2008-12-03

# Using Pedometers as a Valid Method of Determining Physical Activity Intensity Level

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# USING PEDOMETERS AS A VALID METHOD OF DETERMINING PHYSICAL ACTIVITY INTENSITY LEVEL

by

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A thesis submitted to the faculty of

Brigham Young University

in partial fulfillment of the requirements for the degree of

Master of Science

Department of Exercise Sciences

Brigham Young University

December 2008

BRIGHAM YOUNG UNIVERSITY

GRADUATE COMMITTEE APPROVAL

of a thesis submitted by

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ABSTRACT

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Master of Science

As researchers explore the benefits of using pedometers to assess physical activity they are discovering that intensity of physical activity may be estimated from steps per minute (SPM). The purpose of this study was to determine the SPM and kilocalories (kcals) expended associated with moderate physical activity in middle school students (12 - 14 years old). Methods: Ninety-three (49 boys, 44 girls) middle school youth between the ages of 12 and 14, walked on a treadmill at four different speeds (4.0, 4.8, 5.64, and 6.4 km·h$^{-1}$) for three minutes at each speed. Each participant wore a pedometer in order to obtain their steps per minute and a heart rate monitor to record their heart rate level during each test speed. Results: Moderate physical activity was reached, on average, by girls and boys at 122 SPM (5.64 km·h$^{-1}$) and 115 SPM (4.8 km·h$^{-1}$), respectively. At this SPM rate boys and girls expended 232.55 kcals and 176.66 kcals per hour. This study

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Abstract

As researchers explore the benefits of using pedometers to assess physical activity they are discovering that intensity of physical activity may be estimated from steps per minute (SPM). The purpose of this study was to determine the SPM and kilocalories (kcals) expended associated with moderate physical activity in middle school students (12 - 14 years old). Methods: Ninety-three (49 boys, 44 girls) middle school youth between the ages of 12 and 14, walked on a treadmill at four different speeds (4.0, 4.8, 5.64, and 6.4 $km \cdot h^{-1}$) for three minutes at each speed. Each participant wore a pedometer in order to obtain their steps per minute and a heart rate monitor to record their heart rate level during each test speed. Results: Moderate physical activity was reached, on average, by girls and boys at 122 SPM (5.64 $km \cdot h^{-1}$) and 115 SPM (4.8 $km \cdot h^{-1}$), respectively. At this SPM rate boys and girls expended 232.55 kcals and 176.66 kcals per hour. This study augments previous studies that explored ways to assess activity levels using SPM calculations.

## Introduction

The office of the Surgeon General of the United States of America has changed its emphasis from stopping smoking, which has been its focus for the past twenty years, to controlling obesity (U.S. Department of Health and Human Services, 2001). Obesity rates have reached epidemic status in the United States to the point that the cost to treat obesity ranks second only to that spent on tobacco use. Surgeon General Richard H. Carmona stated, “Because of the increasing rates of obesity, unhealthy eating habits, and physical inactivity, we may see the first generation that will be less healthy and have a shorter life expectancy than their parents” (Carmona, 2004, n.p.).

The Center for Disease Control and Prevention (CDC) reported that between the years of 1974 and 2003 the number of overweight children between 6 and 11 years old has increased from 4% to almost 19%. In that same time period, overweight adolescents (12-19 years old) have increased from 6% to over 17% (CDC, 2007b). These trends mirror those associated with adults over the same period of time. The National Health and Nutrition Examination Survey reported that the percentage of adults who were overweight (BMI > 25) rose from 56% in 1994 to over 66% in 2004 (CDC, 2007a).

A key component in the battle against childhood obesity is physical activity. The National Association for Sport and Physical Education (NASPE) has recommended that children participate in a minimum of 60 minutes of moderate to vigorous physical activity each day (NASPE, 2004). Physical education teachers are given the responsibility to contribute to their students’ 60 minutes of moderate activity by planning for and assessing if each of their students is achieving enough moderate to vigorous activity to combat the effects associated with obesity. Physical educators should choose methods that students can easily use when they leave the class and are responsible for maintaining their own physically active lifestyle.

There are many ways to assess if an individual has accumulated the recommended guideline of 60 minutes of moderate to vigorous physical activity per day. Observation, heart rate monitors, accelerometers, and pedometers are all viable means whereby the amount of physical activity and the physical activity levels can be assessed (Vanhees, Leferve, Philippaerts, Martens, Huygens, Troosters, et al., 2005). Pedometers are a popular choice because they are non-invasive, simple to use, and cost effective when compared to heart rate monitors, accelerometers, and $VO_2$ assessment (Vanhees et al., 2005).

Only a few of these methods can assess energy expenditure, which plays a major role in the onset of obesity. Vanhees et al. (2005) describe doubly labeled water, indirect calorimetry, and use of heart rate monitors as the best means to measure energy expenditure. However, these methods are costly, intrusive, and limited in their availability to the general public. If pedometers are only used to count total steps, they lack the ability to account for the individual variances (e.g. weight) that contribute to energy expenditure. Development of a method which compares pedometer information with information from assessment tools proven valid in expressing energy expenditure (i.e., heart rate monitors) may provide pedometer users a means to estimate energy expenditure.

Researchers (Tudor-Locke, Sisson, Collova, Lee, & Swan, 2005; Vincent Graser, Pangrazi, & Vincent, In Press) have been studying the relationship between steps per minute (SPM) and exercise intensity. Guidelines which would allow users to infer exercise intensity and energy expenditure from SPM data would make the use of pedometers comparable to heart rate monitors or accelerometers, while still benefiting from the low cost and ease of use that is customarily associated with pedometers. To this end, Tudor-Locke et al. (2005) examined step frequency and its relationship to activity intensity via step frequency. They found that cut points for moderate physical activity for both men and women was roughly 100 SPM. Vincent Graser et al. (in press) performed a similar study with elementary-aged children. They used a moderate to vigorous $km \cdot h^{-1}$ range and found the corresponding SPM associated with that range, suggesting an SPM range of 120-140 SPM for youth 10-12 years old.

The development of SPM guidelines pertaining to school-aged children might be one way that physical education teachers can use pedometers as assessment tools relative to intensity levels in their physical education classes and in their activities outside of school. Association of energy expenditure with SPM would allow users to relate physical activity with other areas of their life that contribute to obesity as well. With information that links SPM and kcals teachers could illustrate the dynamic between moderate physical activity and kcals their students consume through the food they eat. Teachers could even associate specific food sources (i.e., a hamburger, a bag of potato chips, an apple, or one Oreo cookie) with specific activity time in class in order to help students conceptualize the relationship between physical activity and kcal intake. Pedometers used in this way can provide information for both students and teachers in order to determine if they are participating in physical activity at an intensity level necessary to help them meet the NASPE guidelines for physical activity. One objective of Healthy People 2010 (U.S. Department of Health and Human Services, 2000) is to increase the proportion of students who spend at least half of their physical education class time in moderate to vigorous physical activity and pedometer use can aid in determining if students have reached this goal. Therefore, the purpose of this study was to determine the SPM and kilocalories (kcals) expended associated with moderate physical activity in middle school students (12 - 14 years old).

