To the Graduate Council:

I am submitting a thesis by Stephen Sefchick entitled "Pedometer-Measured Physical Activity in Elementary School Children." I have examined the final paper copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Human Performance and Sport Studies.

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PEDOMETER-MEASURED PHYSICAL ACTIVITY IN ELEMENTARY SCHOOL CHILDREN

A Thesis
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Degree
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Dedication

To my fiancée, April Jones, and my mother, Margaret Sefchick. Thank you for all your love, support, encouragement, and patience. I love you both very much.

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I would like to thank all the subjects and subject's parents who participated in this study. You all did an excellent job and I appreciate your time and effort. I would also like to thank the Principal of West Hills Elementary School Pat Shelburne, and the teachers there for allowing me to do this study. Thank you to Sara Perdue, Nick Rich, Kathleen McCombs, Anna Ameglio, Tia VanOstrand, Lindsey Hornbuckle, and Cherilyn Hultquist for all your help with testing and baseline measurements. Without you my study could not been done.

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Abstract

The purpose of this study was to assess how many steps per day Elementary school children take. Specifically, the study sought to (a) determine the average number of steps per day that are taken in children from kindergarten through fifth grade; (b) to estimate the percentage of children who meet the President's challenge standards for step counting; and (c) to ascertain if there is a correlation between steps per day and body mass index. Additionally, physical activity was assessed using the Third National Health and Nutrition Examination Survey (NHANES III) and these scores were compared with step counts from the pedometer. A total of 110 children (54 boys and 56 girls) between the ages of five and eleven years old were used in the final assessment of step counts from original 131 participants from baseline. Participants completed the physical activity section of the youth questionnaire (NHANES III) and wore a pedometer (NL-2000) for seven consecutive days except while showering, swimming or sleeping. The average number of steps per day was 11,429 for boys and 11,180 for girls. Children took significantly fewer steps per day on Sunday than on other days of the week ($p<0.001$). When grades were put into groups of Kindergarten and first grade (K/1); second and third (2/3) grade; fourth and fifth grade (4/5) found that K/1 was significantly took more steps compared to 4/5 ($p=0.003$). The President's Council on Physical Fitness and Sports has set a standard of $\geq$ 11,000 steps/day for girls and $\geq$ 13,000 steps/day for boys to receive an activity award. Forty-two percent of girls met this recommendation while only 35.2% boys met this recommendation. A significant correlation ($r=-0.212$) was found between step counts and BMI ($p<0.05$). These results suggest that pedometers can be used to

monitor physical activity in children over seven days, and that only a minority of children are meeting the national recommendation set forth in the President's challenge.

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Chapter 1

Introduction

The Centers for Disease Control and Prevention (CDC) recommends that children and adolescents need to become more physically active and maintain this activity level throughout a lifetime (36). Physical activity has been shown to have a wealth of health benefits. Physical activity has been strongly correlated with a reduced risk of several chronic diseases, including obesity, coronary heart disease, diabetes, and colon cancer (1,6,39). The question that still has not been answered is, "How much physical activity is needed to obtain the optimal health benefits in children?" In addition, there is some concern over how physical activity should be assessed.

The measurement of physical activity is important to determine the level of activity necessary to achieve health benefits, to distinguish between moderate and vigorous activity, and to document physical activity (1). A valid measure of physical activity is also needed to help conduct successful programs in health promotion and help to develop new guidelines for physical activity (5). There are a number of ways to measure physical activity but the accuracy varies. For example, there are many different self-reported methods (such as questionnaires, logs, and surveys) but these all rely on the individual to recall the physical activity (10, 13). Objective methods such as heart rate monitoring and indirect calorimetry have been shown to be accurate, but are limited by cost and time constraints. Motion sensors have been proposed as an alternative measure of physical activity. The advantages to using some motion sensors in measuring physical activity are that they are low-cost, easy to use, and unobtrusive to the individual.

One popular type of motion sensor is the electronic pedometer (11). A pedometer measures the number of steps taken, average walking distance in models with stride length adjustments, and estimates energy expenditure when body weight is entered. The pedometer is positioned at the waist in the midline of the thigh. The electronic pedometer is an inexpensive, easy to use, and unobtrusive way to assess physical activity (3,4).

A few studies have used pedometers to help assess how many steps children take per day. What these studies have demonstrated is that as children get older they tend take fewer days per day. Vincent et al. (54) studied physical activity in children six to twelve years of age. The study reported girls in this age range took an average of 10,611 to 11,383 steps/day and boys took an average of 12,554 to 13,872 steps/day in America. Wilde (57) found that children between ages of 14 to 16 years reported an average of 11,000-12,000 steps/day. Tudor-Locke and Myers (53) conducted a review of 32 studies that assessed steps per day. They reported that one can expect an average 12,000-16,000 steps/day in eight to ten year old; 7,000-13,000 steps/day for younger adults; 6,000-8,500 steps/day in healthy older adults; 3,500-5,500 steps/day in disabled and chronically diseased individuals.

The prevalence of obesity has increased dramatically in recent decades. The CDC completed NHANES in 1980 (NHANES II) and 1994 (NHANES III) (9). These surveys found that the prevalence of obesity in children and adolescents has increased in all racial groups, ages, and sex groups over the past twenty years (44). The prevalence of childhood obesity is 15.3% among children age of six to 11 years from NHANES (1999-2000) (35). In previous, NHANES III (1988-1994) approximately 11% children and

adolescents were defined as being in the 95th percentile for BMI for age and sex (51). From National Health Examination Survey (NHES) and NHANES I to III, the prevalence of obesity increased by 54% in children age six to eleven years old and 39% for adolescents 12 to 17 years old (30).

Many studies have assessed physical activity in obese versus nonobese children but the results have varied due to the methods of assessing physical activity. Trost et al. found that for both moderate and vigorous activity levels, non-obese children exhibited a significantly higher total amounts of daily activity than obese children (50). A uniaxial accelerometer (CSA 7164) was used to assess physical activity in the sixth grade children. In another study, Crespo et al. found a strong association between TV watching (a marker of physical inactivity) and obesity (9). However, no significant relationship was seen between self-reported participation in physical activity and participants defined as being obese. The highest prevalence of obesity was in children that watched four or more hours of TV/per day. In study by Rowlands et al. (41) found a negative correlation between physical activity and body fatness. Physical activity was measured with a triaxial accelerometer, a pedometer, and a heart rate monitor in children eight to ten.

The electronic pedometer has been shown to be an appropriate tool for measuring physical activity but few studies have described normative data on steps per day comparing obese and nonobese children. The purpose of this research study is three-fold: (a) to determine the average number of steps/day taken in children in kindergarten through fifth grade; (b) to determine what percentage of elementary school children meet the President Council on Physical Fitness and Sports standard to receive an activity

award; and (c) to determine if there is a correlation between steps per day and body mass index.

Chapter II

Review of Literature

Childhood Obesity

Healthy People 2010 has set objectives designed around activity outcomes rather than fitness outcomes (34). The purpose of Healthy People 2010 is to establish national health objectives designed to address the most significant preventable threats to health and to establish national goals to reduce these threats. One of the objectives for Healthy People 2010 is to "reduce the proportion of children and adolescents who are overweight or obese." Currently eleven percent of children age six to eleven years are obese (34), but the target goal for obesity in this group is five percent according to Healthy People 2010.

Childhood obesity is a very complex issue because obesity is related to both genetics and environmental factors, but in simple terms it is caused by an imbalance between energy intake and energy expenditure (22). Causes of obesity include overeating, lack of physical activity, and/or low resting metabolic rate (20). Obese children do not consume a great number of calories compared to their peers, but their energy output from physical activity is lower (30). Therefore, a small imbalance can lead to major weight gain over a period of several years. High levels of body fat are associated with coronary artery disease, type 2 diabetes, hypertension, stroke, some forms of cancer, and dyslipidemia, which can all lead to early mortality (10,37). Children with high levels of body fat has been associated with type 2 diabetes, sleep apnea, and gallbladder disease. Having obesity at any age increases the risk of being obese later in life (30). For example, if a child is obese, it is likely this individual will be obese as an adult.

Genetics is one of the factors associated with childhood obesity. Many studies have found that genetics have an influence on childhood obesity (16). In a twin study done by Stunkard et al. (46) an association was found with heredity of fat mass for monozygotic twins (0.7-0.9) compared to dizygotic twins (0.35-0.45). A number of studies have found that parental obesity is associated with childhood obesity (43,56). In addition, elevations of serum leptin concentrations have been correlated with % body fat (8). Thus, higher levels of leptin concentrations are associated with higher levels of % body fat and BMI. Recently, five single gene disorders have been discovered to be associated with some causes for early onset of obesity (7,8,24,28,36).

Other factors associated with childhood obesity include: time spent watching TV, playing on the computer, the availability of facilities for participation in physical activities, and concerns over the safety of engaging in sports activity and exercise (9). Low levels of physical activity can lead to lower levels of energy expenditure and lean body mass, which will affect resting metabolic rate (RMR) and the total energy expenditure (22). Recent studies have compared individuals watching TV to individuals playing video games. These studies found individuals who watched TV had lower levels of oxygen consumption compared to the individuals that played video games. They also suggested that TV viewing could influence energy intake through promotion of snacks and foods due to the commercial advertisement. Combining all the hours of playing video games, watching TV, and videos, they found that children spend 25% of their waking hours watching TV (39). In addition, African Americans, Latinos, and children from lower socioeconomic position (all demographic groups are at greater risk for obesity), tend to watch more television than other US children (38).

Assessment of Physical Activity

Low levels of physical activity in children are has been associated as one of causes for the epidemic of childhood obesity but how is physical activity measured in children? There are different methods used to measure physical activity but the accuracy varies (3,55). For example, there are many different methods for self-reporting physical activity such as questionnaires, logs, and surveys but these all rely on the individual to recall physical activity. For example, bouts that are more vigorous are easier to record for most people but less intense bouts are not as accurately recorded (3,4,53). This may be because vigorous activity is more structured, while light to moderate activity can be spread throughout the day, which makes recalling activity more difficult.

Some other forms of assessing physical activity include indirect calorimetry, heart rate monitors, and motion sensors such as pedometers and accelerometers (18,21,29,55). A motion sensor picks up motion or acceleration of the trunk (3,5). There are two types of motion sensors: pedometers and accelerometers. The pedometer will be discussed later. An accelerometer is a device that is being used more commonly and is a respected tool for assessing physical activity (53). The accelerometer measures the increase and decrease in speed of the body mass (5). Along with this data collected by the movement of the body mass, it calculates net energy expenditure (kcal). It is user-friendly and has some potential for estimating energy expenditure (53). However, one problem with this device is its cost, which ranges from $50 to $400. The cost of this device might require smaller sample sizes to keep the cost of the studies down.

Heart rate monitors are another way to assess physical activity and energy expenditure (54). Weston et al. study was with twenty-six students (fourteen boys and

twelve girls) who were monitored by a Polar Vantage heart rate monitor that stored of heart rates values minute-by-minute. The participants wore the monitor for several hours after school from 3:00 to 11:30 PM while normal daily activities were carried out. A 30-minute block was taken from the time period and was converted to % heart rate reserve (%HRR), afterward multiplied by 100 to find the mean% HRR. After the mean %HRR was calculated it was used to estimate energy expenditure. This method of assessing physical activity is not ideal, because other factors besides physical activity can affect heart rate. For example, emotional stress can increase heart rate but is independent of physical activity. In addition, the methodology of estimating energy expenditure from heart rate is not always a straightforward method as seen above. In study by Rowlands et al. (41) the children found the HR belt to be uncomfortable and some of the participants did not wear the HR belt for the entire time allowed to assess physical activity. Thus, HR monitors are uncomfortable and obtrusive in monitoring physical activity in children.

