University of Rhode Island

DigitalCommons@URI

2013

South County Food, Fitness, and Fun Program: A Comprehensive Intervention on Childhood Obesity

Amanda S. Tassoni
University of Rhode Island, amanda.tassoni21@gmail.com

Follow this and additional works at: https://digitalcommons.uri.edu/theses

Recommended Citation
Tassoni, Amanda S., "South County Food, Fitness, and Fun Program: A Comprehensive Intervention on Childhood Obesity" (2013). *Open Access Master's Theses.* Paper 55.
https://digitalcommons.uri.edu/theses/55

SOUTH COUNTY FOOD, FITNESS, AND FUN PROGRAM:

A COMPREHENSIVE INTERVENTION

ON CHILDHOOD OBESITY

BY

AMANDA S. TASSONI

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

MASTERS OF SCIENCE

IN

KINESIOLOGY

UNIVERSITY OF RHODE ISLAND

2013

MASTERS OF SCIENCE THESIS

OF

AMANDA S. TASSONI

APPROVED:

Thesis Committee:

Major Professor   Furong Xu

Tom Manfredi

Geoffrey Greene

Nasser H. Zawia
DEAN OF THE GRADUATE SCHOOL

UNIVERSITY OF RHODE ISLAND
2013

ABSTRACT PAGE

Recently, obesity in children had risen to epidemic levels. There is an urgent need to develop primary prevention strategies to prevent current and future unhealthy weight gain. Physical activity and nutrition have been linked to the increased prevalence of childhood obesity. **PURPOSE:** The purpose of this study is to examine the effectiveness of a comprehensive intervention developed to help maintain BMI in overweight and obese children aged 7 to 11 years while improving physical activity levels, fitness levels, and psychosocial behavior. **METHODS:** Twenty obese children and their parents from South County, Rhode Island participated in a 16-week intervention that met one time each week and follow-up periods at 6-months and 12-months following the completion of the intervention. Of the 20 children, 17 completed all measures and were included in the analyses. The children and their parents were educated on healthy nutritional and physical activity behaviors, and participated in various physical activities throughout the study. Participants were assessed at baseline and follow-up on body composition, physical fitness, and psychosocial behaviors. Data was abstracted from medical records for each participant from age 5 up to the start of the intervention to analyze trends in their BMI. Accelerometers were used at baseline, mid-intervention, and post intervention to measure changes in physical activity levels. Changes in BMI were assessed by comparing each participant's BMI trends prior to the

intervention with their BMI following the completion of the program. Fitness levels were assessed using a Fitnessgram, and psychosocial behavior was assessed using a Pediatric Symptoms Checklist. **RESULTS:** From four years prior to the beginning of the intervention, BMI increased significantly (ß=1.12 (95% CI: 0.90-1.35); p<0.001). No significant changes were seen in BMI z-score (ß=0.02 (95% CI: -0.05-0.04); p=0.928). Measures of BMI from pre to post intervention show a statistically significant decrease in BMI (24.9 ± 3.8 kg/m² vs. 24.3 ± 4.2 kg/m², p=0.034), and BMI z-score showed a statistically significant decrease (2.1 ± 0.3 vs. 1.9 ± 0.5, p=0.26). Follow-up data showed no significant changes in BMI or BMI z-score, however BMI remained stable in the participants. Fitness test data showed statistically significant improvements in the curl-up test (5.6 ± 7.3 vs. 12.2 ± 7.1, p=0.004) as well as the trunk-lift test (5.9 ± 3.1 vs. 8.1 ± 3.4, p=0.001) from pre to post. All other fitness score data showed no significant changes. Neither data from the pediatric symptoms checklist nor data from the accelerometers showed any significant changes (p>0.05). **CONCLUSION:** The comprehensive intervention showed significant effects on BMI and core fitness level. Prior to the intervention, trends showed an increase in BMI in the participants. After the participation in the intervention, children showed a stabilization of BMI. Children also demonstrated improvements in overall core strength following the intervention. Overall this study was successful in the primary purpose of stabilizing the BMI in overweight and obese children.

ACKNOWLEDGEMENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The prevalence of childhood obesity continues to rise at alarming rates despite many efforts to promote weight reduction. According to the American Heart Association in 2011, about 1 in 3 children aged 2 to 19 years were overweight or obese (American Heart Association, 2012). Compared with 1973 to 1974, the proportion of children 5 to 17 years of age who were obese was 5 times higher in 2008 to 2009 (American Heart Association, 2012). According to a study by Wang et al. (2008), it has been predicted that the prevalence of overweight in children and adolescents will double by the year 2030, and by 2070, over half of U.S. children and adolescents will be overweight if no changes are made (Wang et al., 2008). Since these rates are predicted to continue to increase, it is important to use the factors affecting this increase to counteract this problem. The increasing prevalence of obesity in children is due to complex interactions between diet, exercise, genetic factors, and other environmental stimuli leading to energy intake outweighing energy expenditure (Biro & Wien, 2010);(Berkey et al., 2000);(CDC, 2010); (Gorden-Larsen et al., 2000). In spite of many intervention studies focusing on this topic, the rates of childhood obesity continue to rise (Berkey et al., 2000); (Janssen & LeBlanc, 2010);(Ogden & Carroll, 2010);(Warburton et al., 2006).

Therefore, it is urgent to find a solution to decrease the rising rates of childhood obesity (Dehghan et al., 2005).

In order to rectify this problem, it is important to consider the ways that children behave. At the age of 6 to 15 years, a child is beginning to establish his or her independence, dietary and physical activity patterns become habitual in their lives, and it is important to promote these healthy behaviors at this stage of growth (Berkey et al., 2000). Therefore, further research is exceedingly important in determining a way to implement daily physical activity and healthy nutritional behaviors into the lives of children.

Accordingly, this study was created to address the existing behavioral concerns regarding physical activity levels and nutrition in overweight and obese children. This study was designed to analyze a unique community-based intervention that educated both children and parents on healthy diet and physical activity behaviors. The intervention focused on improving the lifestyles of overweight and obese children and their families.

PURPOSE AND HYPOTHESES

Purpose: To evaluate the effects of a previously performed 16-week comprehensive intervention that integrated both physical activity and nutrition in overweight and obese children

> **H1:** Children maintained a stable BMI throughout the intervention despite the growth factors

H2: The participation in the intervention improved the muscular

strength, muscular endurance, and flexibility of the participating

children

H3: The participation in the intervention improved the physical

activity levels of the children.

H4: The children showed improvements in their overall psychosocial

behavior following the completion of the program.

CHAPTER 2

REVIEW OF THE LITERATURE

The purpose of this chapter is to review the literature concerning the prevalence of childhood obesity and the components that have been associated with treating this epidemic. The focus is to identify approaches that have been found successful and unsuccessful in the treatment of childhood obesity, specifically the use of physical activity, nutrition, and parental involvement. This chapter will be divided into five sections: (a) the childhood obesity epidemic, (b) physical activity behaviors in children, (c) nutritional behaviors and parental influences, (d) childhood obesity interventions using physical activity, nutrition, and/or parental involvement, and (e) a summary of the findings.

The Childhood Obesity Epidemic

In the United States, childhood obesity affects approximately 12.5 million children and adolescents (Ogden et al., 2010). According to the Centers for Disease Control and Prevention (CDC), a child is considered a healthy weight if their body mass index (BMI), specific to age and sex, ranges from the 5th to <85th percentile. A child with a BMI between the 85th and <95th percentile is considered overweight, and if a child's BMI is >95th

percentile, then they are categorized as obese (Center for Disease Control and Prevention, 2010).

Currently, about one in every three American children and adolescents are overweight or obese, which is nearly triple the rate in 1963 (American Heart Association, 2012). From 1976 to 2008, the percentage of 2-5 year olds categorized as obese increased from 5% to 10.4%. In children aged 6 to 11 years, obesity levels have risen from 6.5% to 19.6%, and in 12 to 19 year olds, obesity levels increased from 5% to 18.1% (Ogden & Carroll, 2010). Due to the rising rates, childhood obesity has become the number one health concern among parents, physicians, and health professionals in children in the United States, topping both drug abuse and smoking (American Heart Association, 2012).

This problem has entered the spotlight because of the consequences that this epidemic will have on the future. Childhood obesity has been associated with multiple health implications including, but not limited to health problems that previously were known to only affect adults such as type 2 diabetes, factors leading to signs of cardiovascular disease, decreased health-related quality of life, sleep apnea, and orthopedic problems (Lakshman et al. 2012). These children are also at a higher risk of anxiety, depression, and low self-esteem (Griffiths et al., 2010).

One of the most prevalent health risks associated with childhood obesity is Type 2 diabetes. A study by Young et al. (2000) set out to determine

the prevalence of obesity and investigate its association with fasting glucose and insulin among children and adolescents in a population at high risk for type 2 diabetes. This study was a cross-sectional screening survey of 719 individuals. All children in the study were 4 to 19 years old. The results of this study found that 64% of females, and 60% of males had a BMI exceeding the 85th percentile, and 40% of females and 34% of males had a BMI exceeding the 95th percentile. These results signify that having an increased BMI is a significant predictor of both glucose and insulin in both sexes independent of age. Having an increased BMI also puts children at an increased risk of being classified as having diabetes or having an impaired fasting glucose. The results of this study show that the early onset of type 2 diabetes in childhood is increasing as larger amounts of children becomes obese at a young age. Childhood obesity is a strong risk factor. The study suggests that early detection and interventions directed at obesity are potential strategies to avert the long-term consequences of type 2 diabetes (Young et al., 2000). These findings are supported by the research of Arslanian (2000), Fagot-Campagna (2000), and Rosenbloom (2002).

Alongside of diabetes, childhood obesity has also been linked to cardiovascular disease and its predictors. As part of the Bogalusa Heart Study, Srinivasan et al. (1996) conducted a biracial cohort on 783 participants in two cross-sectional surveys. All subjects were 13 to 17 years old at the start and 27 to 31 years old later in the study. The cohorts were categorized as adolescent-

onset adult overweight or lean according to age-, race-, and sex-specific body

mass index greater than the 75th percentile or between the 25th and 50th

percentile on both surveys. As young adults, the overweight cohort showed

adverse levels of body fatness measures, systolic and diastolic blood pressure,

lipoprotein cholesterol, insulin, and glucose when compared to the lean

cohort. The prevalence of clinically recognized hypertension and dyslipidemia

increased 8.5-fold and 3.1-8.3-fold respectively, in the overweight cohort

versus the lean cohort. Clustering of adverse values (<75th percentile) for the

total cholesterol to high-density lipoprotein cholesterol ratio, insulin level, and

systolic blood pressure occurred only among the overweight cohort. This

study shows that excess weight in adolescence has a strong adverse impact on

multiple cardiovascular risk factors, requiring primary prevention early in life

(Srinivasan et al., 1996). A study by Chu et al. (1998) found similar results in

children aged 12-16, and another study by Freedman et al. (1999) found

similar results in children aged 5 to 17 years old.

 Along with diabetes and cardiovascular disease, childhood obesity also

leaves individuals with a lower health-related quality of life. A study by

Schwimmer et al. (2003), examined the health-related quality of life in obese

children and adolescents compared to children and adolescents who were

healthy or diagnosed with having cancer. Health-related quality of life

includes physical, emotional, social, and school functioning. This was a cross-

sectional study of 106 children and adolescents between the ages of 5 to 18

years. This study found that compared with healthy children and adolescents, obese children and adolescents reported significantly lower health-related quality of life in all domains. Obese children and adolescents were more likely to have impaired health-related quality of life than healthy children and adolescents and were similar to children and adolescents having cancer. Also, a child or adolescent's BMI z-score was significantly inversely associated with physical functioning, social functioning, and psychological functioning. This study shows that severely obese children and adolescents have lower health-related quality of life than healthy children and adolescents and similar quality of life to children having cancer. It is important to note the risk for impaired quality of life in these children (Schwimmer et al., 2005). A similar study was conducted by Williams et al. (2005) in overweight and obese children aged 9 to 13 years old. This study found similar results, with overweight and obese children showing decreases in physical and social functioning compared with non-obese children (Williams et al., 2005).