## Methods

### *Participants*

Ninety-three (49 boys and 44 girls) 7$^{th}$ and 8$^{th}$ grade (age 12-14 years) participants were tested. All participants were from the same school and volunteered to participate. Each participant completed an informed assent and a consent form signed by both the participant and their parent or guardian. The school principal, the school district, and the university Institutional Review Board regarding human subjects all gave approval to the study prior to it being conducted. Participants were 71% White, 22% Hispanic, 2% African-American, and 2% Pacific Islander/Asian.

### *Instruments*

The Walk4Life LS-2505 pedometer (Walk4Life, Plainfield, IL) was used in order to determine SPM. Beets, Patton, and Edwards (2004) studied the LS-2505 and found them to be accurate with a high degree of agreement between pedometer recorded steps and manually counted step counts recorded on walking children. Pedometers are easy- to-use simple electronic devices that can provide information about steps taken, exercise time, and/or distance traveled. Pedometers have been proven to be valid and reliable for use with both adults and children (Barfield, Rowe, & Michael, 2004; Bassett, Ainsworth, Swartz, Strath, O'Brien, & King, 2000; Cardon & De Bourdeaudhuij, 2004; Freedson & Miller, 2000; Gretebeck & Montoye, 1992; Sirard & Pate, 2001).

Each participant also wore a Polar Vantage heart rate monitor (Polar Electro Inc., New Hyde Park, NY) during testing. These monitors measured each participant's heart rate at each phase of testing. The Polar Vantage was compared to six other heart rate monitors and to heart rate results obtained from electrocardiogram (ECG) recordings (Terbizan, Dolezal, & Albano, 2003). Terbizan et al. showed that at 4.8, 5.64, and 6.42 $km \cdot h^{-1}$, the heart rate monitor recorded the same heart rate data as the ECG, thus validating its ability to accurately monitor heart rate data.

The speed at which each participant walked was regulated by a SportsArt T600 treadmill (SportsArt Fitness, Woodinville WA) which was calibrated using established procedures (Bassett, Ainsworth, Leggett, Mathien, Main, Hunter, et al., 1996), and was tested accurate to ± 2%. The treadmill was kept secured between testing sessions at the testing site.

*Procedures*

*Anthropometric measures.* Each participant completed two testing sessions, the first of which was conducted in the morning before school started and consisted of measuring resting heart-rate, height, and weight. All participants were measured for height and weight, with their shoes off, using a Health-O-Meter L4-100 scale (Jarden Consumer Solutions, Rye, NY) which has the ability to measure both height and weight. These measurements were used to determine Body Mass Index (BMI) ($kg{\cdot}m^{-2}$), as per instructions described by the American College of Sports Medicine (ACSM) (Whaley, 2006).

*Physiological measures.* Resting heart-rate levels were measured by having each participant lay supine for five minutes on exercise mats placed on the ground. The participants were required to close their eyes and refrain from talking, with their heart rate being recorded from the heart-rate monitor watch before the participant was allowed to get up off the mat. Research has established five minutes of quiet rest time as an acceptable protocol when finding both resting heart rate levels and resting blood pressure levels (Chan, Spangler, Valcour, & Tudor-Locke, 2003). Resting heart rate was used to calculate each participant's target heart range for moderate physical activity level. The target heart rate range for moderate intensity (40%-59% of maximum heart rate) was determined by using the formula (Target heart rate range = ([heart rate $_{max}$-heart rate$_{rest}$] x percent intensity) + heart rate$_{rest}$) outlined by the American College of Sports Medicine (ACSM) (Whaley, 2006, p. 145).

Kcal information was calculated by the ACSM recommended formula used to calculate calories expended per minute: kcals = $[(kg{\cdot}VO_2)/1000]\ {\cdot}5$ (Whaley, 2006, p.293). METs for each speed were obtained from the ACSM guidelines (Whaley, 2006) and used to calculate $VO_2$ (METs = $VO2(mL{\cdot}kg^{-1}{\cdot}min^{-1})/3.5$) (Whaley, 2006, p. 292) for each speed, which was then used in the calculation for each participant's kcal expenditure.

*Shake test.* Each pedometer used in the study was calibrated before and after the study using a "shake test" to ensure the pedometer's accuracy (Vincent & Sidman, 2003). Prior to commencement of the study, all six of the pedometers used were found to be accurate to within ± 1% error. After the study had concluded the pedometers were again tested for reliability and all six pedometers used in the study again tested reliable to within ± 1% error. This was done to ensure that the data collected from the pedometers was accurate before and throughout testing.

*Treadmill walking.* Before testing, each participant put on a heart rate monitor (chest strap and watch) and placed a pedometer on the midline of the right thigh as per standard pedometer research protocol. Each participant was familiarized with operating the pedometer and completed a 20-step test to ensure that the pedometer was working.

Participants then proceeded to walk on the treadmill at each of the test speeds (4.0, 4.8, 5.64, and 6.42 $km \cdot h^{-1}$). Walking speeds were determined based on guidelines for adolescent physical activity, current research conducted concerning step frequency, and a pilot study conducted prior to the study for the benefit of research design. Tudor-Locke et al. (2005) used speeds of 4.8 and 6.4 $km \cdot h^{-1}$, finding that these speeds resulted in moderate intensity levels in adults.

Vincent Graser et al. (In Press) conducted a study investigating elementary students' step frequency when performing moderate to vigorous activity and they found 4.8, 5.6, and 6.4 $km \cdot h^{-1}$ required the children to perform a brisk walk. To ensure that participants began below or at the low end of their target heart rate range for moderate intensity the slowest speed was 4.0 km·h$^{-1}$. Therefore, the test speeds for this study were 4.0, 4.8, 5.64, and 6.42 km·h$^{-1}$.

The testing procedure began by giving each participant an opportunity to practice moving from the treadmill belt to the side rails at the slowest and fastest speeds, as well as retrieving pedometer and heart rate information so that this could be done easily during testing. The testing procedure called for each participant to walk at each speed for three minutes, in accordance with ACSM protocol for establishing a steady-state heart rate at each speed (Whaley, 2006). With their pedometers set to zero, participants were given a three second countdown (three, two, one, go) whereupon they stepped to the treadmill belt from the side rails and began walking, with the three minute timer starting on the participant's first step. During the last five seconds at each speed, the participants were given a verbal countdown (five, four, three, two, one, off) at which time the participant stepped from the treadmill belt back to the side rails. The heart rate and the step count information were recorded while the participant was standing on the side rails. The pedometer was reset to zero, the treadmill was set to the next speed, and the procedure was repeated at 4.8, 5.6, and 6.4 km·h$^{-1}$. The data recording process took less than 30 seconds in order to ensure that HR levels remained elevated. Stride length was then determined by calculating the distance traveled in three minutes and dividing that by the number of steps that were taken at each particular speed.

# Results

Height, weight, and BMI statistics were calculated for each gender. The boys had an average height, weight, and BMI of 162 cm, 61.17 kg, and 24.39, respectively. The girls had an average height and weight of 156.92 cm and 58.53 kg, respectively, and an average BMI of 21.56.

Stride length results are described in Table 1. Stride length increased for both boys and girls as the speeds increased. The boys' stride length averaged 0.67 m during the first speed and 0.82 m during the final speed. The girls' average stride length was 0.66 m initially and increased to 0.80 m by the last stage.