One method that can be used to validate physical activity is indirect calorimetry (5). Indirect calorimetry can be used both in the field and in the laboratory setting. Indirect calorimetry assesses VO_2, which can be used to estimate physical activity by calculating metabolic rate through measurement of oxygen consumption during physical activity. This method is a valid way to measure energy expenditure, but the equipment is expensive and obtrusive. This method is obtrusive due to the device that goes into the mouth and/or covers the nose.

The electronic pedometer is a motion sensor that measures the number of steps taken, walking distance (in models with stride length adjustment), and estimates energy expenditure when body weight is entered into the pedometer (11). This device has many

benefits and some limitations. One benefit of the pedometer is the accuracy compared to direct observation in terms of measuring steps taken (23). The pedometer is inexpensive, easy to use, unobtrusive, and is an effective way to measure physical activity in walking (53). The pedometer can also be used as a motivational tool. This is especially true when recording steps everyday and setting goals in the format of how many steps to take. The limitation is that the electronic pedometer does not distinguish vertical accelerations above a certain threshold. (In other words the pedometer cannot distinguish between walking and running.) Another constraint with the pedometer is that it does not record time and occurrence of physical activity. Overall, the pedometer is an effective way to measure physical activity in steps taken. After comparing and contrasting these different ways of measuring physical activity, all of the devices have limitations as well as benefits but the electronic pedometer has the most promise for measuring physical activity in large groups (14,41). Assuming that most of the participant physical activity is accounted for by walking or running. A Japanese researcher (Yoshiro Hatano) proposed the idea of 10,000 steps a day for optimal health benefits. However, it has been suggested that this goal (developed for adults) may not be applicable to children (4).

Kilanowaki et al. (27) studied the validity of an electronic pedometer for measurements of physical activity in children. The study consisted of 10 participants (seven male and three females) with average age of 10.7±1.7 years. Both normal classroom and recreational activities were studied. During the first period six participants performed recreational activities and the other four were in the normal classroom and then the participants changed activities. The average amount of time observed was 57±10.4 minutes. Two observers assessed one child's activity levels during the

recreational period by the Children's Activity Rating Scale (CARS). CARS is a system designed to evaluate children's activity by a trained observer, and CARS five-level category reflects the children's energy expenditure. The participants wore the pedometer on the left side of the waist and the triaxial accelerometer on the right side of the waist. Four of the participants were defined as obese with having a BMI over 85th percentile. All measures were correlated significantly with both activity periods combined. The pedometer and accelerometer had high correlations with recreational activities but were significantly lower in classroom activities. The results show that pedometers and accelerometers are highly correlated with children's physical activity.

Todd et al. studied assessing physical activity in young-adolescents with Digi-Walker pedometer (49). The study was divided into three parts. The first part consisted of 37 seventh graders (12 to 14 years old) both walking and walk/jog 1600m on separate days with a pedometer worn on each hip. A research assistant was assigned to each child to hand-tally the participants' step counts. The second part of the study consisted of 23 seventh graders to walk five 400m intervals wearing pedometer in different positions that were randomly placed (self-selected (SS), umbilicus (UM), criterion (CR; manufacturer's instructions) iliac (IL) or open (OP) position). The data collected from third part was compared with the childrens' data from the first part of this study. In the first part of the study there was a significant relationship in both walking and walk/jog for pedometers on the right and left hip ($r=0.844$ to $r=0.988$). In addition, there was a significant relationship between hand-tally and pedometer counts on the left hip for walking and walk/jog. In second part of the study the only significant correlation found was between CR and OP counts ($r=0.47$, $p<0.05$). In third part of the study no significant difference in

the pedometers accuracy was found between children and adults. To conclude, the pedometer is both valid and reliable in young-adolescents to assess step counts when the device is properly used.

Flohr et al. studied pedometer counts in young-adolescents (17). Forty-five seventh graders (12 to 14 years old) were classified as either participating in after school activities (ACT) or not (nACT). Step counts were recorded at end of school day and the end of observational days. The participants wore pedometer for two weeks while recording step counts. The mean (mean±SD) number of step counts for ACT group was 12919 ± 4991 and for nACT was 10269 ± 3139. The ACT group took an average of 12697 ± 4885 steps/day on weekdays and the nACT group took 9793 ± 3354 steps/day. On weekend days the ACT group took 12794 ± 6429 steps day and the nACT group took 9529 ± 4947 steps/day. The study found that there was a significant difference for ACT to nACT group for step counts. The study shows that students in after school activities are significantly more active.

Eston et al. (14) studied the validity of heart rate, pedometry, and accelerometry for predicting energy cost in Welsh children (eight to ten years of age (N=30)). The activities that were measured were walking, running, hopping, catching, and sitting and crayoning. First, the child walked on a treadmill at four and six km/hr for four minutes each. In addition, the participants ran on treadmill at eight and ten km/hr for four minutes each. After each speed the child was allowed time to rest, which allowed the heart rate to lower back to resting levels. Then the child played hopscotch for four minutes and rested again. The child played catch with a soccer ball for four minutes. Finally the child sat

and crayoned for a ten minute period. During each activity, the physical activity was monitored with a pedometer, uniaxial accelerometer, triaxial accelerometry, heart rate, and indirect calorimetry (VO_2). Eston et al. (14) found that all measurements had a strong correlation with VO_2. The triaxial accelerometer was considered to be the best indicator of physical activity compared to the other measuring devices. The pedometer also showed higher correlations with VO_2 than the heart rate monitor. The results demonstrate that triaxial accelerometer is the most valid measure of physical activity but it is more realistic and considered valid to use a pedometer in a large population studies.

Rowlands et al. (41) studied the relationship between physical activity levels, aerobic fitness, and body fat in children between the ages of eight and ten. Thirty-four children were recruited from two local schools in Bangor, Northern Wales. All anthropometric measurements were assessed at the children's home including: height, weight, and skinfold measurement. The skinfold sites included the triceps, biceps, abdominal, subscapular, supraillium, thigh, and the medial calf. All the measurements were added together to estimate body adiposity. Physical activity was measured with a triaxial accelerometer, a pedometer, and a heart rate monitor. Physical activity was assessed for four weekdays and two weekend days with pedometer and accelerometer. Heart rate was only measured for one weekday. Aerobic fitness was assessed by the Bruce maximal treadmill protocol. Heart rate was recorded during this protocol, and if the child's heart rate did not reach 186 beats/min the participants were not used in the study. Rowlands et al. (41) found a positive correlation between physical activity and fitness. In addition, there was a negative correlation between physical activity and body fatness. The mean pedometer count in this study for boys was 16,035 steps/day and girls

took 12,728 steps/day. The study also showed that both accelerometer and the pedometer had similar results, which validates both tools in measuring physical activity in children. Heart rate was found not to be significantly related to fitness. The results from this study suggest that low levels of physical activity are related to higher levels of body fat in children.

Wilkinson et al. (58) studied the relationship between energy intake and physical activity in obese children. This study consisted of two groups of 12 year old: normal-weight children and obese children. The definition of obesity in this study was defined as being >97th percentile at age 10 and being >90th percentile at age 12 for weight and height for both their age and sex. The normal weight children were defined as having weight and height between 25th and 75th percentile for their age and sex. Dietary intake was assessed by food logs that were recorded by the children over a period of a weekend (Friday to Monday). The food entries were discussed within a day or two of the study period to confirm the dietary logs. A mechanical pedometer assessed physical activity in the children. The participants wore pedometers for only one day of assessment. The children wore pedometers during waking hours except when swimming. Wilkinson et al. (58) found no significant differences between the obese and nonobese children with energy intake and physical activity. In addition the study found participants who had above average energy intake also had above average physical activity levels. The results showed that normal-weight and obese participants in the study had no significant differences in physical activity and energy intake.

Skalik et al. (44) studied weekly physical activity in secondary schools in different countries. Schools were chosen from Sweden (Halmstad), Poland (Katowice),

and Czech Republic (Olomouc). Students were randomly selected from classes of first and third year students. Students (total boys=68 & girls=58 in all three regions) ages ranged from 16 to 18 years of age. The student's physical activity was monitored for one week with Caltrac accelerometers, Omron pedometers, and recording sheets. The study found that students with lower and higher adiposity had no significant differences in physical activity energy expenditure. The major form of physical activity in both boys and girls was walking in all three regions. Students who were more physically active during physical education class had higher level of physical activity throughout the week. Skalik et al. regarded the participants' physical activity levels to be inadequate except for the students at Olomouc.

Vincent et al. (54) studied physical activity and body composition of American, Swedish, and Australian children. Children (six to twelve years of age) volunteered from selected schools in the countries previously mentioned. A total of 1,954 children participated in the study (711 American, 563 Australian, and 680 Swedish children). Physical activity was measured by Yamax pedometer (MLS-2000) for four weekdays. The children wore a pedometer from beginning of the school day until they went to bed. The study found that physical activity remained constant as age increased in all three countries. American children were least active (boys 12,554-13,872 steps/day and girls 10,661-11,383 steps/day) and Swedish children were the most active (boys 15,673-18,346 steps/day and girls 12,041-14,825). Australia boys took 12,554-13,872 steps/day and girls took 11,221-12,322 steps/day. There were only a few significant correlations between step counts and BMI (i.e. American boys age 11 and 12; American girls age eight and nine; Australian girls age eight). In addition, American children had the highest

rate of increase for BMI with age compared to Swedish and Australian children. The greatest percentage of children that were classified as being either overweight or obese were American children. The results from this study show American children are less active than Swedish and Australian children and that American children have the highest BMI levels.

Physical Activity and Television Viewing

Trost et al. (52) studied physical activity and determinates of physical activity in obese and non-obese children with physical activity and the determinants of physical activity. The study initially consisted of 213 sixth grade students from four public middle schools in Columbia, South Carolina. After exclusions for incomplete physical activity data, the final population consisted of 187 students (98 females, 89 males). Height and weight were measured and from this information, BMI was calculated. Obesity in this study was classified as BMI equal to or greater than race, sex, and age of 95^{th} percentile from NHANES I. By this criterion, there were 54 obese participants in the study. A uniaxial accelerometer (CSA 7164) was used to assess physical activity. The CSA 7164 monitored seven consecutive days of activity except when sleeping. From the data, physical activity patterns were assessed for moderate (3-5.9 METS) and vigorous (≥ 6 METS) levels of activity in 5, 10, and 15 minute bouts. In addition, a questionnaire was completed by students to assess demographic, psychosocial, and environmental determinants of physical activity. The study found that for both moderate and vigorous activity, non-obese children exhibited a significantly higher total amount of daily activity than obese children. In addition, obese children had fewer bouts of 5, 10, and 15 minutes in the moderate and vigorous range than the non-obese children.

