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Physical Activity Patterns in Missoula Youth

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PHYSICAL ACTIVITY PATTERNS IN MISSOULA YOUTH

by

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STATEMENT OF PROBLEM: Physical activity (PA) is a critical determinant of long term health and is necessary for the prevention of youth onset–adult diseases. It is recommended that all youth accumulate at least 60 min of moderate to vigorous physical activity (MVPA) most days of the week in bouts lasting at least 10 min. PURPOSE: To evaluate the PA patterns of Missoula youth in order to make better recommendations for PA interventions for a wellness policy. METHODS: 324 elementary and middle school students from 5 schools wore accelerometers on their wrists for 5 days. The data were converted to activity energy expenditure (AEE) and also evaluated for single min and bouts of activity lasting at least 10 min of MVPA daily, in- versus out-of-school, and during sport, physical education (PE), and recess. Grade and gender differences were also assessed. RESULTS: The data show better than national averages in daily min of MVPA, with 70% of all students meeting the recommendation in 10 min bouts. Students showed low levels of MVPA during PE, recess, and sport. Sport was responsible for the highest accumulation of MVPA, followed by recess and then PE in both 1 and 10 min bouts. There was a drop in MVPA in both genders as grade level increased (both in and out of school), with more MVPA in single and 10 min bouts occurring out of school than in school. Males showed higher levels of MVPA than females during PE in 1 min bouts, recess in 1 and 10 min bouts, and in school in 1 and 10 min bouts. When scaled for body weight, genders did not differ in AEE. CONCLUSIONS: These data suggest an overall healthy youth PA environment in Missoula. However, the 30% of students not meeting the recommendations for health in 10 min bouts are still of concern. Interventions could focus on encouraging slight increases of MVPA during PE, sport, and recess, especially at the middle school level. Increasing out of school MVPA is also necessary to make the biggest impact due to already overburdened school systems.

Keywords: accelerometers, children, students, exercise, recess, physical education, sport, academic performance

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CHAPTER ONE: STATEMENT OF THE PROBLEM

Problem Statement

The growing incidence of health problems related to obesity and inactivity have reached epidemic status in the United States. Coronary heart disease remains the leading cause of death in the United States and is responsible for close to half a million deaths per year. It is estimated that more than one third of all children and adolescents (>25 million) in the United States are overweight or obese. Low physical activity (PA) levels are prevalent in our children, leading to an increase in obese and overweight children and an accelerated atherosclerotic process in inactive youth that continues into adulthood. A high percent of obese children and adolescents go on to display characteristics of metabolic syndrome such as hypertension, low high density lipoprotein (HDL) cholesterol concentrations, high low density lipoprotein (LDL) cholesterol and triglyceride concentrations, and insulin resistance, which may lead to cardiovascular disease (CVD). Physically active lifestyles have been associated with decreased clustering of these risk factors for CVD that are presenting themselves in childhood and adolescence. Thus, it is vital to push for increased PA levels in children to promote the improvement of cardiovascular health of children and adults in the United States.

Introduction

This research utilized accelerometry to examine how many minutes per day Missoula, Montana 2nd through 8th grade students were spending in sedentary, light, moderate, and vigorous activity intensities and how many single minutes and minutes in 10 minute bouts they were spending in MVPA intensity. The distribution of PA intensity during PE, sport, and recess programs and in- versus out-of-school was evaluated. Total AEE was also examined. Furthermore, the researchers evaluated if activity patterns differed by grade level and gender. This study provided a broad "snapshot" of PA patterns across a portion of Missoula youth.

Research Hypotheses

The Centers for Disease Control and Prevention (CDC) and American Dietary Guidelines from 2005 currently recommend that children get 60+ minutes of MVPA per day, which research is now showing should be met in bouts of activity lasting at least 10 minutes. The researchers collected baseline descriptive data to evaluate the percentage of Missoula, Montana 2nd through 8th grade students whose accelerometer-determined PA met this recommendation in 10 minute bouts. The researchers hypothesized that the amount of MVPA would decline from elementary to middle school and that males would participate in more MVPA than females.

Significance of Study

Contrary to common beliefs, dramatic increases in the energy intake of American children have not been found in recent National Health and Nutrition Examination Surveys (NHANES), and therefore, caloric increases do not seem to play as large of a role in the increased prevalence of obesity (Troiano, Briefel, Carroll, & Bialostosky, 2000). Thus, the evidence points to a decrease in PA among American youth being primarily responsible for the obesity epidemic and the associated increases in type II diabetes, early onset of CVD, and other chronic diseases (Troiano et al., 2000). Only a modest amount of information is known about the PA status and patterns of youth in general, and before this study no information was known regarding Missoula youth. This study documented the PA levels in Missoula youth and made comparisons between local PA patterns and accepted national standards.

Rationale for Study

In the past, little was known regarding the PA status of Missoula County Public School (MCPS) students, or American youth in general, so it was not feasible to develop school or community-specific PA prescriptions. If it was determined through this baseline study that many MCPS students were below recommended levels of PA, the data may help officials assist in school-specific strategy development to implement additional PA into the daily school routine and out of school activity of students. This information may also help the health department to work with community members and organizations to increase the awareness of, and access to, PA for Missoula youth outside of school. This project was the first step in developing a long-term strategy to monitor and document changes in PA in the MCPS system. It will be carried out over multiple years as interventions are implemented to increase PA. Overall, the ultimate goals are for these implemented community-wide programs, both in and out of school, to improve health and wellness, reduce childhood development of adult-onset diseases, decrease body weight to healthy levels, and improve or maintain good academic performance.

Limitations

Accelerometers have been validated for children during steady state but not during free living conditions and thus may not accurately estimate energy expenditure during normal daily activity (Heil, 2006). They also do not accurately measure activities such as pushing or lifting objects, stair climbing, cycling, rowing, or resistance training (Puyau, Adolph, Vohra, & Butte, 2002). Accelerometers tend to overestimate energy expenditure for activities with a small force displacement ratio (jumping and running) and underestimate energy expenditure for activities with a large force displacement ratio (stair climbing and knee bends) (Puyau et al., 2002). Finally, lack of consensus on AEE cutpoints, which define the ranges between activity intensity levels, and methodology make it difficult to compare results to other studies (Heil, 2006). Even though activity monitors have limitations, they have been validated as an accurate mode of assessing intensity, frequency, time, and duration of movement in children (Heil, 2006; Puyau et al., 2002; Puyau, Adolph, Vohra, Zakeri, & Butte, 2004). The recent advances in activity monitors allow measurement of free-living activity for extended periods of time in an unobtrusive manor.

Delimitations

This research group examined a random sample from a voluntary pool of 2nd through 8th grade students in the MCPS system during the spring of 2007.