As touched on in the research by Schwimmer et al. (2005), childhood obesity has also been associated with poor sleep quality in overweight and obese children. In a study by Gupta et al. (2002), 383 males and females participated in a sleep quality study. Sleep was measured using two variables, total sleep time and sleep disturbance time obtained by 24-hour actigraphy. Percent body fat and BMI were used to define obesity. Results of this study found that obese adolescents experienced less sleep than their non-obese

counterparts. For each hour of lost sleep, the odds of obesity increased by 80%. Daytime physical activity decreased by 3% for every hour increase in sleep disturbance. These results show that childhood obesity is linked to poor sleep quality, and this interruption in sleep is a significant variable in the decreased amounts of physical activity that these obese children are participating in (Gupta et al., 2002). A similar study by Kong et al. (2011) found similar results in children aged 6 to 20 years old.

Aside from the immediate health implications obesity has on children, this problem will affect their adult years as well. The et al.. (2010) conducted a cohort study in 8834 individuals aged 12 to 21 years old to determine incidence and risk of severe obesity in adulthood by adolescent weight status. This study was a part of the US National Longitudinal Study of Adolescent Health. Height and weight of the participants were obtained using anthropometry and surveys administered in study participants' homes using standardized procedure. In this study, new cases of adult-onset severe obesity were calculated by sex, race/ethnicity, and adolescent weight status. Results of this study found that in 1996, 79 adolescents were severely obese, and 60 of these adolescents remained severely obese in adulthood. By 2009, 703 non-severely obese adolescents had become severely obese in adulthood. Obese adolescents were significantly more likely to develop severe obesity in adulthood than normal-weight adolescents (The et al., 2010).

Another study by Freedman et al. (2007), confirms these results. This study performed cross-sectional (n=10,099) and longitudinal (n=2392) analyses among subjects who participated in the Bogalusa Heart Study. This study found that of children with a BMI≧95th percentile of the CDC's growth charts, 65% had an adult BMI of ≧35kg/m². Of those with a BMI ≧99th percentile, 88% had an adult BMI of ≧35kg/m². These results confirm the suggestion that obesity during childhood puts these individuals at a greater risk for obesity in adulthood (Freedman et al., 2007). These findings by Freedman et al. (2007) coupled with the findings of The et al. (2010) suggest that as the prevalence of obese children continues to rise, the amount of obese adults will continue to rise as well. This leads to an abundant unhealthy population at risk for disease, increased health care costs, and decreased quality of life.

Clearly, the consequences of childhood obesity are shown through the many health disparities arising. In addition to the many health risks that childhood obesity has, this epidemic has a large economic impact as well. The costs of childhood obesity were about $117 billion dollars in 2002, and this rose to about $147 billion dollars in 2008 (Finkelstein et al., 2009) (WHO, 2000) (Wang & Dietz, 2002). The costs of childhood obesity are extremely difficult to calculate due to the correlation between childhood and adult obesity, and the rising numbers of overweight and obese children. As overweight children become overweight adults, the diseases associated with

obesity and health care costs are likely to increase even more (Wang & Dietz, 2002). Another study also evaluated the economic impact of this epidemic. Finkelstein et al. (2003) used a data set that was representative of the U.S. population to evaluate the medical spending associated with overweight or obesity. This study found that the spendings on obesity accounted for 5.3% of national health spending. When combining overweight and obesity, this disease accounted for 9.1% of total annual U.S. medical spending (Finkelstein et al., 2003). The tremendous economic impact of this epidemic paired with the many health related consequences give rise to the need for solutions.

In order to find solutions to this problem, the factors that contribute to it must be identified. Physical activity and nutritional behaviors are the main contributing modifiable factors to this epidemic (CDC, 2010). The promotion of healthy nutritional behaviors and increasing physical activity time is necessary to reduce the growing epidemic of childhood obesity. Likewise, reducing sedentary time in children is also necessary. The participation in regular physical activity is especially important in the health and wellness of children as they grow and develop.

Physical Activity Behaviors in Children

Regular physical activity in children and adolescents promotes both health and fitness (CDC, 2012). Participation in the recommended amount of physical activity will lead to healthy outcomes for children. According to the US Department of Health and Human Services (2008), regular physical

activity helps to build and maintain healthy bones and muscles, reduces the risk of developing obesity and chronic diseases such as diabetes, cardiovascular disease and certain cancers, reduces feelings of depression and anxiety, promotes psychological well-being, and helps to improve a students academic performance.

Research supports that physical activity has positive beneficial effects for children. For example, a study by Ekelund et al. (2012) sought to examine the independent and combined associations between objectively measured time in moderate to vigorous intensity physical activity (MVPA) and sedentary time with cardiometabolic risk factors. This study pooled data from 14 studies between 1998 and 2009 compromising 20,871 children aged 4 to 18 years from the International Children's Accelerometry Database. This study utilized accelerometry to analyze time spent in MVPA and sedentary time in the participants. Meta-analyses were used to examine the independent associations between time in MVPA and sedentary time. Results found that the time spent in MVPA was significantly associated with all cardiometabolic outcomes independent of sex, age, monitor wear time, time spent sedentary, and waist circumference. In the combined analyses, higher levels of MVPA were also associated with better cardiometabolic risk factors across the tertiles of sedentary time. Participants who participated in higher amounts of MVPA were found to have a smaller waist circumference, lower systolic blood pressure, and higher high-density lipoprotein cholesterol levels. Also, after the

follow-up, a higher waist circumference at baseline was associated with higher amounts of sedentary time at follow-up. In conclusion, higher MVPA time by children and adolescents was associated with better cardiometabolic risk factors regardless of the amount of sedentary time (Ekelund et al., 2012). A study by Owen et al. (2010) found similar results in primary school children.

Along with reducing risk for cardiometabolic factors, participation in physical activity also has positive effects on a child's weight. In a study by Trost et al. (2001), 133 non-obese and 54 obese children with a mean age of 11.4 were studied. The purpose of this study was to compare the physical activity patterns and the hypothesized psychosocial and environmental determinants of physical activity in an ethnically diverse sample of children. Objective measurements were collected of physical activity over a 7-day period using accelerometers. Also, self-reported measures were collected of physical activity self-efficacy, social influences regarding physical activity, beliefs about physical activity outcomes, perceived physical activity levels of of parents and peers, access to sports and fitness equipment at home, involvement in community-based physical activity organizations, participation in community sports teams, and hours spent watching television or playing video games. Results of this study found that compared to their non-obese counterparts, obese children exhibited significantly lower daily accumulations of total counts in moderate or vigorous physical activity, as well as fewer 5,

10, and 20 minute bouts of moderate to vigorous physical activity throughout the day. Obese children also reported significantly lower levels of physical activity self-efficacy, were involved in significantly fewer community organizations that promote physical activity, and were significantly less likely to report their male guardian as physically active. Therefore, this study suggests that physical inactivity is an important contributing factor in the maintenance of childhood obesity. Participating in regular physical activity can control the weight status of these children (Trost et al., 2001).

Even though research shows the multiple benefits of physical activity, many children still do not meet the recommended amounts of daily physical activity. Due to the benefits of physical activity, the Centers for Disease Control and Prevention (2011) recommends that children and adolescents should participate in at least 60 minutes or more of physical activity each day. Aerobic activity should make up most of the child's activity time on at least 3 days per week. These activities can include either moderate-intensity aerobic activity such as brisk walking, or vigorous-intensity activity such as running. Children should also participate in muscle strengthening and bone strengthening activities for 3 days per week. These types of activities include gymnastics, push-ups, and jumping rope. Many studies indicate that physical inactivity has become much more consistent in youth (Brownson et al., 2005). One study by Sisson et al. (2009) analyzed data from The National Health and Nutrition Examination Survey from 2001 to 2006. This study included 8707

individuals aged 2 to 15 years with 70% normal weight, 18.1% overweight, and 11.5% obese. This study found that the total proportion of young people engaged in TV/video viewing, computer use, and total screen time ≅ 2 hours daily was 33.0% for normal weight, 6.7% for overweight, and 47.3% for obese individuals. Also, 58.5% of obese children engaged in ≅ 2 hours daily in screen time compared to 50.8% of overweight and 44.6% of normal weight children. This study shows that nearly half (47%) of US children exceed ≅ 2 hours/day of time in sedentary behavior. The high amount of sedentary time in youth is not healthy and must be reduced (Sisson et al., 2009).

Another study by Trost et al. (2002) evaluated the age and gender differences in objectively measured physical activity in a population-based sample of students in grades 1 through 12. There were 185 male participants and 190 female participants in the study. All participants wore an accelerometer for 7 consecutive days. Students were grouped as follows: grades 1-3 (n=90), grades 4-6 (n=91), grades 709 (n=96), and grades 10-12 (n=92). Bouts of physical activity as well as time spent in moderate to vigorous physical activity (MVPA) and vigorous physical activity (VPA) were examined. Results of this study found that daily MVPA and VPA exhibited a significant inverse relationship with grade level, with the largest differences occurring between grades 1-3 and 4-6. Across all grade levels, boys exhibited more bouts of MVPA than girls. For both genders, weekly 5-. 10-, and 20-minute bouts of MVPA exhibited a significant inverse relationship with grade

level, with the largest difference occurring between grades 1-3 and 4-6. On average, boys and girls from all grade levels exhibited few bouts of VPA over the 7 day monitoring period. Over the course of this study, very few children and adolescents performed sustained bouts of physical activity. These results support the notion that physical activity declines rapidly during childhood and adolescents (Trost et al., 2002).

Another study by Troiano et al. (2008) founded similar results. The purpose of this study was to describe the physical activity levels of children age 6 to 11 years, adolescents age 12 to 19 years, and adults age 20+ using objective data obtained with accelerometers. The results were obtained from the 2003-2004 National Health and Nutritional Examination Survey (NHANES). This study included 6,329 participants who obtained at least one day of valid accelerometer data, and 4,867 participants who obtained four or more days of data. The data from this study showed that only 49% of boys between the ages of 6 to 11 years met public health recommendations of 60 minutes of at least moderate intensity activity per day, and only 12% of boys aged 12 to 15 years met these recommendations. For girls, only 35% of participants age 6 to 11 years met the physical activity recommendations, and only 3% of female girls age 12 to 15 years achieved those recommended levels. This study continues to show that children in the US are still failing to meet daily recommendations for physical activity, and that the accelerometer-

measured activity is substantially lower than self-reported activity levels (Troiano et al., 2008).

Even though research shows that physical activity has positive benefits in treating childhood obesity, tackling this epidemic is a complex and multifaceted undertaking. The optimal approach to prevention of this problem has yet to be found. However, many research studies and interventions have been completed that suggest certain factors that yield positive results in the reduction of this problem.

Nutritional Behaviors and Parental Influences

Physical activity is not the only contributor to the childhood obesity epidemic. The nutritional behaviors of children are equally important. The current environment, including the availability of more food that is more energy dense, growth in popularity of socially eating and drinking, the expanding fast food industry, and an increase in the variety and marketing of snack foods, promote the behaviors that consequently lead to obesity (Swinburn et al., 2004). While these nutritional factors arise, the opportunities for individuals to expend energy throughout their daily lives are diminishing as well (Peterson, 2012). Unfortunately, these environmental behaviors have become the way of life for modern day society, and most children have no control over them. Therefore, high energy intake and low energy expenditure have led to the increase in childhood obesity (Anderson & Butcher, 2006).

Portion sizes have changed drastically in the past years contributing to the childhood obesity epidemic. In a study by Piernas and Popkin (2011), 31,337 children participated in four U.S. nationally representative surveys from 1977 to 2006. Trends in portion sizes of selected foods (sugar-sweetened beverages, salty snacks, desserts, French fries, burgers, pizza, and Mexican fast foods), and energy intake at eating occasions during which the selected foods were consumed were measured. Results found that in 2003-2006, the selected foods accounted for 38% of daily energy intake in 13-18 year olds, 35% of daily intake in 7-12 year olds, and 28% of daily energy intake in 2-6 year olds. All age groups showed larger portion sizes of pizza which coincided with higher energy intakes at eating occasions during which pizzas were consumed. In 7-12 year olds and 13-18 year olds, higher energy intakes at meals coincided with larger portion sizes of sugar-sweetened beverages, French fries, or salty snacks. Adolescent boys consumed larger portion sizes of the selected foods and had higher energy intakes at meals for all periods than girls. This study shows that adolescents are very susceptible to increased portion sizes. When applied to the growing trends in obesity in the U.S., larger portion sizes of energy-dense, nutrient-poor foods have increased in parallel with energy intakes at meals, especially in adolescents and middle-aged children (Piernas et al., 2011). This research shows evidence that increased portion size has a huge impact on the rising levels of childhood obesity.