Hernandez et al. (22) studied the association of obesity with physical activity, television programs, and other forms of video viewing in children. The participants in this study ranged in age from nine to sixteen. Seven schools were randomly selected from Mexico City. Seven hundred and sixty-four subjects between fifth and eighth grade were asked to take part in this study but only 654 subjects participated. The participants' height, weight, and triceps skinfolds were obtained. The information from anthropometric measurements were used to classify obesity by age and sex-specific criteria of the 85th percentile of BMI or greater from NHANES I. Television viewing, physical activity and dietary intake was assessed by surveys. The 11-item television survey asked questions about TV viewing, VCR, and video games use. From this survey, hours of watching TV and viewing videos were estimated per day. The Youth Activity Questionnaire was to assess moderate and vigorous physical activity levels of the participants. The Mexican Children Food Frequency Questionnaire assessed dietary intake. This questionnaire asked questions about normal food intake by types of food and consumption of snacks while watching TV and videos. Children rated both their mother's and father's physical characteristics ranging from very thin to obese, which was used to assess parental weight status. Hernandez et al. (22) found a relationship between TV viewing and physical activity in obese children. Out of the 654 participants who were in the study, 461 participants completed the information in all the variables that were used in the study from Mexico City. Twenty-four percent of the children were classified as obese. Middle-income children had higher odds of obesity than the children from the low-income part of town. The study found that for every additional hour in a day of TV viewing there was 12% increase in the likelihood of being obese. In addition,

there was 10% decrease in the relative risk of obesity for every additional hour of moderate activity per day. There was a risk reduction of obesity of 20% for every hour/day of vigorous activity.

Crespo et al. (9) assessed television watching, energy intake, and obesity from NHANES III. The sample from this study consisted of 4,069 children ranging in age from eight to ten. The participants completed a physical activity questionnaire and a body composition analysis at a mobile examination center or at the home interview. One of the questions on the physical activity survey was "How many times per week do you play or exercise enough to make you sweat or breathe hard?" TV viewing was also assessed on a questionnaire asking how many hours of TV the participant watched on the previous day (on two separate interviews). Both BMI and skinfolds were used to assess body composition. A 24-hour dietary recall was used to obtain information on the participants' food intake. Crespo et al. (9) found a stronger association between TV watching and obesity than with physical activity and obesity. The study found that girls had a higher prevalence of obesity when engaged in less physical activity, but no association was found in boys. The prevalence of obesity among boys (12.4%) was somewhat higher than in girls (10.9%). Boys tended to have a higher total energy intake than girls. The girls reported less physical activity than the boys did but only 56.7% participated in regular physical activity five days or more per week. The participants who watched more hours of TV showed higher prevalence of childhood obesity. In addition, the study showed a stronger correlation with TV watching and food intake in girls (R=0.43) than in boys (R=0.26). Watching more than four hours per day of TV was associated with a higher prevalence in childhood obesity.

Anderson et al. (2) studied the relationships of physical activity and TV watching with body weight and level of body fatness among children ages eight to ten that participated in NHANES III. The methodology in NHANES III was previously described. Anderson et al. (2) found that children spent the majority of their leisure time sleeping and watching TV. Skinfold measurements increased with the amount of watching TV. In addition, the more TV the children watched the less likely they were to participate in vigorous activity and the more likely they were to have a higher BMI. Children who watched the most TV also had the highest body fat. This study also found that 80% of the children were regularly active but adolescent girls, blacks, and Mexican Americans were less active. One-fourth of US children watch TV four or more hours per day, and 43% of black children meet these criteria. The results showed that watching more TV was related to having a higher adiposity, and BMI.

DuRant et al. (11) studied the relationships between TV watching, physical activity, and body composition in young children. The study consisted of 191 children between the age of three and four, who were monitored over a one-year time frame. Exclusion criteria in this study included immediate family members with history of chronic illness, families without at least one parent living in the household, and children with disabilities that could affect activity levels. In addition, children were excluded if born outside of the United States to avoid cultural differences. The children's activity level was measured with the Children's Activity Rating Scale (CARS). Trained observers observed children activity for six to twelve hours. Activity levels were recorded minute-to-minute. Two observers alternated in two-hour shifts while each child was being observed. Height and weight were measured to calculate BMI. Skinfold measurement

was used to assess body composition. The sites included biceps, triceps, subscapular, suprailiac, abdominal, thigh, and calf. Waist/hip ratio was measured. DuRant et al. (11) found that more physically active children tended to be leaner. Also, the children's median value for longest bout of television watching was only 15 minutes, which is lower than national estimates for children watching TV. The variation in results from national estimates may be due to some discrepancies in this study. For example, the children in this study were younger compared to the children who were in previous TV watching studies. In addition, TV watching was only monitored when the children attended the program and did not include either evenings or weekends, which are considered high TV viewing times for children. Children watched TV an average 14.8% of the total time. When the subjects watched TV, the physical activity was lowest compared to other forms of activities. No association between TV watching and body composition was found. The results indicated that TV watching has no significant effect children's body composition. However, as discussed before, the results have some limitations, so these results should be viewed with caution.

Relationships Between Parental and Childhood Obesity

The prevalence of overweight and obesity has increased among children in the United States, and with their families members. The reason for this increase could be due environmental factors. One question concerning this issue is the relationship between parents and their children? If there is a relationship, what factors play a role with this epidemic?

Fogelholm et al. (18) studied the parent and child relationship of physical activity patterns and obesity. The study consisted of children ranging from seven to twelve years

of age Western Finland. The participants' weight was obtained by biannual school health examination. Obesity was defined as being ≥20% and marked obesity as being ≥40% above mean weight-for-height for the age and sex. This study included both obese (n=129) and normal weight children (n=142) who had parents willing to take part in the study. Both the child and parents' physical activity was measured. The parent and child kept a three-day physical activity record (two week days & one Sunday), which was modified by a trained interviewer. From this information, daily physical activity (PAL) was calculated. In addition, the Netherlands Health Education Project Questionnaire was used to assess physical activity in the children. This questionnaire assesses the habitual physical activity in children. The parents were classified into three categories for habitual physical activity: 1) vigorous activity 2 or more times per a week; 2) vigorous activity once per week; 3) no regular vigorous activity. Fogelholm et al. (18) found that the parent has a role in the child's activity level and obesity. Parental inactivity was a strong predictor of a child's inactivity. In addition, parental obesity had the strongest association with childhood obesity. Also, the study found that physical inactivity did not predict childhood obesity.

Sekine et al. (43) studied parental obesity, lifestyle factors, and obesity in preschool children from the Toyama Birth Cohort Study. All the subjects in this study were born in a one-year time frame from April 2, 1989 and April 1, 1990. The study population consisted of 8,914 subjects (4,590 males and 4,351 females). Childhood obesity was defined as age and sex-specific criteria of BMI (17.55-18.13 kg/m^2 for males and 17.28-17.76 kg/m^2 for females), which is linked to adult BMI of 25 kg/m^2. Parental obesity was defined as ≥25 kg/m^2. A questionnaire was conducted from April 1992 to

March 1994. The parents filled out a questionnaire on eating, exercising, and sleeping habits. Health professionals measured height and weights for the children. The parent's height and weight were self-reported on the questionnaire. Sekine et al. (43) found a dose-response relationship between less sleep and the more likely the child would be obese. In addition, parental obesity was strongly correlated with childhood obesity. The study showed that the less active group had a higher prevalence of childhood obesity but it was not statistically significant. The results show that parental obesity and less sleep are two factors that are associated with childhood obesity.

Treuth et al. (50) studied the relationship of parental obesity to physical activity and fitness of prepubertal girls. The study involved prepubertal girls (n=101) ranging in age from eight and nine. Participants were defined into groups by parental body characteristics (lean or obese). The children were classified into groups depending on parents BMI. BMI was used to define the lean parents, (<25 kg/m^2) or obese (>28 kg/m^2). If both parents of the child were lean then the child was characterized as being in the lean group (LN group; n=30) and if both parents were obese the children were characterized as being in the obese group (OB group; n=27). In addition, if one parent was lean and the other was obese then the child was classified as being in the lean and obese group (LNOB group; n=44). Inclusion in this study required that the child either was normal weight or between 12 and 30 percent body fat. The VO_2 test was measured with indirect calorimetry while the child was exercising on a treadmill. Criteria for achieving $VO_{2\ peak}$ included at least one of the following: heart > 195 bpm or respiratory quotient (RQ) >1.0. Body composition was assessed by DXA. The participant's heart rate was measured for two days by either POLAR Vantage XL Heart Rate Monitor or

Mini-mitter unit. In addition, the subjects spent 24 hours in room calorimeter while basal heart rate (BHR) and basal metabolic rate (BMR) was being assessed. Total energy expenditure (TEE) was assessed by doubley-labeled water and BMR in the respiration calorimetry room. TEE/BMR was defined as physical activity level (PAL). TEE was assessed for over 14 days for each participant by daily urine analysis. Physical activity of children for the past year was assessed by a physical activity questionnaire, which was filled out by the parents. The Physical Activity Interview for Children was used in assessing exercise of the children. Treuth et al. (50) found no significant differences in either physical activity or physical fitness in the three groups. In addition, similar results were found in BMR, sleeping metabolic rate, and 24-hour energy expenditure for the three groups. The results show that girls predisposed to obesity that have normal weight did not differ in physical activity or fitness to those not predisposed to obesity.

Whitaker et al. (56) studied the relationship of childhood adiposity to parent BMI and their eating behaviors. The participants were recruited from a study that was evaluating infant feeding. This study lasted from the child's age of 3 to 36 months. The study started with 165 white infants and concluded with 118 subjects. The children body compositions were measured by DXA at 3, 6, 12, 34, and 36 months of age. In addition, height and weight was measured to calculate BMI. When the child reached the age of 36-months, the parents filled out a survey called Stunkard and Messick's Three Factor Eating Questionnaire (TFEQ). TFEQ asked questions about the parents and children eating habits. The parent's self-reported their height, weight, educational level, and age. Whitaker et al. (56) found that parents eating habits were related to parents BMI, but not to their child's body composition at age 36 months. Twenty-six percent of both mothers

and fathers were classified as obese (≥30 kg/m²). The study found no significant difference between BMI, height, and weight between boys and girls. Eleven percent for the boys and 10% for the girls were considered in the 85th percentile for their age group for both their weight and height. The only significant correlation between parents BMI and children's body fat was found between mothers and daughters.

Romanella et al. (40) studied physical activity and attitudes in lean and obese children and their mothers. Fliers and TV advertisements were used in recruitment for pairs of biological mothers and their child. The children's ages ranged from eight to twelve (mean=9.7 yrs). The child and the mother filled out a survey to determine attitudes toward physical activity. The survey assessed social experience, health and fitness, pursuit of vertigo, aesthetic experience, catharsis, ascetic experience and chance with relationship to physical activity. After the survey was filled out, anthropometric measurements were taken from both the parent and child. Triceps, thigh, and suprailiac were measured on the mother with a skinfold caliper. In addition, triceps and subscapular skinfolds were measured on the child. Height and weight were also measured. Physical activity was measured for two days (Friday and Saturday) with an electronic accelerometer on both the mother and her child. The accelerometer was placed on belt on the right hip except for when riding a bike, in which the accelerometer was placed on the calf. Romanella et al. (40) found no significant difference in physical activity between obese and nonobese children. Nonobese children had higher levels of mean physical activity scores but there was no significant difference. The study found no relationship between mother's physical activity and her child's activity. The children's activity levels were only 14-20% higher than the mothers' activity levels.

Treatment of Childhood Obesity

There are many different methods for treating childhood obesity but the overall idea is to lose the excess fat that affects immediate and long-term health risks (12). More recently, healthcare professionals have targeted obese children to make lifestyle modifications. The idea is for the child to lose excess fat to reduce health risk and enhance health throughout life. Most treatments consist of a diet that has reduced energy intake to help with the weight loss, reduction in sedentary behaviors, and an exercise program. The Centers for Disease Control and Prevention (CDC) recommend that students between the ages of five to 18 years old have daily physical education class (20). Most students do not meet this recommendation. For example, 60% of high school students are enrolled in physical education but only 25% take physical education daily.