Definition of Terms

Abbreviation	Meaning	Definition
	Accelerometer	A device that measures human movement by ascribing counts (an arbitrary unit) to the amount of work a person is performing related to device acceleration.
AEE	Activity Energy Expenditure	The amount of energy expended during PA independent from energy expended at rest. AEE= Total Energy Expenditure – Basal Metabolic Rate
ANOVA	Analysis of Variance	A test of the statistical significance of the differences among the mean scores of 2 or more groups on 1 or more variables.
	Atherosclerosis	The build-up of a waxy plaque on the inside of blood vessels.
BMR	Basal Metabolic Rate	The metabolic rate at rest for a 24 hour period.
BMI	Body Mass Index	BMI=Weight (kilograms)/ Height (meters) ^{2} Provides a simple numeric measure of a person's “overweightness” or “thinness.” However, it is easily distorted by factors such as muscle mass, bone structure, etc.
CDC	Centers for Disease Control and Prevention	United States government organization that makes public health recommendations based on current research.
HDL	High Density Lipoprotein	A complex of lipids and proteins in approximately equal amounts that functions as a transporter of cholesterol in the blood. High levels are associated with a decreased risk of atherosclerosis and heart disease.
LDL	Low Density Lipoprotein	A complex of lipids and proteins, with greater amounts

		of lipid than protein, that transports cholesterol in the blood. High levels are associated with an increased risk of atherosclerosis and heart disease.
MCPS	Missoula County Public Schools	Missoula, Montana public school system.
METs	Metabolic Equivalents	A way to express work relative to the metabolic cost of being at rest. Ex. 3 METs would be an energy expenditure 3 times that of resting energy expenditure.
RMR	Resting Metabolic Rate	Similar to basal metabolic rate only measured under less strict conditions.
VCO_2	Volume of Carbon Dioxide	The amount of carbon dioxide expired in liters per minute.
VO_2	Volume of Oxygen	The amount of oxygen intake in liters per minute.

CHAPTER TWO: REVIEW OF LITERATURE

Health concerns of physical inactivity

Major health concerns in the United States are related to the prevention and treatment of chronic disease. The increase in CVD related to inactivity in children and adults is of great concern. Coronary heart disease is the leading cause of death in the United States, responsible for close to half a million deaths per year (Williams et al., 2002). The CDC stated that in 2000, 74% of adults failed to meet recommended guidelines for PA of moderate-intensity for 30 minutes most days of the week. Lack of adequate PA in children has contributed to childhood obesity, which has nearly tripled since the 1970s (Nader et al., 2006). It is now estimated that more than one third of all children and adolescents (>25 million) in the United States are overweight or obese. Results from recent NHANES surveys have not found a dramatic increase in the energy intake of American children (Troiano et al., 2000). Since childhood obesity is the result of a long lasting imbalance between energy intake and energy expenditure (Zahner et al., 2006), this evidence seems to point to a decrease in PA in American youth as being the primary cause for the increased prevalence of obesity (Troiano et al., 2000). There is growing evidence that supports the idea that the atherosclerotic process begins in youth (American Heart Association, 2007; McCrindle, 2006). A high percent of obese children and adolescents will go on to display characteristics of metabolic syndrome such as hypertension (high blood pressure), low HDL cholesterol concentrations, high LDL cholesterol and triglyceride concentrations, and insulin resistance (Facchini, Hua, Abbasi, & Reaven, 2001; Jiang, Srinivasan, & Webber, 1995; Reinehr, de Sousa, Toschke, &

Andler, 2006), which may lead to CVD, as shown by greater intima-media thickness (a marker for early atherosclerotic changes) in affected obese children (Reinehr, Kiess, de Sousa, Stoffel-Wagner, & Wunsch, 2006). Physically active lifestyles have been associated with decreased clustering of these risk factors for CVD that are presenting themselves in childhood and adolescence (Ribeiro et al., 2004; Williams et al., 2002). A meta-analysis by Kelley and Kelley (2007) determined that triglyceride levels decrease with aerobic exercise in obese and overweight children and adolescents, while decreases in LDL concentration were associated with increased training intensity. Reinehr, de Sousa, Toschke, and Andler (2006) were able to significantly reduce the body mass index (BMI) of obese children through an intervention program including exercise, nutrition education, and behavioral therapy. These obese children originally had significantly higher blood pressure, insulin resistance indices, insulin levels, triglycerides, and LDL cholesterol concentrations and lower HDL cholesterol concentrations than the normal weight children in the comparison group. In the obese children whose BMI were successfully reduced, blood pressure, triglycerides, LDL cholesterol, insulin, and insulin resistance indices improved significantly. The reduction of BMI and the accompanying improvements in CVD risk factors were sustained in a 1 year follow-up after the intervention program. Since youth PA behaviors often determine lifetime habits (Williams et al., 2002), early intervention is vital to increase our children's daily energy expenditure to promote improved cardiovascular health in youth and adults.

Current PA recommendations

The CDC and American Dietary Guidelines from 2005 recommend that children and adolescents participate in a minimum of 60 minutes per day of MVPA for health. In the past, it wasn't specific how exactly this recommendation should be met, and an accumulation of single minutes throughout the day was considered sufficient; however, current research shows that this recommendation should be met in bouts lasting at least 10 minutes that accumulate to the recommendation. For children, the National Institute of Diabetes and Digestive Kidney Diseases, which is a branch of the CDC, recommends meeting this recommendation in 5 or 10 minute bouts of MVPA. The National Association of Sport and Physical Education recommends bouts of at least 15 minutes of MVPA for children. The American Dietary Guidelines from 2005 and the American College of Sports Medicine recommend that adults meet their recommendation of 30 minutes of moderate-intensity activity most days of the week in 10+ minute bouts.

Academics and PA

Other than the numerous health benefits of adequate PA, it has been determined that one may also expect small academic benefits with increased PA. Shephard (1996) randomly assigned students to either a group that participated in a 50 minute PE class or a group that was not allowed to participate in PE class but had 50 minutes of additional academic time. No significant differences were found in short-term or long-term test scores in subject-specific or general standardized testing. This may suggest that the addition of the PE class improved the rate of learning. Raviv and Low (1990) tested the level and quality of student concentration before and after either PE or science class and found that it was not the subject matter but the time of day that was the main influence on concentration. This suggests the need for careful lesson planning and not the removal of PE classes in schools to increase student concentration. Ahamed, MacDonald, Reed, Naylor, Liu-Ambrose, and McKay (2007) found that there were no significant differences in test scores between students who participated in a school-based intervention program to increase PA and a control group of students who did not. This suggests that school-based PA does not compromise children's academic performance. PA may also be indirectly related to enhanced academic performance by improving physical health and self-esteem (Tremblay, Inman, & Willms, 2000).

A possible theory for why PA is beneficial for cognition is that it causes an acceleration of psychomotor development, which could provide a mechanism for the accelerated learning of academic skills. It is also possible that PA causes increased cerebral blood flow, greater arousal, changes in hormone levels, and enhanced nutrient intake (Shephard, 1997).

<u>Early intervention in schools</u>

Because the majority of American youth attend public school, implementation of frequent PA accompanied with fitness testing in our public schools could contribute to a reduction in the prevalence of overweight children and CVD. The CDC reported in 2006 that only 36% of high school students participated in 60+ minutes per day of MVPA for >5 of the last 7 days and that participation in PA declines strikingly as children age. Also, participation in organized athletics diminishes greatly after middle school (Williams et al., 2002). Tightening school budgets and changing curriculum priorities have contributed to the reduction in PA in children by deemphasizing PE programs (Williams et al., 2002). Research by Dale, Corbin, and Dale (2000) showed that when children were encouraged to be active by participating in recess and PE class at school, they also engaged in more PA after school compared to children who were not given the chance to participate in recess or PE class. Additionally, children now tend to walk or bicycle less and increasingly rely on cars or busses for transportation. Non-school outdoor play time and recreational activities have also diminished with an increase in the sedentary use of video games, television, and computers (Williams et al., 2002).