Along with increased portion sizes, snacking trends have also become more evident in youth. A study by Jahns et al. (2001), set out to determine snacking trends and changes in nutrient contributions of snacking over time. The sample consisted of 21,236 individuals aged 2 to 18 years. The results of this study found that the prevalence of snacking increased in all age groups from 1977 to 1996. The average size of snacks and energy per snack remained relatively consistent, however the number of snacking occasions increased significantly, therefore increasing the average daily energy from snacks. When compared with non-snack eating occasions, the nutrient contribution of snacks decreased in calcium density and increased in energy density and proportion of energy from fat. This shows that snacking has become extremely prevalent in our society, and therefore, it is important for an emphasis to be placed on healthy food choices instead of high-energy dense snacks (Jahns et al., 2001).

Along with the increased amount of snacking in children, more children are consuming large amounts of fast-food throughout their childhood. In a study by Bowman et al. (2004), 6212 US children and adolescents aged 4 to 19 years were examined. This study found that on a typical day, 30.3% of the total sample reported consuming fast food. The consumption of fast food was highly prevalent in both genders, all races and ethnicities, and in all regions of the US. Children who ate fast food consumed more total energy, more energy per gram of food, more total fat, more total carbohydrates, more added sugars, more sugar-sweetened beverages, less fiber, less milk, and

fewer fruits and non-starchy vegetables when compared with children who did not consume fast food. This study shows that the consumption of fast food among children in the US seems to have an adverse effect on diet quality. These results also support the relationship between fast food consumption and the increased rates of childhood obesity (Bowman et al., 2004).

Sugar-sweetened beverages have also been in the spotlight as a contributor to this epidemic. According to data from the US Department of Agriculture (USDA), per capita soft-drink consumption has increased by almost 500% over the past 50 years (Putnam & Allshouse, 1999). In adolescents, 65% of girls and 74% of boys consumer soft drinks daily (Harnack et al., 1999). Also, soft drinks currently constitute for the leading source of added sugars in the diet, accounting for 36 grams daily for adolescent girls and 57 grams for boys (Guthrie & Morton, 2000). A study by Ludwig et al. (2001) evaluated this relationship. This study enrolled 548 ethnically diverse schoolchildren from public schools in Massachusetts communities. These groups were studied for 19 months. Results of this study found that for each additional serving of sugar-sweetened drink consumed, both body mass index and frequency of obesity increased. Baseline consumption of sugar-sweetened drinks was also independently associated with change in body mass index. These results show that there is a clear relationship between sugar-sweetened beverages and obesity in children (Ludwig et al., 2001).

Due to all of the research supporting the importance of a healthy diet to avoid obesity, The USDA (2010) recommends that children eat a diet rich in fruits and vegetables, whole grains, and fat-free and low-fat dairy products for persons aged 2 years and older. Also, children, adolescents, and adults should limit intake of solid fats, cholesterol, sodium, added sugars, and refined grains. The USDA also advises drinking water instead of the trending sugar-sweetened beverages, and limiting fast food intake as often as possible. Educating children on healthy choices and the consequences of unhealthy choices will help the children understand their behaviors and help them to change. However, children are often not the ones who choose what they eat, their parents play a large role in that as well.

Along with physical activity and nutrition, it is important to note the role that a parent plays in the unhealthy behaviors of their children. Parents are in control of many aspects of their child's environment, and therefore, they are vital to the implementation of recommended strategies to reduce childhood obesity rates (Warschburger & Kroller, 2012). Unfortunately, however, parents do not recognize their importance in the problem and in preventive actions (Warschburger & Kroller, 2012). Studies have shown that many parents fail to recognize the overweight, or at-risk status of their child, and the associated health problems (Chaparro et al., 2011) (Cottrell et al., 2007) (Etelson et al., 2003). It is important to understand why it is important for parents to

recognize the problems, and why they are so important in making any treatments in overweight and obese children successful.

Parents determine what food is available for their children, and they shape their eating and activity behaviors as well (Birch & Davidson, 2001). A parent has an impact on how much time a child spends in front of a television, how often they go outside to participate in activity, and they control if a child participates in sports, and other organized activities. As stated previously however, parents rarely realize the risk their child is at. Studies suggest that parenting interventions may work best as a component as a comprehensive intervention to decrease childhood obesity (CDC, 2010). Therefore, it is not surprising that behavior modification programs that involve parents can have a large impact on the success of the child. Assessing a parents' readiness to make lifestyle and dietary changes therefore will be an important step towards helping their children lose weight. Following a healthy diet, and participating in regular physical activity will help lower the rising rates of childhood obesity.

Childhood obesity interventions

Physical activity, nutrition, and parental involvement are all factors that have been extensively studied in regards to the childhood obesity epidemic, whether it be individually or comprehensively. Combining these components creates an intervention that touches on all of the important factors leading to obesity with the goal of minimizing the unhealthy behaviors. For

example, in a study by Epstein et al. (2000), the purpose was to compare the

influence of targeting decreases in sedentary behavior to increases in physical

activity in the comprehensive treatment of obesity in 8 to 12 year old children.

The study included 90 families with obese children, and they were randomly

assigned to groups that were provided a comprehensive family-based

behavioral weight control program including dietary and behavior change

information. The groups differed in whether sedentary or physically active

behaviors were targeted and the degree of behavior change required. At the

start of the study, 64% of the parents were obese. There were 33 obese

mothers and 16 obese fathers. Throughout the study, the percent of overweight

children decreased significantly from baseline through 2 years by 41%.

Through the 2 years, the children grew on average 11.4 cm and gained 9.0 kg,

which was equivalent to a decrease in percent overweight of 12.9% and 20.8%

from baseline. The participants also showed a significant improvement in

aerobic fitness. Self-reported activity minutes increased and targeted sedentary

time decreased during the treatment. Lastly, children substituted non-targeted

sedentary behaviors for some of their targeted sedentary behaviors by the end

of the study. This study supports that reducing sedentary behaviors shows

significant results in treating childhood obesity (Epstein et al., 2000). A

similar study was completed by Hands et al. (2011). This study was designed

to examine the strength and direction of the relationship between physical

activity level, screen use, and BMI in a cohort at ages 6, 8, 10, and 14 years.

23

The sample consisted of 1403 males and females. The relationships between physical activity level, BMI, and screen time were analyzed. Results of this study found that predictors of BMI at ages 6, 8, 10, and 14 years explained 1.3%, 76.1%, 80.1%, and 73.1% respectively with previous BMI being the largest predictor. Increased screen time predicted a higher BMI and lower physical activity level in children age 8 and 10 years. At 14 years old, physical activity was found to be a predictor of BMI. Sedentary patterns of behavior in early childhood were predictive of later and concurrent obesity. Physical activity was predictive of obesity in adolescents. The results of this intervention highlight how important it is to teach healthy behaviors to children at a young age in order to minimize poor behaviors. Reducing a child's screen time, and increasing the participation in physical activity are also important behaviors to reduce the risk for childhood obesity (Hands et al., 2011).

In another weight management program for children, Savoye et al. (2007) set out to compare the effects of a weight management program on adiposity and metabolic complications of overweight children with a control group. This study was a one-year randomized controlled trial including 119 overweight children ages 8 to 16 years. The participants in this study were randomly assigned to either a control group or a weight management group. The control group received traditional clinical weight management counseling every 6 months, and the weight management group received an intensive

family-based program including exercise, nutrition, and behavior

modification. For the first 6 months, the intervention occurred bi-weekly, and

after that they occurred bimonthly. Results of this study found that six month

improvements were sustained at 12 months in the weight management group

compared to the control, including changes in weight, BMI, insulin resistance,

and body fat. This study shows that a family-based program that uses nutrition

education, behavior modification, and supervised exercise can lower BMI,

improve body composition, and increase insulin sensitivity (Savoye et al.,

2007).

A similar comprehensive intervention completed by Nemet et al.

(2005) examined the short- and long-term effects of a 12-week, combined

dietary-behavioral-physical activity intervention on anthropometric measures,

body composition, dietary and leisure-time habits, fitness, and lipid profiles

among obese children aged 8 to 13 years old. This study was a randomized

prospective study on 24 obese subjects compared to 22 obese, age- and

gender-matched controls. All intervention subjects participated in a twice-

weekly training program, and also instructed to add one extra 30 to 45 minute

session of walking or weight-bearing sport activity on their own at least one

time per week. Subjects also met with a dietician 6 times throughout the 12-

week intervention, and received a balanced hypocaloric diet to follow.

Anthropometric assessments were completed, as well as nutritional

assessments, fitness assessments, and habitual activity assessments at the

beginning of the program, following the termination of the 12-week intervention, and at a 1-year follow-up. Results found that at 12 weeks, there were significant differences in changes in body weight (-2.8 ± 2.3 kg vs. 1.2 ± 2.2 kg), BMI (-1.7 ± 1.1 kg/m^2 vs. -0.2 ± 1.0 kg/m^2), body fat percentage (-3.3 ± 2.6% vs. 1.4 ± 4.7%), serum total cholesterol level (-24.6 ± 15.1 mg/dL vs. 0.8 ± 18.7 mg/dL), low-density lipoprotein cholesterol level (-23.3 ± 15.2 mg/dL vs. -3.7 ± 17.3 mg/dL), and fitness in the intervention group compared to the control group (215 ± 107 seconds vs. 50 ± 116 seconds). After a 1-year follow-up period, there were significant differences between the intervention group and the control group in regards to body weight, BMI, and body fat percentage. There was also a significant increase in leisure-time physical activity among the intervention participants, compared with a decrease among the control subjects (Nemet et al., 2005).   The data from this study suggests the short- and long-term beneficial effects of a combined dietary-behavioral-physical activity intervention among obese children (Nemet et al., 2005).

The results of these programs show the importance of the utilization of multidisciplinary programs to address many of the factors contributing to childhood obesity (Epstein et al., 2005) (Hands et al., 2011) (Nemet et al., 2005). It also shows that following the completion of a strict program, long-term effects can be seen. The involvement of physical activity, nutrition, and the involvement of parents have all been found effective in treating this problem. However, finding ways to combine all of these components, and

implementing them into daily life to produce maintenance of these healthy behaviors continues to be a problem for many interventions.

Summary

Due to the many health implications, as well as the impact this epidemic has on the nation, it is clear that changes are necessary to halt the rising rates of childhood obesity. Despite all of the current research that has been completed on this topic, it is still unclear how to maintain the behaviors learned in the programs.

The first important topic is that children must participate in more physical activity overall. As mentioned previously, the average child in the US spends the majority of his or her time sedentary, and few children participate in the recommended amounts of physical activity daily (Sisson et al., 2009) (Troiano et al., 2008). In order for interventions to be successful, children must be educated on healthy physical activity behaviors. They also must be introduced to a variety of activities so that they find activities that are enjoyable for them, and to prevent boredom from participating in the same activity over and over. Lastly, it seems that parents getting involved in the activities and playing with the children make the participation in these behaviors more successful. When combined, these steps will help maintain healthy activity behaviors in children.

Physical activity alone will show some benefit for overweight and obese children, however, when combined with dietary changes, more positive

results will be seen. It is clear that children are not engaging in healthy eating habits (Jahns et al., 2001) (Ludwig et al., 2001). Children must first be educated on healthy eating behaviors, and also on why certain foods and behaviors are unhealthy so that they understand the difference. It is also important to educate the parents because they are often the one's who choose what food is available to their children. Lastly, both parents and children should integrate healthy eating behaviors into everyday life in order for the diet to have successful effects.

Overall, it is known which components have an impact on childhood obesity. All components must be combined for an intervention to be successful. As research shows, diet and physical activity are important factors, however it is also clear that involving parents is a key factor as well. In the following study, physical activity, nutrition, and parental involvement have been combined to treat childhood obesity, and teach behaviors that should prevent unhealthy behaviors in the future for these children.

Although nutrition has been discussed in this review, the focus of this thesis will be on physical activity. Nutrition was extensively explained to clarify how the program was implemented, and the factors that were included. Nutrition played a large role in the program design, however the focus of this analysis and results is physical activity.