Heart rate and SPM data are depicted in Table 2. Mean heart rate and SPM increased with each successive speed, which was true for both boys and girls. Mean SPM increased from 100 at 4.0 km·h$^{-1}$ to 131 SPM at 6.42 km·h$^{-1}$ for boys. For girls, mean SPM was 102 at the initial speed and increased to 133 at the final testing speed.

Heart rate levels followed a pattern similar to SPM (Table 2). The mean heart rate level for boys was 109 BPM at the initial speed and rose to 136 BPM after the final testing speed. The heart rate for girls started at 122 BPM and ended at 151 BPM. The average threshold for moderate exercise (40% of MHR) for boys was 121BPM and the threshold out of moderate exercise (59% of MHR) was 146 BPM and 124 and 148 BPM for girls.

Kilocalorie expenditure (Table 2) also followed a similar pattern, with the boys' kcal levels averaging 183.59 kcal per hour (3.05 kcal per minute) during the first testing speed (4.0 km·h$^{-1}$, 100 SPM), and averaged 305.98 kcal per hour (5.1 kcal per min) during the final stage (6.42 km·h$^{-1}$, 131 SPM). The girls averaged 160.60 kcal per hour (2.68 kcal per minute) for the initial stage of testing (4.0 km·h$^{-1}$, 102 SPM) and finished at 267.67 kcal per hour (4.46 kcal per minute) for the final stage (6.42 km·h$^{-1}$, 133 SPM).

## Discussion

The purpose of this study was to determine a range of SPM that junior high age students could associate with moderate levels of physical activity. This would provide them, and perhaps their physical education teachers, with a quick and simple means to determine if they had met the moderate physical activity guideline. Past studies have been able to associate SPM ranges with a specific activity level. In the Tudor-Locke et al. study (2005) conducted on adults, the SPM threshold for moderate activity (males: 96 SPM; females: 107 SPM) was different than the threshold seen in this study (boys: 122 SPM; girls: 115 SPM). Heart rate levels were also different from the Tudor-Locke et al. study; their levels measured 103 BPM and 113 BPM for males at 4.8 and 6.42 km·h$^{-1}$, with females measuring 100 BPM and 122 BPM at the same respective speeds. In this study the average heart rate for those two comparable speeds was 118 BPM and 136 BPM for boys and 128 BPM and 151 BPM for girls. The Tudor-Locke et al. (2005) stride lengths for the adults (males: 0.7 m and 0.8 m; females: 0.8 m and 0.9 m) was longer overall than what was seen in this study (0.7 m and 0.8 m for both boys and girls). The differences in HR and SPM seen between the adults and children are to be expected because of the physiological differences in adults and children. The stride length difference was also expected, considering the size difference in adults and the adolescents who participated in this study. Physical education teachers may experience problems applying adult data to children, making the need for a more individualized approach to assessment of physical activity intensity imperative.

In the Vincent Graser et al. (2007) study on elementary-aged participants, they saw their moderate intensity SPM thresholds (boys: 120 SPM; girls: 123 SPM) was slightly lower for boys and higher for girls in the present study (boys: 122 SPM; girls: 115 SPM) which used the same test speeds. The participants in the present study recorded a longer stride length, especially the girls (boys: 0.67 to 0.82 m; girls: 0.70 to 0.80 m), than the elementary aged students recorded (boys: 0.67 to 0.77 m; girls: 0.65 to 0.75 m) which may explain why the girls need to take more steps at the same speed. Once again there is a discrepancy between elementary-aged children and middle school-aged children, suggesting the need for an assessment approach that addresses the uniqueness of middle school-aged children.

This study used personal heart rate levels (40%-59% of maximum heart rate) to determine when each participant reached their threshold of moderate physical activity. The differences in the activity habits of boys compared to girls, as well as trends concerning the physical activity habits as people age may necessitate a more individual approach to determining moderate physical activity levels than can be provided by the use of METs. The many physiological differences, as well as the unique social characteristics experienced by middle school-aged children, warrant research efforts that can find an accurate way to easily assess physical activity intensity in physical education classrooms. By using a more personal method of defining moderate physical activity this study speaks to these differences, but still uses a method (SPM and kcal) that is easy to use and accessible for physical education classes.

The uniqueness of each student in a physical education class can be manifest in a variety of ways. First, the physiological differences seen between boys and girls have been shown to have an effect on the exercise levels of boys versus girls. Rowland (2006) noted that variations between the sexes seen in exercise are the rule, rather than the exception. On average males are taller and weigh more than females (Rowland, 2006), which will affect both stride length and kcal expenditure. This discrepancy between genders is also present in children, resulting in boys having a 15%-19% higher absolute $VO_{2max}$ and a lower stroke volume in submaximal exercise (Rowland, 2006). Because boys have a higher $VO_{2max}$ and stroke volume than girls, they may have to work at a higher intensity level than girls to perform the same amount of work.

These physiological differences between boys and girls were manifest in this study. The mean moderate training zone for girls was 124-148 BPM, which as a group, was reached at 4.8 $km{\cdot}h^{-1}$. The mean training zone for moderate exercise for boys was similar (121-146 BPM), but was not reached until 5.64 $km{\cdot}h^{-1}$. The corresponding SPM levels were very different with the girls achieving their threshold for moderate physical activity at 115 SPM and the boys needing 122 SPM to reach moderate physical activity. Over the course of a 60-minute lesson, if both groups were working at their threshold for moderate physical activity, an average boy would take 420 more steps than the average girl. Kcal results also illustrate this difference between boys and girls. The kcals used at the threshold of moderate physical activity was 176.66 kcals per hour for the girls and

232.55 kcals per hour for the boys, again the boys expending more energy at the same activity intensity.

Ransdell, Oakland, & Taylor (2003) reported that among boys and girls of similar ages, girls are less physically active and value participation in physical activity less than boys. Additionally, other studies have shown that as children grow older they participate in regular physical activity less often (Chase, Vealey, Galli, Evers, Klug, & Reichert, 2007). These differences in activity habits can widen the gap between those who are currently physically active and those who have stopped participating regularly in physical activity. In an average physical education class, some students may participate in physical activity on a regular basis while others may not participate in physical activity at all. Middle-school students also develop at different rates physiologically. When walking the halls of a middle-school it is normal to see both students whose bodies have already matured close to their adult form and children who look like they still belong on the elementary school playground. All of these differences underscore the importance of an individualized approach when establishing intensity levels.

For many physical education teachers these differences between students are all too common because often each of their classes is a myriad of sizes and abilities. In these instances it may be useful to interpret this data using Table 3, which describes the percentages of participants who were in or above their threshold for moderate activity (based on heart rate) at each of the test speeds. At 4.8 km·h$^{-1}$, 43% of the boys and 66% of the girls were working at or above their threshold for moderate exercise. At 5.64 km·h$^{-1}$, 63% of boys and 81% of girls had reached the threshold for moderate activity. One hundred percent of girls reached their threshold for moderate activity when the speed was 6.42 km·h$^{-1}$, while 82% of the boys had reached their training zone for moderate exercise. Eighteen percent of the boys never reached their threshold for moderate activity, even at the fastest test speed. These findings clearly illustrate the impact that individual differences can have on exercise levels. One student may achieve his moderate level in the first three minutes of activity, while his classmate may never achieve his moderate intensity level, even after 12-15 minutes of sustained classroom activity. This may result in some students becoming bored or unchallenged at lower SPM levels or some students being required to work at vigorous levels at higher SPM levels. In either case, the students' time would be much better spent at the pace that is more fitting for them.