Pedometers

Monitoring PA is complex and difficult to accurately assess under free-living conditions. Two methods of objectively recording activity are to use motion sensors such as accelerometers or pedometers. Both monitors have been shown to be valid measures of PA assessment (Eston, Rowlands, & Ingledew, 1998). Pedometers are a less expensive option for measuring PA by counting the number of steps taken during a period of time; however, they do not provide as much information as accelerometers. Pedometers have been effectively used in school curriculums to increase PA (Oliver, Schofield, & McEvoy, 2006). In this intervention, researchers increased the students' knowledge of health and activity, and students also performed various physical activities related to what they were learning in the academic curriculum. The intervention was successful in increasing the least active students' PA levels. Tudor-Locke, Lee, Morgan, Beighle, and Pangranzi (2006) found that having 6th grade students wear pedometers was a feasible way to monitor PA. The authors also found that after wearing pedometers for 6 days, boys were more active than girls, and lunchtime PA represented the most important source of daily PA (15-16%) obtained during school hours for both girls and boys. Recess accounted for only 8-9% of PA, and PE class accounted for 8-11%. The authors also found that almost half of daily steps taken were attributable to after-school activities.

Accelerometers

Accelerometers were developed in response to the lack of self-report reliability, the intrusiveness of direct observation, and the complexity of heart rate monitoring (Puyau et al., 2002). They have been validated to accurately measure frequency, intensity, time, and duration of activity over extended periods of up to several weeks, using advanced, integrated circuitry and memory capacity (Puyau et al., 2002). Although there is not a universally accepted accelerometer brand used in all activity monitoring studies, there are brands that are more conducive to working with children in free-living conditions. Specifically, Mini Mitter Actical® accelerometers are small ($2.8 \times 2.7 \times 1.0 cm^3$), lightweight (17g), durable, waterproof, and noninvasive. Actical® accelerometers are also sensitive to movement frequencies in the 0.5-3.2 Hz range, which allows for detection of sedentary, as well as high-energy, movements. This reduced frequency, compared to other accelerometer models, minimizes the effect of undesirable noise impulses, which tend to skew energy expenditure results.

During movement, a raw acceleration signal is summed over a specific time interval, called an epoch, and translated into activity counts (AC), which are stored in the device's memory system. The counts are later converted, based on regression equations, algorithms, and activity intensity cutpoints from validation studies, into a value that represents some biological variable, such as AEE or oxygen consumption (VO_2) and/or analyzed for time spent at different intensity levels during PA.

Converting ACs to metabolic equivalents (METs), as many published equations have done in the past, is not as practical in children as converting counts to AEE (Heil, 2006; Puyau et al., 2002). AEE is the relative energy expenditure to perform a task above resting metabolism. METs are units that estimate the amount of oxygen used by the body during PA. METs express work relative to rest. For example, 3 METs would equal an energy expenditure 3 times greater than resting energy expenditure. Converting ACs to METs is less accurate in children because the conversion from METs to energy expenditure assumes adult population averages for basal and resting metabolic rates (BMR and RMR, respectively). In children, BMR and RMR can vary with age, maturation, body mass, and level of PA. For example, defining 1 MET as a VO_2 of 3.5 mL O_2/kg per minute, as is done in adults, is not accurate to use for children because children have higher RMR values. Using the adult value for children would significantly overestimate their energy expenditure. The higher energy cost of activity at younger ages has been attributed to this higher RMR, a higher stride frequency, and a less efficient economy of locomotion (Puyau et al., 2002).

Using AEE as the criterion for converting raw accelerometer counts to a useable variable is appropriate when the research examines obesity, heart disease risk factors, type 2 diabetes, or other metabolic risks because energy expenditure is theorized to be physiologically related to mechanisms of these chronic diseases (Freedson, Pober, & Janz, 2005). Analyzing time spent at different intensity levels during PA is appropriate as well because current public health guidelines for PA are expressed in terms of time spent above a particular intensity level. Specifically, the recommendation for children's daily PA is 60+ minutes of MVPA, thus accelerometry is useful in surveillance of adherence to these recommendations (Troiano, 2006). Another reason that MVPA is important to assess is because the majority of differential classification of moderate-intensity time during free-living happens between the moderate and vigorous categories, and differential classification between moderate-intensity and either light or sedentary PA is minimal (McClain, Sisson, & Tudor-Locke, 2007).

Actical® accelerometers are omnidirectional, which means they sense motion primarily in a single plane and less sensitively in the other planes. The single plane they are most sensitive to measuring is marked on the outside of the monitor by a blue arrow. Actical® accelerometers are specifically designed for measurement of whole body PA, which gives a more accurate representation of the complexity of human movements and the resulting AEE than uniaxial instruments, which only measure movement in a single plane. AEE is a function of body acceleration and the mass of the body displaced, so attachment of accelerometers to the center of body mass, where it is most sensitive to vertical movements of the torso, seems to be an optimal placement. A study by Puyau, Adolph, Vohra, Zakeri, and Butte (2004) determined that Actical® accelerometers were a valid mode of PA assessment in children when affixed above the iliac crest of the right hip. However, placement of the activity monitors at the hip cannot accurately detect the energy expenditure associated with upper body movements (Swartz et al., 2000). Investigators have also reported compliance problems with attaching the monitors to the hip in studies with children. Complaints ranged from discomfort to insecurity issues from being able to see the monitor through clothing.

A study by Heil (2006) validated the wrist as an accurate attachment point for the Mini Mitter Actical® in children. The researchers utilized portable indirect calorimetry systems to measure VO_2 and carbon dioxide production (VCO_2) related to Actical® ACs. The participants performed 10 activities, including sedentary activities to obtain RMR, housecleaning, and locomotion (walking or jogging). It is important to validate the accelerometers in children using a variety of activities, since no single regression equation accurately predicts energy expenditure for all activities (Puyau et al., 2004). After the simultaneous counts and VO_2 were obtained, regression methods were applied to determine the relationship between the 2 measures, and equations to predict AEE and cutpoints for a particular intensity of activity from the accelerometer counts were determined. This study was unique because it utilized 2 linear regression models; 1 for sitting and cleaning activities and 1 for locomotion because the relationship between AEE and ACs was different at the different activity intensities.

The regression equations that were determined from Heil's (2006) study incorporated demographic variables including age, weight, gender, and height. It is important to factor in these variables as they all influence the acceleration signal. For example, AEE is influenced by body mass, making the metabolic economy of movement higher in heavier children, so they expend more energy than their lighter peers at the same speed of movement. Also, the distance from the center of gravity, when the same positioning strategy is employed, influences the signal. The acceleration signal is greater when the accelerometer is further from the center of gravity, as it is in heavier children with more body fat. Even the interplay of stride length and step frequency influences the sensitivity of the acceleration signal so that at the same speed of movement, the signal is lower when step frequency is higher. To remedy these variables, the regression equations factor in age to serve as a proxy for maturity, while height and weight serve as a proxy for stride length and distance from the center of mass, respectively. Gender is factored in as well to remedy specific differences between the sexes.

Also, the relatively wide 95% prediction intervals for energy expenditure suggest that the accelerometers are best applied to groups rather than individuals when individual calibration is not feasible (Puyau et al., 2004). Heil (2006) also found considerable individual differences resulting in large standard deviations in the difference scores. This suggests that using regression equations to track individual PA levels rather than group PA levels may involve considerable error. It may be possible to correct for individual prediction outliers by designing a choreographed series of activities that calibrate a PA monitor to a specific person. However, this process is very time consuming, and at present, utilizing general regression equations seems more feasible.

Finally, activity bouts are a fairly new area of research. Trost et al. (2002) recommended defining a bout as ≥90% of counts in the bout being above the cut off value for the particular activity intensity. Ward, Evenson, and Vaughn (2005) recommended allowing for 1 to 2 minute interruptions anywhere in the bout to simulate acts such as stopping at a stoplight during a jog. If interruptions are not allowed, the number of bouts would be underrepresented.