CHAPTER 3

METHODOLOGY

Study Design

This project was secondary data analysis of a pediatric weight management program that was collected during the spring of 2011 and the spring of 2012. The study was collaboration between The University of Rhode Island, Busy Body Studio in South Kingstown, two pediatricians and one pediatric dietitian. This project used the existing data to analyze the effects of the program. None of the data that were analyzed in this project has been previously used in research.

This study took place at Busy Bodies Studio located in South County, Rhode Island. This study followed a single group, non-experimental design consisting of baseline testing, a 16-week intervention, post testing, and post-intervention follow-up assessments at 6-months, 12-months, and 24-months. The study design and procedures were approved by the Institutional Review Board (IRB) at the University of Rhode Island (HU1011-140-EXP4).

Subjects and Recruitment

All the subjects were physician-referred by their pediatric physician after their assessment as overweight or obese. In order for a subject to be included in the study they had to be at or above the 85th percentile according

to their BMI, between the ages of 7 and 11 years, and at least one of their

parents had to attend each intervention meeting. Subjects were excluded if

they were unable to speak or understand English, if they had a severe chronic

disease that limited their participation in the diet or exercise program, or if

they were already participating in any intensive nutrition or physical activity

counseling.

The height and weight of each participating subject was abstracted

from medical records from age 5 to the start of the intervention in order to

track their growth over time. Twenty subjects signed up for participation in the

study. All subjects were Caucasian, and were residents of the South

Kingstown, RI. Three subjects were excluded from analyses due to drop out

following pre intervention testing or because they were missing pre or post

intervention data. The subjects used for analyses included 10 males and 7

females. Subject characteristics can be found in table 1. All subjects ranged

from 89 months (7.42 years) to 132 months (11 years) of age with the mean

age being 108.41 months (SD= 11.97), or about 9.03 years. All subjects had a

body mass index (BMI) ranging from 19.9 to 38.4 kg/m^2 with the mean BMI

for all subjects being 24.9 kg/m^2 (SD= 3.8) and a BMI z-score ranging from

1.37 to 2.11 with a mean BMI z-score of 2.1 (SD= 0.3) at the start of the

intervention. At the start of the intervention, our subjects ranged from the 91st

to the 99th percentile with a mean of 97.47% (SD= 2.401) according to the

growth charts of the CDC used in calculation through The Children's Hospital

of Philadelphia Research Institute website (The Children's Hospital of Philadelphia, 2008).

Intervention

The intervention consisted of physical activity, nutrition, and parental involvement components. The intervention was 16-weeks long. Each weekly session met for approximately 90 minutes. Figure 1 shows a general layout of each weekly session. At the beginning of the session parents met with the physical activity specialist to go over ideas for family activities and games the parents can do with their children at home, how they need to get involved, and why this is important. Also, the parents shared their daily routines with the physical activity specialist in order for the specialist to gain knowledge on the best ways to implement activities into their day. During this time, the children meet with a nutritionist to discuss healthy nutritional behaviors and food choices. The children participated in activities on various nutrition practices such as identifying healthy food choices, and reading food labels. After approximately 30 minutes, the children then moved to the gym to participate in activities with the physical activity specialist. During this time, the parents met with a nutritionist who educated them about healthy diets and their role in their child's success. The nutritionist gathered information on what a typical meal is like for the parents and gained insight into their daily routines. At the same time, parents asked any questions they had. At the end of each session, the parents met their child in the activity room for family activity time. At this

time the children were instructed to teach their parents what they learned, and the parents and children participated in the activity together. Before leaving, the children also learned the take-home challenge that they completed with their parent throughout the week following the session to keep them active.

Table 2 shows a layout of the weekly activities. The purpose of the exercise program was to promote lifestyle activities that motivated the children to be active. The focus of the program was on behavior and attitude changes in the children and to make their outlook on physical activity positive. The program followed a progressive design, and each week built upon the topics from the previous session. The activities were often designed to complement the weekly nutritional topic. For example, if the nutritional topic focused on "heart health", the physical activity topic of that week was cardiovascular health as well. Sometimes however, there were no physical activity topics to complement the nutritional topic. In this case, the program was designed for another important lifestyle physical activity topic to be covered in this week. For example, if the nutritional topic was "beans and legumes", then the activity topic may have been "hand-eye coordination" since this was still an important topic, but it was not related to nutrition.

Baseline and Post-intervention Testing

Anthropometrics. Body weight was measured to the nearest 0.25 lb. and height was measured to the nearest 0.25 in. using a Tanita WB300731 scale. All heights and weights were obtained from the pediatricians. Body

mass index (BMI), BMI percentiles, and z-scores were calculated utilizing the

collected height and weight data. BMI, BMI percentile, and z-score were

calculated using The Children's Hospital of Philadelphia Research Institute

website (The Children's Hospital of Philadelphia, 2008) which can be

accessed at: http://stokes.chop.edu/web/zscore/index.php. This web page

allowed the calculation of BMI, BMI percentile, and z-score (standard

deviation) based on the growth charts of the Center for Disease Control

(CDC).

A BMI z-score was used in addition to BMI because of the special

population being measured. A BMI z-score is particularly useful when

monitoring changes in subjects that have a BMI above the 99th percentile or

below the 1st percentile. The BMI z-score is a quantitative measure of the

deviation of a specific BMI percentile from the mean of that population

(National Obesity Observatory, 2011). A positive BMI z-score indicates that a

child is heavier than the mean, and a negative BMI z-score tells you the child

is lighter than the mean. A BMI z-score of +1.0 is one standard deviation

above the mean. The BMI z-score allows the comparison of the BMI of any

given child to the BMI distribution for a population of children of the same

age and sex (Moore, 2010). A BMI z-score greater than +1.0 standard

deviations means that a child is overweight, and a BMI z-score greater than

+2.0 standard deviations identifies a child as obese (Moore, 2010).

Questionnaires and Evaluation. Prior to the beginning of the study, pediatric physicians performed a physical exam on each participant. A layout of the measures that were collected, and the times in which they were collected can be found in table 3. Measures included a demographic questionnaire, a pediatric symptoms checklist, a Harvard youth/adolescent questionnaire, and general consent and assent forms, which were filled out by the subject or their parent/guardian and returned to the study prior to its start. The first session of this study took place between March 2011 and July 2011. The second session of the study began March 2012 and weekly sessions terminated in July 2012. All past medical history was obtained for each subject as mentioned.

The study utilized a pediatric symptoms checklist (PSC). The checklist was filled out by the parent of each subject prior to the beginning of the study, and also at the termination of the 16-week intervention. The PSC was used to identify any cognitive, emotional, or behavioral problems in the participants (Jellinek et al., 2000). It is a 35-item checklist (range, 0-70 points) in which the parent rated the frequency of the subject's emotional and behavioral problems from 0 (never) to 2 (often) (Stein et al., 2003). It has been found both reliable and valid in its use to assess a child's behavioral patterns (Jellinek et al., 2000) (Stein et al., 2003).

There were four separate scores that were obtained from the PSC. In order to analyze this survey, a total score was calculated using the sum of the

35 questions. A score ≥ 28 suggested a psychological impairment in the child.

The scale was then further broken down into 3 sub-scales. The first sub-scale,

the internalizing sub-scale, pulled five questions from the original checklist

(Feels sad/unhappy, feels hopeless, is down on him or herself, worries a lot,

seems to be having less fun). A score of 5 or more suggested that the child

could have impairments with anxiety and/or depression. The attention sub-

scale also generates a score using 5 of the original questions (fidgety,

daydreams too much, distracted easily, has trouble concentrating, acts as if

driven by a motor). A score of 7 or more on the attention sub-scale indicated

attention disorders. Lastly, 7 questions are used to calculate a score regarding

externalizing problems (fights with others, does not listen to rules, does not

understand other people's feelings, teases others, blames others for his or her

troubles, takes things that do not belong to him or her, refuses to share). A

score of 7 or more on the externalizing sub-scale indicated possible problems

with conduct. These sub-scales were analyzed for changes between pre and

post measures. Variables were categorized in order for analysis.

The study also utilized the Harvard youth/adolescent questionnaire

(FFQ) (Rockett et al., 1995). This nutritional survey was completed pre- and

post-intervention by the parent/guardian of each subject. The FFQ has been

found to provide a reliable and accurate description of the eating patterns of

young people (Vereecken & Maes, 2003). The Harvard youth/adolescent

questionnaire has been extensively validated for the use in nutritional research

among children and youth (Fung et al., 2012) (Vereecken & Maes, 2003). The analyses in this study do not analyze this measure.

Physical Activity. This study utilized the Fitnessgram to test physical functioning. The tests selected for this study were the curl-up test, push-up test, trunk lift test, back-saver sit and reach test, and shoulder stretch test. All five tests were analyzed seperatly for changes from pre to post intervention.The Fitnessgram was originally developed by the Cooper Institute for Aerobic Fitness (Murray & Squires, 2008). The tests selected for the Fitnessgram determine whether or not a subject is in a "healthy fitness zone" for their age and gender (Murray et al., 2012). This test is both valid and reliable in assessing the physical functioning of children and adolescents (Meredith & Welk, 2007) (Murray & Squires, 2008) (Murray et al., 2012).

Accelerometers were also administered to the children three times during the study. An accelerometer measures accelerations caused by body movements in one to three orthogonal planes and generates activity counts and minutes spent active (Rowlands, 2007). The accelerometer that was used was the Actigraph GT3X. Students were educated to place the accelerometer on the right hip, as close to the skin as possible. Accelerometers were not to be worn during any water activity or while sleeping. The accelerometers were used for the collection of pre-, mid-, and post-intervention data. They were worn for 7 consecutive days from the moment the child woke up until bed at night with an epoch set at 60 seconds. Data were downloaded from the

accelerometers using the Actilife software and stored for analysis. The Actilife

software is a specialized software used to prepare the ActiGraph devices for

data collection, as well as download, process, and manage collected data.

Accelerometer non-wear time will be defined as a count of 0 for 2 consecutive

minutes (Troiano et al., 2008). Moderate to vigorous physical activity

(MVPA) was defined as 1500-5999 counts per minute. The Actigraph GT3X

is a triaxial accelerometer that has shown adequate reproducibility, validity

and feasibility in children and adolescents (De Vries et al., 2006) Verloigne et

al., 2012) (Yildirim et al., 2011).

Statistical Analysis

Descriptive statistics were used to describe the group in regard to

participants' age, demographic information, BMI, BMI z-scores, and BMI

percentiles. Paired T-tests were used to analyze changes from pre to post in

BMI, BMI z-score, and fitness test data. McNemar's tests were used to

analyze improvements in psychosocial behavior by categorizing the variables

of the PSC. A score at or above the cut-point for each variable was categorized

as a one, and all others were categorized as 0 for analyses. Mixed model

analyses were used to evaluate the changes in BMI over different time points,

as well as accelerometer data .

Data extrapolation was used for subjects that were missing certain data

points. Three subjects were missing a data point in their historical data, and

one subject was missing data for their 6 month follow-up. For these

participants, a mean height and weight were calculated using the data point

right before and right after the missing point. The exact month between the

two collected points was also calculated. Using these data, a mean BMI, BMI

z-score, and BMI percentile was calculated using The Children's Hospital

Philadelphia Research Institute website and used for data analysis. Data

extrapolation was not used in any subject missing either pre or post

intervention data. A subject missing these data was excluded from analyses.

SAS 9.3 was used for all analyses and statistical significance was defined as p

$\leq .05$.

CHAPTER 4

RESULTS

Participant Characteristics

A total of 20 subjects involved in the program at Busy Bodies Studios consented to participate in the intervention. Of the 20 participants, 3 subjects were excluded due to missing data. The final data analysis consisted of 17 subjects (10 males and 7 females) whose mean BMI at the start of the intervention was 24.9 ± 3.8 kg/m^2 with a mean BMI z-score of 2.1 ± 0.3 and a BMI percentile of $97.47 \pm 2.401\%$. All subjects ranged from 6 to 11 years of age with the mean age being 108.41 ± 11.974 months (about 9 years) at the start of the study.

