incurred when obese children become obese adults. In 2011, the health care costs of obesity-related diseases among adults were estimated at approximately $147 billion per year, and by 2030, the health care costs attributed to overweight and obesity are projected to account for $900 billion per year, or for one in every 6 dollars spent on health care (Y. Wang et al., 2008). In addition, adult obesity accounts for about $4.3 billion related to job absenteeism per year (Cawley, Rizzo, & Haas, 2007), and $506 of losses related to low work productivity per obese worker per year (Gates, Succop, Brehm, Gillespie, & Sommers, 2008). Thus, cost-effective childhood obesity prevention and intervention programs are urgently needed for the nations' financial health.

Need for the Study

Considering the magnitude of childhood obesity epidemic and its great health and economic effects, cost-effective interventions or programs are urgently needed. Evidence has supported that unhealthy behaviors – physical inactivity and unhealthy eating – are significantly correlated with the childhood obesity epidemic (Slyper, 2004). However, the majority of American children do not meet the recommendations for physical activity and nutrition (Bock & Miller, 2008; Slyper, 2004). Furthermore, the overall decline in fitness and nutrition levels lead to the inescapable conclusion: American children need more physical activity, along with knowledge of health, wellness, nutrition and physical activity (Center for the Advancement of Physical Education, 2004; Rowland, 2007). Both family-based and school-based healthy lifestyle programs have shown significant effects on reducing weight and sedentary activity, and increasing physical activity (Bacardi-

Gascon, Perez-Morales, & Jimenez-Cruz, 2012; Greening, Harrell, Low, & Fielder, 2011; Sacher et al., 2010). School-based healthy lifestyle programs are cost-effective, and schools are considered an ideal setting for healthy lifestyle promotion programs (Bacardi-Gascon et al., 2012; H. S. Brown et al., 2007). Further, evidence indicates that children in rural areas are more likely to be overweight or obese, and participate in unhealthy behaviors (Liu, Bennett, Harun, & Probst, 2008; Liu et al., 2010). Childhood is a crucial time when healthy behaviors are learned and adopted, and early childhood intervention programs can make a significant difference to a child's life changes (Gray & Francis, 2007). Therefore, comprehensive school-based programs have a promising role in promoting healthy lifestyle and preventing or controlling obesity among children, especially children in rural areas.

Purpose of the Study

The purpose of this study was to assess the preliminary effects of a comprehensive school-based program on physical activity and healthy eating behavior using multiple-sample repeated measures ANOVA and mixed-effects regression models among children from kindergarten to fifth grade in four rural elementary schools in Kentucky. The overall aims of the intervention are to increase children's daily physical activity, improve children's cardiorespiratory fitness, and improve children's nutrition habits. The school-based healthy lifestyle intervention was developed based on the principles of the Coordinated School Health Program recommended by Centers for Disease Control and Prevention (CDC) (2011c). The intervention included four goals: (1) improving physical activity level, (2) improving health and nutrition education (U.S. Department of Health and Human Services, 2012), (3) promoting family/community

involvement through Family Fitness Fun Nights, and (4) realigning school's wellness policy with *HealthierUS School Challenge* (U.S. Department of Agriculture, 2011b). For purposes of this study, children's physical activity level and eating behavior were assessed over the course of the first year of the program.

Research Questions

1. How did sex, school and grade influence the effects of the program on physical activity level over time among children?

2. How did sex, school and grade influence the effects of the program on eating behavior over time among children?

3. Which statistical method is more efficient used in repeated measures design?

Significance of the Study

This study found that the comprehensive school-based healthy lifestyle program had significant effects on promoting healthy behaviors − physical activity and healthy eating − among children. Future researchers or policy makers could adopt and popularize this program to other rural elementary schools throughout the U.S. to improve children's health and lower health care costs related to childhood obesity. In addition, future studies can learn valuable lessons through assessing the design, procedure and evaluation methods in this study. Though this program is school-based, it also involves parents and community through hosting Family Fitness Fun Nights. The design of this program also emphasizes the important role of school health policy in promoting healthy behaviors and controlling childhood obesity.

Findings from this study could make significant contributions on designing healthy lifestyle programs and improving American's health from one generation to

another. This study recommends that healthy lifestyle promotion programs should focus on lifelong, habit-forming behaviors of physical activity and healthy eating, because healthy habits can be maintained throughout life from one generation to another. However, further studies are still needed to evaluate its cost effectiveness and effects on controlling childhood obesity.

This study emphasizes the significance of using mixed-effects regression models in analyzing repeated measures data. Mixed-effects regression models are robust to the assumption of sphericity, and can fit different covariance patterns leading more appropriate fixed effects estimates (H. Brown & Prescott, 2006). Results from this study indicates that the two most promising variance-covariance structures were unstructured and autoregressive heterogeneous variances, which did not meet the assumption of sphericity. In other words, multiple-sample repeated measures ANOVA was not suitable in analyzing the data. Moreover, mixed-effects regression models can deal with missing data easily without deleting cases with missing data, and they can be applied to the repeated measures data with unequal time intervals.

Definition of Terms

To clarify the meaning of the concepts, the following definitions were used in this study.

Body Mass Index (BMI): Child's BMI is a number calculated from weight and height using the formula '*BMI = (Weight in Kilograms / (Height in Meters × Height in Meters))*'. For children, BMI is age- and sex-specific, and is often referred as BMI-for-age. BMI cannot directly measure body fat, but it has been supported to be a reliable indicator of body fatness for most children. After obtaining BMI, the number is plotted

on a CDC BMI-for-age chart to obtain a percentile ranking. The BMI percentile is an indicator to assess the size and growth patterns of individual child in the U.S. (CDC, 2011a).

Child and Adolescent: A child is defined as a person aged 4 to 11 years old, and an adolescent is defined as a person aged 12 to 19 years old (CDC, 2011b). For this study, all participants will be referred to as children, although some were adolescents.

Overweight: Childhood overweight is defined as a BMI at or above the 85th percentile and lower than the 95th percentile for children of the same age and sex (CDC, 2011f).

Obesity: Childhood obesity is defined as a BMI at or above the 95th percentile for children of the same age and sex (CDC, 2011f).

Physical Activity: Physical activity refers to "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen, Powell, & Christenson, 1985, p. 126). Generally, physical activity has four elements: (1) bodily movement produced by skeletal muscles, (2) results in energy expenditure, (3) energy expenditure varies continuously from low to high, and (4) positive correlation with physical fitness (Caspersen et al., 1985).

Exercise: Exercise is physical activity that is planned, structured, repetitive, and purposive to improve or maintain some component of physical fitness (Caspersen et al., 1985). Exercise is one subset of physical activity, that is, physical activity includes exercise.

Physical Fitness: Physical fitness is a set of attributes that people have or achieve that relate to the ability to perform movement. Physical fitness has five components:

cardiorespiratory, body composition, muscular strength, muscular endurance, and flexibility (Caspersen et al., 1985).

Fruit and Vegetable: Both fruits and vegetables − when prepared without adding solid fats or sugars − are nutrient-dense foods, which provide vitamins, minerals, and other substances that have positive health effects with relatively low calorie. Nutrient-dense refers to the nutrients or other beneficial substances that have not been diluted by the addition of calories from solid fat, sugar, or other added refined starches (U.S. Department of Agriculture, 2011a).

Categorical Variable: Categorical variable has a measurement scale consisting of a set of categories and it has two primary types of scales, nominal and ordinal. Nominal variables refer to the variables that have categories without a natural ordering, while ordinal variables are variables that have ordered categories. Though ordinal variables have ordered categories, distances between categories are unknown (Agresti, 2007).

Numerical Variable: Numerical variable refers to a variable that has a numeric value and it can be divided into two categories, interval and ratio. Both interval variables and ratio variables have equal intervals between two values and absolute zero is the only difference between these two kinds of variables. An interval variable does not have absolute zero while a ratio variable has absolute zero (Kutner, Nachtsheim, Neter, & Li, 2005).

Two-Independent-Samples *t* test: Two-independent-samples *t* test is a test to compare the mean scores of two groups on a dependent variable. The assumptions for using this method are: (1) the distribution of the sample means is normally distributed; and (2) the two groups are independent from each other. Based on the Central Limit

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Theorem, if the sample size is ≥ 30, then the distribution of the sample means will be normally distributed approximately (Norusis, 2010).

One-Way Analysis of Variance (ANOVA): One-Way ANOVA is a test to compare the means of two or more groups on a dependent variable. The assumptions for using this method are: (1) the distribution of the sample means is normally distributed; (2) the two or more groups have approximately equal variances on the dependent variable, which can be assessed by Levene's or Bartlett's Tests; and (3) the two or more groups are independent from each other. Based on the Central Limit Theorem, if the sample size is ≥ 30, then the distribution of the sample means will be normally distributed approximately (Norusis, 2010).

Cochran-Mantel-Haenszel Test: Cochran–Mantel–Haenszel test is a test to examine the independence of repeated tests for ordinal variables and it is analogous to a two-way ANOVA for a measurement variable. The Cochran-Mantel-Haenszel test potentially removes the confounding influences of the explanatory variables that comprise the stratification and can provide increased power for detecting associations by comparing similar subjects (Stokes, Davis, & Koch, 2000).

Simple Linear Regression: Simple linear regression is a statistical technique to assess the effects of an independent variable X on a dependent variable Y. The assumptions for using this test are: (1) all Y values are independent of each other; (2) the values of Y follow normal distribution for each X value; (3) there is a linear relationship between X and Y; and (4) the standard deviation of Y at any given value of X is the same. The linear model can be expressed by $Y_i = \alpha + \beta X_i + \varepsilon_i$. The parameters α and β are called regression coefficients. The parameter α is the intercept of the regression model,

that is, α gives the mean of the probability distribution of Y when $X = 0$. The parameter β

is the slope of the regression line, which indicates the change in the mean of the

probability distribution of Y per unit increase in X. ε_i is the random error with mean 0 and

variance σ^2 (Kutner et al., 2005).

Univariate Repeated Measures ANOVA: Univariate repeated measures ANOVA,

as an extension of paired t-test, is used to test the equality of means when a dependent

variable is measured under a number of different conditions. Three assumptions should

be held to use the repeated measures ANOVA: (1) the observations are independent; (2)

multivariate normality, that is, each individual variable is normally distributed with

respect to each other variable, which can be assess by Mardia's tests of multivariate

Skewness and Kurtosis, or multivariate Shapiro-Wilk test; and (3) Sphericity, that is, the

homogeneous of variance, assessed by the Mauchly's test (Stevens, 2009). A principal

advantage of univariate repeated measures ANOVA is that the variations between

subjects are excluded from the experimental error, and only variations within subjects are

included in the experimental error (Kutner et al., 2005). In this study, multiple-sample

repeated measures ANOVA was used to test the effects of intervention (time effect) –

within-subject effects, factor A (a demographic variable) – between-subject effects, and

interaction effects between intervention and Factor A on healthy behaviors.

Mixed-Effects Regression Models: Mixed-effects regression models can be used

in the repeated measures design. Compared to univariate repeated measures ANOVA,

they have three advantages: (1) it can handle missing data easily; (2) the time interval can

be unequal among subjects; and (3) it is robust to the assumption of sphericity (Howell,

2010). In a mixed-effects regression model, it has both fixed effects and random effects.

Through adding random effects in the model, we assume that subjects differ on average, or the random effects have different influences on each individual. If the research purpose is to infer the general change patterns of a dependent variable, it is suggested that the time should be considered as a random factor (Blackwell, de Leon, & Miller, 2006).

Main Effect: Main effect is the overall effects of one independent variable on a dependent variable, while ignoring the effects of all other independent variables (Stevens, 2009).

Interaction Effect: Interaction effect is that the effects of one independent variable on a dependent variable depend on another independent variable (Stevens, 2009).

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter presents a review of literature related to the physical activity levels and eating behaviors among children, childhood obesity interventions, and statistical methods used to evaluate interventions. Further, rural residency as a health indicator and policy/programs in controlling childhood obesity in Kentucky will be addressed. Finally, the two commonly used statistical methods, multiple-sample repeated measures ANOVA and mixed-effects regression models, in repeated measures design studies are discussed.

Physical Activity

Correlation with Childhood Obesity

Weight is gained when energy intake exceeds energy expenditure. In order to maintain a stable weight, a delicate balance between energy intake and energy expenditure is required. Generally, energy expenditure comprises three components: resting energy expenditure, the thermic effects of food (the energy expenditure in consuming and processing food), and the thermic effects of physical activity. Except the three components of energy expenditure, children need additional energy for growth. The requirement energy need for growth is about 1-2% of total energy expenditure in childhood (Steinbeck, 2001). The resting energy expenditure is the minimum energy need to sustain life, and remains relatively constant within individuals over time (Goran & Treuth, 2001). The thermic effects of food are primary influenced by the composition of

food, and are relatively stable within individuals over time (Steinbeck, 2001). The thermic effects of physical activity are the most variable component of energy expenditure, and vary within and between individuals due to the variable nature of physical activity (Goran & Treuth, 2001). Thus, physical activity is the discretionary component of energy expenditure, and lack of physical activity is the most significant contributor to childhood obesity (Hills, Andersen, & Byrne, 2011; Janssen et al., 2005). Physical activity can increase energy expenditure through its influences on body composition (includes body fat and lean body mass) and metabolism. Moreover, it can increase the capacity to mobilize and burn body fat while using muscles through increasing and maintaining lean body mass (LBM) (Nowicka & Flodmark, 2007).