CHAPTER THREE: METHODOLOGY

Overview

In this study, descriptive baseline data on PA patterns in MCPS 2^{nd} through 8^{th} grade students were collected. Student gender, age, height, weight, programmed activity and school times, and grade level were collected prior to activity monitoring. Randomly selected students from a volunteer pool wore Actical® accelerometers for 5 days. Subsequent data analysis allowed researchers to evaluate AEE and activity intensity patterns overall, during PE, recess, and sport, and in-school versus out-of-school. The Institutional Review Board (IRB) for Human Subject Research at The University of Montana approved this protocol.

Subjects

Three hundred and twenty four randomly selected students (130 males and 194 females) from a convenience sample from 5 Missoula, Montana elementary and middle schools participated in this study. Specifically, 33-36 students per week over a 12 week period were tested. Researchers did not include students who had any acute injuries that may have limited PA. Students with chronic illnesses or injuries were considered part of the population.

Procedures

Meetings and Recruitment

A pilot study with the faculty of the Missoula public schools that were willing to participate was conducted to demonstrate the noninvasiveness of the monitors and to familiarize the faculty with the research protocols. This was also used as a recruitment strategy, in hopes that the faculty would encourage students to participate. Meetings were held for the parents and faculty where researchers explained the procedures of the study and answered any questions related to monitoring PA in the students. Interested students and their parents were familiarized with the accelerometers and research protocols prior to data collection. Following all data collection, there was a follow-up meeting at each school to explain the findings, and individual participants received a report of their activity.

Forms

Interested students over the age of 10 signed their own consent forms, and parents of students, who were all younger than 18, signed assent forms prior to participating. Participants also completed a health screening and descriptive data questionnaire.

Descriptive Data Collection

We utilized a descriptive data questionnaire to gather information such as name, age, grade, and school the student attended. Students were asked for their sport times. Researchers determined the start and end time of each school day, PE, and recess from

Wednesday through Friday from school schedules, including special schedules such as early-out times on any of these days. Body mass was measured to the nearest 0.1 kg and height to the nearest 0.1 cm without shoes by the researchers prior to PA data collection.

Instrumentation

Accelerometers (Actical®-Mini Mitter Co., Inc., Bend, OR) were used to record PA. Actical® accelerometers were initialized using a serial port computer interface to store data in 1 minute epochs. On Tuesday mornings, accelerometers were attached to the dorsal side of the students' non-dominant wrist using a non-removable wrist band. The accelerometer was placed so that the blue arrow on the outside of the monitor pointed toward the elbow using the methods of Heil (2006). The Actical® accelerometers were worn for 5 days and started data collection on Tuesday evening at midnight after 8 to 14 hours of wearing the monitors. This delay in start time was done to reduce the collection of atypical PA routines. The students may have been curious about the monitors right after they were attached, possibly making them more likely to attempt to increase their activity early on.

Instructions

Students were instructed not to tamper with the devices during the data collection period and to go about their normal activities. Specifically, they were informed that the Actical® accelerometers were not supposed to be removed unless they were forced to take them off during an official sport game or practice or if they were causing them any pain or discomfort. However, those students without a full 5 days of data collection were excluded. They were instructed to wear the accelerometers until Monday morning, when their homeroom teachers would cut the wrist bands off.

Data Organization

The accelerometers were collected on Mondays and downloaded via a serial port computer interface. The raw data were then processed using Microsoft EXCEL©. The data were coded for each class and school.

Data Transformation

All accelerometer data were corrected for outliers using a double-pass smoothing spline developed in The University of Montana Exercise Physiology Laboratory. Heil's (2006) double regression equations were then utilized to convert AC data to AEE per kilogram body weight (kcal•min^{-1}•kg^{-1}). AEE was assumed constant at 0.01130 when $50 < AC < 900$ due to poor predictability of AEE during the light-intensity seated activities in Heil's study. The equation that predicted AEE when $900 \leq AC \leq 2{,}000$ during Heil's moderate-intensity cleaning activities was:

$$AEE = 0.01149 + (3.236E\text{-}5) \cdot AC$$

R^2=0.59, *SEE*=0.020, p<0.001

The equation that predicted AEE when AC ≥ 2,000 during Heil's locomotion activities was:

$$AEE = 0.03115 + (1.58E\text{-}5) \bullet AC$$

R^2=0.69, *SEE*=0.019, p<0.001

Note: *SEE* = standard error of estimate reported in kcal• min^{-1}• kg^{-1}.

AEE cutpoints defining sedentary and light, moderate, and vigorous activity were <0.05, 0.05 to <0.10, and ≥0.10 kcal•min^{-1}•kg^{-1}, respectively. MVPA was defined as an AEE of ≥0.05 kcal•min^{-1}•kg^{-1} (Heil, 2006; Puyau et al., 2002).

A 10 minute bout of MVPA was defined as at least 9 out of 10 minutes being above the intensity cutpoint for MVPA. An algorithm was developed to count appropriate minutes of MVPA intensity meeting the 10 minute guideline.

Statistical Analyses

The data were evaluated for single minutes and 10 minute bouts of MVPA daily, in-school versus out-of-school, and during recess, PE, and sport. Total AEE was also determined and scaled for body weight. Data were further separated by grade and gender. Time spent sleeping during the night was eliminated, and researchers only examined the portion of the day from when students awoke in the morning until their bedtime. Data were then analyzed using univariate and 2-way analysis of variance (ANOVA) designs for all comparisons except in- versus out-of-school single minutes and

10 minute bouts of MVPA, which required a mixed design (time x group) repeated measures ANOVA. Analyses were performed using SPSS software, and p values ≤ 0.05 were considered significant.

Physical Activity Patterns in Grades 2-12 in a Rural Western Montana Town

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Running Title: Physical Activity Patterns in Grades 2-12

Youth physical activity (PA) is a critical determinant of long term health and is necessary for the prevention of youth onset–adult diseases. **PURPOSE:** To evaluate youth PA patterns prior to intervention recommendations for a wellness policy. **METHODS:** 533 students from 8 schools, grades 2 through 12, wore accelerometers on their wrists for 5 days. The data were converted to activity energy expenditure (AEE) and evaluated for single minutes (min) of vigorous physical activity (VPA) and both single and 10 min bouts of moderate to vigorous physical activity (MVPA) daily, in- vs. out-of-school, and during sport, physical education (PE), and recess. Grade point average (GPA), absences, grade level, and gender differences were also assessed. **RESULTS:** Overall, 46.5% of students met the PA recommendation for health of 60+ min in 10 min bouts most days of the week, and 15.8% of students met the recommendation for fitness of 20+ min of VPA on any 2 of 5 days monitored. There was a significant decline in MVPA across genders with increasing grade level. MVPA during PE, recess, and sport was low for both genders across all grade levels. When scaled for body weight, AEE dropped 50% from elementary to high school (19.77±.4 to 9.86±.23 $kcal \cdot day^{-1} \cdot kg^{-1}$). **CONCLUSIONS:** These data suggest a need for interventions to focus on increasing PA levels of middle and high school students in the Missoula, MT area. Encouraging slight increases in MVPA during PE, sport, and recess and increasing out of school PA is critical to reduce the risk of chronic diseases of adulthood.