BMI as a measure of weight maintenance

This study hypothesized that following the completion of the program, BMI would stabilize in the participants when compared with trends in their BMI before the intervention. As part of the intervention, BMI data was obtained for each participant from age 5 to the start of the study. This data is represented by negative variables in the analyses. Therefore, -4 to -1 represent the number of years prior to the start of the study (-1 is one year prior to the intervention, -2 is 2 years prior, etc., 0 represents pre-intervention measures, 1 represents post-intervention measures, 2 represents the 6-month follow-up

data, and 3 represents the 12-month follow-up data in all analyses. Table 4

shows a profile analysis of the mean BMI and BMI z-score for our sample

from four years prior to the start of the intervention through the termination of

the study. Two subjects were missing historical data so 15 subjects were

included in data analysis prior to the intervention. Seventeen subjects were

included in the analyses for the intervention and follow-up measures.

Analyses of the mean BMI and BMI z-score prior to the start of the study is

shown in table 5. Table 5 shows that prior to the start of the intervention, the

BMI in our sample showed a statistically significant increase over the four

years [ß=1.12 (95% CI: 0.90-1.35)] (p<0.001). No significant changes were

seen in regards to BMI z-score prior to the start of the intervention [ß=0.02

(95% CI: -0.05-0.04)] (p=0.928). Following the start of the intervention, pre/

post analyses completed in table 6 show a statistically significant decrease in

BMI from 24.9 ± 3.8 kg/m^2 at the start of the intervention to 24.3 ± 4.2 kg/m^2

at the end of the intervention period (p=0.034). BMI z-score also showed

statistically significant changes from pre to post, decreasing from 2.1 ± 0.3 to

1.9 ± 0.5 (p=0.026). Table 7 shows changes in BMI and BMI z-score from the

start of the intervention period through the completion of the study (12-month

follow-up). BMI showed no significant changes [ß=-0.02 (95% CI:

-0.15-0.11)] (p=0.765) during this time. BMI z-score also showed no

significant changes [ß=-0.03 (95% CI: -0.06-0.002)] (p=0.062) from the start

of the intervention through the termination of the program. Figure 2 shows a

trend in the distribution of the changes in BMI from four years prior to the start of the intervention through the termination of the study in comparison to the average child between the ages of 7 to 11 in the 50th percentile according to their BMI. This figure shows a significant increasing trend in our subject's data from four years prior to the intervention to the start of the intervention [ß=1.12 (95% CI: 0.90-1.35)] (p<0.001). From 0 (pre) to 1 (post) there is a statistically significant decrease in BMI from 24.9 ± 3.8 kg/m^2 to 24.3 ± 4.2 kg/m^2 (p=0.034). No statistically significant changes were seen from the start of the intervention (0) through the termination of the study (3) (p=0.765). In comparison, the data of the children at the 50th percentile according to their BMI show a more gradual increase from year to year. It is also clear there is a large difference in BMI between our participants compared to children of the same age range at the 50th percentile of BMI for age. Figure 3 shows a trend in the distribution of the changes in BMI z-score from four years prior to the start of the study through the termination of the study. The only significant changes in BMI z-score were seen from pre (0) to post (0) (p=0.026) No significant changes were seen from data prior to the start of the study (p=0.928), or from the start of the intervention through the end of the study (p=0.062).

Accelerometer data as a predictor of physical activity level

Another hypothesis of this study was that physical activity levels would improve following the completion of the program. No significant

changes were found in the collected accelerometer data. Tables 8 and 9 show

the analyses of the accelerometer data from the participants in the study. In

table 8, mean and standard deviation were calculated for three time points

throughout the intervention period (pre, mid, and post). No significant

changes were seen in association with MVPAB (moderate to vigorous

physical activity bouts). The mean MVPAB at the start of the study was 9.5

min·day^{-1} (SD=4.9). At the middle of the intervention, the mean MVPAB was

10.4 min·day^{-1} (SD=7.1), and the mean at the end of the intervention was 10.1

min·day^{-1} (SD=8.3). Similar results were seen in regards to MVPAM, which is

minutes engaged in moderate to vigorous physical activity weekly. The mean

at the start of the study was 140.6 7d.wk^{-1} (SD=74.3), and the mean at the end

of the study was 160.1 7d.wk^{-1} (SD=133.1). These means are compared using

an ANOVA in table 9. Table 9 shows coefficients with a 95% confidence

interval for the accelerometer data. Changes over the three test points were

analyzed for both MVPAB and MVPAM. No significant changes were

analyzed for MVPAB [ß=0.28 (95% CI: -2.04-2.61); p=0.807]. Likewise, no

significant changes were seen in MVPAM [ß=9.72 (95% CI: -23.91-43.35);

p=0.559]. Overall, there was no statistically significant improvements seen in

the time spent physically active throughout the intervention in the participants.

Fitness tests in assessing changes in overall fitness levels

It was hypothesized that fitness test scores in the participants would

improve from pre to post testing. Significant changes were found in only the

curl-up and trunk-lift tests. Table 6 shows an overview of the differences from post to pre measurements for the fitness test. Significant changes were seen in both the curl-up test and the trunk-lift test. The curl-up test showed improvements from 5.6 ± 7.3 curl-ups to 12.2 ± 7.1 curl-ups from pre to post (p=0.004). The trunk-lift test showed significant improvements from 5.9 ± 3.1 inches to 8.1 ± 3.4 inches from pre to post (p=0.001). The push-up test showed no significant improvements, showing only a slight increase from 5.5 ± 4.4 push-ups to 7.0 ± 5.1 push-ups from pre to post (p=0.597). The sit and reach test showed no significant improvements on the right (-2.9 ± 3.3 inches to -1.4 ± 2.6 inches, p=0.057) or the left (-2.7 ± 2.7 inches to -1.4 ± 2.7 inches, p=0.093). The shoulder stretch test also showed no significant improvements on neither the right side (1.4 ± 0.5 inches to 1.3 ± 0.5 inches, p=0.333) nor the left side (1.7 ± 0.5 inches to 1.6 ± 0.5 inches, p=0.333). The improvements found in abdominal strength and trunk extensor strength confirm our hypothesis that fitness level would improve following the intervention.

Pediatric Symptoms Checklist as a measure of psychosocial behavior

Psychosocial behavior was predicted to improve following the completion of the program. No significant changes were found in overall psychological impairment or in the internalizing, attention, or externalizing sub-scales. Table 6 shows an overview of the differences from pre to post measurements for the pediatric symptoms checklist. Four variables were analyzed using the pediatric symptoms checklist (overall psychological

impairment, internalizing sub-scale, attention sub-scale, externalizing sub-scale) to identify changes in psychosocial behaviors in the participants. Overall psychological impairment is indicated if a child scores a 28 or higher on the pediatric symptoms checklist. In our sample, no significant changes were seen in overall psychological impairment, showing an non-significant decrease from 12.9 ± 3.8 to 12.3 ± 9.7 (p=0.224) with the number of children who showed any psychological impairment (score ≥ 28) decreasing from 3 children to 2 children (p=0.318) from pre to post. The checklist was then divided into three additional sub-scales. A score of five or more on the internalizing sub-scale identifies a child as having impairments with anxiety or depression. The internalizing sub-scale showed no significant changes (p=0.859) with the number of children scoring 5 or more decreasing from 3 children to 1 child (p=0.158). The attention sub-scale was used to identify attention disorders in the participants. A score of 7 or higher identified these problems. No significant changes were found using the attention sub-scale (p=0.646). Lastly, a score of 7 or more on the externalizing sub-scale identified a participant as having problems with conduct. No significant changes were seen on the externalizing sub-scale (p=0.509) with the number of children scoring 7 or more remaining unchanged (p=1.000). Overall, no significant changes were seen in regards to the pediatric symptoms checklist in our sample.

CHAPTER 5

DISCUSSION

The purpose of this intervention was to stabilize the BMI in overweight and obese participants. The intervention also proposed to increase physical activity levels, improve physical fitness, improve dietary intake, and improve psychosocial behaviors in the participants. Significant changes were seen in regards to BMI, BMI z-score, as well as fitness level following the completion of our intervention. One thing that made this intervention different from many others, in addition to the physical activity and nutrition components, is that it included a parental involvement component allowing parents to take part in every step of the intervention with their child. This study demonstrates the effectiveness of a comprehensive intervention focused on childhood obesity.

The results of our study confirm that following the participation in the intervention, participants would maintain BMI. Following the start of the program, measures from pre to post showed a significant decrease in BMI (24.9 ± 3.1 to 24.3 ± 4.2, p=0.034) followed by a stabilization in BMI. These results become even more important when comparing these results to the trends showing an increase in BMI with age [ß=1.12 (95% CI: 0.90-1.35); p<0.001] prior to the participation in the intervention. Although increases in BMI are normal with age, BMI in our sample was well above the normal as

indicated by the BMI z-scores of participants being two standard deviations above the mean. Therefore, this large increase in BMI from year to year prior to the start of the study show the significance of the maintained BMI after the intervention terminated.

The results of our study are consistent with the results of Eliakim et al. (2002). The study by Eliakim et al. (2002) completed their analysis in 177 obese boys and girls aged 6 to 16 years old, similar to the age group studied in our program. Findings from Eliakim et al. (2002) show that following the participation in a 12-week dietary-behavioral-exercise program, participants showed a maintenance of BMI. In comparison, children who did not participate in the intervention (control group) showed an increasing trend in BMI over the three month period. Our current findings extend this body of research confirming that the participation in a comprehensive program has significant effects on BMI in overweight and obese participants. Weight maintenance with continued linear growth, accompanied by the teachings of a healthier lifestyle, create an attainable goal for children. Since BMI increases naturally with age, maintenance of weight is considered successful (Reilly & Wilson, 2006). In our study, the intervention participants maintained a stable BMI when trends prior to the start of the intervention predicted a continuous increase in BMI if the participants refrained from change. These results suggest the successfulness of a comprehensive program to reverse the rising rates of childhood obesity.

Similarly to BMI, results of our study found a significant maintenance in BMI z-score following the intervention. BMI z-score was used in addition to BMI because the BMI z-score takes both age and sex into consideration. It compares the participants to the growth charts of The Center of Disease Control and Prevention. BMI z-score showed a significant decrease from pre to post intervention measures (2.1 ± 0.3 vs. 1.9 ± 0.5, p=0.026). Though changes after the start of the intervention did not show significant changes, BMI z-score was kept stable. Prior to the intervention, BMI z-score showed no significant changes [ß=0.02 (95% CI: -0.05-0.04); p=0.928]. Though BMI z-score did not change much throughout the study, BMI was maintained. Therefore, trends show as the participants continue to grow and maintain their BMI, their BMI z-score will begin to decrease. These results are similar to results found by Economos et al. (2007), however this was a community-wide intervention. This non-randomized controlled trial was completed in a sample similar to ours with a mean age of 7.6 ± 1.0 years. Unlike our study, this study did not use a parental involvement component. Results found that following the participation in an intervention that sough to increase physical activity and make healthy foods more available to children, subjects showed an overall decrease in BMI z-score compared with a control community. These results confirm that the participation in an intervention encouraging healthy physical activity and nutrition behaviors can stabilize BMI and BMI z-score in children at a high risk for obesity.

In addition to BMI and BMI z-score, physical activity levels were also expected to increase following the completion of our study. Results found no significant changes in daily physical activity levels in the children. However, this study found no significant changes in daily physical activity levels in children. In contrast, research by Nemet et al. (2005) found significant increases in activity in 54 overweight children aged 6 to 16 years old following the completion of a 12-week program compared with control subjects. Results from this study found a significant increase in habitual physical activity time among the intervention participants (22.5 ± 12.5 units vs 45.7 ± 12.6 units, $p<0.05$), compared with a decrease among the control subjects (24.3 ± 20.1 units vs. 22.1 ± 16.9 units, $p>0.05$). It is possible that the non-significant results of our study are due to improper wear time of the participants. Many of the parents reported to researchers that children would remove accelerometers prior to participating to sporting events because they felt the accelerometers would bother them. Also, it was reported that children would also sometimes forget to put the accelerometers on in the morning. It is possible that further participation in the activities that were taught during the intervention could lead to continuing progression towards healthy physical activity levels in participants, but accelerometer data was not collected during the follow-up periods in this study. It is also believed that the participation in a comprehensive intervention leads to long-term positive effects on lifestyle.