Consistent evidence has shown that overweight or obese children participate in lower levels of physical activity compared to normal weight children (Hills et al., 2011; Nowicka & Flodmark, 2007), and children with higher levels of physical activity have reduced skinfold thickness, while obese children participate in higher levels of sedentary behaviors (Davis et al., 2007; Hills, King, & Armstrong, 2007). In addition, the 2001-2002 Health Behavior Survey among 137,593 school-age children from 34 countries reported that greater physical activity participation was significantly correlated with lower odds of overweight in 29 out of 34 countries, including the U.S. (Janssen et al., 2005). Similarly, a study among 1,204 children and adolescents indicated that physical inactivity and sedentary lifestyles were significant determinants of elevated BMI and risk factors contributing to childhood overweight and obesity (Bukara-Radujkovic & Zdravkovic, 2009).

Physical Activity Level

The CDC (2011d) and the U.S. Department of Health and Human Services (2012) recommend that children should participate in at least 60 minutes or more physical activity per day. Specifically, children should participate in several bouts of intermittent moderate to vigorous-intensity physical activity daily, as well as muscle-strengthening and bone-strengthening physical activity at least 3 days a week (U.S. Department of Health and Human Services, 2012).

The Third National Health and Nutrition Examination Survey (NHANES) from 1988 to 1994 found that 44.1% of boys and 38.4% of girls aged 8-10 years old, and 53.1% of boys and 43.8% of girls aged 11-13 years old participated in physical activity for more than 5 days a week (Crespo et al., 2001). However, in 2002, the Youth Media Campaign (YMC) conducted a survey among children aged 9-13 years old, and the results indicated that 61.5% of children did not engage in any organized physical activity during their non-school hours and 22.6% of children did not participate in any free-time physical activity (Duke & Huhman, 2003). The 2003-2004 NHANES found that on average boys and girls performed 45 and 26 minutes of moderate- or vigorous-intensity physical activity per day and about 48% of boys and 35% of girls participated in at least 60 minutes physical activity daily (Troiano et al., 2008). Furthermore, boys and girls watched a daily average of 137 and 128 minutes of television (TV) respectively, and approximately 30% of boys and 25% of girls watch 4 hours or more TV per day (Marshall, Gorely, & Biddle, 2006).

Physical activity levels among American children have dropped sharply between age 9 and age 15, and most of the children did not meet the daily recommended physical

activity level (Bock & Miller, 2008). At age 9, children participated on average three hours of moderate- or vigorous-intensity physical activity on weekdays and weekends, but by age 15, they only participated on average 49 minutes per weekday, and 35 minutes per weekend (Bock & Miller, 2008). Additionally, in 2006, more than 69% of elementary schools, 84% of middles schools, and 95% of high schools were required to have physical education. However, only 4% of elementary schools, 8% of middle schools, and 3% of high schools had provided daily physical education to students (Lee, Burgeson, Fulton, & Spain, 2007). During 1991-1995, there was a significant decline in daily physical education and no change observed during 1995-2003 in high school students, which resulted in the failed achievement of national health objectives (CDC, 2004).

Eating Behavior

Association to Childhood Obesity

In addition to physical inactivity, diets with high calories, high sugar, and low fiber have been reported to contribute to childhood obesity (Wieting, 2008). Cross-sectional studies have found that children who consumed fast food meals have higher energy intake than children who did not consume fast food (Paeratakul, Ferdinand, Champagne, Ryan, & Bray, 2003). Moreover, a longitudinal study indicated that for 8 to 12-year-old girls consuming fast food two or more times a week at baseline, 96% of the girls had larger weight gain at a three-year follow-up compared to girls who did not consume fast food (Thompson et al., 2004). In addition, children consuming fast food consumed more fat, carbohydrate, sugars, while less fibers, milk, and fewer fruits and vegetables than children not consuming fast food (Bowman, Gortmaker, Ebbeling, Pereira, & Ludwig, 2004).

Similarly, a longitudinal study among 70 children reported that the mean fat intake recorded between the ages of 2 and 8 years was significantly positive predictor of BMI at 8 years old (Skinner, Bounds, Carruth, Morris, & Ziegler, 2004). Pediatric experts suggest that an increase in the dietary carbohydrate may be the most important contributor to the childhood obesity epidemic (Slyper, 2004). Evidence strongly supports that sweet beverage consumption is positively correlated with BMI and obesity incidences among children (Ludwig, Peterson, & Gortmaker, 2001). Furthermore, increased portion sizes have also been reported to contribute to the increasing prevalence of childhood obesity through promoting excessive energy intake. When presented with portions that were twice as big as the age-appropriate standard size, children would consume 25% more meals and 15% more calories at lunch (Orlet, Rolls, & Birch, 2003).

In addition, lower intakes of calcium from milk, cheese, and yogurt are associated with childhood obesity. A longitudinal study among 52 children found that dietary calcium intakes between 2 months and 8 years old were negatively correlated with percentage of body fat at 8 years old (Skinner, Bounds, Carruth, & Ziegler, 2003). In addition, evidence has supported that fruits and vegetables can protect against increased adiposity in children. Fruits and vegetables have been recommended for obesity prevention/intervention due to their low energy density, high fiber content, and satiety value (Davis et al., 2007).

Eating Behavior

The U.S. Department of Agriculture (2011b) suggests that children should consume three or more servings of vegetables and two or more servings of fruits per day. In 2004, only 21% of children had the recommended five or more servings of fruits and

vegetables each day. Interestingly, nearly half of all of their vegetable servings were fried potatoes (e.g. French fries or potato chips). From the early to mid-1990s, soda consumption increased dramatically while milk consumption declined dramatically among children (Slyper, 2004). Children as young as seven months old started to consume soda, and about 40% of children consumed three or more eight-ounce servings of soda per day. In 1977-78, children drank 4 times as much milk as sugar sweetened beverages, but that has decreased to 1.5 times as much milk as sugar sweetened beverages in 1990s. From 1965 to 1996, milk consumption in America declined by 36% because the saturated fat content of dairy food has placed milk a suspect food (e.g. the negative perception of a food), that is, milk was the top one source of saturated fat (24%) for children at that time (Slyper, 2004). Currently, more than 33% of children consume fast food daily (U.S. Department of Health & Human Services, 2012). Carbohydrate intake has increased because of the decrease in dietary fat. Between 1989 and 1991, the top ten categories of carbohydrate for children were yeast bread (13% carbohydrate), sodas (8.5%), milk (7.9%), ready-to-eat cereals (7.4%), cookies (7.2%), sugars (6.0%), fruit drinks (4.3%), pasta (3.9%), white potatoes (3.7%), and orange/grapefruit juice (2.9%) (Subar, Krebs-Smith, Cook, & Kahle, 1998).

Childhood Obesity Interventions

The lack of physical activity combined with unhealthy diets has broken the energy balance equation in children. Diets with high calorie, high sugar, and low fiber increase energy intake greatly, while the lack of physical activity decreases energy expenditure. Thus, both physical inactivity and unhealthy diets contribute to the current childhood obesity epidemic. Interventions of childhood obesity focusing on healthy lifestyles can be

summarized into two categories: family-based and school-based interventions. Both family-based and school-based interventions have shown significant contributions to childhood BMI reduction.

One randomized controlled trial of a family-based community intervention found that children in the intervention group showed beneficial changes in waist circumference, BMI, heart rate, physical activity, sedentary activity, and self-esteem compared to children in the control group after 6 months of intervention (Sacher et al., 2010). In addition, evidence supported that family-based interventions had long-term effects on children's BMI, physical activity, sedentary activity, blood pressure, and diet, and the influence patterns were similar between boys and girls (Brotman et al., 2012).

Since children spend most of their daytime in school, this setting has been considered an ideal site for healthy lifestyle promotion programs (Bacardi-Gascon et al., 2012). A randomized cluster controlled trial indicated that a six-month, school-based intervention had significant effects on decreasing abdominal obesity, sedentary activity, snacks consumption, and increasing vegetable consumption and physical activity (Bacardi-Gascon et al., 2012). Similarly, another eight-month, school-based, healthy lifestyles intervention in a rural community found that schools in the intervention group showed significant changes in percentage of body fat, physical activity, physical fitness, and eating habits compared to schools in the control group. However, the effects of the program were not significantly different based on sex or ethnicity (Greening et al., 2011). Thus, both family-based and school-based childhood healthy lifestyles interventions have effects on controlling obesity, and promoting healthy behaviors, but the influence patterns are not different between boys and girls.

Pediatric experts have recommended four primary behavioral strategies for weight management: (1) reduce energy intake while maintaining optimal nutrition intake; (2) increase energy expenditure through promoting more physical activity and less sedentary activity; (3) engage family as agents of change; and (4) facilitate a supportive family environment (Kirk, Scott, & Daniels, 2005). Childhood obesity programs promoting lifestyle changes showed reductions in percent overweight of 8.2% during treatment and 8.9% at follow-up (Kelly & Kirschenbaum, 2011).

Evidence also shows strong public support for interventions aimed at controlling overweight and obesity among children. The majority of Americans favored school-based interventions, such as teaching students healthy eating and exercise habits in school; requiring more physical education classes, recess, and supervised intramural activities; restricting unhealthy foods and drinks in school vending machines and school cafeterias; and providing exercise programs for obese children (Evans, Finkelstein, Kamerow, & Renaud, 2005). In addition, a comprehensive intervention in elementary schools including a classroom curriculum, a physical education program, modifications to the school food services and family-based programs, is supported to be highly cost-effective compared to other programs among adolescents or adults (H. S. Brown et al., 2007; Cawley, 2010). Therefore, comprehensive school-based programs have a promising role in preventing and controlling childhood obesity.

Statistical Techniques to Evaluate Interventions

Concerning the childhood obesity epidemic, many programs have been designed and conducted to promote children's healthy behaviors and control childhood obesity. This section focuses on the statistical techniques used to assess the effects and cost-

effectiveness of childhood obesity prevention/intervention programs on healthy behaviors and weight loss.

Effects of Interventions

For the majority of the studies, outcomes were assessed twice (pretest and posttest) (Greening et al., 2011; Sacher et al., 2010; Siegrist, Hanssen, Lammel, Haller, & Halle, 2011). IBM SPSS Statistics were the most popular software used in the previous studies. Independent t-test, paired t-test, Mann-Whitney test, chi-square test, and ANOVA were the mostly used statistical techniques to assess the outcome differences between control group and intervention group in pretest and posttest, or to evaluate the intervention effects from pretest to posttest (Bacardi-Gascon et al., 2012; Greening et al., 2011; Sacher et al., 2010; Siegrist et al., 2011). One-way or two-way repeated measures (pretest vs. posttest) MANOVA were used to assess the main effects of intervention and conditions, and the interaction effects of conditions and time (West, Sanders, Cleghorn, & Davies, 2010). In addition, linear (simple or multiple) and logistic regression have been applied to model the changing patterns of outcomes over time (Brotman et al., 2012; Plachta-Danielzik, Landsberg, Lange, Seiberl, & Muller, 2011). Blackwell and colleagues (2006) suggested that mixed-effects regression models provide a more flexible and accurate framework for managing repeated measures data compared to conventional statistical techniques, such as, t-test, ANOVA, repeated measures ANOVA/MANOVA, and linear regression et al. For many longitudinal studies, data collected for each subject is correlated over time. Mixed-effects regression models describe complex covariate effects in each subject, while allowing for unexplained population heterogeneity and serial or spatial correlation among repeated measurements (Pedan, n.d.). However, no

study in behavioral science has been identified to use this statistical method to assess the effects of healthy lifestyle programs.

Cost-Effectiveness of Interventions

In a world of limited resources for healthy behavior promotion and public health, the healthy lifestyle programs should not just be effective, but also be cost-effective. In 2003, Wang and colleagues first introduced an economic evaluation technique for assessing the cost-effectiveness of childhood obesity prevention programs. This societal method used standard cost-effectiveness and cost-benefit analysis methods to assess the costs and benefits of a program compared to a control program (no intervention). The benefits of a program were measured as quality-adjusted life years (QALYs) and averted costs, that is, the medical costs and productivity costs associated with cases of adulthood overweight prevented (L. Y. Wang et al., 2003). The cost-effectiveness of the program was assessed by the cost-effectiveness ratio (CER) ($CER = {program\ costs}/{QALYs}$).

The cost-benefit of the program was assessed by net benefits ($net\ benefits = averted\ costs - program\ costs$) (L. Y. Wang et al., 2003). This societal method has been widely used to assess the cost-effectiveness of school-based healthy lifestyle programs (H. S. Brown et al., 2007; McAuley et al., 2010).

To perform the economic evaluations, researchers need to be aware of the six steps: (1) retrospective estimation of the program costs; (2) mathematical modeling to transform observed overweight reduction at the current age of children into an estimate of the number of overweight cases prevented in adulthood after age 40 years; (3) estimation of the medical costs averted per case of adulthood overweight prevented; (4) estimation of the number of QALYs saved per case of adulthood overweight prevented; (5)

estimation of productivity costs averted per case of adulthood overweight prevented; and (6) calculate the CER and the net benefits of the program (Ganz, 2003; L. Y. Wang et al., 2003). However, limitations still exist in the societal method: small sample size, estimation bias, and ignorance of the monetary values of health outcomes, et al (Dalziel & Segal, 2006). Thus, quality evaluation methods of the cost-effectiveness of programs are urgently needed to provide valuable information for decision-makers and future research activities.