In a mixed-gender physical education class of 50 students comprised of half boys and half girls, 54.5% of the class (43% of boys and 66% of girls) would be working at or above their threshold for moderate activity while working at 113 SPM or above. At 122 SPM or above this same class would have 72% (63% of boys and 81% of girls) of the class working at or above their threshold for moderate activity. Finally, at 131 SPM or above this class would have 91.5% (82% of boys, 100% of girls) of the class working at or above their threshold for moderate activity.

There are several factors to consider when deciding at which SPM level a class should work. Table 4 describes the distribution of participants below, in, or above their moderate training zone at each speed. At 5.64 km·h$^{-1}$, 53% of the boys are in their training zone and 77% of the girls are in their training zone for moderate physical activity, 65% of a class with an even number of boys and girls. A small percentage, 10%

of boys and 14% of girls, would be working above the threshold of their moderate training zone, and 37% of boys and 9% of girls would have yet to reach their threshold for moderate activity. While a higher speed might elicit more students working above their moderate physical activity threshold, a higher speed would also require 23% of boys and 55% of girls to work at a vigorous level, which would be difficult for these students to do over an extended period of time.

There may be a temptation to push all the students to the highest level in order to assure that as many students as possible are meeting the recommended intensity level, but teachers must use caution when aiming for a specific SPM level. The students who get their moderate physical activity primarily from physical education classes are often those who achieve their threshold for moderate activity at a slower speed. Forcing these students to work at such a high level for a sustained period of time could end up discouraging them from further physical activity. In essence, a major theme illustrated by this study is that the impact that individual differences have on intensity makes one-size-fits-all physical education ineffective. Technologies which assess activity intensity are most beneficial when they help each individual in finding what their own intensity levels feel like. SPM information can give pedometer users an objective measure which they can use to experience and identify what moderate physical activity feels like. Middle-school years are a time when many children are developing their own physical activity habits, so any experiences that offer information or understanding will help to refine their physical activity habits and will assist them in the creation of beneficial habits that will last into their future.

The world of public education is becoming more and more data driven. Use of SPM guidelines would give physical education teachers more of an opportunity to collect objective data that would allow them to evaluate the effectiveness of their lessons, as well as the activity habits of their students. Steps per minute information provides an objective way for teachers to get feedback for the class time activities, and it can show if teachers are meeting the objectives of Healthy People 2010 which call for half of student's physical education class time to be spent being active (U.S Department of Health and Human Services, 2000). This can be as easy as having all the students who had 1220 or more steps raise their hands after a 10 minute activity (122 SPM). Steps per minute information can be easily recorded at home by students and students can use this information to evaluate their physical activity habits outside of the classroom. Coupling the SPM guidelines with the kcal information will help pedometer users learn to balance physical activity habits (energy expenditure) to their eating habits (energy intake). This relationship is so important because it can result in excess weight or obesity when unbalanced.

Using an object lesson format, teachers could have the class pick a fast-food item that they enjoyed eating and having them estimate the amount of time at a given SPM level that it would take to use the kcals that were ingested with that food item. For example, a Big Mac from McDonald's has 540 calories (McDonald's USA, 2008). After having the students work at 122 SPM (232.55 kcal per hour), a teacher could point out that they would need to work at that level for 2 hours and 19 minutes if they wanted to use all the energy they ingested by eating a Big Mac. This kind of application can help students bridge the experiences of their physical education class with those they may encounter in the rest of their life.

Other health care professionals may also benefit from SPM guidelines by giving their clients specific SPM goals for their physical activities. Personal trainers or after-school coordinators could easily use SPM guidelines when determining the activity needs of their patrons by encouraging participation in and organizing activities that produce SPM levels high enough to obtain moderate physical activity intensity. Those who work in wellness promotion can use SPM guidelines with clients or with the general public in a manner that is user friendly and readily accessible. With pedometers becoming readily available, more cost effective and easier to use, SPM guidelines offer a less intimidating way to assess physical activity intensity levels than heart rate monitors, accelerometers, or $VO_2$ assessment.

Pedometer manufacturers are continually improving the pre-programmed capabilities of pedometers to meet the needs of users. Manufacturers are beginning to develop pedometers that will calculate and display SPM, length of time, number of bouts of continuous exercise, and kcal expenditure associated with your prescribed SPM range (*Walk4Life MVPA*, Walk4Life, Plainfield, IL). This added pedometer function would make calculating SPM much easier for users. Steps per minute data seem to be one solution that pedometer users can utilize in their efforts to assess the intensity of their physical activity.

This study was conducted in a controlled steady-state laboratory setting and may not be directly applied to a field setting. Steps per minute information is only applicable to specific bouts of activity and it is not applicable to longer timeframes which combine bouts of moderate activity with periods of inactivity or with more intense physical activity. This study was conducted using participants between the ages of 12 and 14 years and may not apply to younger or older individuals.

## Conclusion

This study adds to previous studies that explored ways to assess physical activity levels using SPM calculations. Because of the impact that individual differences have on each person's moderate physical activity level no specific SPM range can be confidently stated. For 12-14-year-old youth, boys and girls on average reached their moderate activity intensity threshold at 122 SPM and 115 SPM, respectively. At this SPM rate boys and girls expended 232.55 and 176.66 kcals per hour, respectively. These data were collected in a laboratory setting making additional research which explores these findings in a field setting necessary.

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Table 1

*Mean Stride Length (SL) in Meters and Standard Deviation (SD)*

| | Boys | | Girls | |
|---|---|---|---|---|
| | SL | SD | SL | SD |
| 4.0 $km \cdot h^{-1}$ | 0.67 | 0.08 | 0.66 | 0.06 |
| 4.8 $km \cdot h^{-1}$ | 0.71 | 0.05 | 0.70 | 0.04 |
| 5.64 $km \cdot h^{-1}$ | 0.77 | 0.04 | 0.75 | 0.03 |
| 6.42 $km \cdot h^{-1}$ | 0.82 | 0.05 | 0.80 | 0.03 |

Table 2

*Mean Heart Rate (HR) Beats per Minute, Steps per Minute (SPM), and Kilocalories (Kcal) Expended per Hour with Standard Deviation (SD)*

| | Boys | | | | | | Girls | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HR | SD | SPM | SD | Kcal | SD | HR | SD | SPM | SD | Kcal | SD |
| 4.0 km·h$^{-1}$ | 109 | 16 | 100 | 11 | 183.59 | 55.22 | 122 | 13 | 102 | 9 | 160.60 | 38.13 |
| 4.8 km·h$^{-1}$ | 118 | 18 | 113 | 7 | 201.95 | 60.74 | 128* | 12 | 115 | 6 | 176.66 | 41.94 |
| 5.64 km·h$^{-1}$ | 126* | 17 | 122 | 6 | 232.55 | 69.94 | 138 | 13 | 125 | 5 | 203.42 | 48.30 |
| 6.42 km·h$^{-1}$ | 136 | 20 | 131 | 8 | 305.98 | 92.03 | 151 | 15 | 133 | 6 | 267.67 | 63.55 |

*Note*: * Denotes initial level at which mean HR was higher than mean threshold of moderate physical activity zone. Mean moderate physical activity zone for boys was 121-146 BPM and 124-148 BPM for girls.