Ebbeling et al. (12) examined the effects of exercise combined with diet therapy on protein utilization in obese children. The subjects included five obese boys and girls (3 boys, 2 girls) between the ages of 8-10 years old. The study consisted of a 14-week intervention program. The first two weeks were the control period where they measured RMR, physical activity, body composition, and protein utilization for their normal daily life. For the next six weeks the subjects adhered to a reduced calorie diet. The caloric intake was estimated by RMR multiplied by 1.2 to promote a loss of ≤ 0.5 kg a week. Then they factored in protein intake of 1.5 grams of protein for every kg of fat free mass (FFM). After the six week period was over, the children still stayed with the same diet and added in exercise therapy. This consisted of walking five days a week with distance ranging from 3.2 to 4.8 km for the six-week period. During the exercise therapy, the emphasis was put on frequency and duration rather than intensity. They found that

subjects lost 4.2 ±0.4 kg during the 12-week intervention. The results of the weight loss with this program suggest exercise offers metabolic benefits with maintaining metabolic activity while on a hypocaloric diet.

Johnson et al. (25) investigated the influence of dietary and exercise interventions for juvenile obesity. The study consisted of 32 participants between ages 8 and 17 years. The inclusion criteria consisted of a body weight above 20% ideal body weight, active parental involvement in weekly sessions, and child's desire to lose weight. Participants were monitored for one week for baseline information. The participants were randomly assigned to the nutrition and eating habit change followed by exercise (NE), exercise followed by nutrition and eating habit change (EN), or the information control group (INFO). Both the NE and EN group consisted of 11 participants while INFO group had 10 participants. EN group did aerobic exercise intervention for the first seven weeks followed by nutrition and eating habit intervention for seven weeks with NE receiving the opposite sequence. INFO group were educated about exercise and diet with behavioral changes for 14 weeks but did not receive training as NE and EN did in behavior, habit, and cognitive change. NE and EN dietary composition was 60-65% carbohydrate, 15-20% fat, and 15% protein. During dietary intervention, participants were instructed not to change their physical activity. The seven-week aerobic exercise intervention lasted up to 45 minutes for five to seven days a week at 60-80% maximal heart rate. During the exercise intervention, participants were advised not to change their dietary intake. A food survey, survey of activity, and a submaximal step test were used to assess compliance of participants. After 5 years, 18 of 28 parents were interviewed by phone for height, weight and demographical information on the participant. Johnson et al. (25)

found that in the NE and EN group lost significant amounts of weight, which was maintained over long periods of time in contrast to the INFO group, which displayed little change. In the NE and EN group there was decrease in T-chol, LDL-c, and increase in HDL-c. LDL-c showed significant reductions during nutrition and eating habit intervention but not during the exercise intervention. This study suggests that improved nutrition and eating-habits, fitness, and increased physical activity helps improve lipid profiles, and decreases body weight for the long-term. . In addition, getting information on dieting and exercise in an educational format may not yield weight loss.

Sothern et al. (47) studied obese child to examine the role of structured exercise in pediatric weight management. There were 73 subjects (33 boys and 40 girls) between the ages of seven and seventeen. They were assigned to three treatment groups according to the severity of obesity, consisting of a exercise program, and methods to participants motivated. Group I consisted of severely obese children that were $\geq$ 200% ideal body weight (IBW), group II children were moderately obese between 150% to 199% of IBW, and group III were children mildly obese that were 121% to 149% IBW. Group I lasted for 30 weeks, while group II lasted for 20 weeks, and group III lasted for 10 weeks. Once participants reached their goal weight ($\leq$ 120% of IBW) they were put into phase IV that was considered the "maintenance" phase. The interventions included a protein-sparing modified fast (PSMF) diet, behavior modification, and moderate exercise (45% to 55% of VO_2max) that were gradually increased the intensity. The PSMF consisted of 2 grams of protein to every kilogram of IBW and carbohydrates were limited to 20 to 25g /day. Group I participants had shorter exercise duration and frequencies compared to group II and group III. The exercise program was of moderate intensity (defined as 45%

to 55% of VO_2max) and was gradually increased in volume. Participants were allowed to choose their preferred type of aerobic activity from a provided list. This 10 to 30 week weight management period was followed up by a long reinforcement period of 22 to 42 weeks, which consisted of a balanced diet with a caloric-deficit of 1200 kcal, continued exercise, and behavior modification. Sothern et al. (47) found there was significant weight loss and reduction in body fat, which was sustained after a one-year follow-up. Subjects also showed improved physical activity patterns. Thus, a progressive exercise program with behavior modification and nutritional intervention provides motivation. In addition, this program showed a loss of excess body fat in participants and helped with adoption of regular structured physical activity patterns.

Faith et al. (15) looked at the effects of contingent television on physical activity and television in obese children. The study consisted of ten obese (seven boys and three girls) children between the ages of 8 and 12. These subjects were randomly assigned to a control group or a treatment group. The contingent TV was then placed in the subjects' homes for the duration of the study. During this time, the investigators discouraged the use of TV watching on any other TV in the home. This study lasted 12 weeks, which included a two-week baseline period and a 10-week treatment stage. During the initial two weeks, all the subjects were in the control condition so they could get baseline measurements. In the control group, TV viewing was not contingent on pedaling. The control group stayed inactive throughout the entire study. In the treatment group, the TV viewing was dependent on pedaling at prescribed intensity or greater. The TV cycle was left to use for the child as much he/she choose to. No other instructions were given. Faith et al. (15) found that the experimental group increased pedaling time while reducing

TV viewing time. In the control group, the subjects watched TV an average of 21 hours week (compared to 1.6 hours a week for the experimental group) without pedaling on the cycle ergometer. The experimental group averaged pedaling 64.4 minutes per week compared to 8.3 minutes per week for the control group. In addition, the experimental group showed a noteworthy reduction in total body and leg fat. Faith et al. (15) concluded that the home environment could be arranged to alter physical activity and TV viewing. This could possibly play a role in the treatment of obesity.

Epstein et al. (13) compared the effect of increasing physical activity and decreasing sedentary behavior in obese children. The population in this study consisted of 61 families. The obese children in this study ranged from 8 to 12 years old and were between 20% to 100% overweight. Inclusion in this study included one parent willing to attend the treatment meetings, no parent more than 100% over-weight, no current psychiatric problems, and no medical conditions preventing exercise. Body fat was estimated by electrical impedance; waist and hip circumferences were also measured. Cycle ergometry was used to assess fitness of the children in this study. After anthropometric measurements and fitness, families were randomly assigned to sedentary group, exercise group, or combined group. The sedentary group decreased their sedentary activity, while the exercise group increased their physical activity, and the combined group decreased sedentary activity while increasing physical activity. Children and overweight parents consumed between 1,000 to 1,200 calories per day and followed recommendations from the eating-right pyramid. Parents who were not overweight had no caloric restrictions. A five-level system was used to help reinforce targeted behaviors. For example, participants were rewarded for decreasing sedentary activity and the

exercise group was rewarded for increasing physical activity. Every week both parents and children attended separate treatment meetings. During the four-month study, a habit book was used to record food intake, physical activity, and sedentary activity. After one year from the baseline of the study, participants in the study were followed up. The study indicated that reducing sedentary behaviors might be essential in the treatment of childhood obesity. Children in sedentary group substituted sedentary activities with higher energy expenditure activities. The sedentary group showed the greatest decrease in body weight and percentage of body fat. All groups showed improvements in fitness level. The results in this study demonstrated that decreasing time spent in sedentary activities, improves weight loss in obese children.

Owens et al. (37) studied the effect of physical training on total and visceral fat in obese children. In this study, 81 obese children took part and were between ages of seven and 11. These participants were randomly assigned to the physical training group or the control group. All the participants were tested for body composition, aerobic fitness, and daily physical activity. Visceral adipose tissue was assessed with MRI. The physical training group trained 5 days a week for the 4-month period. The participants worked out at approximately 70 to 75% of their maximal heart rate. This was maintained for approximately 40 minutes for each session, which included 20 minutes of exercise machines and 20 minutes of playing games. In this study, Owens et al. (37) discovered three things. First, obese children are capable of training at high intensities for a 4-month period. Second, total body composition improved and less visceral adipose tissue accumulated compared to the control group. Third, the participants experienced other beneficial changes in total and regional body composition. This study suggests that in

obese children, physical activity can improve body composition even without dietary intervention.

Prevention

Muller et al. (31) studied the first results of the Kiel Obesity Prevention Study (KOPS). The purpose of KOPS is to test long-term effectiveness of interventions with prevention of childhood obesity. The participants in this study were recruited from different schools in Kiel, Germany from 1996 to 2002. The study consisted of 2,440 children that ranged in age of 5 to 7. Schools were either taking part in the intervention or were in the control group. Baseline measurements consisted of bioelectrical impedance (BIA), dietary and physical activity questionnaire, triceps skinfold thickness, and BMI. In addition, blood pressure, lipid profiles, 24-hour energy expenditure, muscular strength, and physical fitness was assessed. Obesity was defined as age and sex-specific criteria for 90th percentile of tricep skinfold (TSF) for children northwest Germany in 1978. The assessment will be reinvestigated in the 4^{th} and 8^{th} year of this study. The intervention in this study was to have parents and children eat more fruits and vegetables, reduce intake in high fat foods, and reduce TV watching to less than 1 hour/day. In addition, families with overweight or obese children and/or parents (BMI > 30 kg/m^2) were offered counseling and support for the family environment. Muller et al. (31) found that 22% of the children in the study were either overweight or obese. Participants in the low socioeconomic class frequently had high levels of physical inactivity and unhealthy food choices. In addition, mean BMI in the low social class was the highest out of all the socioeconomic groups. The short-term effects of this intervention include increasing daily physical activity. Twenty-eight percent of the children joined a sports team,

vegetable consumption increased (40 to 60%), low fat food intake increased (20 to 50%), and mean TV watching decreased from 1.9 to 1.6 hour/day. All changes were significant. The control group showed greater increases in TSF compared to the intervention group (mean values of 13.0 vs. 11.33 mm) after one-year follow-up. The KOPS intervention is promising with the prevention of childhood obesity even with the simple message of better eating, less time watching TV, and increasing physical activity.

Conclusion

Childhood obesity has increased dramatically in the past two decades. One of the causes for this increase may be a decrease in physical activity in children but some of the studies contradict this idea. For example, Fogelholm et al. (18) found no relationship between physical activity and childhood obesity. Another theory for the increase childhood obesity is the relationship with having one or both parents obese or overweight but a study by Treuth et al. (50) study contradicts this theory. They found that having a family history of obesity does not predispose prepubertal girls to being obese. The problems in both of these studies are that activity logs or questionnaires measured physical activity. Physical activity measured by either a electronic pedometer or accelerometer is a more valid, objective measure. Electronic pedometers are considered the best method of measuring physical activity in large studies of children. In addition, studies have shown several ways to treat obesity that are effective but the best safeguard against childhood obesity is to prevent it before it occurs. The prevention of obesity is accomplished by regular physical activity, reducing sedentary behavior, proper eating habits, and positive reinforcement.

Chapter III

Methods

Children from the age of five to eleven years from West Hills Elementary School were invited to participate in this study. A letter was sent home with the children in their explaining the study (Appendix A). The parents and children who volunteered to take part in the study were asked to sign an informed consent form and informed assent form, respectively (Appendix B & C). The participant and parent received a copy of these forms. The signed forms were returned to the child's homeroom teacher. This study protocol was approved by the University of Tennessee's Institutional Review Board, the Knox County Public School System, and the Principal of West Hills Elementary School.