Rural Residency as a Health Indicator

Nearly 20% of the U.S. population resides in non-metropolitan areas and are not immune to many health challenges (Bellamy, Bolin, & Gamm, 2011). Compared to urban children, the majority of rural children is white, poor, and has less-educated parents. Only 22% of overweighed or obese rural children live in a household with annual family income >200% of the federal poverty level compared to 32% of metropolitan children (Lutfiyya, Lipsky, Wisdom-Behounek, & Inpanbutr-Martinkus, 2007). Evidence supports that overweight or obese school age children are more likely to live in a rural area rather than a metropolitan area (Liu et al., 2008; Lutfiyya et al., 2007). Consistently, rural children are more likely to be overweight or obese compared to urban children after controlling the socio-demographic characteristics, health and obesity-related behavioral factors. This significant difference is found both in boys and girls (Liu et al., 2010).

Although it would be tempting to assume that rural children might have more opportunities to participate in physical activity and eat healthy food due to the more outdoor spaces and more access to the fresh foods, this is not the case (Cherry, Huggins, & Gilmore, 2007). Studies revealed that rural children aged 6 to 11 years old consumed

more fat and tended to have more sugar in their diets than urban children (Cherry et al., 2007; Liu et al., 2010). Overweight or obese rural children are reported to watch TV for more than 3 hours a day and use a computer for non-school work more often than overweight or obese urban children. Moreover, about 41% of rural children do not participate in any after school activities (Lutfiyya et al., 2007). The difference in prevalence of overweight and obesity might be attributed to the higher prevalence of unhealthy behaviors among rural children. Therefore, rural residency is a risk factor for children being overweight or obese. The higher prevalence of overweight or obesity and unhealthy behaviors (sedentary behaviors and sugar/fat consumption) calls for further research on effective intervention programs among rural children.

<div align="center">

Children in Kentucky

</div>

Physical Activity and Nutrition

In Kentucky, about 61% of adolescents participated in physical activity at least 60 minutes per day, but fewer than 5 days per week, 29% watched television three or more hours per day, and 17% did not participate in at least 60 minutes of physical activity on any day (CDC, 2010). Additionally, 86% of adolescents consumed fruits and vegetables less than five times per day, 89% consumed vegetables less than three times per day, 19% did not eat fruits, and 88% drank less than three glasses of milk per day (CDC, 2010). It is recommended that children should consume three or more servings of vegetables and two or more servings of fruits (U.S. Department of Agriculture, 2011a), and participate in 60 minutes or more of moderate- or vigorous-intensity physical activity per day (U.S. Department of Health and Human Services, 2012). Accordingly, the majority of Kentuckian children did not meet the recommendations for fruits, vegetables and physical

activity. Therefore, physical activity and nutrition interventions are urgently demanded

for Kentuckian children, especially in low-socioeconomic, rural children, who have been

reported to have higher risks of unhealthy behaviors and obesity (Chen & Matthews,

2002).

Policy and Programs

   Healthy, Hunger-Free Kids Act of 2010. On December 13, 2010, President

Obama signed S. 3307, the Healthy, Hunger-Free Kids Act of 2010 into law (The White

House: Office of the Press Secretary, 2010). This act aims to authorize funding for

federal school meal plan and child nutrition programs and increase access to healthy food

for low-income children. Moreover, it reauthorizes child nutrition programs for five

years, including $4.5 billion new funding for over 10 years. Table 1 describes the specific

aims and strategies the act will adopt. The U.S. Department of Agriculture (USDA) has

released a chart detailing the implementation timelines for this law (School Nutrition

Association, 2011).

Table 1

Aims and strategies of the Healthy, Hunger-Free Kids Act of 2010

Aim	Strategy
Improve nutrition	(a) set nutritional standards, (b) provide funding to schools, (c) help communities establish local farms to school networks, (d) improve nutritional quality of foods, (e) increase access to drinking water in schools, (f) set standards for school wellness policies while permitting local flexibility to tailor the policies, (g) promote nutrition and wellness in child care settings, and (h) expand breastfeeding support
Increase access	(a) enroll more children in school meal programs, (b) maintain enrolling additional 4,500 students per year to school meal programs, (c) allow more universal meal access for students in high poverty communities, and (d) provide meals for more vulnerable children in afterschool programs
Increase program monitoring	(a) audit school districts every three years, (b) demand school districts to make information more readily available to parents, (c) include provisions to ensure the safety of school foods, and (d) provide training and technical assistance for school food service providers

Coordinated School Health Program. The CDC (2011c) recommends the

Coordinated School Health Program (CSHP) to improve students' health and learning in

U.S. It is an organized set of programs, policies, and activities with eight components to

promote students' health, achievement, and life success − health education, physical

education, nutrition services, health services, counseling and social psychological

services, healthy and safe school environment, family and community involvement, and

health promotion for staff (CDC, 2011c). Table 2 describes the eight components of a

CSHP. The goals of CSHP are to increase health knowledge, health attitudes, health

skills, health behaviors, health outcomes, educational outcomes, and social outcomes for

children (CDC, 2011c).

Table 2

Eight components of a Coordinated School Health program

Component	Description
Health Education	It includes a variety of health topics related to physical activity, nutrition, alcohol tobacco or drug use, abuse, mental prevention, sexual health, safety and injury prevention, and violence prevention. It should address the National Health Education Standards (CDC, 2011e).
Physical Education	It is a planned, sequential K-12 curriculum to improve students' knowledge and skills for lifelong participation in physical activity.
Nutrition Services	It requires school to provide meals meeting the U.S. Dietary Guidelines for Americans.
Health Services	It ensures every child and family have the access to health care services, emergency care for illness and injury, and educational and counseling opportunities for maintaining and promoting health.
Counseling & Social Psychological Services	It ensures every student receive these services from school counselors, psychologists and social workers, and aims to improve students' mental, emotional and social health.
Healthy & Safe School Environment	It is designed to obtain healthy physical and aesthetic surroundings and psychosocial climate and culture of the school.
Family & Community Involvement	It requires the school to involve parents and engage community resources and services to improve students' health.
Health Promotion for Staff	It aims to provide health assessment, health education and health-related fitness activities for school staff to pursue a healthy lifestyle and improve their health status.

The CDC (2011c) has developed a coordinated model to implement a CSHP, consisting of (1) assessing school environment, (2) forming a school health/wellness council, (3) identifying a school health coordinator, (4) developing an action plan, (5) implementing the eight components, (6) focusing on students, (7) addressing priority health or risk behaviors, and (8) providing professional development for staff. To

facilitate the implementation of this program, state education and health agencies should provide technical assistance, resource plan, political support, professional development, and evaluation system (CDC, 2011c). The Kentucky Department of Education (2012) calls upon all school districts to approve and adopt a CSHP to improve children's health and learning in school. To facilitate the adaptation and administration of CSHP, the Kentucky Department of Education (2012) proposed to: (1) provide leadership and support to develop a state-level infrastructure; (2) demonstrate an integrated, collaborative approach among educators, health service providers, and policy agencies; and (3) make sure every child has the access to health services and support. The Kentucky Department of Education has advocated this program to all the school districts, and provided resources and technical training to the schools.

Statistical Methods Used in Repeated Measures Design

Multiple-Sample Repeated Measures ANOVA

Multiple-sample repeated measures ANOVA, sometimes called "split-plots" ANOVA model, is the simplest and most commonly used, but most restrictive model used in longitudinal studies (Hedeker & Gibbons, 2006). This method is used to examine the effects of two factors (one between-subject factor and one within-subject factor) on dependent variables. Suppose factor A is the between-subject factor with *s* groups, and time is the within-subject factor with *n* time points. For group *h*, there are N_h subjects ($N = \sum_{h=1}^{s} N_h$). There are four effects of interest – between-subject main effect (factor A effect or group effect), within-subject main effect (time effect or intervention effect), interaction effect between factor A and time, and random subject effects. The multiple-sample repeated measures model can be written as:

$$y_{hij} = \mu + \gamma_h + \tau_j + (\gamma\tau)_{hj} + \pi_{i(h)} + e_{hij}$$

Where:

y_{hij} is a $(sN_s) \times n$ response matrix, such as,

Group	Subject	Timepoints			
		1	2	...	n
1	1	y_{111}	y_{112}	...	y_{11n}
1	2	y_{121}	y_{122}	...	y_{12n}
1	...	...	...	...	...
1	...	...	...	...	...
1	N_1	y_{1N_11}	y_{1N_12}	...	y_{1N_1n}
...	...	...	...	...	...
s	1	y_{s11}	y_{s12}	...	y_{s1n}
s	2	y_{s21}	y_{s22}	...	y_{s2n}
s	...	...	...	...	...
s	...	...	...	...	...
s	N_s	y_{sN_s1}	y_{sN_s2}	...	y_{sN_sn}

with $h = 1,\ldots,s$ groups, $i = 1,\ldots,N_h$ subjects in group h ($N = \sum_{h=1}^{S} N_h$), and $j = 1,\ldots,n$ time points.

μ is a constant, the grand mean.

γ_h is the main effect of group h ($\sum_h \gamma_h = 0$).

τ_j is the main effect of time j ($\sum_j \tau_j = 0$).

$(\gamma\tau)_{hj}$ is the interaction effect between group h and time j ($\sum_h \sum_j (\gamma\tau)_{hj} = 0$).

$\pi_{i(h)}$ is the individual difference component for subject i nested in group h.

e_{hij} is the error for subject i in group h at time j.

The distributional assumptions for the above model are:

$$\pi_{i(h)} \sim N(0, \sigma_\pi^2) \quad and \quad e_{hij} \sim (0, \sigma_e^2)$$

The variance-covariance structure follows compound symmetry:

$$Var\left(y_{hij}\right) = \begin{bmatrix} \rho_e^2 + \sigma_\pi^2 & \cdots & \sigma_\pi^2 \\ \cdots & \rho_e^2 + \sigma_\pi^2 & \cdots \\ \sigma_\pi^2 & \cdots & \rho_e^2 + \sigma_\pi^2 \end{bmatrix}$$

The sum of squares and expected mean squares for the repeated measures model

are given in Table 3. To test the significance of random subject effects, the test statistics

is $F_{S(A)} = {MS_{S(A)}}\Big/{MS_R} \sim F_{N-s,(N-s)(n-1)}$. Compared to a univariate ANOVA, multiple-

sample repeated measures ANOVA uses a whole covariate matrix – variances and

covariances as the error for the within-subject factor in the model. The variance-

covariance structure used in the multiple-sample repeated measures ANOVA is

compound symmetry, which assumes that all variances are the same with each other, and

all the covariances are equal to one another over time (Kincaid & COMSYS Information

Technology Services, 2005). This assumption has little validity for longitudinal data,

because typically, variances increase with time because some subjects respond and others

do not, and covariances for proximal occasions are larger than covariances for distal

occasions (Hedeker & Gibbons, 2006). Moreover, this model can only allow each subject

to have his/her own trend line in terms of intercept but not in slope.

Table 3

Analysis of variance for two-factor experimental with repeated measures on time

Source of Variation	Sum of Squares (SS)	Degree of Freedom (df)	Mean Squares (MS)	F-ratio
Between Subjects Effects				
Factor A	$SS_A = n \sum_{h=1}^{s} N_h (\bar{y}_{h..} - \bar{y}_{...})^2$	$s - 1$	$MS_A = SS_A/(s-1)$	$MS_A/MS_{S(A)}$
Subjects in Groups	$SS_{S(A)} = n \sum_{h=1}^{s} \sum_{i=1}^{N_h} (\bar{y}_{hi.} - \bar{y}_{h..})^2$	$N - s$	$MS_{S(A)} = SS_{S(A)}/(N-s)$	
Within Subjects Effects				
Time (T)	$SS_T = N \sum_{j=1}^{n} (\bar{y}_{..j} - \bar{y}_{...})^2$	$n - 1$	$MS_T = SS_T/(n-1)$	MS_T/MS_R
T*A	$SS_{TA} = \sum_{h=1}^{s} \sum_{j=1}^{n} N_h (\bar{y}_{h.j} - \bar{y}_{h..} - \bar{y}_{..j} + \bar{y}_{...})^2$	$(s-1)(n-1)$	$MS_{TA} = SS_{TA}/(s-1)(n-1)$	MS_{TA}/MS_R
Residual	$SS_R = \sum_{h=1}^{s} \sum_{i=1}^{N_h} \sum_{j=1}^{n} (\bar{y}_{hij} - \bar{y}_{h.j} - \bar{y}_{hi.} + \bar{y}_{h..})^2$	$(N-s)(n-1)$	$MS_R = SS_R/(N-s)(n-1)$	
Total	$SSy = \sum_{h=1}^{s} \sum_{i=1}^{N_h} \sum_{j=1}^{n} (\bar{y}_{hij} - \bar{y}_{...})^2$	$Nn - 1$		

Note. $\bar{y}_{...}$ = average across groups, time points, and subjects,
$\bar{y}_{h..}$ = average for group h across time points and subjects,
$\bar{y}_{..j}$ = average for timepoint j across groups and subjects,
$\bar{y}_{hi.}$ = average for subject i in group h across time points,
$\bar{y}_{h.j}$ = average for group h at time point j across subjects.