Keywords: accelerometers, children, students, exercise, recess, physical education

INTRODUCTION

Paragraph Number 1 The growing incidence of health problems related to obesity and inactivity has reached epidemic status in the United States. Coronary heart disease is the leading cause of death in the United States, responsible for close to half a million deaths per year (Williams et al., 2002). Low PA levels are prevalent in children, leading to an increase in obese and overweight children and an accelerated atherosclerotic process in inactive youth that continues into adulthood (American Heart Association, 2007; McCrindle, 2006). A high percent of obese children and adolescents will go on to display characteristics of metabolic syndrome such as hypertension, low HDL cholesterol concentrations, high LDL cholesterol and triglyceride concentrations, and insulin resistance (Facchini et al., 2001; Jiang et al., 1995; Reinehr et al., 2006), which may lead to CVD, as shown by greater intima-media thickness (a marker for early atherosclerotic changes) in affected obese children (Reinehr, Kiess et al., 2006). Physically active lifestyles have been associated with decreased clustering of these risk factors for CVD (Kelley & Kelley, 2007; Reinehr et al., 2006; Ribeiro et al., 2004; Williams et al., 2002). Thus, it is vital to push for increased PA levels in children to promote the improvement of cardiovascular health of children and adults in the United States.

Paragraph Number 2 This research utilized accelerometry to provide a broad "snapshot" of PA patterns across a portion of elementary through high school students in a rural Western Montana town. Missoula, Montana is considered a physically active community with access to many outdoor recreational opportunities. These data may help both to assist in school-specific strategy development to implement additional PA into the daily school routine and to increase out of school youth activity. This information can be utilized by the health department to work with community members and organizations to increase the awareness of, and access to, PA for Missoula youth. This project was the first step in developing a long-term strategy to monitor and document changes in PA of students in the Missoula school system. It will be carried out over multiple years as interventions are implemented to increase PA. Overall, the ultimate goals are for these implemented community-wide programs, both in and out of school, to improve health and wellness, reduce childhood development of adult-onset diseases, decrease body weight to healthy levels, and improve or maintain good academic performance.

Paragraph Number 3 **PA Recommendations.** The Centers for Disease Control and Prevention (CDC) and American Dietary Guidelines from 2005 recommend that children and adolescents participate in a minimum of 60 minutes per day of MVPA. The recommendation for fitness is 20+ minutes of VPA at least 3 days per week. In the past, it wasn't specific how exactly the 60+ minute recommendation should be met, and an accumulation of single minutes throughout the day was considered sufficient; however, current research shows that this recommendation should be met in bouts lasting at least 10 minutes that accumulate to the 60+ minute total (National Association for Sport and Physical Education, 2003; National Institute of Diabetes and Digestive and Kidney Diseases, 2004).

Paragraph Number 4 **Academics and PA.** Other than the numerous health benefits of adequate PA, it has been determined that one may also expect small academic benefits with increased PA due to an improved rate of learning (Shephard, 1996). PA may also be indirectly related to enhanced academic performance by improving physical health and self-esteem (Tremblay et al., 2000). Other studies have shown that although increased

PA did not improve academic performance, it did not have a negative impact on academic scores (Ahamed et al., 2007) or concentration levels (Raviv & Low, 1990).

Paragraph Number 5 **Hypotheses.** The researchers hypothesized that the amount of MVPA would decline as a continuum from elementary to high school and that males would participate in more MVPA and VPA than females.

METHODS

Paragraph Number 6 **Overview.** In this study, descriptive baseline data on PA patterns of 2nd through 12th grade students were collected. Student gender, age, height, weight, grade level, and start and end times for the school day, PE, recess, and sport were collected prior to activity monitoring. The school districts later provided GPA and absentee data for participating students. Randomly selected students from a volunteer pool wore Actical® accelerometers for 5 days with data collection starting Wednesday morning at 00:01 and ending at midnight, 24:00, the following Sunday. Subsequent data analyses were completed to evaluate activity intensity patterns overall, during PE, recess, and sport, and in-school versus out-of-school. Minutes of MVPA in 10 minute bouts and single minutes of VPA were of particular interest so adherence to PA recommendations could be determined. Daily AEE scaled for body weight was calculated, and GPA and absences in relation to MVPA were examined. Furthermore, the researchers evaluated if activity patterns differed by BMI, grade level, and gender.

Paragraph Number 7 **Subjects.** Five hundred and thirty three students were randomly selected from a volunteer pool from 8 Missoula, Montana elementary, middle, and high schools. Researchers did not include students who had any acute injuries that may have limited PA. Students with chronic illnesses or injuries were considered part of the population, although this was not kept track of. All parents signed an assent form, and all students gave informed consent approved by the Institutional Review Board (IRB) for Human Subject Research at The University of Montana.

Paragraph Number 8 **Descriptive Data Collection.** The researchers utilized a descriptive data questionnaire to gather information such as age, grade, and gender. Students were asked for their sport times if they played a school or community sponsored sport during the monitoring week. Researchers determined the start and end time of each school day and PE and recess periods on Wednesday through Friday from school schedules, including special schedules such as early-out times on any of these days. School administrators of participating districts later shared GPA and absence data for students in this study. Body mass was measured to the nearest 0.1 kg and height to the nearest 0.1 cm without shoes by the researchers prior to PA data collection.

Paragraph Number 9 **Instrumentation.** Accelerometers have been validated to accurately measure frequency, intensity, time, and duration of activity over extended periods of up to several weeks (Puyau et al., 2002). Specifically, a study by Heil in 2006 validated the wrist as an accurate attachment point for the Mini Mitter Actical® accelerometer in children.

Paragraph Number 10 During movement, a raw acceleration signal is summed over a specific time interval, called an epoch, and translated into activity counts (AC), which are stored in the device's memory system. The counts are later converted, based on regression equations, algorithms, and activity intensity cutpoints from validation studies, into a value that represents some biological variable, such as AEE, and/or analyzed for time spent at different intensity levels during PA.

Paragraph Number 11 Actical® accelerometers (Actical®-Mini Mitter Co., Inc., Bend, OR) were used to measure PA and were initialized to store data in 1 minute epochs. On Tuesday mornings, accelerometers were attached to the dorsal side of the students' non-dominant wrist using a non-removable wrist band. The accelerometer was placed such that the blue arrow on the outside of the monitor pointed toward the elbow using the methods of Heil (2006). The activity data collection started on Tuesday evening at midnight after 8 to 14 hours of wearing the monitors and continued until the following Sunday evening at midnight. This delay in start time was done to reduce the collection of atypical PA routines.

Paragraph Number 12 **Instructions.** Students were instructed not to tamper with the devices during the data collection period and to go about their normal activities. Specifically, they were informed that the accelerometers were not supposed to be removed unless they were required to take them off during an official sport game or practice or if they were causing them any pain or discomfort. However, those students without a full 5 days of data collection were excluded.

Paragraph Number 13 **Data Organization.** The accelerometers were collected on Mondays, and the data were downloaded. The raw data were coded for each class and school and stored in a master data set using Microsoft EXCEL©.

Paragraph Number 14 **Data Transformation.** All accelerometer data were corrected for individual minute data greater than 100% above the average 8 minutes either before or after the 4 minutes to each side using a double-pass smoothing spline developed at The University of Montana Exercise Physiology Laboratory. This was done to correct for single minutes of exaggerated high hand movement. The double regression equations of

Heil (2006) were then utilized to convert AC data to AEE adjusted for body weight (kcal·min^{-1}·kg^{-1}). (See Table 1 for AC to AEE conversion equations.)

Paragraph Number 15 AEE cutpoints defining sedentary and light, moderate, and vigorous activity used for this analysis were <0.05, 0.05 to <0.10, and ≥0.10 kcal·min^{-1}·kg^{-1}, respectively. MVPA was defined as an AEE of ≥0.05 kcal·min^{-1}·kg^{-1} (Heil, 2006; Puyau et al., 2002).