Testing was done during the students' homeroom class. Testing included anthropometric measurements of height and weight, and body composition assessed with Lange calipers using the triceps and calf skinfold sites (45). The skinfold total from the tricep and calf measurements were put into formulas for boys (%BF = 0.735 (ΣSKF) + 1.0) and girls (%BF = 0.546 (ΣSKF) + 9.7) to predict the participants body composition (45). All participants' anthropometric measurements were protected by assigning an identification number to each child in the study.

The children were then given a pedometer. The participants wore a pedometer (NL-2000 Activity Monitor) positioned at the waist in line with in the midline of the thigh, and on right side of the body. The children were instructed to wear it for seven days except when sleeping, and showering. The NL-2000 stored total steps per day for seven days. The step counter remained closed with a zip-tie during the seven-day

assessment. In addition, the NL-2000 has an internal clock and it resets itself daily at 12:00 PM. The participants were asked not to change their activity levels during the study.

Testing procedures were divided into four stations during the homeroom class. The subject's information, obtained from these stations, was recorded on a general information sheet (Appendix E). The first station consisted of measurement of the participant's height and assigning an identification number to keep the participant's data confidential. At the second station, weight and caliper measurements were done. All skinfold measurements were assessed by same person for baseline testing. At the third station, participants were interviewed on their physical activity habits. The students were asked to report on TV watching and daily activity (such as organized exercise programs for past year including how many times per week of play or exercise made the student sweat or breathe hard) with the physical activity section of the NHANES III youth questionnaire (Appendix F). The question on the survey was read to the participants by the interviewer. At the fourth station, the students were instructed on positioning of the pedometer and when to wear the pedometer (Appendix G). Privacy during measurements was maintained by spacing the stations 10-15 feet apart, and by working with only one student at a time.

After seven days of monitoring the pedometer was returned to the principal investigator and he documented that the student returned the pedometer. Participants all received immediate feedback on individual's steps per day for seven days of monitoring.

Obesity was defined by age and sex specific criteria of the 95th percentile of the NHANES I from 1971 to 1974. Groups were separated based on Body Mass Index

(BMI) (Appendix H) and triceps skinfold criteria (Appendix I). BMI uses height and weight values to determine whether a person is at risk for weight-related health problems.

Statistical Analysis

Statistical analysis was performed using SPSS 11.0 and was based on 110 pedometers that were returned after seven days of monitoring (54 males, 56 females) from the original 131 participants. Twenty-one pedometers were either returned late (14 pedometers) or were not returned at all (5 pedometers), and two of the pedometers malfunctioned. Values less than 500 steps/day were not used in the final analysis because it was considered very unlikely that participant took less than 500 steps/day. For missing data (i.e. days where the pedometer was not worn or values that were less than 500 steps/day), an SPSS function (EM) was used to estimate the means, the covariance matrix, and the correlation variables with missing values using an iterative process. Data were presented as mean ±standard deviation. Independent t-tests were used to determine statistical significance between boys and girls, age, height, weight, BMI, BMI of 95th percentile, percent body fat, and mean steps taken per day. ANOVAS were used assess participants physical characteristics, step counts for individual and grouped grades, boys and girls. For all statistical analyses, the alpha level was set at 0.05.

Chapter IV

Results

Table 1 contains demographic characteristics (means and standard deviations) for grade, age, sex, BMI, and percent body fat. Average BMI was 18.9 ±4.56 for boys and 17.39 ± 3.76 for girls. The average height and weight for the girls was 132 ± 14 cm and 30 ± 11 kg respectively. The average height and weight for the boys was 137 ±13 cm and 36 ±13 kg respectively. Twenty-two percent of the participants were classified as being obese.

Figure 1 illustrates the mean step counts by individual grade. On average, children accumulated 11,429 ± 2,898 (mean ± standard deviation) with boys taking 11,687± 2,815 and girls taking 11,180 ± 2,980 steps per day. There was a significant relationship between step counts and individual grades. When grades were put into groups of Kindergarten and first grade (K/1), second grade and third (2/3) grade, and fourth grade and fifth grade (4/5), a significant difference (p=0.003) was found between K/1 compared to 4/5 (Table 2 & Figure 2). Figure 3 illustrates the overall mean step

Table 1 : Physical Characteristics of Study Participants (N=110). Values are mean ±standard deviation.

GRADE	Kindergarten	First	Second	Third	Fourth	Fifth
N	17	17	18	14	20	24
Age (y)	5.3±.5	6.4±.5	7.6±.5	8.3±.5	9.3±.6	10.5±.5
Males	4	10	9	8	7	16
Females	13	7	9	6	13	8
BMI (kg/m^2)	16.9± 3.6	15.3±2.6	16.9±3.1	17.3±3.1	18.7±3.5	22.0±4.9
% BODY FAT	21.0±3.9	19.3±5.3	18.0±3.5	21.6±6.3	23.3±4.2	22.7±6.4

Significance accepted at $p<0.05$



Figure 1: Average Steps Taken by Grade.
No significant difference between individual grades were found.

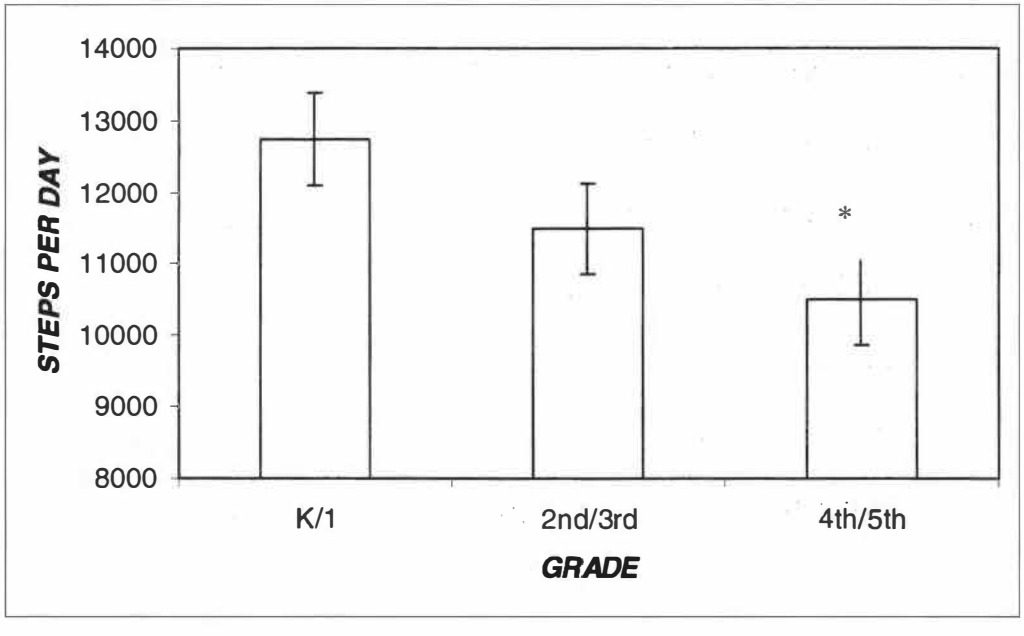


Figure 2. Average Step Counts Taken By Kindergarten-First graders, Second-Third Graders, and Fourth-Fifth Graders. (*Significant difference from K-1.)

Table 2. Comparison between K/1, 2/3, and 4/5 Grade for Step Counts. Kindergarten and first graders take more steps than fourth and fifth graders

Multiple Comparisons

Dependent Variable: M_SUN

Tukey HSD

					95% Confidence Interval	
GRADES	GRADES	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
K-1	2-3	1457	684	.089	-169	3083
	4-5	2150*	634	.003	642	3658
2-3	K-1	-1457	684	.089	-3083	169
	4-5	693	645	.532	-840	2227
4-5	K-1	-2150*	634	.003	-3658	-642
	2-3	-693	645	.532	-2227	840

Based on observed means.

*. The mean difference is significant at the .05 level.

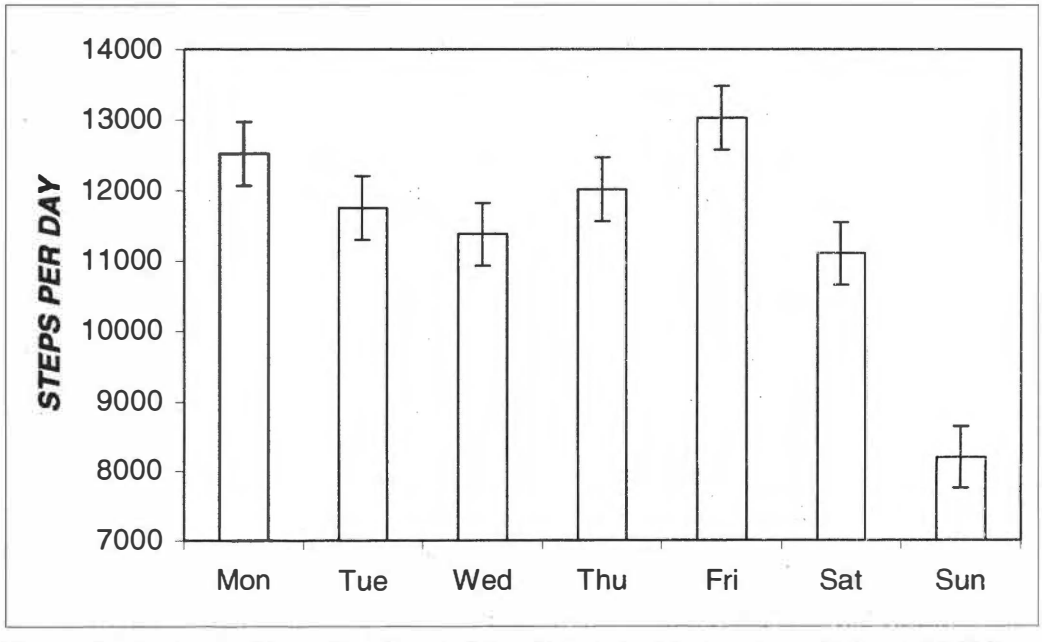


Figure 3: Average Steps Per Day of the Week in Elementary School Children. (N=110)

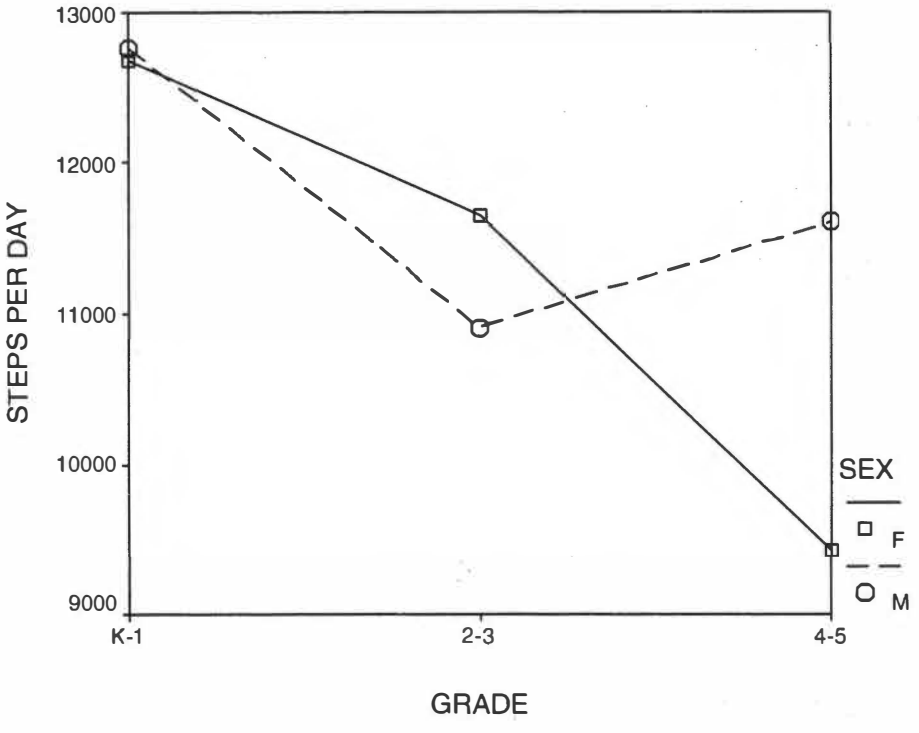


Figure 4. Average Step Counts Taken By Sex and Grade. No statistically significant interaction was found.

counts per day. There was no significant difference between boys and girls (p=0.334), but there was a trend towards a grade and sex interaction (p=0.058; Figure 4).