Mixed-Effects Regression Models

Mixed-effects regression models can be applied to both normally distributed continuous outcomes as well as categorical outcomes, and they are quite robust to missing data (Hedeker & Gibbons, 2006). When analyzing repeated measures data, mixed-effects regression models can help to fit covariate pattern models with more appropriate fixed effects estimates. There is a large selection of variance-covariance structures used in mixed-effects regression models. Four forms of variance-covariance structures are popularly used in mixed-effects regression models: compound symmetry, unstructured, autoregressive and autoregressive heterogeneous variances (See Figure 1) (Kincaid & COMSYS Information Technology Services, 2005). The unstructured form assumes that each variance and covariance is unique. The autoregressive structure has homogeneous variances, and correlations decline exponentially with distance, that is, two measurements that are right next to each other in time are more correlated than measurements that are more distant. The autoregressive heterogeneous variances structure has heterogeneous variances, and correlations decline exponentially with distance as the autoregressive structure (Kincaid & COMSYS Information Technology Services, 2005).

$$\begin{bmatrix} \sigma^2 + \sigma_1^2 & \sigma_1^2 & \sigma_1^2 \\ \sigma_1^2 & \sigma^2 + \sigma_1^2 & \sigma_1^2 \\ \sigma_1^2 & \sigma_1^2 & \sigma^2 + \sigma_1^2 \end{bmatrix} \qquad \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_2^2 & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_3^2 \end{bmatrix}$$

Compound Symmetry Unstructured

$$\begin{bmatrix} \sigma^2 & \rho\sigma^2 & \rho^2\sigma^2 \\ \rho\sigma^2 & \sigma^2 & \rho\sigma^2 \\ \rho^2\sigma^2 & \rho\sigma^2 & \sigma^2 \end{bmatrix} \qquad \begin{bmatrix} \sigma_1^2 & \rho\sigma^2 & \rho^2\sigma^2 \\ \rho\sigma^2 & \sigma_2^2 & \rho\sigma^2 \\ \rho^2\sigma^2 & \rho\sigma^2 & \sigma_3^2 \end{bmatrix}$$

Autoregressive Autoregressive Heterogeneous Variances

Figure 1. Examples for variance-covariance structures

Mixed-effects regression models can be written as:

$$y_i = X_i \beta + Z_i v_i + \epsilon_i$$

Where:

y_i is a $n_i \times 1$ response vector for subject i, with $i = 1…N$ subjects, and $n_i =$ number of repeated measurements for subject i.

X_i is a $n_i \times p$ fixed design matrix, $p =$ number of fixed effects of interest (time effects, group effects, interaction effects).

Z_i is a $n_i \times r$ random design matrix, $r = 1$ or 2 number of random effects of interest (intercept and slope).

β is a $p \times 1$ vector of fixed effects, the parameters of β are the same for all subjects.

v_i is a $r \times 1$ vector of random effects, the parameters of v are allowed to vary among subjects.

ϵ_i is a $n_i \times 1$ residual vector.

Three assumptions are under this model: (1) residual is independent within subject, and follows normal distribution with mean 0 and variance σ^2, (2) ϵ_i and v_i are independent, and (3) v_i follows normal distribution with mean 0 and variance σ_0^2 (random-intercepts model) and $\begin{pmatrix} \sigma_0^2 & \sigma_{01} \\ \sigma_{01} & \sigma_1^2 \end{pmatrix}$ (random intercepts and trend model) (Hedeker & Gibbons, 2006).

Summary

Childhood obesity has become a national public health crisis in the U.S. Evidence supports that unhealthy behaviors − physical inactivity and unhealthy eating − are significantly correlated with the childhood obesity epidemic. Physical inactivity and

unhealthy eating behaviors have broken the energy balance equation among children. In 2002, 61.5% of children did not participate in any organized physical activity during non-school hours and 22.6% of children did not engage in any free-time physical activity. In 2004, only 21% of children consumed the recommended five or more servings of fruits and vegetables a day, but half of the vegetable servings were fried potatoes. Therefore, programs focusing on healthy lifestyle play a promising role in preventing and controlling childhood obesity.

Both family-based and school-based healthy lifestyle programs have shown significant effects on reducing weight and sedentary activity, and increasing physical activity. School-based healthy lifestyle programs are cost-effective, and schools are considered as an ideal setting for healthy lifestyle promotion programs. Furthermore, rural residency has been deemed as a risk factor for children being overweight or obese, and participating in unhealthy behaviors. Therefore, comprehensive school-based programs have a promising role in promoting healthy lifestyle and preventing or controlling obesity among children, especially children in rural area. The purpose of this study was to assess the preliminary effects of a comprehensive school-based program on physical activity and healthy eating behavior among rural children from kindergarten to fifth grade in Kentucky using multiple-sample repeated measures ANOVA and mixed-effects regression models.

CHAPTER 3

METHODOLOGY

Research Design

A Quasi-Experimental Design with repeated measures (intervention group only)

was utilized to improve healthy behaviors – physical activity and eating behavior –

among rural children. All children from kindergarten to fifth grade in four rural

elementary schools in Kentucky were recruited to participate in the study. University

Institutional Review Board (IRB) reviewed and approved the protocol. All participants

were assessed at baseline (January 2010) and started the program immediately. Follow-up

assessments were conducted to assess children's physical activity level and eating

behavior in February (time 1, t1), March (t2), April (t3), and May (t4) of the first year of

the program in 2010.

Measurements

Physical Activity

The number of steps recorded by pedometer was used to assess physical activity

level, with more step counts indicating a higher level of physical activity. All children

were asked to wear a pedometer for consecutive four days each time (baseline and four

follow-up tests), and the average steps of the four days were used to describe the levels of

physical activity among children. A pedometer log (See Appendix A) was created for

children to record their steps each day. In the pedometer log, children were asked to

write down their number of steps and the time and date the number was recorded. Moreover, the pedometer log included detailed instructions for the parents/guardians to supervise or help their children wear the pedometer, record the steps, and reset to zero. Each time on Wednesday morning, classroom teachers handed the pedometers out to children. Children were asked to attach the pedometer to the waistband of his/her clothing in the morning from Wednesday to Saturday, and each night, the pedometer was to be removed before bedtime. At bedtime, children recorded the step counts on the pedometer logs. Once that day's steps had been recorded, children were asked to reset the pedometer to zero. After Day 4 (Saturday), children were asked to return the pedometers and pedometer logs to their classroom teacher on the following Monday.

The CDC (2011d) and U.S. Department of Health and Human Services (2012) recommend that children should participate in 60 minutes or more of moderate- or vigorous-intensity physical activity every day. With the technological advancement of objective measurement of physical activity level, such as pedometers, a new recommendation was informed to obtain the public health guidelines for children in terms of steps/day (Tudor-Locke et al., 2011). In 2008, a sex-specific graduated step index was introduced for children aged 6 to 12 years old. Values for boys were: < 10,000 steps/per day (sedentary); 10,000-12,499 steps/per day (low active); 12,500-14,999 (somewhat active); 15,000-17,499 (active); ≥ 17,500 (highly active). The corresponding values for girls were: < 7,000; 7,000-9,499; 9,500-11,999; 12,000-14,499; ≥ 14,500 (Tudor-Locke, Hatano, Pangrazi, & Kang, 2008). In addition, evidence suggests that 13,000 steps/per day for boys and 11,000 steps/per day for girls provided reasonable estimation of

attainment of 60 minutes of moderate- or vigorous-intensity physical activity (Tudor-Locke et al., 2011).

Eating Behavior

Five items (See Appendix B) selected from the School Physical Activity and Nutrition (SPAN) questionnaire were used to assess children's eating behavior (Penkilo, George, & Hoelscher, 2008; Thiagarajah et al., 2008). The eating behavior was described by the number of times consuming fruits and vegetables on the previous day. Evidence has supported that the SPAN questionnaire has relatively good test-retest reliability with Spearman rank order correlations (test-retest correlations) of 0.79 and 0.78, Kappa values (inter-rater agreement) of 0.65 and 0.60, and percentage agreement of 74.3% and 70.3% for vegetable and fruit items respectively among children (Penkilo et al., 2008). In addition, it has acceptable validity with Spearman rank order correlations of 0.34 and 0.40, Kappa values of 0.17 and 0.27, and percentage of agreement of 27% and 51% between the SPAN questionnaire and a 24-recall scale for vegetable and fruit items (Thiagarajah et al., 2008). In this study, the Cronbach's alpha coefficient was 0.73, and the item-item correlation coefficients ranged from 0.30 to 0.41, indicating that the five-item nutrition scale had acceptable reliability.

Setting

Subjects in this study were recruited from four rural elementary schools in Kentucky. In School 1, there were total 370 students (184 boys and 179 girls) in grades PK-5, 19 classroom teachers with student/teacher ratio of 19.5, and 250 students were eligible for free lunch, and 41 student were eligible for reduced-price lunch. In School 2, total students number was 277 (137 boys and 139 girls), classroom teachers 14.3, with

student/teacher ratio of 19.4, and 157 students were eligible for free lunch, and 26 students were eligible for reduced-price lunch. In School 3, there were total 309 students (139 boys and 139 girls) and 16 classroom teachers with student/teacher ratio of 19.3, and 198 students are eligible for free lunch, and 14 students were eligible for reduced-price lunch. While in School 4, there were total 459 students (247 boys and 200 girls) and 24.7 classroom teachers with student/teacher ratio of 18.6, and 231 students were eligible for free lunch, and 53 students were eligible for reduced-price lunch (National Center for Educational Statistics, 2012).

Intervention

The intervention is an integrated, multicomponent healthy lifestyle program based on the principles of the Coordinated School Health Program recommended by CDC (2011c). The intervention included four goals: (1) improving physical activity level, (2) improving health and nutrition education (U.S. Department of Health and Human Services, 2012), (3) promoting family/community involvement, and (4) realigning school's wellness policy with *HealthierUS School Challenge* (U.S. Department of Agriculture, 2011b). Interventions for all four goals (See Table 4) were conducted in the four schools, except Family Fitness Fun Night was cancelled in School 4 due to time constraints in the school year.

After receiving the funding, a project director, a nutrition consultant, a professional development consultant, a physical education consultant and three Healthy Lifestyle Coaches (HLCs) were hired to implement all activities. The three HLCs worked daily in the 4 schools (one HLC shared 2 schools) implementing the program and collecting data. Activities during the Family Fitness Fun Night included fruits and

Table 4

Elementary school-based intervention goals, descriptions, and key personnel

Goals	Description	Key Personnel
Improve Physical Activity Level	1. Developed improved pedagogy strategies 2. Implemented SPARK (Sports, Play, and Active Recreation for Kids) physical education curriculum (SPARK, 2012) 3. Incorporated physical activity breaks into school	Physical education consultant from local university Each school's physical education teacher Classroom teachers
Improve Health and Nutrition Education	1. Participated in six *HealthierUS School Challenge* nutrition curriculum workshops 2. Attended one national school nutrition conference 3. Provided one-day intensive classroom nutrition education session 4. Incorporated nutrition education into the curriculum 5. Aligned lunch menus with the U.S. Department of Agriculture's Nutrition Guidelines (2012)	Each school's nutrition personnel (cafeteria managers, cooks, and servers) Each school's nutrition personnel Local nutritional non-profit organization Classroom teachers Healthy Lifestyle Coaches Nutrition director
Promote Family/Community Involvement	1. Hosted Family Fitness Fun nights 2. Strengthened family and community partnerships	Healthy Lifestyle Coaches County health departments, local hospitals, universities, and other community health-related groups
Realign School's Wellness Policy With *HealthierUS School Challenge*	1. Developed and/or revised school wellness policy 2. Aligned school wellness policy with national and state physical activity and nutrition standards, and Coordinated School Health models' framework (CDC, 2011c)	Healthy Lifestyle Coaches Each school's site-based decision making council

vegetables taste-testing, physical activity obstacle courses, health and fitness booths and educational literature.

Procedure

Before the baseline data collection, the study protocol was submitted to the University of Louisville IRB for review. Since the lifestyle promotion programs would be adopted and implemented as part of the normal school day practices, the University IRB marked this study as "exempt". Then a letter was sent home to parents indicating that their children's school had been selected to participate in the program, and a variety of healthy interventions were to occur throughout the next 3 years. Children's participation in the data collection was voluntary. For children whose parents contacted the principal and asked for their child to be excluded from this study, their data were not collected. Approximately 10 children's parents requested for their children not to participate in the data collection.

Children in the study were asked to wear the pedometer each day and complete their pedometer logs each night with the help of their parents. At the end of each data collection window, the HLCs collected the pedometer logs and pedometers from each child during class, and asked the children to finish the nutrition questionnaire at the same time.

Data Analysis

Data was compiled and analyzed using SAS 9.3 for Windows (SAS Institute Inc, Cary, NC). Means (*M*) and standard deviations (*SD*) were applied to describe numerical variables, while frequencies and percentages were used to describe categorical variables. Multiple-sample repeated measures ANOVA was applied to assess the main effects of

school, age, sex, and grade through tests on the mean squared errors between subjects, and the intervention effects and interaction effects through tests on the mean squared errors within subjects. Independent t-test was utilized to test sex differences on physical activity level, and fruits and vegetables consumption, while one-way ANOVA was applied to test the school and grade differences on physical activity level, and fruits and vegetables consumption over time. Cochran-Mantel-Haenszel Statistics was used when the dependent variables were percentage. Simple linear regression was used to explore the influence of age on physical activity level and eating behavior. Mixed-effects regression models were applied to assess the change trends of physical activity level and eating behavior over time and to explore the fitted model for physical activity and eating behavior. Akaike's Information Criterion (AIC) (smaller is better) was used to select the best approximating model.