Table 3

*Percentage of Participants In or Above Moderate Physical Activity Zone*

| | Boys | | | | Girls | | | |
|---|---|---|---|---|---|---|---|---|
| | % Below | (N) | % In/Above | (N) | % Below | (N) | % In/Above | (N) |
| 4.0 $km \cdot h^{-1}$ | 76 | (37) | 24 | (12) | 55 | (24) | 45 | (20) |
| 4.8 $km \cdot h^{-1}$ | 57 | (28) | 43 | (21) | 34 | (15) | 66 | (29) |
| 5.64 $km \cdot h^{-1}$ | 37 | (18) | 63 | (31) | 9 | (4) | 81 | (40) |
| 6.42 $km \cdot h^{-1}$ | 18 | (9) | 82 | (40) | 0 | (0) | 100 | (44) |

*Note*: Participants working at levels higher than 59% of maximum heart rate were considered above their moderate physical activity zone.

Table 4

*Distribution of Participants Below, In, or Above Their Moderate Physical Activity Zone at Each Speed*

| | Boys | | | | | | Girls | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % Below | (N) | % In | (N) | % Above | (N) | % Below | (N) | % In | (N) | % Above | (N) |
| 4.0 km·h$^{-1}$ | 76 | (37) | 24 | (12) | 0 | (0) | 55 | (24) | 41 | (18) | 4 | (2) |
| 4.8 km·h$^{-1}$ | 57 | (18) | 37 | (18) | 6 | (3) | 35 | (15) | 61 | (27) | 4 | (2) |
| 5.64 km·h$^{-1}$ | 37 | (26) | 53 | (26) | 10 | (5) | 9 | (4) | 77 | (34) | 14 | (6) |
| 6.42 km·h$^{-1}$ | 18 | (29) | 59 | (29) | 23 | (11) | 0 | (0) | 45 | (20) | 55 | (24) |

*Note*: Participants working at levels lower than 40% of maximum heart rate were considered below their moderate physical activity zone. Those higher than 59% of maximum heart rate were considered above their moderate physical activity zone.

Appendix A

Prospectus

# Chapter 1

## Introduction

Recently the office of the Surgeon General of the United States of America has changed its emphasis from stopping smoking, which has been its focus for the past twenty years, to controlling obesity (U.S. Department of Health and Human Services, 2001). Obesity rates have reached epidemic status in the United States such that the cost to treat obesity ranks second only to that spent on tobacco use. Surgeon General Richard H. Carmona stated, “Because of the increasing rates of obesity, unhealthy eating habits, and physical inactivity, we may see the first generation that will be less healthy and have a shorter life expectancy than their parents” (Carmona, 2004, n.p.).

The Center for Disease Control and Prevention (CDC) reported that between the years of 1974 and 2003 the number of overweight children between 6 and 11 years old has increased from 4% to almost 19%. In that same time period, overweight adolescents (12-19 years old) have increased from 6% to over 17% (CDC, 2007b). These trends mirror those associated with adults over the same period of time. The National Health and Nutrition Examination Survey reported that the percentage of adults who were overweight (BMI > 25) rose from 56% in 1994 to over 66% in 2004 (CDC, 2007a).

One key component in the battle against childhood obesity is physical activity. The National Association for Sport and Physical Education (NASPE) has recommended that children participate in a minimum of 60 minutes of moderate to vigorous physical activity each day (NASPE, 2004). Physical education teachers are given the responsibility to contribute to their students’ 60 minutes of activity by planning for and assessing if each of their students is achieving enough moderate to vigorous activity to combat the effects associated with obesity. Physical educators should choose methods that students can easily use when they leave the class and are responsible for maintaining their own physically active lifestyle.

There are many ways to assess if an individual has accumulated the recommended guideline of 60 minutes of moderate to vigorous physical activity per day. Observation, heart rate monitors, accelerometers, and pedometers are all viable means whereby the amount and intensity of physical activity can be assessed. However when determining physical activity levels, only a few of these ways can provide objective, easily obtained, and easy to use data.

Current research is being conducted which is studying the relationship between steps/minute and exercise intensity. Guidelines which would allow users to infer exercise intensity from steps-per-minute data would make the use of pedometers comparable to heart rate monitors or accelerometers, yet users would still benefit from the low cost and ease of use that is customarily associated with pedometers. Some research has directly studied step frequency and its relationship to activity intensity. Tudor-Locke, Sisson, Collova, Lee, and Swan (2005) examined step frequency and its relationship to activity intensity and established means whereby activity intensity can be assessed using step frequency. Their study on adults compared the metabolic equivalent levels with steps/minute. They compared step counts measured by a pedometer with $VO_2$ measurements and heart beats per minute obtained using a heart rate monitor. With their results they created a scale where by intensity estimations could be made by calculating steps per minute and associating it with a prescribed intensity level. Vincent-Graser, Pangrazi, and Vincent (2007b) performed a similar study with elementary-aged children. They used a moderate to vigorous km/hr range and found the corresponding steps/minute associated with that range. Finally, Rowlands, Stone, and Eston (2007) investigated how walking and running speeds affected the reliability of step frequency data recorded by motion sensors.

The development of steps/minute guidelines pertaining to school-aged children would provide physical education teachers with ways to use pedometers as assessment tools relative to intensity levels in their physical education classes. Research in this area would also help teachers in plans to show students how to assess the intensity level of their activities outside of school. Pedometers used in this way can provide information for both students and teachers in order to determine if they are participating in physical activity that will help to curb the epidemic of obesity.

*Statement of the Problem*

National physical education standards call for 60 minutes of moderate to vigorous physical activity each day for our nation’s children, and determining the intensity level of an activity can be challenging. The purpose of this study is to determine the steps/minute associated with moderate physical activity in junior high students (12 - 14 years old).

*Operational Definitions*

Pedometer - A small electronic device that fastens to one’s waistband and counts steps during walking or running by detecting the vertical movement produced by each step (Beighle, Pangrazi, & Vincent, 2001).

Moderate Physical Activity - 40-59% of maximum heart rate using the Karvonen (Heart Rate Reserve) method (Whaley, 2006).

Vigorous Physical Activity - 60-84% of maximum heart rate using the Karvonen (Heart Rate Reserve) method (Whaley, 2006).

*Assumptions*

The study assumes that participants will be able to walk at their normal pace on a tread mill at 4.0, 4.8, 5.64, 6.42 and 7.24 km/hr.

*Delimitations*

This study will be delimited to

1. Seventh and eighth grade boys and girls ages 12-14 living in Utah County.
2. All students will come from the same school.

*Limitations*

Limitations of this study include

1. Intensity measurements taken in a laboratory setting may not be applicable in a field setting.
2. This convenience sample may not be representative of all 12-14-year-old children in this school or in other geographic locations.