Figure 5 illustrates mean step counts on different days of the week. A significant difference was found between Sunday and all other days of the week (p <0.001).

A significant correlation was found between step counts and BMI at p<. 05 (p= -.212). A weak negative correlation between percent body fat and step counts but was not significant (p=-0.137).

The only significant correlation found in the NHANES III survey was between the number of sport teams participated on for the past year and BMI (Table 3).

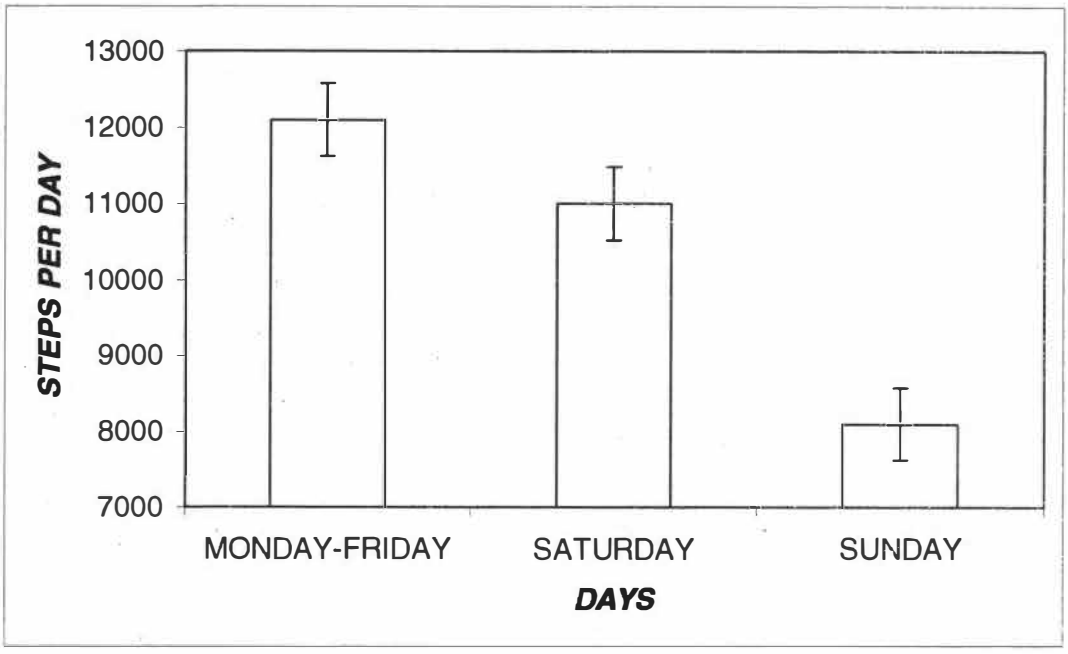


Figure 5: Average Step Counts for Monday-Friday, Saturday, and Sunday. Sunday is significantly less active than other days.

Table 3: NHANES III Physical Activity Survey compared with Body Mass Index. (N=110)

Correlation Between NHANESIII Physical Activity Survey and BMI

	BMI	How many times/week play or exercise enough to make you sweat and breathe hard?	Total number of Sport Teams participated in the past year?	How many hours did you watch TV yesterday?
BMI	1.000	-.002	.228*	-.002

*

*. Correlation is significant at the .05 level (2-tailed).

Chapter V

Discussion

Step Counts

In this study Elementary School Boys took 11,687 ± 2,815 steps/day and girls took 11,180 ±2,980 steps day. There was an age-related decline in steps per day. Figure 2 shows that kindergarten-first graders were significantly more active than fourth-fifth graders. No significant differences were found in steps per day between boys and girls. If the sample size had been larger in this study, a significant interaction might have been found.

In study by Vincent et al (54) reported pedometer-measured physical activity remained steady from participant ages six to twelve years. The study had a total of 1,954 children from Sweden, America, and Australia. In their study, American boys took 12,554-13872 steps/day while girls took only 10,661-11,383 steps/day. In Australia, boys took 13,864-15,023 steps/day while girls took 11,221-12,322 steps/day and in Sweden boys took 15,673-18,346 steps/day while girls took 11,221-12,322 steps/day. Thus, Vincent and co-workers found a significant difference between boys and girls. The mean step count for weekdays in this study was 12,000 steps per day, which is consistent with Vincent et al. Overall, our values for steps per day for American elementary school boys were slightly lower than those reported by Vincent et al.

Rowlands et al. (41) found an age-related decline in British children from eight to 10 years old. The mean pedometer counts in that study for boys were 16,035 steps/day and girls took 12,728 steps/day, which was a significant difference. The discrepancy

between the study of Rowlands et al. and the present one may be due to different geographical locations (United Kingdom and United States).

A new finding of the current study is that children are less active on Sunday than on other days of the week. Vincent et al collected data over four school days, and did not include weekends (54). Rowlands assessed activity for four weekdays and two weekend days. In this study, a pedometer with data` storage capability was used (40). If Sundays are excluded, this may result in an overestimation of steps/day (averaged over one week). This shows a need to assess step counts for seven days instead four-six days as done in previous studies (41, 52, 54).

In addition, the present study found that children who participate in team sports accumulated more steps per day then those who did not. This is similar to the finding of a study by Flohr et al. (17) that study assessed steps/day in older children (12 to 14 years old) who were classified as either participating in after school activities or not (ACT or nACT (17)). The mean number of step counts for ACT group was 12,919 ±4,991 and nACT was 10,269 ±3,139 for the two week assessment.

President's Council on Physical Fitness and Sports

The President's Council on Physical Fitness and Sports has set a standard of ≥ 11,000 steps/day for girls and ≥ 13,000 steps/day for boys to receive a President's challenge active lifestyle award. Forty-two percent of girls met this recommendation while only 35% of boys met this recommendation. Overall, 39% of the children would have received the President's challenge award. Since children in the U.S. are less active

than those in Australia, Switzerland, and Great Britain (41, 54) this suggests that there is considerable room for improvement.

Relationship of Step Counts to Adiposity

A significant negative correlation (p = -0.212) between BMI and steps counts was found in this study. Twenty-two percent of the children were obese as defined by being in the 95th percentile of age- and sex-specific BMI (Based on NHANES I). This is very close to the estimated national average (25-30%) of obesity in children (30). A significant correlation was found in the physical activity survey was between BMI and participation in sport teams. This suggests that the current epidemic of childhood obesity is related, at least in part, to low levels of physical activity.

For Future Studies

Based on my experience, when future studies are conducted with pedometers in Elementary School Children, the following things should be attended to. The teacher should have a good understanding of the purpose of the study and why the study is being done. The principal investigator should present the study to the participants prior to starting study to get them interested in taking part in the study, and make sure all questions from teachers, parents, and participants are completely answered.

Conclusion

This study revealed that children five to eleven years old take 11,687 steps/day (boys) and 11,180 steps/day (girls). Children are less active on Sunday compared to other days of the week. The results of the study indicate that only 39% of children meet the national physical activity recommendation for step counts. There was a significant association between pedometer measures of activity and BMI. In summary, the results

suggest that pedometers can be used to monitor physical activity in children over seven days, and that only many children are not meeting the national recommendation set forth in the President's challenge.

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Appendices

Appendix A

Letter to Parents Explaining Study

Dept of Health, Safety, and Exercise Science
HPER Building,
University Of Tennessee, Knoxville
1914 Andy Holt Ave. Knoxville, TN 37996
Phone: (865) 974-8768

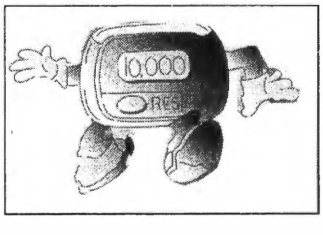
August ____, 2002

Dear parents,

My name is Stephen Sefchick and I am a graduate student in the Exercise Science program at the University Of Tennessee. The purpose of this letter is to help find participants for a study I am doing. My study will determine how physically active children (kindergarten to fifth grade) are, as measured by steps taken per day. Both the attached consent form and assent form outlines the procedures for my study. If you are interested in having your child take part in this study please sign the consent form, and read to your child or have your child read the assent form. Please have your child return these to his/her homeroom teacher. If you have any questions or concerns please contact me at ssefchic@utk.edu or at the phone number above.

Sincerely,

Stephen Sefchick
Graduate Student
University of Tennessee



Appendix B

Informed Consent

INFORMED CONSENT FORM

TITLE OF THE STUDY: Steps Per Day in Elementary School Children

Investigators: Stephen Sefchick
Faculty Advisor: David Bassett, Jr., Ph. D

Address: Dept of Health, Safety, and Exercise Science
HPER Building, room 322
University of Tennessee, Knoxville
1914 Andy Holt Ave. Knoxville, TN 37996-2700

Phone: (865) 974-8768

PURPOSE

Your child is invited to take part in a research study. The purpose of this study is to use a step counter to compare the number of steps per day taken in children, in kindergarten to fifth grade.

PROCEDURES

The testing will be done during your child's homeroom class. Your child's body fat, height, and weight will be measured. Your child will then be asked to wear a step counter for seven days except when sleeping, showering, and swimming.

Testing Procedures

We will measure your child's height and weight to determine Body Mass index (BMI). We will measure skinfold thickness of the triceps and calf to estimate body fat. The skinfold thickness will be measured by a gentle pinch of the skin with caliper.

Survey

Your child will be asked to report on TV watching and daily activity. I will use a survey that was developed by the Center of Disease Control and Prevention for the National Health and Nutritional Examination Survey III (NHANES IIII) to obtain information when I talk to him/her.

Record Of Steps Taken Per Day

Your child will wear a step counter at his/her waist in line with the foot, and on right side of the body. After this information has been obtained, your child will then be instructed to wear the step counter for seven days except when sleeping and bathing. The step counter (NL-2000) will record total number of steps each day for the seven day period. Your child should not change his/her activity levels during the study.

After seven days your child will return the step counter to Stephen Sefchick during your child's homeroom class. Your child will receive feedback-on their steps per day for the seven days of monitoring.

BENEFITS OF PARTICIPATION

Benefits to your child include knowledge of your steps per day. This study will provide scientists and the general public with information on the number of steps taken per day in children, kindergarten to fifth grade.

RISKS OF PARTICIPATION

The research involves no known physical or psychological risk to the participants involved.

RIGHT TO ASK QUESTIONS AND/OR WITHDRAW FROM THE STUDY

If you have any questions or concerns at any time during the course of the testing procedures or after completion of the procedures you can contact the investigator at (865) 974-8768. If you have any questions about your child's rights as a subject you may contact the University of Tennessee Institutional Review Board at (865) 974-3466. As a volunteer in this study your child has the right to withdraw at any time.