Sample

There were 1,508 children, 814 boys and 679 girls (15 children did not indicate sex), participating in this study with an average age of 8.32 years old ($SD = 1.88$). Table 5 displays the demographics distribution of the subjects in this study. The results of ANOVA indicated that there were significant differences among schools in children's age ($F = 82.39$, $p < 0.001$). Specifically, children from School 4 were older on average than children from School 1, 2 and 3, and children from School 1 were older than children from School 2 and 3. Thus, for inferential analysis among these four schools, age was controlled.

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Table 5

Demographic information of subjects

Variables	Overall	School 1	School 2	School 3	School 4
Total	1508	492 (32.6%)	242 (16.1%)	323 (21.4%)	451 (29.9%)
Grades					
Grade K	236 (15.6%)	81 (16.5%)	35 (14.5%)	51 (15.8%)	69 (15.3%)
Grade 1	232 (15.4%)	71 (14.4%	36 (14.9%)	52 (16.1%)	73 (16.2%)
Grade 2	263 (17.4%)	91 (18.5%)	42 (17.4%)	53 (16.4%)	77 (17.1%)
Grade 3	265 (17.6%)	72 (14.6%)	46 (19.0%)	73 (22.6%)	74 (16.4%)
Grade 4	265 (17.6%)	98 (19.9%)	36 (14.9%)	40 (12.4%)	91 (20.2%)
Grade 5	247 (16.4%)	79 (16.1%)	47 (19.4%)	54 (16.7%)	67 (14.9%)
Sex					
Boys	814 (54.5%)	263 (53.5%)	140 (58.1%)	165 (51.7%)	246 (55.8%)
Girls	679 (45.5%)	229 (46.5%)	101 (41.9%)	154 (48.3%)	195 (44.2%)
Age	8.3 ± 1.9	8.3 ± 1.8	7.6 ± 1.7	7.5 ± 1.7	9.3 ± 1.6
	(5 - 13)	(5 - 12)	(5 - 10)	(5 - 10)	(6 - 13)

CHAPTER 4

RESULTS

Physical Activity

Physical Activity Recommendation

At baseline, 11 (1.6%) girls and 9 (1.1%) boys participated in at least 60 minutes moderate- or vigorous-intensity physical activity per day, that is, 13,000 steps/per day for boys and 11,000 steps/per day for girls. At t1, t2, t3 and t4, the number of girls meeting physical activity recommendation was 13 (1.9%), 33 (4.9%), 31 (4.6%), and 46 (6.9%) respectively, while the number of boys was 30 (3.7%), 27 (3.3%), 37 (4.5%), and 33 (4.1%) respectively.

The results of Cochran-Mantel-Haenszel statistics showed that the intervention had significant effects on the percentage of children meeting physical activity recommendation ($p < 0.001$). At t1, the percentage of girls meeting physical activity recommendation was lower than the percentage of boys meeting physical activity recommendation ($p = 0.04$), while at t4, the percentage of girls meeting physical activity recommendation was higher than the percentage of boys meeting physical activity recommendation ($p = 0.02$). Specifically, from baseline to t2, t3 and t4, the percentage of girls meeting physical activity recommendation increased significantly ($p < 0.01$); and from baseline to t1, t2, t3 and t4, the percentage of boys meeting physical activity recommendation increased significantly ($p < 0.01$). Similarly, from t1 to t2, the

percentage of girls meeting physical activity recommendation increased significantly ($p =$ 0.003).

Multiple-sample Repeated Measures ANOVA

The between subject tests of repeated measures ANOVA indicated that there were significant school effects ($p < 0.001$) and age effects ($p < 0.001$) on the physical activity level assessed by pedometer. The results of ANOVA indicated that the effects of intervention on physical activity level were significantly different among the four schools from baseline to t4. The results of Tukey's HSD indicated that at baseline, children in School 3 participated in the lowest level of physical activity while children in School 1 had the highest level of physical activity (3437.21 vs. 5481.95, $p < 0.001$). At t1, children in School 2 had the lowest level of physical activity while children in School 1 engaged in the highest level of physical activity (4550.88 vs. 5740.94, $p < 0.001$). At t2, children in School 2 had the lowest level of physical activity while children in School 1 had the highest level of physical activity (5015.82 vs. 6699.22, $p < 0.001$). At t3, children in School 4 participated in the lowest level of physical activity (School 4 did not have the Family Fitness Fun Night) while children in School 3 participated in the highest level of physical activity (5966.35 vs. 7788.82, $p < 0.001$). At t4, children in School 4 had the lowest level of physical activity while children in School 3 had the highest level of physical activity (6606.99 vs. 7982.75, $p < 0.001$).

The results of simple linear regression indicated that from baseline to t4, children's physical activity level increased as children grew ($physical\ activity = 399.4 + 243.1 \times age + 2936.0$). The within subject test indicated that there were significant time effects ($p < 0.001$), interaction effects between time and school ($p <$

0.001), and interaction effects between time and age ($p = 0.031$) on physical activity level. In other words, time or intervention had significant effects on physical activity, and the effects of intervention depended on which school were the children in and the age of the children.

There was significant sex effects ($p < 0.001$), time effects ($p < 0.001$), but no significant interaction effects between time and sex ($p = 0.328$) on physical activity level. Specifically, at t1, t2, and t3, boys participated in significantly higher level of physical activity than girls. The effects of intervention on physical activity did not depend on sex. There was significant grade effects ($p < 0.001$), time effects ($p < 0.001$), and interaction effects between time and grade ($p < 0.001$) on the physical activity level recorded by pedometer. In other words, the effects of intervention depended on which grade were the children in.

Mixed-Effects Regression Models

Figure 2 demonstrates that there was an increasing linear trend of physical activity level over time among all schools, and there were unequal linear regressions of physical activity on time for the four schools ($p < 0.001$). Physical activity level increased dramatically among children in School 3, while increased slower among children in School 4. Figure 3 shows that there was an increasing linear trend of physical activity over time according to sex ($p < 0.001$). Figure 4 reveals that physical activity level increased linearly over time among children from different grades ($p < 0.001$), and physical activity level increased more slowly from baseline to t4 among children from kindergarten than students from other grades. The best approximating model for physical activity with AIC of 138.74×10^3 was shown in Table 6. The results of physical activity

model indicated that the average step counts at baseline were 4809.26. The conditional on average step counts (when controlling for other factors) increased by 273.8 per month, and increased by 288.39 with one grade level increasing. For each individual, the baseline physical activity level was different.
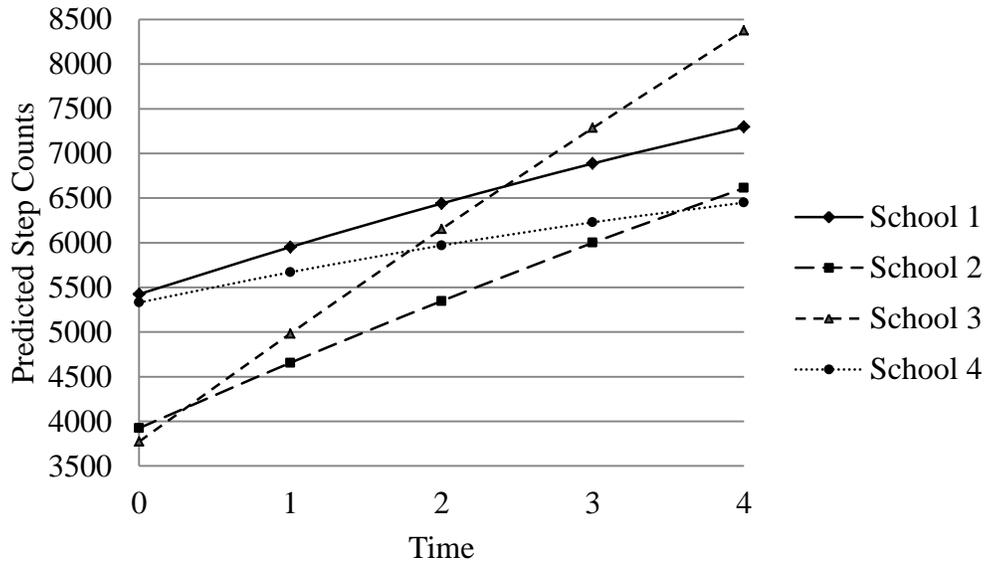
Figure 2. School-wised trend of children's physical activity level over time
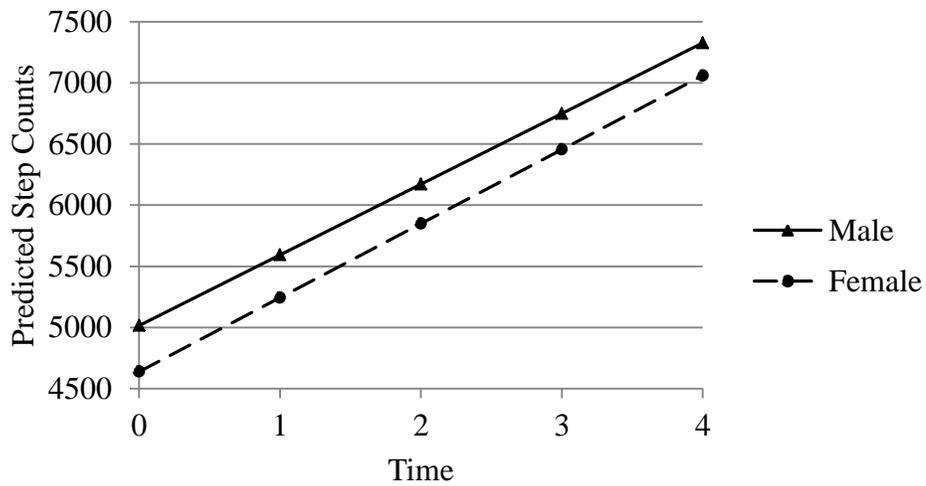
Figure 3. Trend of children's physical activity level over time based on sex
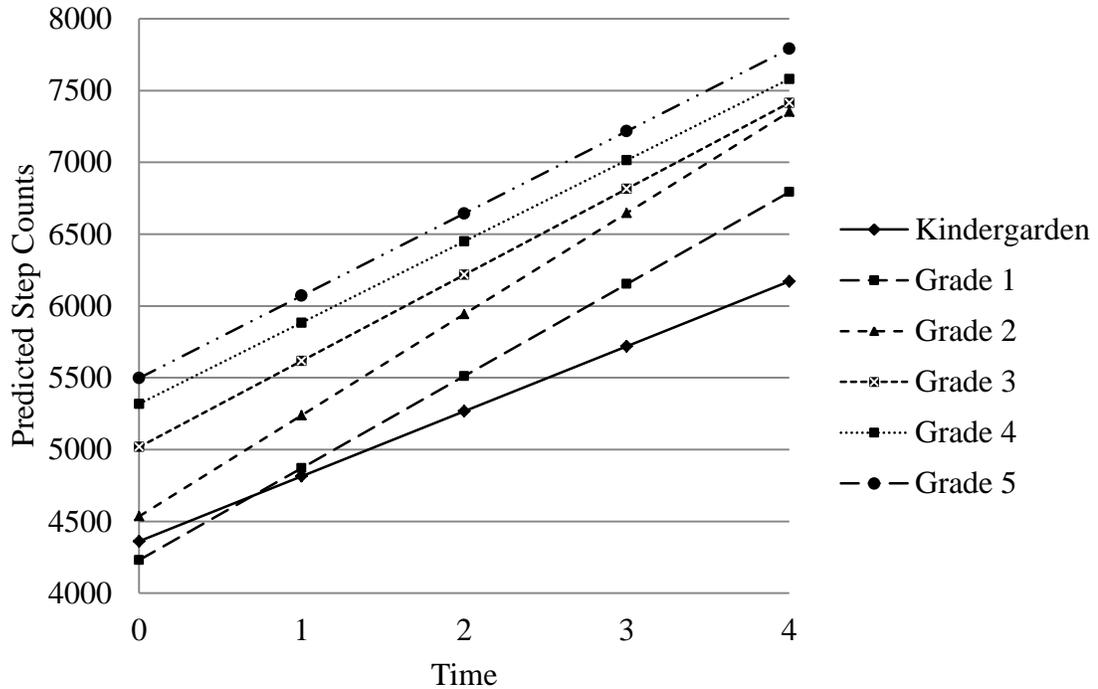
Figure 4. Trend of children's physical activity level over time based on grade level

Eating Behavior

Nutrition Recommendation

At baseline, 206 (14.8%) children met the recommendation of eating three or more servings of vegetables and two or more servings of fruits per day. At t1, t2, t3 and t4, the number of children meeting the nutrition recommendation was 209 (15.3%), 384 (27.8%), 410 (30.2%), and 347 (25.9%) respectively. The results of Cochran-Mantel-Haenszel statistics showed that the intervention had significant effects on the percentage of children meeting nutrition recommendation ($p < 0.001$). Specifically, from baseline to t2, t3, and t4, the percentage of children meeting nutrition recommendation increased significantly ($p < 0.001$). Similarly, from t1 to t2, the percentage of children meeting nutrition recommendation increased significantly ($p < 0.001$), but from t3 to t4, the

percentage of children meeting nutrition recommendation decreased significantly ($p = 0.012$).