Paragraph Number 16 Activity bouts are a fairly new area of research. Recommendations for defining bouts of activity seem to consistently agree on allowing for a 1 minute interruption anywhere in the bout to simulate acts such as stopping at a stoplight during a jog (Trost et al., 2002; Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005). If interruptions are not allowed, the number of bouts would be underrepresented. Thus, the researchers defined a 10 minute bout of MVPA as at least 9 out of 10 minutes being above the intensity cutpoint for MVPA. An algorithm was developed to count minutes of MVPA meeting the 10 minute guideline.

Paragraph Number 17 **Statistical Analyses.** The data were evaluated for single minutes and minutes in 10 minute bouts of MVPA daily, in-school versus out-of-school, and during recess, PE, and sport. VPA was examined only in 1 minute bouts. Data were further separated by BMI category, grade, and gender. Within each grade, students were separated into the lowest, middle, and highest third of daily minutes of MVPA occurring in 10 minute bouts. GPA and absences were then averaged within each grade for each tertile of MVPA. Data were analyzed using univariate and 2-way analysis of variance (ANOVA) designs for all comparisons except in- versus out-of-school MVPA, which required a mixed design (time x group), repeated measures ANOVA. Data are reported as mean ± standard error. Analyses were performed using SPSS software, and p values ≤0.05 were considered significant.

RESULTS

Paragraph Number 18 **Adherence to Recommendations.** (See Table 2 for descriptive information.) (Note: MVPA in 1 minute bouts only reported in graphs for comparison to other papers.) With all grade levels combined, 46.5% of students met the PA recommendation for health of 60+ minutes of MVPA, and 15.8% met the recommendation for fitness of 20+ minutes of VPA on any 2 of the 5 day monitoring period. When broken down by grade level, most elementary students met the 60+ minute PA health recommendation, with no grade level falling below the 2nd grade average of 70.4% of students meeting the health recommendation. Middle schools students were less active, with 8th grade being lowest in PA with only 52.3% of students meeting the recommendation. High school students were least active. No 11th grade students out of the 44 monitored met the health recommendation. (See Table 3 for percentages of students meeting recommendations by grade level.)

Paragraph Number 19 **Daily MVPA and VPA.** Grades 2 through 4 showed higher levels of MVPA than grades 8 through 12, with the greatest decrease in MVPA occurring between 8th and 9th grades. High school students had lower VPA than 2nd through 6th graders. There was no overall significant difference between genders for minutes of MVPA; however, males averaged significantly higher VPA than did females (males= 10.99±1.11, females= 5.78±.52 minutes·day^{-1}, $p<0.001$). (See Figure 1.)

Paragraph Number 20 **In versus Out-of-School.** Across all grades, out-of-school MVPA was significantly higher than during scheduled school hours (out-of-school=

53.1±1.2 minutes·day^{-1}, in-school= 34.9±2.1 minutes·day^{-1}, $p<0.001$). There were significant decreases ($p<0.001$) from elementary to middle school and from middle to high school both in and out of school. (See Figure 2.)

Paragraph Number 21 **Recess.** Recess, PE, and sport data are expressed as minutes of activity per 30 minutes of recess, PE, or sport to standardize across students. There was a significant decrease in MVPA during recess from elementary to middle school and from middle to high school ($p<0.001$). Males had significantly higher MVPA during recess than females (6.3±.42 and 3.4±.28 minutes, respectively, $p<0.001$). (See Figure 3a.)

Paragraph Number 22 **PE.** Elementary and middle school students accumulated more MVPA per 30 minutes than high school students during PE ($p\leq0.002$). Genders did not differ. (See Figure 3b.)

Paragraph Number 23 **Sport.** There were significant decreases in MVPA during sport from elementary to high school and from middle to high school ($p\leq0.008$). Genders did not differ significantly in minutes of MVPA per 30 minutes of reported sport time. (See Figure 3c.)

Paragraph Number 24 **GPA.** Within each grade, students were separated into the lowest, middle, and highest third of daily minutes of MVPA. GPA was then averaged across all grades for each tertile of MVPA. There was a significant increase ($p<0.001$) in GPA from students in the lowest (GPA=2.7±.03) to middle (GPA=3.1±.04) and highest (GPA= 3.1±.04) PA tertiles. (See Figure 4.)

Paragraph Number 25 **Absences.** The number of days missed, prorated for the entire school year, were also averaged across all grades for each tertile of MVPA. There was a significant decrease ($p<0.001$) in number of absences from students in the lowest

(6.99±.42 days) to middle (3.9±2.5 days) and highest (3.34±.25 days) PA tertiles. (See Figure 5.)

Paragraph Number 26 **AEE.** AEE was standardized as kcal·day^{-1}·kg^{-1}. There were significant ($p<0.001$) AEE declines from 19.77±.4 in elementary school to 15.1±.45 in middle school to 9.86±0.23 kcal·day^{-1}·kg^{-1} in high school when combining both genders. Across all grade levels, males expended significantly ($p=0.016$) more kcal in daily AEE per kg than did females at 15.78±.47 and 14.32±.34 kcal·day^{-1}·kg^{-1}, respectively. (See Figure 6.)

DISCUSSION

Paragraph Number 27 With all grade levels combined, only 46.5% of the students met the recommendation for health of 60+ minutes in bouts of MVPA, and only 15.8% met the recommendation for fitness of 20+ minutes of VPA on any 2 of the 5 day monitoring period; however, when broken down by school level, there was a large drop in students meeting recommendations from elementary to middle to high school. Elementary students, on average, did very well, while only a little over half of middle school students and very few high school students met the recommendations.

Paragraph Number 28 The decrease in MVPA and VPA from elementary to middle to high school is similar to the findings of Trost et al. (2002) that there is a decrease in PA as children age. Similar to the findings of Ridgers, Stratton, and Fairclough (2004), males were more active than females during recess. Males also had higher AEE scaled by body weight. Unlike the findings of Trost et al. (2002), there was no difference between genders in daily MVPA. Our data also show no difference between genders for

PE, which was similar to the findings of a study by Tudor-Locke, Lee, Morgan, Beighle, & Pangranzi (2006). We also found no gender difference in sport.

Paragraph Number 29 Students who were the most active had the highest GPAs. This does not denote cause and effect but suggests a relationship between PA and higher academic performance, which is in agreement with other studies (Shephard, 1996; Tremblay et al., 2000). Although MVPA may not have a large influence on improving academic achievement directly, it may indirectly affect it by having a positive influence on factors such as health, well-being, fitness, and self esteem. The most active students also had the least school absences, which could also factor into improved GPA.

Paragraph Number 30 Distribution of MVPA during PE, recess/lunch, and sport was low across all grades and both genders. In both genders combined, for every 30 minutes of participation, sport had the highest accumulation of MVPA (13.5±.8 min), followed by PE (4.9±.38 min) and then recess/lunch (4.5±.24 min). Ninety eight percent of the students participated in recess/lunch during the week they were monitored, compared to 84% in PE and only 22% in sport.

Paragraph Number 31 These data show that, in general, Missoula youth PA patterns are following the national trend for inactivity. Approximately 53.5% of the students in this study did not meet the 60+ minutes of daily MVPA recommendation for health in 10 minute bouts, with significant decreases from elementary through middle and high school. Based on these data, interventions are being developed to increase PA in the schools and community of Missoula in these groups of youth who did not meet the health recommendations and are at greatest risk for future chronic disease. Encouraging small increases in the amount of MVPA and VPA students get within PE and recess/lunch is recommended, along with encouraging more sport participation since sport was the most effective time period for accumulating MVPA. Increasing out of school PA is also recommended. Specifically, interventions should focus on middle and high school students.