Following the completion of a comprehensive intervention, results showed statistically significant changes in fitness test scores of the participants. Both the curl-up test (5.6 ± 7.3 vs 12.2 ± 7.1, p=0.004), and the trunk-lift test (5.9 ± 3.1 vs 8.1 ± 3.4, p=0.001) yielded significant results from pre to post intervention measures. While the push-up test, the sit-and-reach test, and the shoulder-stretch test showed no significant changes, the tests involving abdominal and trunk extensor strength showed improvements. Due to the design of our physical activity program, the results of the fitness test were expected. The program was aimed at improving the activity levels of the children. It was designed to involve the children in multiple activities that would motivate them to be physically active throughout their daily lives. The activities were not chosen in order to directly improve physical strength, endurance, or flexibility. In a population where the children were mostly inactive prior to the start of the intervention, the participation in new activities that required the children to run, jump, throw, and change direction would have more of an impact on abdominal and trunk extensor strength than on endurance or flexibility. In a similar study by Kain et al. (2004), physical fitness was significantly improved in both boys and girls in 1st to 8th grade following the participation in a combined nutritional education and physical activity intervention. In contrast to our study, Kain's intervention also saw improvements in a 20 meter shuttle run test showing that participation in a

comprehensive intervention can lead to greater improvements in fitness level than our study observed.

The final measurement in our study sought to prove that the participation in our program would show significant improvements in psychosocial behaviors in our participants. Results of our study found no significant improvements in overall psychological impairments, or in the internalizing, attention, and externalizing sub-scales. However, a similar study by Zahner et al. (2006) that encouraged 1st to 5th grade children to be more physically active throughout the day found an increase in quality of life assessed using a child health questionnaire in the intervention group compared to the control group. This confirms that improving physical activity behaviors have a positive effect on psychosocial behaviors. It is likely that the lack of change observed in our study was related to measurements. Few of the participants (n=3) had a score at the start of the intervention that signified psychological impairment. Moreover, it is important to note that the participants of our study ranged from 6 to 11 years of age. Research shows that often psychological impairments related to overweight and obesity become more prominent in the teenage years after puberty sets in and appearance becomes more of a focus (Doyle et al., 2006). Changes in psychological impairment may have been observed if the sample was older. Lastly, it is important to note that the parents scored the PSC. Children spend much of their day in school away from their parents, so their parents may not

be aware of certain behaviors that are apparent in social settings such as school, or they may ignore that their child could have a problem. Results may have been different if the children had rated themselves. Overall, there is evidence supporting that the participation in a comprehensive intervention should improve the psychosocial behaviors of overweight and obese participants, and help them maintain confidence as they grow older (Zahner et al., 2006).

The findings of our study extend the body of research suggesting the successful nature of a comprehensive intervention in maintaining BMI while improving core fitness. The results of our intervention are consistent with the findings of others who have reported on the effectiveness of comprehensive interventions on childhood obesity (Nemet et al., 2005) (Taylor et al., 2007). A major strength of our study was the consistency of the measures. All of the tests were conducted by the same researcher, and the sessions were run by the same people each week. The subject's and their parents became familiar and comfortable with the researchers, and this allowed them to open up, ask questions, and get involved without being embarrassed. All of the measures were consistent and reliable throughout the intervention as well. Other strengths of this study include the involvement of the parents, the Fitnessgram and accelerometer tools, and the collection of the historical data for each participant allowing the analysis of weight gain prior to the start of the intervention. Also, the use of a diverse group of activities gave the participants

options, and allowed them to find activities that interested them and that they enjoyed without them becoming bored with the tasks.

Overall, the results of our intervention confirm the effectiveness of a comprehensive intervention program. The primary aim of the study was to maintain a stable BMI in participants following the start of the intervention. This study also successfully improved the core fitness levels of the participants. Participants were able to complete the intervention, and move forward in their lives with new skills that allowed them the ability to successfully engage in a more healthy lifestyle.

LIMITATIONS

Several limitations should also be mentioned. Most importantly, the small sample size limited the ability to analyze differences by sex and age. We also did not use a control group, which may have helped analyze maintenance of BMI. Also, the sample was similar in regards to race and socioeconomic status. There were limitations in regards to the Fitnessgram that was used as well. Since our program was not focused on improving these scores, it may have been more beneficial to use a test that focused more on cardiovascular fitness or full body strength. Another limitation was the lack of an instrument to measure the effect the parent's may have had on the intervention. Our study also only met one time each week. This left little control over the participants, and it could be beneficial to meet more frequently to reinforce positive behaviors. It may have also been beneficial if analyses of the dietary data had

been included so that we could compare changes in this data to changes in BMI, however the data were not available for this study. Lastly, although accelerometers provide valid objective measures of amount of time spent at various physical activity intensities, they cannot provide information about the types of activities being performed. Additional descriptive measures could be used in order to identify the types of activities the children are participating in allowing the researcher to guide the participant towards activities that may be more beneficial.

IMPLICATIONS FOR FURTHER RESEARCH

Future research should consider including measurements regarding the parental involvement aspects of the study. Parent's of the children were included in each step of the study. They were educated on healthy nutritional behaviors, physical activity, participated in the activities with the children throughout the intervention, and were encouraged to be active with their children at home. However, no surveys or tests were used to analyze how their participation affected the study. This could be beneficial information in regards to the further success of childhood obesity interventions.

Also, further research should be conducted in regards to fitness levels of the children in the interventions. For example, measuring cardiovascular fitness from the beginning of the intervention to the end could have showed more significant improvements than the Fitnessgram that was used. Since the activities in the program were not focused on improving any specific test,

identifying other fitness tests that could better measure improvements could have been more effective.

The use of a control group could have led to great insight into our BMI changes. Since our subject's showed significant trends in increasing BMI prior to the start of the study, it would have been beneficial to apply the data suggesting a maintenance of BMI following the study to a control. Also, using additional measurements during the follow-up periods would be beneficial in analyzing continuous changes in physical activity levels and psychosocial behavior as the participants get older.

It is also necessary to identify more ways to keep children active outside of the intervention itself. Finding ways to motivate children on their own time possessed a challenge for our intervention. It seems that getting parents involved in this process pushes the children to be more active, however maintaining this behavior is challenging. It is important to keep children active outside of the intervention in order to achieve results.

Our study contributes to the growing body of research suggesting that the participation in a comprehensive program can maintain BMI in overweight and obese children while improving fitness levels. The use of physical activity and nutrition components, combined with keeping parents involved in the process shows success in the treatment of this problem. With slight modification, this study can continue to grow as a successful means of treating and maintaining childhood obesity.

TABLE 1: Descriptive statistics of participants at the start of the intervention

Variables	n	Minimum	Maximum	Mean	SD
Age (months)	17	89	132	108.41	11.974
BMI	17	19.9	38.4	24.9	3.8
BMI Percentile	17	91	99	97.47	2.401
BMI z-score	17	1.37	2.80	2.1	0.3

note: n is number of participants; SD is standard deviation; BMI is body mass index; all data calculated using pre-intervention measures

TABLE 2: An outline of the activity topics for each weekly session

Week	Topic Concentration
1	Introduction class, fitness testing
2	My activity pyramid education
3	Cardiovascular health and aerobic activities (jogging, jump roping)
4	Flexibility (yoga, stretching)
5	Hand-eye coordination (badminton, Frisbee)
6	Core muscle strength (balance on fitness ball, hoola hoop)
7	Ball activities (basketball, soccer)
8	Review previous weeks (flexibility, aerobics)
9	School vacation week
10	Jumping activity (pogo ball, jump rope, skip it)
11	Team sports skills (passing ball, throw and catch)
12	Backyard activities (horseshoes, beanbag toss, Frisbee)
13	Speed and endurance (Hoola hoop, jump rope, relay races)
14	Strength
15	Fitness testing
16	Concluding session and wrap-up

note: this chart shows a layout of the activities that were performed each week during the physical activity portions of the intervention session

TABLE 3: A summary of the forms and evaluations that were completed throughout the intervention

	Prior to Study	Week 1	Week 8	Week 16	Follow-up Period
Referral Medical Evaluations	✓				
Demographics		✓			
Assent/ Consent Forms	✓				
Historical Data (age 5+)	✓				
Food Frequency Questionnaire		✓		✓	
Accelerometer		✓	✓	✓	
Pediatric Symptoms Checklist		✓		✓	
Physical Fitness Assessment		✓		✓	
Height & Weight		✓		✓	✓

note: This chart shows a layout of all the forms and evaluations completed throughout the study, and at which points they were collected

TABLE 4: Profile analysis of mean BMI and BMI z-score from four years prior to the intervention through the termination of the study

Time Points	n	BMI mean	BMI SD	Z-Score mean	Z-score SD
-4	15	20.7	2.8	2.1	0.7
-3	15	21.2	3.2	2.0	0.7
-2	15	22.4	3.8	2.0	0.6
-1	15	23.8	3.3	2.0	0.4
0	17	24.9	3.8	2.1	0.3
1	17	24.3	4.2	1.9	0.5
2	17	24.7	4.0	2.0	0.4
3	17	24.7	3.9	2.0	0.4

Note: n is number of participants; Two subjects were missing data prior to the intervention so n=15 for all historical data analyses (-4 to -1) and n=17 for all study analyses (0 to 3); SD is standard deviation; -1 is one year before intervention, -2 is two years before intervention, etc.;

TABLE 5: Coefficients with 95% confidence intervals for the BMI and Z-score changes for previous five years before the start of the intervention (time points -4 through 0)

Variables	ß (95% CI)	P-Value
BMI	1.12 (0.90-1.35)	< 0.001
Z-score	0.02 (-0.05-0.04)	0.928

note: n= 15; BMI is body mass index, CI is confidence interval

58

TABLE 6: Differences between pre and post measurements

Variables	Pre	Post	P-value
BMI			
BMI	24.9 ± 3.8	24.3 ± 4.2	0.034
Z-Score	2.1 ± 0.3	1.9 ± 0.5	0.026
PSC			
Total score	12.9 ± 9.3	12.3 ± 9.7	0.224
Psychological impairment (score≥28), n (%)	*3 (18.8)*	*2 (12.5)*	*0.318*
Internalizing subscale	2.0 ± 2.3	2.1 ± 2.1	0.859
Score ≥ 5, n (%)	*3 (18.8)*	*1 (6.3)*	*0.158*
Attention subscale	2.5 ± 2.2	2.5 ± 1.6	0.646
Score ≥ 7, n (%)	*1 (6.3)*	*0 (0.0)*	*-*
Externalizing subscale	2.6 ± 2.3	2.6 ± 2.7	0.509
Score ≥ 7, n (%)	*2 (12.5)*	*2 (12.5)*	*1.000*
Fitness Test			
Curlup	5.6 ± 7.3	12.2 ± 7.1	0.004
Trunklift	5.9 ± 3.1	8.1 ± 3.4	0.001
Pushup	5.5 ± 4.4	7.0 ± 5.1	0.597
Sarr	-2.9 ± 3.3	-1.4 ± 2.6	0.057
Sarl	-2.7 ± 2.7	-1.4 ± 2.7	0.093
Ssr	1.4 ± 0.5	1.3 ± 0.5	0.333
Ssl	1.7 ± 0.5	1.6 ± 0.5	0.333

note: n= 17; values are mean ± SD unless otherwise specified; BMI is body mass index; PSC is pediatric symptoms checklist; Sarr is sit and reach right and left; Ss is shoulder stretch right and left

TABLE 7: Coefficients with 95% confidence intervals for the BMI and Z-score changes after the start of the intervention (time points 0 through 3)

Variables	*ß (95% CI)*	P-Value
BMI	-0.02 (-0.15-0.11)	0.765
Z-score	-0.03 (-0.06-0.002)	0.062

note: n=17; BMI is body mass index, CI is confidence interval

TABLE 8: Mean and SD for accelerometer data

Time-points	MVPAB		MVPAM	
	Mean	SD	Mean	SD
1	9.5	4.9	140.6	74.3
2	10.4	7.1	155.9	115.4
3	10.1	8.3	160.1	133.1

note: n= 14; SD is standard deviation; MVPAB is moderate to vigorous physical activity bouts; MVPAM is
moderate to vigorous physical activity minutes weekly

TABLE 9: Coefficients with a 95% confidence interval for accelerometer changes over three test time-points

	MVPAB		MVPAM	
	ß (95% CI)	P-Value	ß (95% CI)	P-Value
Times	0.28 (-2.04-2.61)	0.807	9.72 (-23.91-43.35)	0.559

note: n= 14; MVPAB is moderate to vigorous physical activity bouts; MVPAM is moderate to vigorous
physical activity minutes; CI is confidence interval.