Multiple-sample Repeated Measures ANOVA

There were significant school effects ($p < 0.001$) but no significant age effects ($p = 0.584$) on the previous day fruits and vegetables consumption. From baseline to t4, children in School 1 consumed more fruits and vegetables than children from other schools. The results of simple linear regression indicated that at baseline, the previous day fruits and vegetables consumption significantly increased with age ($\hat{\beta} = 0.075$, $p = 0.004$). The within subject test indicated that there were significant intervention effects ($p < 0.001$), interaction effects between time and school ($p < 0.001$), and interaction effects between time and age ($p = 0.011$) on the previous day fruits and vegetables consumption. In other words, the effects of intervention on previous day fruits and vegetables consumption depended on which school were the children in and the age of the children.

There was significant sex effects ($p = 0.006$), time effects ($p < 0.001$), but no significant interaction effects between time and sex ($p = 0.245$) on the previous day fruits and vegetables consumption. Specifically, at t2, t3, and t4, girls consumed more fruits and vegetables than boys. The effects of intervention on fruits and vegetables consumption did not depend on sex. The between subject tests indicated that there was no significant grade effects ($p = 0.786$) on the previous day fruits and vegetables consumption. The within subject test showed that there were significant time effects ($p < 0.001$), and interaction effects between time and grade ($p < 0.001$) on the previous day fruits and vegetables consumption. In other words, the effects of intervention depended on which grade were the children in. The results of ANOVA indicated that at t1, children

in Grade 4 consumed more fruits and vegetables than children in Grade 3 (4.21 vs. 3.91, $p = 0.040$).

Mixed-Effects Regression Models

Figure 5 displays that there was an increasing quadratic trend of previous day fruits and vegetables consumption over time among the four schools, and there were unequal quadratic regression of eating behavior on time for the four schools ($p < 0.05$). From baseline to t2, the previous day fruits and vegetables consumption increased dramatically, while from t2 to t4, the consumption increased slowly or kept the same among children. The previous day fruits and vegetables consumption increased slower among children in School 4. Figure 6 demonstrates that there was an increasing quadratic trend of the previous day fruits and vegetables consumption over time among all children, and consumption increased faster among girls compared to boys ($p = 0.01$). Figure 7 reveals that there was an increasing quadratic trend of previous day fruits and vegetables consumption over time among children from different grades. From baseline to t3, the previous day fruits and vegetables consumption increased stably, while from t3 to t4, the consumption increased slowly or did not increase among all grades children. The best approximately model for eating behavior with AIC of 40.89×10^3 was shown in Table 6. The eating behavior model indicated that the average fruits and vegetables consumption at baseline was 2.88. On average, the previous day fruits and vegetables consumption increased by 1.03 fruit or vegetable per month when controlling for other factors. For each individual, the baseline fruits and vegetables consumption was different, and also the increasing trend was different over time.
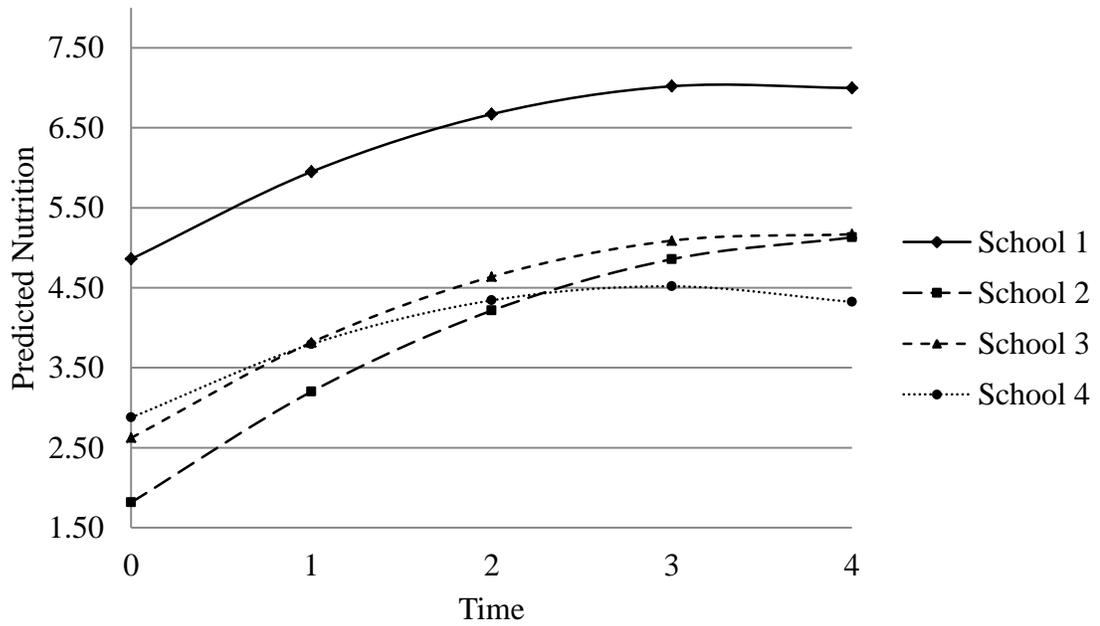
Figure 5. School-wised trend of children's eating behavior over time
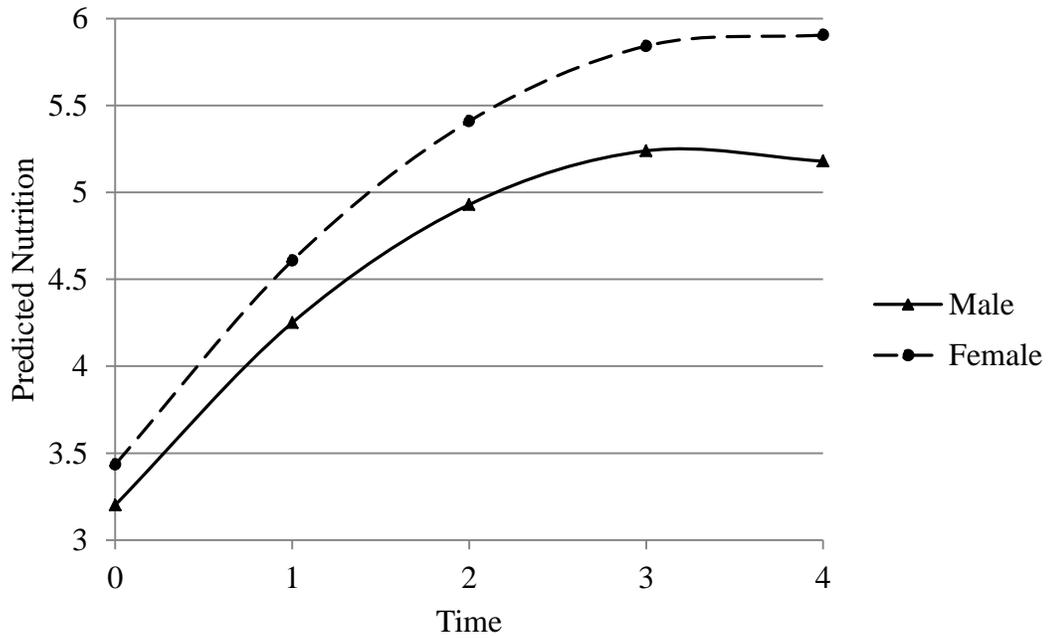
Figure 6. Trend of children's eating behavior over time based on sex
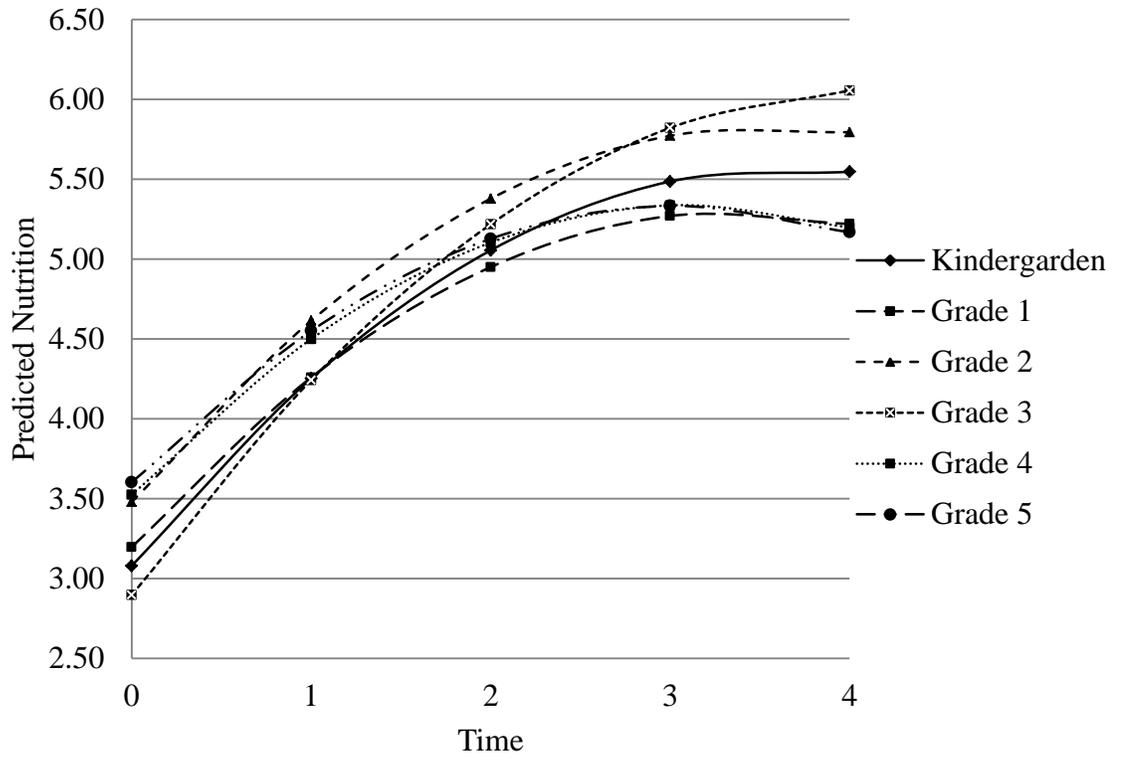
Figure 7. Trend of children's eating behavior over time based on grade level

Table 6

Physical activity and eating behavior change over time

Effect	Physical Activity Model		Eating Behavior Model	
	Coefficient (*SE*)	*p*-value	Coefficient (*SE*)	*p*-value
Fixed effects				
Intercept	4809.3 (132.6)	< 0.001	2.9 (0.2)	< 0.001
Time	273.8 (36.5)	< 0.001	1.0 (0.1)	< 0.001
Time*Time	—	—	-0.2 (0.02)	< 0.001
Sex (female)	-373.6 (87.6)	< 0.001	—	—
Grade	288.4 (26.0)	< 0.001	—	—
School 1	92.3 (149.4)	0.54	2.0 (0.2)	< 0.001
School 2	-1457.6 (182.5)	< 0.001	-1.1 (0.3)	< 0.001
School 3	-1535.5 (167.5)	< 0.001	-0.3 (0.2)	0.27
Time*School 1	194.1 (50.2)	< 0.001	0.2 (0.1)	0.03
Time*School 2	398.6 (61.4)	< 0.001	0.5 (0.1)	< 0.001
Time *School3	882.2 (56.3)	< 0.001	0.3 (0.1)	< 0.01
Time*Sex (female)	—	—	0.2 (0.1)	0.01
	Variance Estimate		Variance Estimate	
Random effects				
Intercept	167×10^4		5.1	
Time	—		0.7	
Residual	5867055		9.2	

Note. *SE* = standard error

Fruits Consumption

There were significant school effects ($p < 0.001$) and age effects ($p = 0.047$) on

the previous day fruits consumption. The results of linear regression indicated that the

previous day fruits consumption increased with age at baseline ($\hat{\beta} = 0.064, p =$

0.014) and t1 ($\hat{\beta} = 0.062, p = 0.017$). From baseline to t4, the effects of intervention on

previous day fruits consumption were significantly different among the four schools.

Children in School 1 consumed more fruits over time than children in other schools. The

within subject test indicated that there were significant intervention effects ($p = 0.002$),

and interaction effects between time and school ($p < 0.001$), but no significant interaction

effects between time and age ($p = 0.322$) on the previous day fruits consumption. In other words, the effects of intervention depended on which school were the children in instead of age.

The between subject tests revealed that there was significant sex effects ($p = 0.012$) on the previous day fruits consumption. The within subject test indicated that there were significant time effects ($p < 0.001$), but no significant interaction effects between time and sex ($p = 0.855$) on the previous day fruits consumption. Specifically, at t3 and t4, girls consumed more fruits than boys, and there was no significant grade effects ($p = 0.136$), but significant time effects ($p < 0.001$), and interaction effects between time and grade ($p = 0.049$) on the previous day fruits consumption. In other words, the effects of intervention depended on which grade were the children in. The results of ANOVA indicated that at t1, students in Grade 4 consumed more fruits than students in Grade 3 (1.24 vs. 0.93, $p = 0.048$).