*Significance*

Pedometers offer an inexpensive way for teachers and students to assess whether or not they are meeting basic physical activity guidelines recommended by NASPE. The current NASPE recommendations necessitate a subjective evaluation in order to classify physical activity as moderate to vigorous. Creating a scale using objective data (steps/minute) allows teachers and students to easily determine activity intensity levels and objectively gauge whether or not they have achieved the suggested level of activity.

# Chapter 2

# Review of Literature

*Rise of Obesity*

"Over the past 20 years, the rates of overweight people doubled in children and tripled in adolescents. Today nearly two out of every three American adults and 15% of American kids are overweight or obese. That's more than 9 million children—one in every seven kids—who are at increased risk of weight-related chronic diseases." (Carmona, 2004, n.p.)

The CDC (1997) indicated that the benefits of physical activity range from improving cardiovascular fitness, to flexibility, to increasing muscle strength and endurance. Physical activity can be part of the prescriptive indications for those suffering from obesity, diabetes, cancer, hypertension, and cardiovascular disease. Overall, physical activity is a key component to maintaining a healthy lifestyle.

Other organizations agree that physical activity is a necessity. The International Consensus Conference on Physical Activity Guidelines for Adolescents recommends that,

> All adolescents...be physically active daily, or nearly every day, as part of play, games, sports, work, transportation, recreation, physical education, or planned exercise, in the context of family, school, and community activities and that adolescents engage in three or more sessions per week of activities that last 20 minutes or more at a time and that require moderate to vigorous levels of exertion. (Sallis & Patrick, 1994, p. 302)

In 1996 the U.S. Department of Health and Human Services issued a report indicating that regular physical activity is associated with lowering overall mortality; decreasing the risk of cardiovascular disease, cancer, and non-insulin-dependent diabetes mellitus. Physical activity can also help relieve symptoms of depression and improve the overall health-related quality of life.

The CDC (2007b) reported that between the years of 1974 and 2003 the number of overweight children between 6-11 years old has increased from 4% to almost 19%. In that same time period, overweight adolescents (12-19 years old) have increased from 6% to over 17%. These trends mirror those associated with adults over the same period of time. The National Health and Nutrition Examination Survey reported that the percentage of adults who were overweight (BMI > 25) rose from 56% in 1994 to over 66% in 2004 (CDC, 2007a).

If these trends continue, the outlook for our progeny is very disheartening. The Surgeon General testified before the Subcommittee on Competition, Infrastructure, and Foreign Commerce, Science, and Transportation about the epidemic of childhood obesity. He stated that, "Because of the increasing rates of obesity, unhealthy eating habits, and physical inactivity, we may see the first generation that will be less healthy and have a shorter life expectancy than their parents" (Carmona, 2004, n.p.). This same report described two main areas to focus on in order to combat the rising obesity rates: diet and physical activity.

The current obesity trends for adults discussed earlier show that not only are parents having a hard time solving their children's obesity problem, but they can not even prevent their own drift toward obesity, either. Imagine a father or mother teaching their children about the importance of car maintenance, specifically about the process involved in changing the oil in the car. This parent may teach their children how often oil changes should take place, what consequences will occur if they fail to change the oil regularly, and the parent may even use the family car to show the child how to change the oil themselves. When this child is responsible for their own car they will be equipped with the knowledge and skill needed to ensure that their car runs efficiently.

When speaking of the importance of physical activity, the above scenario is absent. Participation in athletics and physical education classes will not ensure future participation in physical activity if these classes do not offer students the opportunity to learn how to apply physical activity concepts outside of school. Hortz and Petosa (2006) showed that empowering students with the knowledge needed so they can plan physical activity into their leisure time was effective in changing the students’ behavior outside of physical education classes. Without the knowledge and skill requisite to assess personal physical activity habits the current drift towards obesity will continue. Physical educators are uniquely suited to endow children with the tools needed to engage in a lifetime of physical activity.

The responsibility of today’s physical education teacher is very daunting. The nation is in the midst of a health epidemic and physical education teachers, along with the other community professionals, have been given the charge of solving the problem for the future generations. Because of the rising obesity rates, the requisite amount of physical activity for children has risen to 60 minutes of moderate to vigorous activity on most days of the week (Beighle & Pangrazi, 2006; Carmona, 2004; Corbin & Pangrazi, 2004). Physical education teachers are given the responsibility of not only planning for their students' 60 minutes of moderate to vigorous activity, but they must assess if each one of their students is achieving enough moderate to vigorous activity to combat the effects associated with obesity. Physical educators must also choose methods that students can easily use when they leave the class and are responsible for maintaining their own physically active lifestyle.

*Assessment*

Traditionally, physical education classes have served as participation classes where students receive credit for attendance rather than for learning. Physical educators are now embracing the need to assess student learning. This approach stresses that learning is occurring in the class, with students being regularly assessed to determine if concepts and skills are being internalized. Physical education classes of the past have produced adults who lack the skills and knowledge needed to produce a healthy and physically active life.

There are many different instruments current physical education teachers use to assess physical activity. Accelerometers, self-reported activity logs, heart rate monitoring, and pedometers are the most popular methods teachers use in their efforts to document labors made by students in their quest to maintain a healthy lifestyle (Beighle, Pangrazi, & Vincent, 2001).

*Accelerometers.* Accelerometers provide users the means to track their activity with exactness and detail. An accelerometer is a small device secured to an individual at the waistband. Sirard and Pate (2001) define accelerometry as using "piezoelectric transducers and microprocessors that convert recorded accelerations to a quantifiable digital signal referred to as 'counts'" (p. 445). Accelerometers are unique in that they have the potential to provide information on many different planes. This is useful to those who participate in activities that are not primarily performed in the vertical plane. Accelerometers may provide evaluative information for activities like weight lifting and cycling. Some accelerometers can also provide detailed information concerning activity times and patterns and they are an objective means to provide information about physical activity.

Disadvantages of accelerometers include the fact that they can be costly, especially for bargain hunting physical education programs. Much of the information is not easily accessible, as it is too detailed to view on the tool itself and must be viewed using computer technology. Because of the complicated method of extracting information from accelerometers, they can not provide immediate evaluative feedback concerning bouts of physical activity to individuals.

*Logs/journals.* Reports have shown that diary or activity-log type methods can be effective, but inadequacies may result from recall bias and over-inflation of results (even though it may be good-natured) which can skew the data collected (Tudor-Locke, 2001). Sidard and Pate (2001) report that activity logs can be a precise subjective tool for adults to assess physical activity, but their effectiveness with children and adolescents is limited.

*Heart rate monitors.* The use of heart rate monitors is an effective and reliable way to assess exercise intensity (Buck, 2002; Macfarlane, Lee, Ho, Chan, & Chan, 2006, Whaley, 2006). Heart rate telemetry monitors are also able to provide immediate and easily accessible feedback to users via a digital readout on a watch. Eston, Rowlands, and Ingledew (1998) studied children participating in various levels of activity and measured their activity intensity using pedometers, accelerometers, heart rate monitors, and scaled oxygen uptake ($sVo_2$). They found that heart rate telemetry correlated significantly with measures of $sVO_2$, pedometry, and accelerometry.