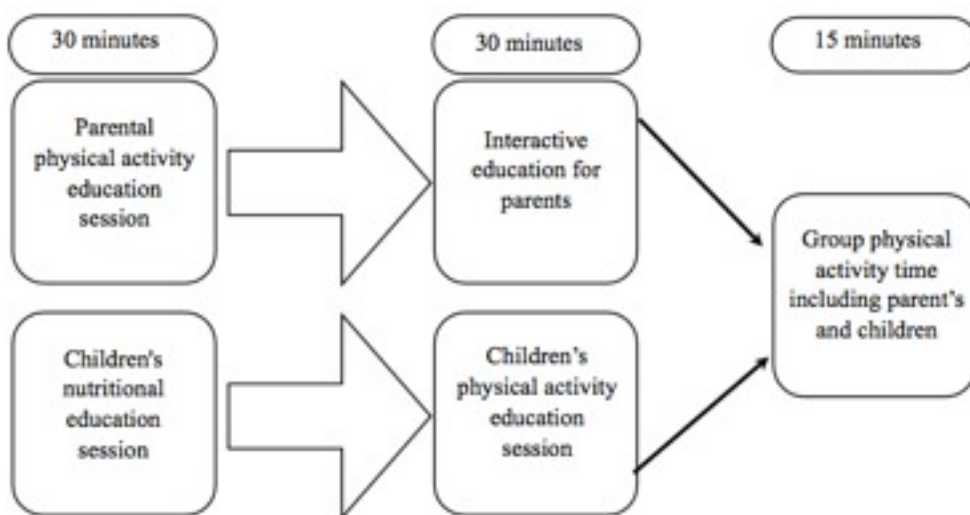**FIGURE 1**: Layout of the weekly intervention sessions throughout the program
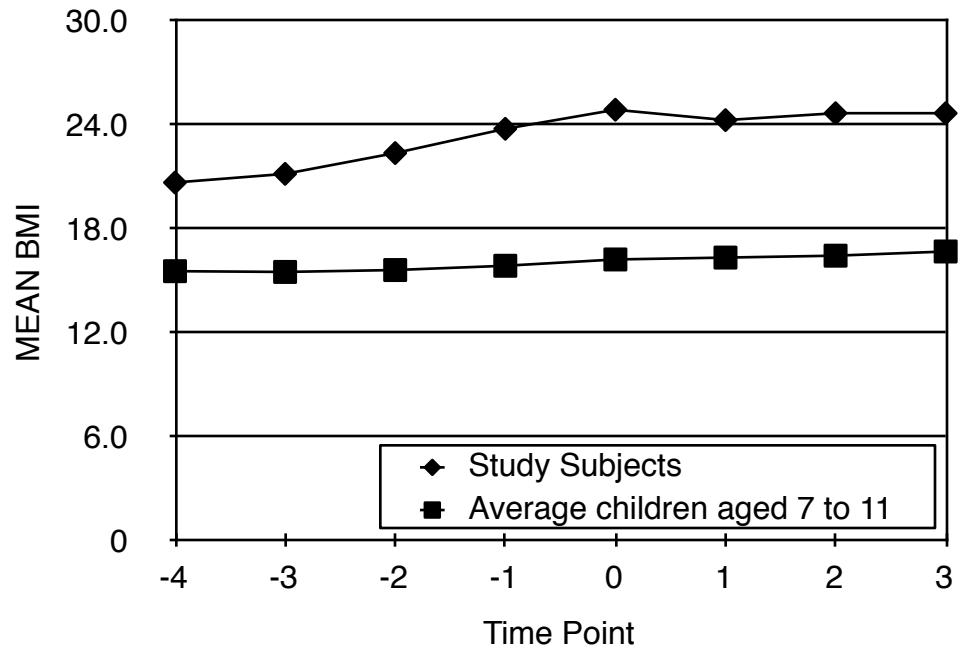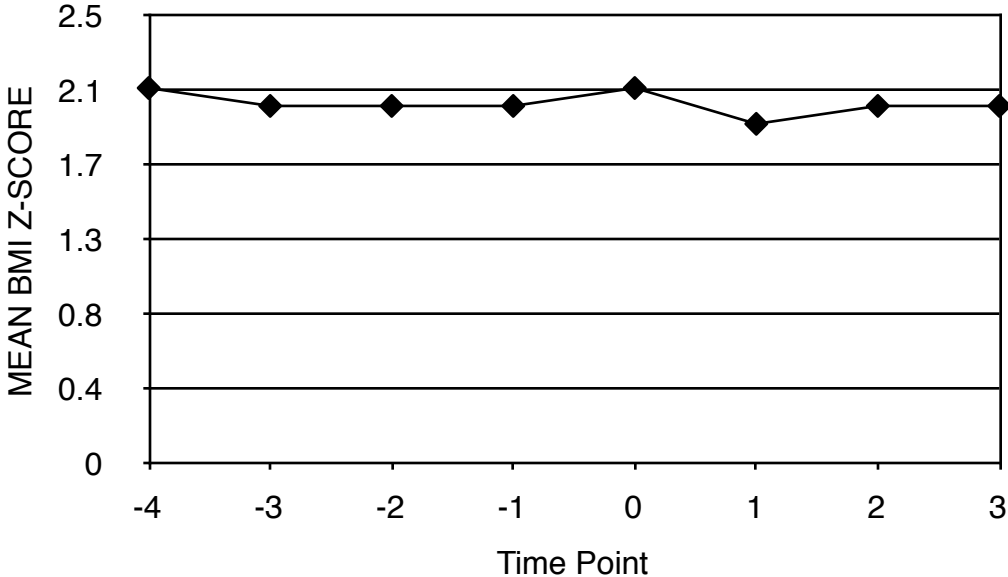
FIGURE 2: Distribution of mean BMI in study subjects compared to children aged 7 to 11 with a BMI at the 50th percentile

note: negative numbers signify years prior to start of the intervention and 0-3 indicate points during the study

FIGURE 3: Distribution of mean BMI z-score throughout the study

note: negative numbers signify years prior to start of the intervention and 0-3 indicate points during the study

BIBLIOGRAPHY

American Heart Association. (2012). Overweight and obesity statistics.
Retrieved from http://www.heart.org/HEARTORG/GettingHealthy/
WeightManagement/Obesity/Overweight-in-
Children_UCM_304054_Article.jsp on May 15, 2012.

American Heart Association. (2012). Overweight in children. Retrieved from
http://www.heart.org/HEARTORG/GettingHealthy/Overweight-in-
Children_UCM_304054_Article.jsp. on July 25, 2012

Anderson, P. M., & Butcher, K. E. (2006). Childhood obesity: trends and
potential causes. *Future Child*, 16(1), 19-45.

Arslanian, S. A. (2000). Type 2 diabetes mellitus in children: pathophysiology
and risk factors. *Journal of Pediatric Endocrinology Metabolism*, 13
Suppl 6, 1385-1394.

Berkey, C. S., Rockett, H. R., Field, A. E., Gillman, M. W., Frazier, A. L.,
Camargo, C. A., Jr., & Colditz, G. A. (2000). Activity, dietary intake,
and weight changes in a longitudinal study of preadolescent and
adolescent boys and girls. *Pediatrics*, 105(4), E56.

Birch, L. L., & Davison, K. K. (2001). Family environmental factors
influencing the developing behavioral controls of food intake and
childhood overweight. *Pediatric Clinics of North America*, 48(4),
893-907.

Biro, F.M., Wien, M. (2010). Childhood obesity and adult morbidities. *American Journal of Clinical Nutrition*, 91(Suppl.), 1499S-1505S.

Bowman, S. A., Gortmaker, S. L., Ebbeling, C. B., Pereira, M. A., & Ludwig, D. S. (2004). Effects of fast-food consumption on energy intake and diet quality among children in a national household survey. *Pediatrics*, 113(1 Pt 1), 112-118.

Brownson, R. C., Boehmer, T. K., & Luke, D. A. (2005). Declining rates of physical activity in the United States: what are the contributors? *Annual Review of Public Health*, 26, 421-443.

Centers for Disease Control and Prevention. (2010). Childhood Obesity. Retrieved from http://www.cdc.gov/obesity/childhood/problem.html on May 17, 2012

Centers for Disease Control and Prevention. (2011). How much physical activity do children need? Retrieved from http://www.cdc.gov/ physicalactivity/everyone/guidelines/children.html on August 22, 2012.

Centers for Disease Control and Prevention. (2011). HRQOL concepts. Retrieved from http://www.cdc.gov/hrqol/concept.htm on August 22, 2012.

Centers for Disease Control and Prevention. (2012). Physical activity facts. Retrieved from http://www.cdc.gov/healthyyouth/physicalactivity/ facts.htm on August 22, 2012.

Chaparro, M. P., Langellier, B. A., Kim, L. P., & Whaley, S. E. (2011).

    Predictors of accurate maternal perception of their preschool child's

    weight status among Hispanic WIC participants. *Obesity (Silver*

    Spring), 19(10), 2026-2030.

Chu, N. F., Rimm, E. B., Wang, D. J., Liou, H. S., & Shieh, S. M. (1998).

    Clustering of cardiovascular disease risk factors among obese

    schoolchildren: the Taipei Children Heart Study. *The American*

    Journal of Clinical Nutrition, 67(6), 1141-1146.

Cottrell, L. A., Minor, V., Murphy, E., Ward, A., Elliott, E., Tillis, G., . . . Neal,

    W. A. (2007). Comparisons of parent cardiovascular knowledge,

    attitudes, and behaviors based on screening and perceived child risks.

    Journal of Community Health Nursing, 24(2), 87-99.

Dehghan, M., Akhtar-Danesh, N., Merchant, A.T. (2005). Childhood obesity,

    prevalence, and prevention. *Nutritional Journal*, 4, 24-32.

DeVries, S.I., Bakker, I., Hopman-Rock, M., Hirasinga, R.A., van Mechelen,

    W. (2006). Clinimetric review of motion sensors in children and

    adolescents. *Journal of Clinical Epidemiology*, 59(7), 670-680.

Doyle, A. C., le Grange, D., Goldschmidt, A., & Wilfley, D. E. (2007).

    Psychosocial and physical impairment in overweight adolescents at

    high risk for eating disorders. *Obesity (Silver Spring)*, 15(1), 145-154.

Economos, C. D., Hyatt, R. R., Goldberg, J. P., Must, A., Naumova, E. N.,

    Collins, J. J., & Nelson, M. E. (2007). A community intervention

reduces BMI z-score in children: Shape Up Somerville first year
results. *Obesity (Silver Spring)*, 15(5), 1325-1336.

Ekelund, U., Luan, J., Sherar, L. B., Esliger, D. W., Griew, P., Cooper, A., &
International Children's Accelerometry Database, Collaborators.
(2012). Moderate to vigorous physical activity and sedentary time and
cardiometabolic risk factors in children and adolescents. *The Journal
of the American Medical Association*, 307(7), 704-712.

Eliakim, A., Kaven, G., Berger, I., Friedland, O., Wolach, B., & Nemet, D.
(2002). The effect of a combined intervention on body mass index and
fitness in obese children and adolescents - a clinical experience.
European Journal of Pediatrics, 161(8), 449-454.

Epstein, L. H., Paluch, R. A., Gordy, C. C., & Dorn, J. (2000). Decreasing
sedentary behaviors in treating pediatric obesity. *Archives of Pediatrics
and Adolescent Medicine*, 154(3), 220-226.

Etelson, D., Brand, D. A., Patrick, P. A., & Shirali, A. (2003). Childhood
obesity: do parents recognize this health risk? *Obesity Research*,
11(11), 1362-1368.

Fagot-Campagna, A. (2000). Emergence of type 2 diabetes mellitus in
children: epidemiological evidence. *Journal of Pediatrics
Endocrinology and Metabolism*, 13 Suppl 6, 1395-1402.

Finkelstein, E. A., Fiebelkorn, I. C., & Wang, G. (2003). National medical
spending attributable to overweight and obesity: how much, and who's

paying? *Health Affairs (Millwood), Supplement Web Exclusives*, W3-219-226.

Finkelstein, E. A., Trogdon, J. G., Cohen, J. W., & Dietz, W. (2009). Annual medical spending attributable to obesity: payer-and service-specific estimates. *Health Affairs (Millwood)*, 28(5), w822-831.