Vegetables Consumption

The between subject tests indicated that there were significant school effects ($p < 0.001$), but no significant age effects ($p = 0.994$) on the previous day vegetables consumption. The results of linear regression indicated that only at baseline, the previous day vegetables consumption significantly increased with age ($\hat{\beta} = 0.067$, $p = 0.009$). From baseline to t4, the effects of intervention on the previous day vegetables consumption were significantly different among the four schools. Children in School 1 consumed more vegetables than children in other schools. The within subject test indicated that there were significant intervention effects ($p < 0.001$), interaction effects between time and school ($p < 0.001$), and interaction effects between time and age ($p =$

0.014) on the previous day vegetables consumption. That is, the effects of intervention depended on which school were the children in and the age of the children.

There was significant sex effects ($p = 0.008$) and time effects ($p < 0.001$), but no significant interaction effects between time and sex ($p = 0.358$) on the previous day vegetables consumption. Specifically, at t2, t3, and t4, girls consumed more vegetables than boys. The between subject tests indicated that there was no significant grade effects ($p = 0.873$) on the previous day vegetables consumption. The results of ANOVA indicated that at t1, children in Grade 1 consumed more vegetables than children in Grade 3 (3.14 vs. 2.30, $p = 0.025$). The within subject test indicated that there were significant time effects ($p < 0.001$), and interaction effects between time and grade ($p < 0.001$) on the previous day vegetables consumption. In other words, the effects of intervention depended on which grade were the students in.

Comparison of Statistical Models

When using Mauchly's test to examine sphericity, the *p*-values for all models were less than 0.05, indicating that the sphericity assumption for multiple-sample repeated measures ANOVA did not hold. Thus, multiple-sample repeated measures ANOVA was not suitable for analyzing this data set. Through comparing the statistical models (with random intercept and slope) using different variance-covariance structures (See Table 7), models using the compound symmetry structures did not fit the data well. Moreover, the mixed-effects regression models using unstructured or autoregressive heterogeneous variances structure had smallest AIC values and the -2 Log Likelihood scores were significantly smaller than the -2 Log Likelihood scores of other models,

suggesting that the variance-covariance structure fitting the data well had heterogeneous variances.

Table 7

Model comparisons (comparing to multiple-sample repeated measures ANOVA using compound symmetry)

Model	AIC	-2RLL	Parameters $(df + 1)$	Diff – 2 RLL (vs. CS)	Diff in df (vs. CS)	p-value for Diff (chi square dist.)
Pedometer = grade + time + grade*time						
Compound Symmetry	140568.9	140572.9	2			
Unstructured	140382.9	140390.9	4	182	2	< 0.001
Autoregressive	140568.9	140572.9	2	0	0	na
Autoregressive Heterogeneous Variances	140382.9	140390.9	4	182	2	< 0.001
Pedometer = sex + time + sex*time						
Compound Symmetry	139446.4	139450.4	2			
Unstructured	139237.4	139245.4	4	205	2	< 0.001
Autoregressive	139446.4	139450.4	2	0	0	na
Autoregressive Heterogeneous Variances	139237.4	139245.4	4	205	2	< 0.001
Pedometer = school + age + time + school*time						
Compound Symmetry	139334.7	139330.7	2			
Unstructured	139144.0	139138.0	3	192.7	1	< 0.001
Autoregressive	139334.7	139330.7	2	0	0	na
Autoregressive Heterogeneous Variances	139144.3	139138.3	3	192.4	1	< 0.001

Eating Behavior = grade + time + grade*time + time*time

Compound Symmetry	41720.7	41724.7	2			
Unstructured	41463.6	41463.6	4	261.1	2	< 0.001
Autoregressive	41720.7	41724.7	2	0	0	na
Autoregressive Heterogeneous Variances	41463.6	41463.6	4	261.1	2	< 0.001

Eating Behavior = sex + time + sex*time + time*time

Compound Symmetry	41343.0	41347.0	2			
Unstructured	41085.6	41093.6	4	253.4	2	< 0.001
Autoregressive	41343.0	41347.0	2	0	0	na
Autoregressive Heterogeneous Variances	41085.6	41093.6	4	253.4	2	< 0.001

Eating Behavior = school + age + time + school*time + time*time

Compound Symmetry	41162.8	41162.8	2			
Unstructured	41002.0	41010.0	4	152.8	2	< 0.001
Autoregressive	41162.8	41162.8	2	0	0	na
Autoregressive Heterogeneous Variances	41002.0	41010.0	4	152.8	2	< 0.001

CHAPTER 5

SUMMARY, DISCUSSION, AND CONCLUSIONS

This chapter summarizes the results of this study, discusses the findings related to literature and directions for future studies, and explains the strengths and limitations. In addition, a brief conclusion is presented to summarize the findings of this study.

Summary

Childhood obesity has become a public health crisis in U.S. Kentucky has the second highest rate of childhood obesity in America. In 2007, 37% of children were overweight or obese in Kentucky compared to 32% of children across the nation (Foundation for a Healthy Kentucky, 2009). Further, the majority of Kentuckians thought childhood obesity was a serious problem influencing children's health and increasing the nation's health care costs. Concerning the childhood obesity epidemic, 87% of Kentucky adults favored for schools to provide 30 minutes physical activity or physical education to students per day (Foundation for a Healthy Kentucky, 2009). However, the state law of Kentucky does not require schools to provide physical education for all grades (K-12) (Kaiser Family Foundation, 2011). In addition, evidence has shown that children from low socioeconomic class were less likely to have physical education in their schools (Lewis, 2007). Thus, healthy lifestyle programs among children from low socioeconomic class in Kentucky are urgently needed.

This study presented a comprehensive, school-based, healthy lifestyle program for children. The design of the program was based on the Coordinated School Health Model

recommendation of the CDC. All children from kindergarten to 5th grade in four rural elementary schools of Kentucky participated in this program. A variety of strategies were integrated in the daily routine of schools to obtain four goals: (1) improving physical activity level, (2) improving health and nutrition education (U.S. Department of Health and Human Services, 2012), (3) promoting family/community involvement through Family Fitness Fun Nights, and (4) realigning school's wellness policy with *HealthierUS School Challenge* (U.S. Department of Agriculture, 2011b). Two measurements (physical activity level and previous day fruits and vegetables consumption) were used to assess the effects of this program.

A total of 1,508 children participated in the healthy lifestyle program in the first year. During this time, the percentages of children meeting physical activity and fruits and vegetables consumption recommendation increased significantly. From baseline to t4, physical activity level was positively correlated with children's age. In other words, older children participated in higher level of physical activity. The fruits and vegetables consumption was positively correlated with children's age only at Baseline. Boys participated in higher level of physical activity while girls consumed more fruits and vegetables. Overall, this healthy lifestyle program had significant effects on improving children's physical activity level and fruits and vegetables consumption. The increasing linear trends of physical activity level over time were unequal among the four schools. Physical activity level increased faster in School 3, and increased slower in School 4. Similarly, the increasing trends of fruits and vegetables consumption were unequal among the four schools, and fruits and vegetables consumption increased slower in School 4. The effects of this program on physical activity level and previous day fruits

and vegetables consumption depended on which school, grade and the age of the children. In all, children's physical activity level increased by 273.8 steps per month, and their previous day fruits and vegetables consumption increased by 1.03 fruit or vegetable per month.

Discussion

In this study, at baseline, only 1.6% of girls and 1.1% of boys met the physical activity recommendation – participating in at least 60 minutes moderate- or vigorous-intensity physical activity per day. Similarly, only 15% of children in this study consumed three or more servings of vegetables and two or more servings of fruits per day. However, one study in two Midwestern communities found that 41.3% of boys and 45.6% of girls met the physical activity recommendation (Laurson et al., 2008), which is much higher than the percentages found in this study. National data suggests that on average, 48% of boys and 35% of girls participate in at least 60 minutes physical activity per day (Troiano et al., 2008), and 21% of children have the recommended five or more servings of fruits and vegetables each day (Slyper, 2004). However, no statewide or national study has been found to assess the percentages of Kentuckian children meeting physical activity and nutrition recommendation. Thus, national research is needed to assess the percentages of children meeting physical activity and nutrition recommendations across state.

The reason for the low percentages of children meeting physical activity and nutrition recommendations may be attributed to the study setting and socioeconomic status of the subjects. Subjects in this study were recruited from a rural district, and about 69% of the children were eligible for free lunch or reduced-price lunch (National Center

for Educational Statistics, 2012). In addition, evidence has supported that rural residency is a risk factor for children being overweight or obese and participating in unhealthy behaviors – sedentary activity and sugar/fat consumption (Liu et al., 2008; Lutfiyya et al., 2007). The low percentages of rural children meeting physical activity and nutrition recommendations suggest that further healthy lifestyle programs need to tailor rural children for improving healthy behaviors and finally preventing or controlling childhood obesity.

Findings from this study suggest that the program had significant effects on improving the percentages of children meeting physical activity and nutrition recommendations, and increasing physical activity level and improving eating behavior over time. In response to the childhood obesity epidemic, many family-based and school-based healthy lifestyle programs have been designed and conducted to improve children's healthy behaviors and control the childhood obesity epidemic. Family-based healthy lifestyle programs have been supported to have effects on reducing BMI, and increasing physical activity and healthy eating behaviors (Brotman et al., 2012; Sacher et al., 2010). Similarly, school-based healthy lifestyle programs have significant effects on decreasing abdominal obesity, sedentary activity and snacks consumption, and increasing vegetable consumption and physical activity (Bacardi-Gascon et al., 2012; Greening et al., 2011).

Evidence shows strong public support for school-based healthy lifestyle programs aimed at controlling overweight and obesity among children. The majority of Americans favored school-based interventions such as teaching students healthy eating and exercise habits in school, requiring more physical education classes, recess and supervised intramural activities, restricting unhealthy foods and drinks in school vending machines

and school cafeterias, and providing exercise programs for obese children (Evans et al., 2005). Similarly, the majority of Kentucky adults would love schools to provide physical activity programs to students (Foundation for a Healthy Kentucky, 2009). In addition, a comprehensive intervention in elementary schools including a classroom curriculum, a physical education program, modifications to the school food services and family-based programs, is supported to be highly cost-effective compared to other programs among adolescents or adults (H. S. Brown et al., 2007; Cawley, 2010). Therefore, comprehensive school-based programs in elementary schools are a public supportive and cost-effective way to prevent and control childhood obesity. Moreover, the effectiveness of the program on improving children's physical activity and eating behavior supports that the Coordinated School Health Program (CSHP) can be successfully integrated into children's routine school life, and has the promising role in promoting healthy lifestyle and controlling childhood obesity.

This study found that the physical activity and eating behavior change trends over time were similar between boys and girls, which was also supported by other studies (Greening et al., 2011). In other words, school-based healthy lifestyle programs do not have different effects based on sex, though boys participated in higher level of physical activity while girls consumed more fruits and vegetables. Moreover, the effects of the program on healthy behaviors depended on which school, grade, or the age of the children, suggesting that further school-based healthy lifestyle programs need to be tailored to the individual needs and contexts of children.

For School 4, the Family Fitness Fun Night was cancelled due to time constraints in the school year. Children in School 4 were older than children from other schools,

based on the findings that physical activity level was positively correlated with the age of children, children in School 4 should participate in higher level of physical activity. However, children in School 4 participated in the lowest level of physical activity since t3, and their physical activity level increased slowly over time. Similarly, children in School 4 consumed the fewest fuits and vegetables since t2, and their fruits and vegetables consumption increased slowly over time. Thus, Family Fitness Fun Night may be an indispensable component that the healthy lifestyle program should include. From another point of view, these findings reflect the important roles that family and community play in the promotion of healthy lifestyle among children. In other words, the support of family and community are necessary in controlling the childhood obesity epidemic (J. E. Williams, 2011).

Findings from this study also suggest that school-based healthy lifestyle interventions, integrated into children's daily routine of schools, have the potential to promote healthy behaviors among children. Schools are an ideal setting for healthy lifestyle promotion programs. School officials should consider incorporating nutrition, physical activity and health messages into school curriculum and aligning school wellness policies with the *HealthierUS School Challenge* criteria. Classroom teachers can play a vital role in helping children adopt healthy lifestyles in school. In addition, schools should collaborate with community and family to obtain resources, conduct healthy lifestyle programs, control childhood obesity, and improve children's health. Results from school-based interventions should be shared with school officials, classroom teachers, health educators, school health scientists and policy makers for further intervention design, conduct and policy change.

Results from this study indicates that the two most promising variance-covariance structures were unstructured and autoregressive heterogeneous variances since they had smallest AIC values and the -2 Log Likelihood scores were significantly smaller than those of other models, suggesting that the variance-covariance structure of the data did not meet the assumption of sphericity. In other words, multiple-sample repeated measures ANOVA was not suitable in analyzing the data. Mixed-effects regression models are robust to the assumption of sphericity, and can fit different covariance patterns leading more appropriate fixed effects estimates (H. Brown & Prescott, 2006). Moreover, they can deal with missing data easily without deleting cases with missing data, and they can be applied to the repeated measures data with unequal time intervals. Thus, further studies are needed to explore the efficacy of mixed-effects regression models in analyzing repeated measures data compared to univariate repeated measures ANOVA.