A key disadvantage of heart rate monitors is their cost. They are much more expensive than pedometers and concerns with durability and maintenance add to their cost as well. Heart rate monitors also require cleaning and maintenance, which can be a problem with adolescent physical education students. Heart rate monitors require a strap be placed on the skin around the chest. This can seem invasive to school-aged children, especially if they have to readjust the strap inside the classroom setting.

*Pedometers.* Pedometers are tools that primarily measure the number of steps taken, but many models also measure exercise time and distance traveled. Like an accelerometer, a pedometer is a small device secured to the user at the waistband and has a digital display for immediate feedback. The President's Council on Physical Fitness lists the uses for pedometers as,, a tracking device (continuously collecting current activity), a feedback tool (providing immediate information on activity level), and as an environmental cue (reminder to be active). Used in combination with record keeping (e.g., calendars or diaries of daily progress), pedometers may be used in an effective way to increase daily physical activity. (President's Council on Physical Fitness, 2002) Many studies have shown pedometers to be valid and reliable for both children and adults (Barfield, Rowe,

& Michael, 2004; Bassett, Ainsworth, Swartz, Strath, O'Brien, & King, 2000; Cardon & De Bourdeaudhuij, 2004; Freedson & Miller, 2000; Gretebeck & Montoye, 1992; Sirard & Pate, 2001).

Pedometers are inexpensive, easy to use, and provide users immediate and continuous feedback regarding their activity level (Beighle et al., 2001). The ease of use is important for those in the school setting because of the age of their students and because of the time constraints that they have in a classroom setting. Pedometers are a re-usable tool, which allows physical education teachers to use one classroom set for their entire student body. They also record data objectively which makes clear the challenging assessment of how hard a student is working. This is why pedometers appear to be the most effective tool available for physical education teachers to use in their promotion and assessment of the physical activity students need in order to sustain a healthy lifestyle.

There are some disadvantages to using pedometers. Pedometers are limited to ambulatory activities, which leaves them ineffective for activities like cycling, yoga, or weight training. Pedometers do not directly assess exercise intensity, especially over an extended period of time when periods of high intensity activity and low intensity activity are viewed together. Past recommendations have advised that pedometer use be coupled with other forms of assessment (journaling or diaries) in order to provide a clearer picture of physical activity habits.

*Steps/Minute Research*

Current research has investigated how users can garner intensity estimates from information provided by pedometers. Rowlands et al. (2007) studied the reliability of three different motion sensors, specifically the effect that speed increases had on these motion sensors. The study recorded observed step counts for 60 seconds and compared the counts with those recorded by a pedometer. They found that the pedometers they tested were reliable at walking speeds of 4 and 6 km/hr.

Tudor-Locke et al. (2005) compared step counts measured by a pedometer with $VO_2$ measurements and heart beats per minute obtained using a heart rate monitor. They compared the data collected with established activity levels that are based upon metabolic equivalent (MET) levels. With their research results they created a scale where by intensity estimations could be made by calculating steps/minute and associating it with a prescribed intensity level. Their scale determined that a moderate intensity level (3-5.99 METs) is achieved at 96-124 steps/minute for males and from 107-135 steps/minute for females. This research was performed on adults, thus; it may not be directly generalizable to children.

Stewart, Dennison, Kohl, and Doyle (2004) studied elementary aged children using pedometers, accelerometers, and a prescribed physical activity program called "Take 10!" The aim of their study was to show that the Take 10! Program provided participants with bouts of moderate to vigorous activity, using both accelerometer and pedometer information to do so. This study used steps/minute to assess intensity levels by correlating them with MET levels. Through this study of step frequency they determined the metabolic equivalents each grade level worked at during the Take 10! activities and they also used step counts to determine the kilocalories used during each activity session.

Beighle and Pangrazi (2006) used pedometers that measured both step counts and activity time to determine steps/minute. The focus of their study was using pedometers that tracked both step counts and activity time. They created an equation that used daily step counts and daily activity time to determine step frequency, or daily steps/minute. This information could be used to infer activity intensity, the higher the step frequency the higher the intensity. However, this study did not associate step frequency with established activity levels, which makes precise assessment of activity intensity difficult. Data was collected from a whole day's worth of activity, including down time and activity time, which limits the ability to assess the intensity of specific bouts of activity.

One promising study by Vincent-Graser et al. (2007b) researched step frequency in elementary-aged children. They showed that moderate activity was achieved by walking at 120-139 steps/minute for boys and 123-142 steps/minute for girls. This study used specific walking speeds that research has associated with moderate activity. By using an established moderate to vigorous level (4.8-6.4 km/hr) they were able to clearly establish a step frequency (120-140) that will allow elementary-aged children to achieve moderate activity. This research is limited to fifth and sixth grade students and only for specific bouts of activity.

*What Now?*

With the myriad of options that technology has provided, where do physical education teachers turn for a suitable method to objectively assess physical activity intensity? Pedometers seem to provide the best option for physical education teachers because of their low cost, durability, ease of use, and ability to give immediate feedback, but they do not measure intensity. Even so, pedometer use is a new practice and standards concerning pedometers are being debated. The Surgeon General has suggested that 10,000 steps per day is an appropriate standard and research has shown that benefits associated with moderate physical activity will occur for many people who take 10,000 steps per day (U.S. Department of Health and Human Services, 2001). On the contrary, other studies (Le Masurier, Sidman, & Corbin 2003; Tudor-Locke, 2001) have revealed that in some cases recording only the number of steps can be too ambiguous. This is the case for people who are at the extreme ends of the physical activity spectrum. One study showed that those who live a sedentary lifestyle can exercise at a very intense level and still not reach 10,000 steps, while others who are very active receive no cardiovascular benefit from 10,000 steps (Le Masurier et al., 2003; Tudor-Locke, 2001).

This discrepancy in research arises because there is no real accounting for intensity with the current pedometer guidelines. It is clear that data concerning simple step counts is too ambiguous and without some way to analyze the intensity level associated with these steps, pedometers are left with a major limitation.

Many of the pedometers on the market today have the ability to store and track variables such as stride length, distance traveled, and exercise time. Guidelines which would allow users to infer exercise intensity from steps/minute data would make use of pedometers comparable to heart rate monitors or accelerometers, yet users would still benefit from the low cost and ease of use that is customarily associated with pedometers. Physical education teachers have yet to benefit from research that would inform them of correlations between steps/minute rates and exercise intensity levels.

Steps/minute information via pedometers seems to be the answer for physical education teachers in their aim to help children reach the prescribed physical activity levels that contribute to a healthy lifestyle. This type of data have the potential to provide needed assessment in a form that is cost effective and feasible for use with the elevated number of students associated with school physical education classes. By providing teachers and students with a method of assessing intensity levels using a pedometer, researchers can take another step toward helping students develop the healthy lifestyles that have so devastatingly eluded them.