CONFIDENTIALITY

Only Stephen Sefchick, David Bassett, Jr., Ph. D, and you will have access to any of the information collected during this research project. The original, signed consent form will be kept in a locked cabinet in room 317 in the Applied Physiology Laboratory, of which Dr. Bassett is the director. The final results will be published, but your child's name will not be used in any of the material published.

AUTHORIZATION

By signing this informed consent form, I am indicating that I have read and understood this document. I have been given the opportunity to ask questions I may have. By signing this form I indicate that I agree to allow my child to serve as a participant in this research study.

_____ _____

Parent's signature Date

_____

Parent's name

_____ _____

Investigator signature Date

Appendix C

Informed Assent

INFORMED ASSENT FORM

TITLE OF THE STUDY: Steps Per Day in Elementary School Children.

Stephen Sefchick a Master student at the University of Tennessee will be conducting this study. Stephen Sefchick can be contacted at (865) 974-8768 or ssefchic@utk.edu to answer any questions or concerns.

PURPOSE

You are invited to be in a study. The study will compare the number of steps per day taken by children, in kindergarten to fifth grade.

PROCEDURES

The testing will be done during your homeroom class. Your body fat, height, and weight will be measured. You will be asked to wear a step counter for one week.

First we will measure your height and weight. We will also measure thickness of the skin on your arm and your lower leg. The thickness will be measured by a gentle pinch of the skin with caliper.

Then, we will ask you about your TV watching and daily activity.

Last, we will show you how to wear a step counter at your waist. You will wear the step counter for seven days. You should not change your activity levels during the study. Then bring the step counter back to your PE class.

After seven days you will return the step counter to Stephen Sefchick during your homeroom class. You will receive feedback-on your steps per day for the seven days of monitoring.

RIGHT TO WITHDRAW

If you decide not to be in the study, that is okay. Even if you start the study, you can stop at any time.

Please check "Yes" below if you are interested in participating in this study. If you are not interested in participating in this study please check "No" below.

_____ Yes
_____ No

Appendix D

Confidentiality Agreement

Confidentiality Agreement

I _____ agree to keep all information collected during this research project confidential.

_____

Signature

_____

Name

_____

Date

Appendix E

General Information Sheet

Name:_____ Age:_____ Sex: M or F

Pedometer #: _____ Grade: _____

Station 1:

Height: _____

Station 2:

Weight: _____ BMI: _____

Tricep Skinfold: _____ Calf Skinfold: _____

Estimated Body Composition: _____

Station 3:

NHANES III

How many times per week do you play or exercise enough to make you sweat and breathe hard?

01
02
03
04
05
06
07
08
77
88
99

In the past year, how many sport teams or organized exercise programs have you been involved in? Do not include physical education or gym classes.

0
1
2
3
4
5
8
9

Blank
About how many hours did you watch TV yesterday?
0
1
2
3
4
5
7
8
9
Blank

Station 4:

Pedometer #: _____

STEPS PER DAY

DAY 1: _____

DAY 2: _____

DAY 3: _____

DAY 4: _____

DAY 5: _____

DAY 6: _____

DAY 7: _____

DAY 8: _____

Appendix F

National Health and Nutritional Examination Physical Activity Survey

NHANES III

MEC YOUTH QUESTIONNAIRE (EXCEPT DIS)

SECTION A. ACTIVITY

Position SAS name	Counts	Item description and code		Notes
4511-4512 MYPA1		How times per week do you play or exercise enough to make you sweat and breathe hard?		
	308	01		
	516	02		
	593	03		
	386	04		
	852	05		
	204	06		
	637	07		
	453	08	Eight or more	
	154	77	Less than once a week	
	161	88	Blank but applicable	
	17	99	Don't know	
	27030	Blank		
4512 MYPA2		In the past year, how many sport teams or organized exercise programs have you been involved in? Do not include physical education or gym classes.		
	1846	0	No teams/programs	
	1034	1		
	627	2		
	337	3		
	139	4		
	120	5	Five or more	
	160	8	Blank but applicable	
	18	9	Don't Know	
	27030	Blank		
4514 MYPA3		About how many hours did you watch TV yesterday?		
	452	0	None	
	684	1	About one hour	
	777	2	About two hours	
	651	3	About three hours	
	441	4	About four hours	
	895	5	About five hours or more	
	210	7	Less than one half hour	
	161	8	Blank but applicable	

10	9	Don't know
27030	Blank	

Appendix G

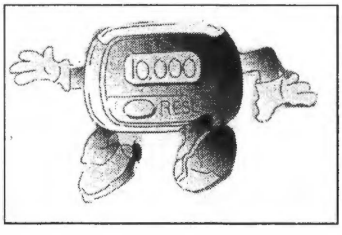
Handout For Participants After Receiving Pedometer

STEPS PER DAY IN ELEMENTARY SCHOOL CHILDREN

Dear Parent/ Guardian:

-We will be measuring steps per day in elementary school children
-Your child will be asked to wear a pedometer for 7 days, on the right side of the waistband
-Please help them remember to wear the pedometer at all times except when sleeping, bathing, or swimming
-If your child forgets to put the pedometer on in the morning, they should not wear the pedometer for that day
-Your child will receive results on how many steps he or she takes each day

THANK YOU FOR REMINDING YOUR CHILD TO WEAR THE PEDOMETER



Appendix H

Reference Data of 85th and 95th percentiles of Body Mass Index from National Health and Nutritional Examination Survey I

Reference Data of 85th and 95th percentiles of Body Mass Index from National Health and Nutritional Examination Survey I

Body Mass Index for overweight and obesity by sex between 6 to 11 years old

	85th Percentile		95th Percentile	
Age	Boys	Girls	Boys	Girls
6	16.64	16.17	18.02	17.49
7	17.37	17.17	19.18	18.93
8	18.11	18.18	20.33	20.36
9	18.85	19.19	21.45	21.78
10	19.60	20.19	22.60	23.20
11	20.35	21.18	23.73	24.59

Appendix I

Reference Data of 85th and 95th percentiles for Tricep Skinfold Thickness from National Health and Nutritional Examination Survey I

Reference Data of 85th and 95th percentiles for Tricep Skinfold Thickness from National Health and Nutritional Examination Survey I

Tricep skinfolds thickness by sex between 6 to 11 years old

	85th Percentile		95th Percentile	
Age	Boys	Girls	Boys	Girls
6	11.10	13.44	14.12	15.57
7	12.38	14.94	15.67	17.89
8	13.66	16.41	17.88	20.18
9	14.93	17.85	18.81	22.47
10	16.02	19.01	20.68	24.38
11	16.87	20.13	22.20	26.15

Appendix J

Original Step Data

Grade	Age	Sex	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
K	5	F	10674	10241	13824	12099	13628	14898	4674
K	5	F	15407	14303	13310	18388	15047	10986	9956
K	5	F	11547	7068	13123	7526	7649	10900	10253
K	5	M	10984	12498	11710	24722	15485	18239	23759
K	5	F	26039	11003	19210	25847	8397	20878	2694
K	6	F	.	13742	19195	12776	11034	13332	12143
K	5	F	7626	21903	25343	30941	17902	21191	12656
K	5	F	14311	15582	13562	15035	10526	6165	9707
K	6	M	20240	9540	.	4437	10073	4749	4853
K	5	M	10649	.	18005	17898	14063	15183	8696
K	6	F	21657	15960	15173	21977	11541	14706	13324
K	6	F	25097	22405	17998	20045	.	11905	10507
K	6	M	9478	7362	4048	15219	10959	6286	6831
K	5	F	9863	7917	9426	4662	10664	.	8870
K	5	F	13849	9112	14200	14061	14385	11442	168
K	5	F	7747	8355	7842	6156	11554	8662	5939
K	5	F	9905	11151	7979	11416	.	.	7954
1	6	F	.	.	16713	23592	22857	5140	9701
1	6	M	16322	.	.	16558	14416	2723	.
1	6	M	10944	13256	11259	14259	14391	10472	5808
1	6	M	15467	17082	12423	.	12141	12995	12915
1	6	M	14788	10997	14216	17683	.	.	.
1	6	M	16310	15532	17460	6211	19038	12406	6069
1	7	F	9434	15641	16659	15584	16133	28205	12862
1	7	M	13505	8995	12057	9999	.	.	5674
1	6	F	14549	.	18544	16981	.	10897	6567
1	7	F	.	.	.	16907	27168	1029	7790
1	6	M	18002	21036	18577	13987	11043	9099	8865
1	6	M	17294	.	819	16499	11157	.	.
1	6	M	13085	.	.	11752	.	14767	.
1	6	M	12970	15141	12970	10498	15433	15590	11751
1	7	F	9207	.	8050	9402	12920	.	7987
1	7	F	9849	8291	8935	7500	13661	.	.
1	7	F	1282	.	8739	8638	9728	2267	.
2	7	F	13471	12126	18806	24874	18978	17814	17379
2	7	F	8296	6021	14086	12300	8088	.	1515
2	7	F	12062	8307	11059	10271	24386	13350	13288
2	8	F	11276	11125	10143	10015	16943	17858	15199
2	8	M	11837	5933	348	1263	13186	9653	6262

Grade	Age	Sex	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2	7	F	11607	14110	13812	.	18290	10709	.
2	8	M	15720	11098	23053	10231	16073	15783	7753
2	7	M	8720	8601	.	7994	9762	18733	6595
2	8	F	13171	8646	13089	9501	14070	7907	7109
2	7	M	12302	10166	11609	13289	21278	15259	7847
2	7	M	10500	8779	.	.	11278	1325	.
2	8	M	6588	10415	10022	6940	11466	10090	3070
2	8	F	10031	7354	10813	7952	15801	15344	9739
2	8	M	9027	7393	10715	8192	13104	9056	9634
2	8	M	.	8763	15531	10453	15975	22453	12766
2	8	F	12167	995	9043	7934	10070	6770	4469
2	7	M	9956	13975	14619	8909	11979	.	.
2	8	F	10705	.	.	13989	10101	8989	.
3	8	M	13635	9709	14279	12268	18952	21228	14033
3	8	M	12531	12667	10459	12658	12815	14214	7662
3	8	F	.	.	.	.	14065	10356	1810
3	9	M	10375	8099	11771	12650	11787	16302	8507
3	8	M	11186	9476	15313	16654	11002	10192	8504
3	9	M	10516	6966	11407	15052	12993	5653	2598
3	8	F	14524	12405	10743	8563	22057	12479	11131
3	8	F	11872	6944	13998	13813	12283	12898	14342
3	8	M	11696	14753	8040	12394	527	1223	568
3	9	F	13570	13951	15129	13975	12713	15017	5584
3	8	M	10166	9279	10784	11725	10533	8348	5436
3	8	F	12603	16195	7191	12300	11457	7638	4562
3	9	M	16502	15233	.	9732	.	.	15030
3	8	F	13304	15524	7858	13943	7436	12207	3859
4	9	F	14712	10283	.	12419	10453	12723	4551
4	9	M	17809	13393	10678	8969	9989	5406	7906
4	9	F	11368	13928	895	10627	11595	15759	10334
4	9	F	8858	1962	7918	5215	7543	13633	10733
4	8	F	8313	9020	13286	12265	12696	6659	5482
4	9	F	10800	.	13724	7883	12597	10137	2947
4	9	F	16031	3904	12478	7641	15342	9880	4850
4	10	M	20256	13622	8745	12205	11705	16947	11141
4	9	M	17309	13104	14936	19539	25905	21893	18895
4	9	F	8643	.	11854	.	13055	12028	7703
4	9	F	10866	8273	.	10214	10777	7988	9104
4	10	M	16164	9370	10118	13878	12026	22572	615