Limitations

Several limitations existed in the study. Quasi-experimental design (intervention group only) places the findings from this study in an untenable position compared to the randomly controlled trial. Due to the lack of a control group, the effects of the intervention may attribute to confounding factors – policy, media or environment. Another limitation is the lack of control of other factors such as socioeconomic status, parents' education level, marital status, employment status and ethnicity, because only the information related to sex, age, grade and school was collected due to the requirement of the school system. Moreover, the consumption of fruits and vegetables was assessed by a self-reported food frequency questionnaire instead of a weighed dietary record. The

BMI, waist circumstance, skin fold or other obesity indices were not applied to evaluate the effects of this program on controlling childhood obesity.

Although there were several limitations in this study, the relatively large-scale study including 1,508 students provided useful information related to the level of physical activity and eating behaviors in this group of rural children from Kentucky. Other strengths included the objective measurement of physical activity level and the reliable scale assessing eating behavior that allowed the results from this study to be generalizable to all rural children in Kentucky. The intervention was easily integrated in the daily routine of schools, which has the potential to act as a model for future school-based program design. In addition, advanced data analysis techniques, especially mixed-effects regression models, were used to manage the data, which provided clear, concise and strong scientific evidence of the effects of the intervention on improving healthy behaviors.

Conclusions

Children in this study participated in lower level of physical activity and consumed fewer fruits and vegetables than those reported in other national surveyed samples. Boys in this study participated in higher level of physical activity while consumed fewer fruits and vegetables. For children in these elementary schools, their physical activity level increased as they aged. The comprehensive school-based intervention had beneficial effects on improving healthy behaviors among children. Results from this study support the feasibility of the Coordinated School Health Program recommended by CDC conducted in school system and the effects on improving children's healthy behaviors in school. However, the data argues in favor of further

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studies on evaluating the long-term effects on improving healthy behaviors, and the cost-effectiveness of this program using the societal method.

Results from this study indicate that school-based healthy lifestyle programs should involve the support and resources from community and family. The American Academy of Pediatrics (AAP) recommends that healthy lifestyle promotion programs should focus on habit forming rather than short-term behavior change (McCambridge et al., 2006), thus, further studies are needed to assess its life-long effects on habit forming. Moreover, future researches are needed to examine the effects of the intervention on controlling childhood obesity and its cost-effectiveness, and test its effects in other contexts, such as in urban areas, other ethnic groups, etc.

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APPENDIX A

Pedometer Log Sheet for k-5th Grade Students

Student's name_____

Student's grade_____

Student's classroom teacher_____

Student's school_____

Time and Date the pedometer was first worn by student

_____

*Directions: Fill out the box below each night before you go to bed.

Do not wear the pedometer in the shower, bath, or while swimming.

	Number of steps taken that day	Time and date this number was recorded from pedometer
Day 1		
Day 2		
Day 3		

*Parents and Guardians:

Student should attach the pedometer to the waistband of his or her clothing as he or she gets dressed at the beginning of Day 1. This will ensure that the pedometer captures steps for as close to a full day as possible, every day.

Also, check every morning that the pedometer has been reset to zero steps.

Each night, the pedometer should be removed before bedtime.
At that point, the student should record the number of steps he or she took that day.
Once that day's steps have been written down on this sheet, the pedometer should be reset to zero.
Place the pedometer in a safe place where the student will remember to put it on the next day.

After Day 4, student should return the pedometer to the school's classroom teacher.

If the student is sick during one or more days that he or she is supposed to be wearing the pedometer, note that in the middle of the column of the above table.
Steps do not need to be recorded if the student is sick.

Nutrition Survey for K-5th Grade Students

Student's name_____

Student's grade_____

Student's classroom teacher_____

Student's school_____

Time and Date_____

Directions: For each question, circle only 1 answer.

1. Yesterday, did you eat fruit? Fruits are all fresh, frozen, canned, or dried fruits. *Do not count* fruit juice.

    0   No, I didn't eat any fruit yesterday.
    1   Yes, I ate fruit 1 time yesterday.
    2   Yes, I ate fruit 2 times yesterday.
    3   Yes, I ate fruit 3 times yesterday.
    4   Yes, I ate fruit 4 times yesterday.
    5   Yes, I ate fruit 5 or more times yesterday.

2. Yesterday, did you eat any starchy vegetables like potatoes, corn, or peas? *Do not count* French fries or chips.

    0   No, I didn't eat any of the foods listed above yesterday.
    1   Yes, I ate one of these foods 1 time yesterday.
    2   Yes, I ate one of these foods 2 times yesterday.
    3   Yes, I ate one of these foods 3 or more times yesterday.

3. Yesterday, did you eat any orange vegetables like carrots, squash, or sweet potatoes?

0	No, I didn't eat any orange vegetables yesterday.
1	Yes, I ate orange vegetables 1 time yesterday.
2	Yes, I ate orange vegetables 2 times yesterday.
3	Yes, I ate orange vegetables 3 times yesterday.
4	Yes, I ate orange vegetables 4 times yesterday.
5	Yes, I ate orange vegetables 5 or more times yesterday.

4. Yesterday, did you eat a salad made with lettuce, or any green vegetables like spinach, green beans, broccoli, or other greens?

0	No, I didn't eat any salad or green vegetables yesterday.
1	Yes, I ate salad or green vegetables 1 time yesterday.
2	Yes, I ate salad or green vegetables 2 times yesterday.
3	Yes, I ate salad or green vegetables 3 times yesterday.
4	Yes, I ate salad or green vegetables 4 times yesterday.
5	Yes, I ate salad or green vegetables 5 or more times yesterday.

5. Yesterday, did you eat any other vegetables like peppers, tomatoes, zucchini, asparagus, cabbage, cauliflower, cucumbers, mushrooms, eggplant, celery, or artichokes?

0	No, I didn't eat any of the foods listed above yesterday.
1	Yes, I ate one of these foods 1 time yesterday.
2	Yes, I ate one of these foods 2 times yesterday.
3	Yes, I ate one of these foods 3 times yesterday.
4	Yes, I ate one of these foods 4 times yesterday.
5	Yes, I ate one of these foods 5 or more times yesterday.

<div align="center">

CURRICULUM VITAE

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</div>

EDUCATION

Ph.D., Nursing   Expected December 2013
University of Louisville
Research Area: Childhood Obesity Intervention (Healthy Behavior Promotion)
Dissertation: Psychosocial and environmental determinants of physical activity in elementary school children: Implications for potential interventions to reduce childhood obesity
GPA: 3.97/4.0

M.S., Biostatistics   May 2013
University of Louisville
Thesis: Preliminary assessment of a school-based healthy lifestyle program among rural children
GPA: 4.0/4.0

M.S., Nursing (not completed)   September 2008-June 2009
Shandong University, China
Concentration: Critical Care Nursing
Credits Earned: 25.5
GPA: 89.7/100

B.S., Nursing   July 2008
Shandong University, China
GPA: 85.1/100

APPOINTMENT

Graduate Research Assistant   2009-Present
School of Nursing, University of Louisville

Statistics Tutor   August-December 2012
School of Nursing, University of Louisville

Graduate Research Assistant for Dr. Celeste Shawler   May-August 2010
School of Nursing, University of Louisville

Graduate Teaching Assistant (Statistics)   May-August 2010
School of Nursing, University of Louisville

Administrative Assistant   2008-2009
School of Nursing, Shandong University, China

GRANTS

Psychosocial and environmental determinants of physical activity in   2013
elementary school children: Implications for potential interventions to reduce childhood
obesity. **Jiying Ling** (PI)
Sigma Theta Tau International−Iota Zeta Chapter Research & Scholarship Award ($500),
Graduate Student Council Research Fund ($300)

Exploring the needs and attitudes about pre-hospital care   2006
among college students. **Jiying Ling** (PI)
Shandong University Innovative Research Grant, ￥1,200

JOURNAL PEER REVIEWER

Nursing: Research and Reviews   2012-Present

Open Access Medical Statistics   2012-Present

PUBLICATIONS

King, K., **Ling, J.,** Ridner, L., Jacks, D., Newton, K., & Topp, R. (2013). Fit into College II: Physical activity and nutrition behavior effectiveness and programming recommendations. *Recreational Sports Journal, 37*(1), 29-41.

Ling, J., King, K., Speck, B., Wu, D., & Kim, S. (2013). Preliminary assessment of a school-based healthy lifestyle program among rural children: Project *BALANCE. Annals of Behavioral Medicine, 45*(Abstract Supplement), s28.

Wang, X., & **Ling, J.** (2012). Multiple valued logic approach for matching patient records in multiple databases. *Journal of Biomedical Informatics, 45*, 224-230. doi:10.1016/j.jbi.2011.10.009

Ling, J., Liu, J., Liu, C., Zou, F., & Wang, K. (2009). Knowledge and attitudes about pre-hospital care among college students. *Journal of Nursing Science, 24*(2), 79-81.

PRESENTATIONS

National

Ling, J., King, K., Speck, B., Wu, D., & Kim, S. Preliminary assessment of a school-based healthy lifestyle program among rural children: Project BALANCE. *The 34th Annual Meeting & Scientific Sessions of the Society of Behavioral Medicine*, San Francisco, CA. March 20-23, 2013.

Ling, J., Jacks, D. E., King, K., Ridner, S. L., Conte, K., & Topp, R. Effects of a 10-week fitness program on fitness and perceptions of nutrition and physical activity among overweight and normal weight college students. *NINR's 25th Anniversary Concluding Scientific Symposium*, Washington, DC. October 13, 2011.

Regional

Speck, J. B., & **Ling, J.** Barriers to regular physical activity in rural and urban low-income women (***Poster Discussion Presentation***). *Midwest Nursing Research Society 37th Annual Conference*, Chicago, IL. March 7-10, 2013.

Ling, J., King, K., Speck, B., Wu, D., & Kim, S. Preliminary assessment of a school-based healthy lifestyle program among rural children (***Top Student Poster Discussion Presentation***). *Southern Nursing Research Society 27th Annual Conference*, Little Rock, Arkansas. February 27- March 2, 2013.

Jackson, B. M., Lehna, C., Alaradi, M., & **Ling, J**. Differences in children's home safety practices between families living in rural and urban areas. *Southern Nursing Research Society 27th Annual Conference*, Little Rock, Arkansas. February 27-March 2, 2013.

Ling, J., & Speck, J. B. Perceived barriers to physical activity in rural and urban low-income women. *Midwest Nursing Research Society 36th Annual Conference*, Dearborn, Michigan. April 12-15, 2012.

Ling, J., Alaradi, M., Jackson, B., & Lehna, C. What baccalaureate registered nursing students found out from a home safety assignment. *Southern Nursing Research Society 26th Annual Conference*, New Orleans, Louisiana. February 22-25, 2012.

Speck, J. B., & **Ling, J.** Descriptive study of participants attending a health fair in a low income urban neighborhood. *Midwest Nursing Research Society 35th Annual Conference*, Columbus, Ohio. March 24-27, 2011.

Ling, J., & Shawler, C. Body mass index is associated with health related quality of life among older mother-adult daughter dyad. *Southern Nursing Research Society 25th Annual Conference*, Jacksonville, Florida. February 16-19, 2011.

HONORS AND AWARDS

PhD Program Travel Funds ($300)	2013
School of Nursing, University of Louisville	
Graduate Student Council (GSC) Travel Funds ($350)	2013
University of Louisville	
Ruth Craddock Research Fund ($500)	2012
School of Nursing, University of Louisville	
Who's Who among Students in American Universities & Colleges	2012

in recognition of outstanding merit and accomplishment as a student at University of Louisville

Outstanding Adult Learner Award for Graduate Student Kentuckiana Metroversity	2012
Ruth Craddock Research Fund ($500) School of Nursing, University of Louisville	2011
Government-Sponsored Graduate Student Shandong University, China	2008
"What can we do after earthquake" contest, Commemoration Prize Shandong University, China	2008
Outstanding Volunteer Shandong Province, China	2008
"May 4th" Academic Paper Competition, Second Place Shandong University, China	2008
Tenth "Challenge Cup", Third Place Shandong University, China	2007
Outstanding Undergraduate Student Shandong University, China	2007
University Scholarship, Second Place Shandong University, China	2007

PROFESSIONAL MEMBERSHIPS

Society of Behavioral Medicine	2013-Present
Honor Society of Nursing Sigma Theta Tau International	2011-Present
Southern Nursing Research Society *Abstract Reviewer for SNRS 27th Annual Conference, 2013*	2011-Present
Midwest Nursing Research Society	2011-Present

NATIONAL BOARD CERTIFICATE AND STATE RN LICENSURE

California (RN, in process), USA	Expected August 2013
Shandong (RN), China License No: 201037002002	March 2010-March 2015
Certificate of General Management Proficiency China Employment Training Technical Instruction Center Certificate No: 20071031501400093	July 2007-Present

First Aider Certificate   2005- Present
Red Cross Society of China
Certificate No: 20050096

CLINICAL PRACTICE

First Affiliated Hospital of Dalian Medical University, China   2007-2008

COMMITTEES AND SERVICES

Wellington Elementary School, School Wellness Policy, Evaluator   2012

Atkinson Elementary, Summer Booth for Students with Learning Disabilities, Tutor 2012

Indiana/Kentucky Tornado Relief, Volunteer   2012

University of Louisville, Department of Mathematics, Tutor   2011

University of Louisville, Association of Graduate Nursing Students, Treasurer 2009-2010

China, Sichuan Earthquake Relief, Volunteer   May 2008