Freedman, D. S., Dietz, W. H., Srinivasan, S. R., & Berenson, G. S. (1999). The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics*, 103(6 Pt 1), 1175-1182.

Freedman, D. S., Mei, Z., Srinivasan, S. R., Berenson, G. S., & Dietz, W. H. (2007). Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study. The *Journal of Pediatrics*, 150(1), 12-17 e12.

Fung, C., Kuhle, S., Lu, C., Purcell, M., Schwartz, M., Storey, K., & Veugelers, P. J. (2012). From "best practice" to "next practice": the effectiveness of school-based health promotion in improving healthy eating and physical activity and preventing childhood obesity. *International Journal of Behavioral Nutrition and Physical Activity*, 9, 27.

Gorden-Larsen, P., McMurray, R.G., Popkin, B.M. (2000). Determinants of adolescent physical activity and inactivity patterns. *Pediatrics*, 105, e83-e90.

Gupta, N. K., Mueller, W. H., Chan, W., & Meininger, J. C. (2002). Is obesity associated with poor sleep quality in adolescents? *American Journal of Human Biology*, 14(6), 762-768.

Guthrie, J. F., & Morton, J. F. (2000). Food sources of added sweeteners in the diets of Americans. *Journal of the American Dietetic Association*, 100(1), 43-51, quiz 49-50.

Hands, B. P., Chivers, P. T., Parker, H. E., Beilin, L., Kendall, G., & Larkin, D. (2011). The associations between physical activity, screen time and weight from 6 to 14 yrs: the Raine Study. *Journal of Science and Medicine in Sport*, 14(5), 397-403.

Harnack, L., Stang, J., & Story, M. (1999). Soft drink consumption among US children and adolescents: nutritional consequences. *Journal of the American Dietetic Association*, 99(4), 436-441.

Jahns, L., Siega-Riz, A. M., & Popkin, B. M. (2001). The increasing prevalence of snacking among US children from 1977 to 1996. *The Journal of Pediatrics*, 138(4), 493-498.

Janssen, I., & Leblanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *The International Journal of Behavioral Nutrition and Physical Activity*, 7, 40.

Jellinek, M.S., Murphy, M., Little, M., Pagano, M.E., Comer, D.M., Kelleher, K.J. (2000). Use of the pediatric symptoms checklist to screen for

psychosocial problems in pediatric primary care: a national feasability study. *The Journal of the American Medicinal Association*, 153(3), 254-260.

Kain, J., Uauy, R., Albala, Vio, F., Cerda, R., & Leyton, B. (2004). School-based obesity prevention in Chilean primary school children: methodology and evaluation of a controlled study. *International Journal of Obesity and Related Metabolic Disorders*, 28(4), 483-493.

Kong, A. P., Wing, Y. K., Choi, K. C., Li, A. M., Ko, G. T., Ma, R. C., . . . Chan, J. C. (2011). Associations of sleep duration with obesity and serum lipid profile in children and adolescents. *Sleep Medicine*, 12(7), 659-665.

Lakshman, R., Elks, C. E., & Ong, K. K. (2012). Childhood obesity. *Circulation*, 126(14), 1770-1779.

Ludwig, D. S., Peterson, K. E., & Gortmaker, S. L. (2001). Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. *Lancet*, 357(9255), 505-508.

Meredith MD, Welk GJ. (2007). FITNESSGRAM ACTIVITYGRAM Test Administration Manual, The Cooper Institute, 4th Ed., Champaign IL: Human Kinetics.

Metcalf, B., Henley, W., & Wilkin, T. (2012). Effectiveness of intervention on physical activity of children: systematic review and meta-analysis of

controlled trials with objectively measured outcomes (EarlyBird 54). *British Medical Journal*, 345, e5888.

Moore, BJ. (2010). Assessment of children: how to use repeated measures of Body Mass Index (BMI) to assess and prevent obesity in children. Retrieved from http://www.shapeup.org/children/pub/assess_child.pdf on May 2, 2012.

Murray, T.D., Squires Jr., W.G. (2008). Texas FITNESSGRAM testing/results and coaches. *Texas Coach*, 53, 32-34.

Murray, T.D., Eldridge, J., Silvius, E., Squires, W.G. (2012). Fitnessgram Friday: A middle school physical activity and fitness intervention. *International Journal of Exercise Science*, 5(1), 4-15.

National Obesity Observatory. (2011). A simple guide to classifying body mass index in children. Retrieved from http://www.noo.org.uk/ uploads/doc/ vid_11601_A_simple_guide_to_classifying_BMI_in_children.pdf on January 5, 2013.

Nemet, D., Barkan, S., Epstein, Y., Friedland, O., Kowen, G., & Eliakim, A. (2005). Short- and long-term beneficial effects of a combined dietary-behavioral-physical activity intervention for the treatment of childhood obesity. *Pediatrics*, 115(4), e443-449.

Ogden, C. L., Carroll, M. (2010). Prevalence of obesity among children and adolescents: United States, Trends 1963-1965 through 2007-2008. *National Center for Health Statistics*.

Ogden, C. L., Carroll, M. D., Curtin, L. R., Lamb, M. M., & Flegal, K. M. (2010). Prevalence of high body mass index in US children and adolescents, 2007-2008. *The Journal of the American Medical Association*, 303(3), 242-249.

Owen, C. G., Nightingale, C. M., Rudnicka, A. R., Sattar, N., Cook, D. G., Ekelund, U., & Whincup, P. H. (2010). Physical activity, obesity and cardiometabolic risk factors in 9- to 10-year-old UK children of white European, South Asian and black African-Caribbean origin: the Child Heart And health Study in England (CHASE). *Diabetologia*, 53(8), 1620-1630.

Peterson, C. (2012). Childhood obesity: Part 2. Retrieved 3/29, 2012, from http://www.experimentation-online.co.uk/article.php?id=1306 on May 15, 2012.

Piernas, C., & Popkin, B. M. (2011). Increased portion sizes from energy-dense foods affect total energy intake at eating occasions in US children and adolescents: patterns and trends by age group and sociodemographic characteristics, 1977-2006. *The American Journal of Clinical Nutrition*, 94(5), 1324-1332.

Putnam, J.J., Allshouse, J.E. (1999). Food consumption, prices, and
expenditures, 1970-97. In F. a. C. E. Division (Ed.), Economic
Research Service. Washington, D.C.: U.S. Government Printing
Office.

Reilly, J. J., & Wilson, D. (2006). ABC of obesity. Childhood obesity. *British
Medical Journal*, 333(7580), 1207-1210.

Rockett, HR, Wolf, AM, Colditz, GA (1995) Development and reproducibility
of a food frequency questionnaire to assess diets of older children   and
adolescents. *Journal of the American Dietetics Association,*
95:336-340.

Rosenbloom, A. L. (2002). Increasing incidence of type 2 diabetes in children
and adolescents: treatment considerations. *Paediatric Drugs*, 4(4),
209-221.

Rowlands, A. V. (2007). Accelerometer assessment of physical activity in
children: an update. *Pediatric Exercise Science*, 19(3), 252-266.

Savoye, M., Shaw, M., Dziura, J., Tamborlane, W. V., Rose, P., Guandalini,
C., . . . Caprio, S. (2007). Effects of a weight management program on
body composition and metabolic parameters in overweight children: a
randomized controlled trial. *The Journal of the American Medical
Association*, 297(24), 2697-2704.

Schwimmer, J. B., Burwinkle, T. M., & Varni, J. W. (2003). Health-related
quality of life of severely obese children and adolescents. *The Journal
of the American Medical Association*, 289(14), 1813-1819.

Sisson, S. B., Church, T. S., Martin, C. K., Tudor-Locke, C., Smith, S. R.,
Bouchard, C., . . . Katzmarzyk, P. T. (2009). Profiles of sedentary
behavior in children and adolescents: the US National Health and
Nutrition Examination Survey, 2001-2006. *International Journal of
Pediatric Obesity*, 4(4), 353-359.

Srinivasan, S. R., Bao, W., Wattigney, W. A., & Berenson, G. S. (1996).
Adolescent overweight is associated with adult overweight and related
multiple cardiovascular risk factors: the Bogalusa Heart Study.
Metabolism, 45(2), 235-240.

Stein, B. D., Jaycox, L. H., Kataoka, S. H., Wong, M., Tu, W., Elliott, M. N.,
& Fink, A. (2003). A mental health intervention for schoolchildren
exposed to violence: a randomized controlled trial. *The Journal of the
American Medical Association*, 290(5), 603-611.

Swinburn, B. A., Caterson, I., Seidell, J. C., & James, W. P. (2004). Diet,
nutrition and the prevention of excess weight gain and obesity. *Public
Health Nutrition*. 7(1A), 123-146.

Taylor, R.W., McAuley, K. A., Barbezat, W., Strong, A., Williams, S. M., &
Mann, J. I. (2007). APPLE Project 2-y findings of a community-based

obesity prevention program in primary school age children. *The American Journal of Clinical Nutrition*, 86(3), 735-742.

The, N. S., Suchindran, C., North, K. E., Popkin, B. M., & Gordon-Larsen, P. (2010). Association of adolescent obesity with risk of severe obesity in adulthood. *The Journal of the American Medical Association*, 304(18), 2042-2047.

Troiano, R. P., Berrigan, D., Dodd, K. W., Masse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise*, 40(1), 181-188.

Trost, S. G., Kerr, L. M., Ward, D. S., & Pate, R. R. (2001). Physical activity and determinants of physical activity in obese and non-obese children. *International Journal of Obesity and Related Metabolic Disorders*, 25(6), 822-829.

U.S. Department of Agriculture. (2010). U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. 7th Edition. Washington, DC, US Government Printing Office.

U.S. Department of Health and Human Services. (2008). *Physical activity guidelines advisory committee report.* Washington, D.C.

Vereecken, C. A., & Maes, L. (2003). A Belgian study on the reliability and relative validity of the Health Behaviour in School-Aged Children food-frequency questionnaire. *Public Health Nutrition*, 6(6), 581-588.

Verloigne, M., Van Lippevelde, W., Maes, L., Yildirim, M., Chinapaw, M.,

    Manios, Y., . . . De Bourdeaudhuij, I. (2012). Levels of physical

    activity and sedentary time among 10- to 12-year-old boys and girls

    across 5 European countries using accelerometers: an observational

    study within the ENERGY-project. *The International Journal of*

    Behavioral Nutrition and Physical Activity, 9, 34.

Wang, Y., Beydoun, M. A., Liang, L., Caballero, B., & Kumanyika, S. K.

    (2008). Will all Americans become overweight or obese? estimating

    the progression and cost of the US obesity epidemic. *Obesity (Silver*

    Spring), 16(10), 2323-2330.

Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of

    physical activity: the evidence. *Canadian Medical Association*

    Journal, 174(6), 801-809.

Warschburger, P., & Kroller, K. (2012). "Childhood overweight and obesity:

    maternal perceptions of the time for engaging in child weight

    management". *BioMed Central Public Health*, 12, 295.

Williams, J., Wake, M., Hesketh, K., Maher, E., & Waters, E. (2005). Health-

    related quality of life of overweight and obese children. *The Journal of*

    the American Medical Association, 293(1), 70-76.

World Health Organization. (2000). "Obesity: preventing and managing the

    global epidemic- Report of a WHO consultation". *World Health*

    Organization Technical Report Series, 894, 1-253.

Yildirim, M., Verloigne, M., de Bourdeaudhuij, I., Androutsos, O., Manios, Y., Felso, R., . . . Chinapaw, M. J. (2011). Study protocol of physical activity and sedentary behaviour measurement among schoolchildren by accelerometry--cross-sectional survey as part of the ENERGY-project. *BioMed Central Public Health*, 11, 182.

Young, T. K., Dean, H. J., Flett, B., & Wood-Steiman, P. (2000). Childhood obesity in a population at high risk for type 2 diabetes. *The Journal of Pediatrics*, 136(3), 365-369.

Zahner, L., Puder, J. J., Roth, R., Schmid, M., Guldimann, R., Puhse, U., . . . Kriemler, S. (2006). A school-based physical activity program to improve health and fitness in children aged 6-13 years ("Kinder-Sportstudie KISS"): study design of a randomized controlled trial [ISRCTN15360785]. *BioMed Central Public Health*, 6, 147.