Paragraph Number 32 Limitations to this study were that it was difficult to accurately assess sport time because the children were often unsure of their exact practice or game time. To remedy this, the researchers only included the sport times that showed increased activity and appeared accurate. It was also questionable whether or not some of the PE and recess/lunch times were accurate because some children showed no increased activity during those time slots. For PE and recess/lunch, the researchers included times with no increased activity in with our data because it may be an accurate representation of what children actually do in recess/lunch and PE. For example, some days in PE they could be watching a video rather than being active. Many students are inactive during recess rather than participating in games or play. We did not want to bias the study by eliminating these sedentary times from our PE and recess/lunch data and felt these times should be more accurate as they were the scheduled times reported by official school schedules and confirmed by teachers rather than the students' recall used to determine sports times.

Paragraph Number 33 In-season high school varsity athletes for football, soccer, basketball, and wrestling were excluded due to official rules not allowing "jewelry" to be worn during competition. This limited the collection of sport and PA data from high school students.

Paragraph Number 34 The Actical® validation study by Heil (2006) utilized children from ages 8 through 17, and some of our students were 18 years old. Although 18 year olds were not within Heil's age range, they are still considered adolescents; and therefore, we chose to analyze their activity data using the same algorithms and AEE conversion formulas. Furthermore, adult regression formulas tend to reduce the AEE for measured counts over youth formulas. This would have further decreased the already low high school MVPA and VPA values.

Paragraph Number 35 Although we feel it was necessary to filter the AC data to eliminate exaggerated high hand movement, this method could also have eliminated some single minutes of VPA. This may have also further decreased the already low VPA values.

Paragraph Number 36 We feel confident that these data are an accurate representation of PA patterns in this youth cohort. We further believe that this cohort was a representative cross section of Missoula youth. Our BMI data show that at risk of overweight and overweight percentages in this population were similar to that reported for Missoula and Montana youth. Finally, the schools monitored represent both a geographical and socio-economical sample of Missoula's youth. These baseline data are proving to be a valuable baseline measure of youth PA interventions in Missoula youth.

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Table 1. Algorithms for predicting AEE.		
$50 < AC < 900$	$900 \leq AC < 2{,}000$	$AC \geq 2{,}000$
AEE= 0.0113	AEE= 0.01149 + (3.236E-5) x AC (R^2= 0.59, SEE= 0.020, $p<0.001$)	AEE= 0.03115 + (1.581E-5) x AC (R^2= 0.69, SEE= 0.019, $p<0.001$)

Note: SEE = standard error of estimate reported in $kcal \cdot min^{-1} \cdot kg^{-1}$.

Table 2. Descriptive Information: Mean (SD)

Characteristic	All (N=533)	Boys (N=201)	Girls (N=332)
Mean Age (years)	12.4 (3.1)	12.1 (3.1)	12.6 (3.1)
Age range (years)	7-18	7-17	7-18
Mean BMI (kg/m^2)	21.3 (5.8)	20.6 (5.3)	21.7 (6.1)
Mean Height (cm)	153.7 (15.5)	155.7 (17.9)	152.4 (13.7)
Mean BMI Age-Adjusted Percentile	66.6 (28.6)	65.6 (27.2)	67.3 (29.4)
Mean Weight (kg)	51.5 (18.8)	51.3 (19.3)	51.6 (18.5)

Note: Mean BMI Age-Adjusted Percentile >95=overweight; 85-95=at risk of overweight

Table 3. Percent of students overall and in each grade meeting physical activity guidelines for health (10+ min bouts) and fitness.

Grade Level	**Number of students monitored**	**Percent of students meeting health guidelines of >60min MVPA**	**Percent of students meeting fitness guidelines of >20min VPA**
2	54	70.4%	37.0%
3	59	76.3%	18.6%
4	62	80.6%	37.1%
5	34	88.2%	26.5%
6	33	57.6%	21.2%
7	38	57.9%	7.9%
8	44	52.3%	6.8%
9	43	23.3%	4.7%
10	72	15.3%	0.0%
11	44	0.0%	2.3%
12	50	2.0%	0.0%
ALL	**533**	**46.5%**	**15.8%**

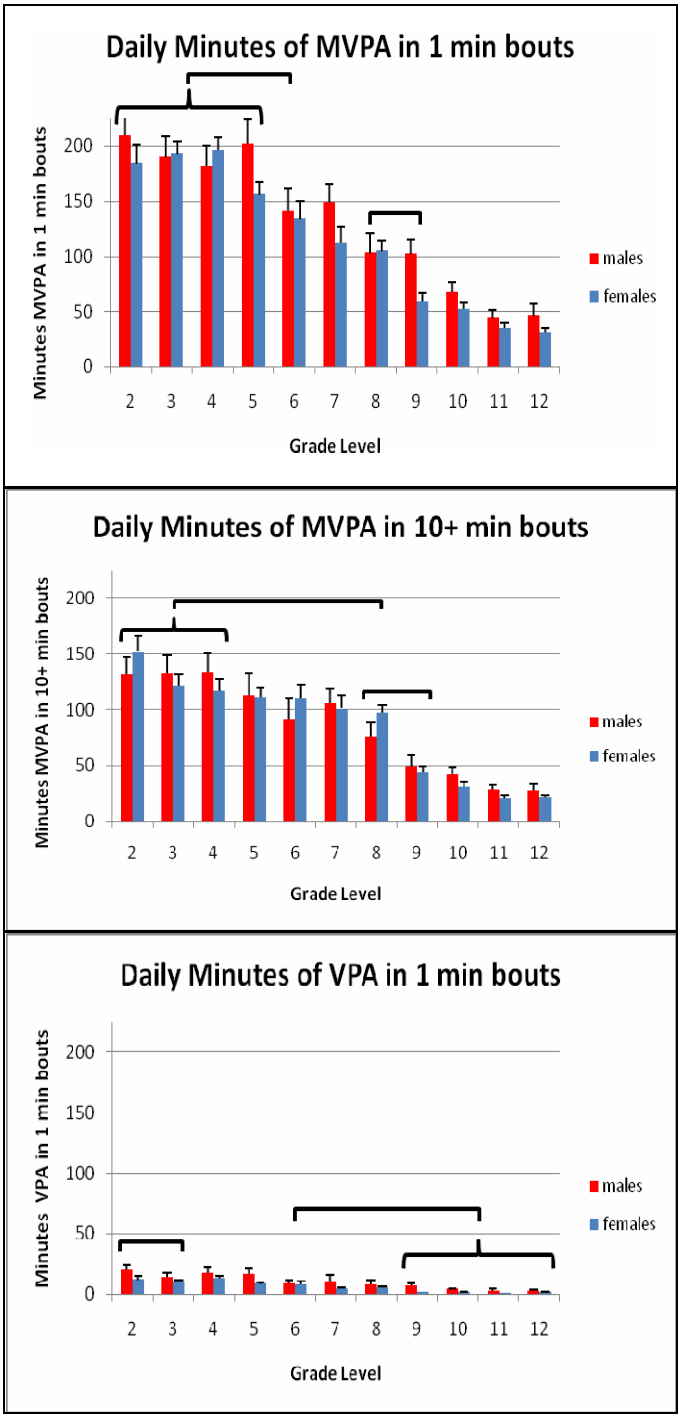

Figure 1a*, 1b, and 1c*.** The change across student grade level in min of MVPA and VPA accumulated during activity lasting 1 min* and at least 10 min**. Horizontal bars show significant decreases in MVPA or VPA ($p<0.05$) between grades, and horizontal brackets group grades with no significant differences (males and females combined). Vertical bars are standard error (SE).