Grade	Age	Sex	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
4	10	M	12276	13581	11302	8720	11549	18972	2601
4	10	F	11603	14195	7187	9400	10457	6638	4562
4	10	F	9852	10572	7910	9579	13436	12130	.
4	9	F	12166	11278	9794	12725	13533	11348	10136
4	9	F	11758	7317	1175	.	1054	.	.
4	9	F	12984	10222	7498	10376	10009	6449	7236
4	10	M	12964	13767	8072	2317	11379	2392	920
4	9	M	16410	34512	6867	13815	7311	8056	15874
5	11	M	11027	8888	9057	.	13560	4885	.
5	11	M	23817	.	.	10741	19970	16196	14065
5	10	M	13125	7923	13506	14111	13859	6957	3908
5	10	M	.	11902	13002	12659	10366	.	.
5	10	M	14667	.	1312	.	15944	7451	17259
5	10	F	12157	3769	.	9613	11724	8029	10107
5	10	F	8988	10256	11776	12694	8861	4821	8057
5	10	F	9290	10705	11734	8037	10710	13977	2361
5	10	M	12395	7510	11195	16613	18425	9825	10205
5	11	M	22331	.	6759	20114	22319	16434	18820
5	10	M	2154	9275	4933	.	11445	11499	10281
5	11	M	11890	10024	12886	14390	11910	13458	10218
5	11	M	12400	.	.	.	13723	15326	5125
5	11	M	7077	8692	3354	6976	6955	11357	3154
5	11	F	14483	20098	8628	9344	15580	10357	3804
5	11	F	9444	10583	9294	9562	12379	9791	8592
5	10	M	8814	12059	9726	8897	14869	5879	5220
5	10	M	9853	19330	7017	7509	13745	7085	10874
5	11	M	9817	12823	6704	6113	8340	6507	3683
5	11	F	7351	11826	6318	7900	7195	2128	.
5	11	M	23777	25051	3682	.	6191	6596	14174
5	10	F	6452	7477	4255	7771	.	10313	8239
5	10	M	6659	10826	9417	7801	8185	6667	5495
5	10	F	10618	11514	8288	7022	11136	6009	.

Appendix K

Estimated Step Data

Grade	Age	Sex	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
K	5	F	10674	10241	13824	12099	13628	14898	4674
K	5	F	15407	14303	13310	18388	15047	10986	9956
K	5	F	11547	7068	13123	7526	7649	10900	10253
K	5	M	10984	12498	11710	24722	15485	18239	23759
K	5	F	26039	11003	19210	25847	8397	20878	2694
K	5	F	7626	21903	25343	30941	17902	21191	12656
K	5	F	14311	15582	13562	15035	10526	6165	9707
K	5	M	10649	11917	18005	17898	14063	15183	8696
K	5	F	9863	7917	9426	4662	10664	86	8870
K	5	F	13849	9112	14200	14061	14385	11442	168
K	5	F	7747	8355	7842	6156	11554	8662	5939
K	5	F	9905	11151	7979	11416	12653	10718	7954
K	6	F	13248	13742	19195	12776	11034	13332	12143
K	6	M	20240	9540	13073	4437	10073	4749	4853
K	6	F	21657	15960	15173	21977	11541	14706	13324
1	6	F	15967	14733	16713	23592	22857	5140	9701
1	6	M	16322	14648	17200	16558	14416	2723	8634
1	6	M	10944	13256	11259	14259	14391	10472	5808
1	6	M	15467	17082	12423	14772	12141	12995	12915
1	6	M	14788	10997	14216	17683	14806	13344	9790
1	6	M	16310	15532	17460	6211	19038	12406	6069
K	6	F	25097	22405	17998	20045	14733	11905	10507
K	6	M	9478	7362	4048	15219	10959	6286	6831
1	6	F	14549	13010	18544	16981	13286	10897	6567
1	6	M	18002	21036	18577	13987	11043	9099	8865
1	6	M	17294	14245	819	16499	11157	12154	9219
1	6	M	13085	19509	16676	11752	16509	14767	11634
1	6	M	12970	15141	12970	10498	15433	15590	11751
2	7	F	13471	12126	18806	24874	18978	17814	17379
2	7	F	8296	6021	14086	12300	8088	9154	1515
2	7	F	12062	8307	11059	10271	24386	13350	13288
1	7	F	9434	15641	16659	15584	16133	28205	12862
2	7	F	11607	14110	13812	13782	18290	10709	10654
2	7	M	8720	8601	8829	7994	9762	18733	6595
2	7	M	12302	10166	11609	13289	21278	15259	7847
2	7	M	10500	8779	10033	8408	11278	1325	5138
2	7	M	9956	13975	14619	8909	11979	9645	7818
1	7	M	13505	8995	12057	9999	12218	10211	5674

Grade	Age	Sex	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	7	F	14182	11986	16392	16907	27168	1029	7790
1	7	F	9207	15607	8050	9402	12920	9674	7987
1	7	F	9849	8291	8935	7500	13661	18995	8447
1	7	F	1282	7221	8739	8638	9728	2267	4456
2	8	F	11276	11125	10143	10015	16943	17858	15199
3	8	M	13635	9709	14279	12268	18952	21228	14033
3	8	M	12531	12667	10459	12658	12815	14214	7662
3	8	F	11535	9093	12627	10385	14065	10356	1810
3	8	M	11186	9476	15313	16654	11002	10192	8504
3	8	F	14524	12405	10743	8563	22057	12479	11131
3	8	F	11872	6944	13998	13813	12283	12898	14342
4	8	F	8313	9020	13286	12265	12696	6659	5482
2	8	M	11837	5933	6810	1263	13186	9653	6262
2	8	M	15720	11098	23053	10231	16073	15783	7753
2	8	F	13171	8646	13089	9501	14070	7907	7109
2	8	M	6588	10415	10022	6940	11466	10090	3070
2	8	F	10031	7354	10813	7952	15801	15344	9739
2	8	M	9027	7393	10715	8192	13104	9056	9634
2	8	M	12127	8763	15531	10453	15975	22453	12766
2	8	F	12167	995	9043	7934	10070	6770	4469
2	8	F	10705	11771	12786	13989	10101	8989	7320
3	8	M	11696	14753	8040	12394	527	1223	568
3	8	M	10166	9279	10784	11725	10533	8348	5436
3	8	F	12603	16195	7191	12300	11457	7638	4562
3	8	F	13304	15524	7858	13943	7436	12207	3859
3	9	M	10375	8099	11771	12650	11787	16302	8507
3	9	M	10516	6966	11407	15052	12993	5653	2598
4	9	F	14712	10283	13989	12419	10453	12723	4551
4	9	M	17809	13393	10678	8969	9989	5406	7906
4	9	F	11368	13928	895	10627	11595	15759	10334
4	9	F	8858	1962	7918	5215	7543	13633	10733
4	9	F	10800	8929	13724	7883	12597	10137	2947
4	9	F	16031	3904	12478	7641	15342	9880	4850
4	9	M	17309	13104	14936	19539	25905	21893	18895
4	9	F	8643	9806	11854	10888	13055	12028	7703
4	9	F	10866	8273	9279	10214	10777	7988	9104
3	9	F	13570	13951	15129	13975	12713	15017	5584
3	9	M	16502	15233	13778	9732	14716	12390	15030
4	9	F	12166	11278	9794	12725	13533	11348	10136

Grade	Age	Sex	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
4	9	F	11758	7317	1175	6776	1054	7169	2424
4	9	F	12984	10222	7498	10376	10009	6449	7236
4	9	M	16410	34512	6867	13815	7311	8056	15874
4	10	M	20256	13622	8745	12205	11705	16947	11141
4	10	M	16164	9370	10118	13878	12026	22572	615
5	10	M	13125	7923	13506	14111	13859	6957	3908
5	10	M	12469	11902	13002	12659	10366	10676	7530
5	10	M	14667	14901	1312	14459	15944	7451	17259
5	10	F	12157	3769	6883	9613	11724	8029	10107
5	10	F	8988	10256	11776	12694	8861	4821	8057
5	10	F	9290	10705	11734	8037	10710	13977	2361
5	10	M	12395	7510	11195	16613	18425	9825	10205
5	10	M	2154	9275	4933	9151	11445	11499	10281
4	10	M	12276	13581	11302	8720	11549	18972	2601
4	10	F	11603	14195	7187	9400	10457	6638	4562
4	10	F	9852	10572	7910	9579	13436	12130	8090
4	10	M	12964	13767	8072	2317	11379	2392	920
5	10	M	8814	12059	9726	8897	14869	5879	5220
5	10	M	9853	19330	7017	7509	13745	7085	10874
5	10	F	6452	7477	4255	7771	12293	10313	8239
5	10	M	6659	10826	9417	7801	8185	6667	5495
5	10	F	10618	11514	8288	7022	11136	6009	6281
5	11	M	11027	8888	9057	9877	13560	4885	6646
5	11	M	23817	15534	17913	10741	19970	16196	14065
5	11	M	22331	17492	6759	20114	22319	16434	18820
5	11	M	11890	10024	12886	14390	11910	13458	10218
5	11	M	12400	10280	13187	12183	13723	15326	5125
5	11	M	7077	8692	3354	6976	6955	11357	3154
5	11	F	14483	20098	8628	9344	15580	10357	3804
5	11	F	9444	10583	9294	9562	12379	9791	8592
5	11	M	9817	12823	6704	6113	8340	6507	3683
5	11	F	7351	11826	6318	7900	7195	2128	4626
5	11	M	23777	25051	3682	16013	6191	6596	14174

Appendix L

Average Steps Taken by Grade and Day

Grade	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Overall
Kindergarten	14,018± 5,808	12,356± 4,584	13,942± 5,110	15,482± 7,648	12,370± 2,697	11,783± 5,621	8,999± 5,208	12,707± 3,660
First	13,126± 4,076	13,937± 3,686	13,393± 4,758	13,577± 4,485	15,112± 4,426	11,174± 6,577	8,715± 2,548	12,719± 2,434
Second	11,086± 2,139	9,198± 3,147	12,492± 3,865	10,349± 4,672	14,490± 4,357	12,216± 5,202	8,530± 4,141	11,195± 2,738
Third	12,429± 1,770	11,449± 3,302	11,669± 2,685	12,579± 2,113	12,381± 4,940	11,438± 4877	7,401± 4,768	11,335± 2,069
Fourth	13,057± 3,346	11,551± 6,339	9,385± 3,758	10,272± 3622	11,620± 2500	11,438± 5,529	7,305± 4,761	10,661± 2,794
Fifth	11,710± 5,298	12,030± 4,707	8,784± 3,917	10,814± 3624	12,486± 4,064	9,259± 3836	8,280± 4,427	10,480± 2,798

Average Steps Taken by Grade and Day (N=110). Values are mean ±standard deviation.

VITA

Stephen Clay Sefchick was born in Woodbridge, Virginia on April 24, 1979. He was raised in Woodbridge, Virginia where he graduated from Gar-field High School in June 1997. His college career began at Bluefield College in Bluefield, Virginia in August 1997. He received Bachelor of Science in Exercise Science in May 2001. In August 2001, he began working on his Master degree in Exercise Science at the University of Tennessee, Knoxville. In May 2003, he received his Master of Science in Human Performance and Sports Studies.