# Chapter 3

# Methods

## *Participants*

A convenience sample of ninety participants (45 girls, 45 boys) between the ages of 12 and 14 will be used for the study. All participants will be enrolled in 7th and 8th grade gender-specific physical education classes. Participants will be excluded if they have health problems that preclude them from walking at rates of 4.0, 4.8, 5.64, 6.42, and 7.24 km/hr. Students will be offered extra credit for their participation in the study. Those students, who choose not to, can not, or who are not allowed to participate will be offered the same amount of extra credit for completing an assignment which involves walking for 20 minutes with a pedometer and turning in a record of the number of steps they took and the distance that they traveled.

All participants will return an informed consent signed by their parent or legal guardian. A letter of collaboration to conduct the study will be obtained from the school, school district, and provided to the university institutional review board.

## *Instruments*

The Walk4Life LS-2505 pedometer (Walk4Life, Plainfield, IL) will be used in the study. Each pedometer used in the study will be calibrated using a validated “shake test” to ensure the pedometer is accurate (Vincent & Sidman, 2003). Researchers have reported the percent error for the shake test is <1% (President’s Council on Physical Fitness and Sports, 2002). Pedometers will be worn on the right side (mid-axillary line), attached to the waistband of pants or shorts (Vincent-Graser, Pangrazi, & Vincent, 2007a). This particular model of pedometer has been found to be accurate in both step count and in measurement of activity time (Beets, Patton, & Edwards, 2005). Participants will also wear a Polar Vantage (Polar Electro Inc., New Hyde Park, NY) heart rate monitor during each phase of testing. The Polar Vantage was compared to six other heart rate monitors and to heart rate results obtained from electrocardiogram (ECG) recordings. This study showed that at our test speeds, the heart rate monitor recorded the same heart rate data as the ECG, thus validating its ability to accurately monitor heart rate data. (Terbizan, Dolezal, & Albano, 2002)

The participants will walk on a treadmill that has been calibrated by measuring the belt length and counting revolutions for a specified period of time. Belt revolutions will be counted for a specified amount of time at our test speeds (4.0, 4.8, 5.64, 6.42, and 7.24 km/hr), and the accuracy of the speed control will be determined by computing the distance traveled using belt revolutions.

*Procedures*

Each participant will participate in two sessions. During the first session, resting heart rate and target heart rate range will be recorded. For descriptive purposes, each participant's gender, height, weight, stride length, and age will be recorded. Height and weight will be recorded using a Health-O-Meter L4-100 scale (Jarden Consumer Solutions, Rye, NY) , which has the ability to measure both height and weight. Calibration will occur by measuring a metal plate know to weight 5 lbs and comparing it to the weight readout on the scale. This calibration will occur before each session. Measurements will take place in a private room, with each participant's height being measured in inches via the height measurement function of the scale. Accurate height measurement will be ensured by comparing the height measurements of the scale to those found on a standard yard stick.

Height and weight will be used to determine the participant's Body Mass Index ($kg/m^2$), as per instructions described by the ACSM (Whaley, 2006). Stride length at each speed will also be determined by calculating the meters traveled divided by the steps/minute.

Participants will be instructed on application and proper placement of the chest strap used to measure heart rate. Each participant's privacy will be ensured by providing a private area where they can put on the heart rate monitoring equipment. All participants will be familiar with use of pedometers through prior use in their physical education classes.

Each participant will put on their own chest strap and corresponding watch and a researcher will check that the watch is reading the participants heart rate. Resting heart rate will be obtained by having the participants lay supine for 5 minutes on exercise mats placed on the ground. The participants will be asked to close their eyes and to refrain from talking for the entire 5 minutes, after which the researcher will read the resting heart rate from the watch prior to the participant getting up off the mat. Research has established 5 minutes of quiet rest time as an acceptable protocol when finding both resting heart rate levels and resting blood pressure levels (Chan, Spangler, Valcour, & Tudor-Locke, 2003).

In between session one and two the researcher will calculate each participant's target heart rate range for moderate intensity (40-59% of maximum heart rate) using the formula (Target heart rate range = ([heart rate $_{max}$-heart rate$_{rest}$] x percent intensity) + heart rate$_{rest}$) outlined by the American College of Sports Medicine (ACSM) (Whaley, 2006, p. 145).

Pedometer steps/min and heart rate data will be collected during the second research session. This session will occur between three and ten days after the initial research session occurred. Before participation, each participant will be screened to ensure they are experiencing normal health conditions. Any participants who are restricted from participating because of sickness or injury will be asked to return at a later date for testing. The participants will be instructed on pedometer placement and treadmill walking and allowed time to acclimatize to treadmill walking, including moving from the treadmill to the side rails at the slowest (4.0 km/h) and fastest (7.24 km/h) speeds.

Walking speeds were determined based on guidelines for adolescent physical activity, current research conducted concerning step frequency, and a pilot study conducted prior to the study for the benefit of research design. Tudor-Locke et al. (2005) used speeds of 4.8 and 6.4 km/hr, finding that these speeds resulted in moderate intensity levels in adults. Vincent-Graser et al. (2007b) conducted a study investigating elementary students' step frequency when performing moderate to vigorous activity and they found that "4.8, 5.6, and 6.4 km/hr represented a moderate to very brisk walk for these children" (p. 10). In an effort to start participants at the low end of their target heart rate range for moderate intensity the slowest speed will be 4.0 km/hr. Additionally, to ensure the participants reach the high end of their target heart rate range for moderate intensity the fastest speed will be 7.24 km/hr. Therefore, the test speeds for this study will be 4.0, 4.8, 5.64, 6.42, and 7.24 km/hr.

Walking tests will begin with the participant standing on the side rail of the treadmill with their pedometer reset to zero. When the treadmill has reached the prescribed speed (4.0, 4.8, 5.64, 6.42, or 7.24 km/hr), participants will step onto the treadmill belt from the side rail and walk for 3 minutes (ACSM recommended length of time to ensure a steady-state heart rate response) (Whaley, 2006). Participants will be given a verbal countdown of the final five seconds and then they will immediately step to the side rail. Pedometer step-count and steady-state heart rate will be recorded while the participant is standing on the side rail. Pedometers will be reset to zero and the process will be repeated for each of the test speeds. The recording phase for each speed will be limited to 30 seconds to ensure that the participant's heart rate does not drop to baseline levels.

*Design and Statistical Analysis*

Descriptive statistics concerning age, height, weight, BMI and stride length will be reported for each age group and for each gender. The steps/minute recorded at the speed in which the participant's heart rate entered the moderate heart rate range will be used to calculate a threshold for moderate steps/minute. The steps/minute recorded at the last speed in which the participants heart rate is still in the moderate heart rate range will be used to calculate an upper boundary for moderate steps/minute. The mean steps/minute for the threshold and the mean steps/minute for the upper boundary will be used to calculate a range of steps/minute that represent moderately intense walking for boys and girls.

A 2 (gender) by 2 (levels of intensity) ANOVA will be used to determine if significant differences exist between boys and girls steps/minute ranges.

An estimate of calories expended will be calculated in order to describe the energy expended by the participants while working at a moderate intensity level. The ACSM recommended formula will be used to calculate calories expended: kcals = $[(kg*VO_2)/1000]*5$ (Whaley, 2006, p.293). The mean calories expended for the threshold of moderate intensity and the mean calories expended describing the upper boundary of moderate intensity will be used to calculate a range of calories expended walking at moderate intensity in this population.

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