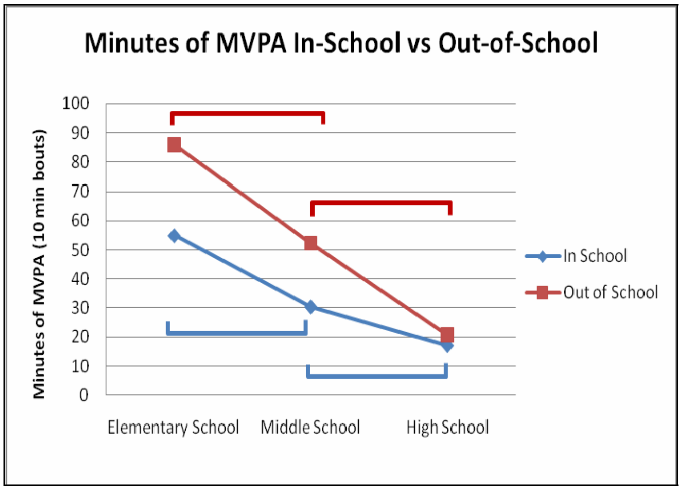

Figure 2. The change across school level in min of MVPA in and out of school accumulated during activity lasting at least 10 min. Horizontal bars represent significant decreases from elementary to middle school and from middle to high school both in and out of school ($p<0.001$).

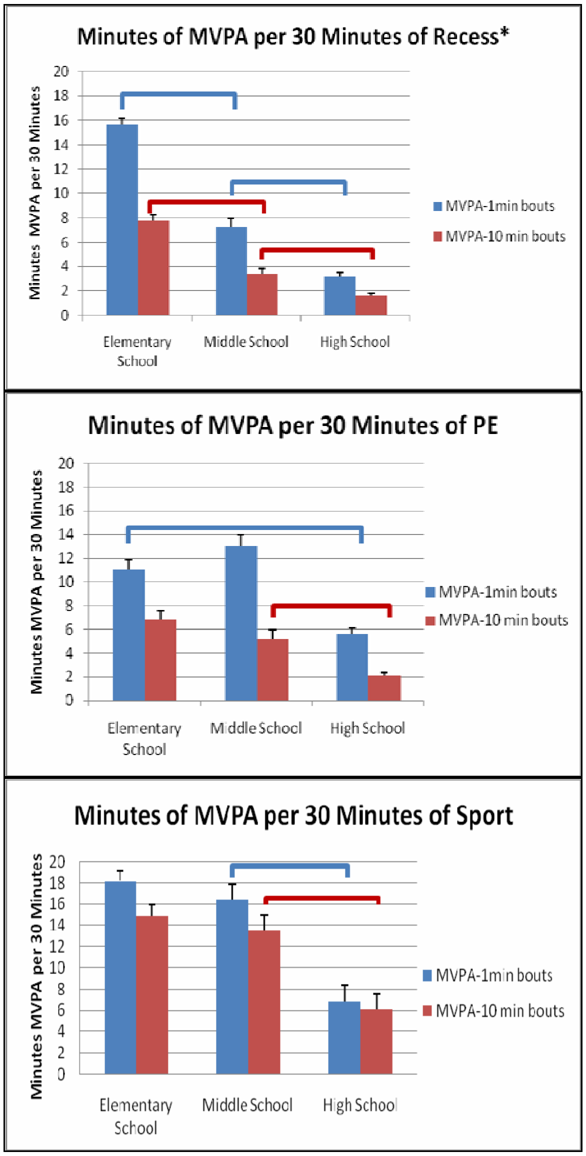

Figure 3. Min of MVPA per 30 min spent in recess, PE, and sport. Vertical bars are SE.

3a: *Average min of MVPA in 1 and 10 min bouts for every 30 min of recess (elementary and middle school) or for the lunch break (high school). Horizontal bars represent a significant decrease in MVPA from elementary to middle school and from middle to high school for MVPA in both 1 and 10 min bouts ($p<0.01$).

3b: Average min of MVPA in 1 and 10 min bouts for every 30 min of PE. Horizontal bars represent significant differences in MVPA between elementary and high school and middle and high school for MVPA in 1 and 10 min bouts ($p<0.01$).

3c: Average min of MVPA in 1 and 10 min bouts for every 30 min of sport. Horizontal bars represent significant decreases in MVPA from elementary to high school and from middle to high school for MVPA in 1 and 10 min bouts ($p<0.01$).

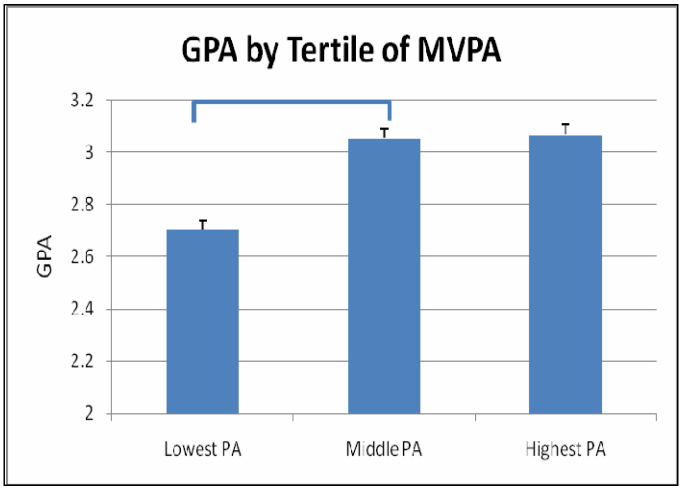

Figure 4. GPA for 135 students (grades 6-12) by tertile of MVPA (10 min bouts) within their grade. The horizontal bar denotes a significant increase in GPA from students in the lowest (GPA=2.7±.03) to middle (GPA=3.1±.04) and highest (GPA= 3.1±.04) PA tertiles. Vertical bars are SE.

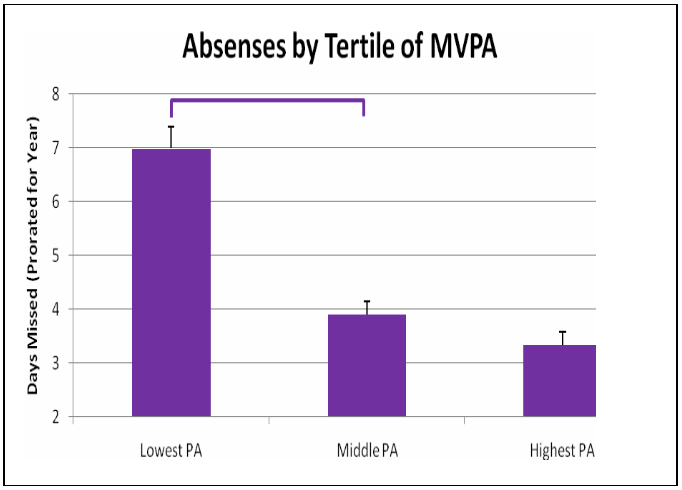

Figure 5. Absences for 162 students (grades 2-12) by tertile of MVPA (10 min bouts) within their grade for the school year in which the student was monitored. The horizontal bar denotes a significant decrease ($p<0.001$) in number of absences from students in the lowest (6.99±.42 days) to middle (3.9±2.5 days) and highest (3.34±.25 days) PA tertiles. Vertical bars are SE.

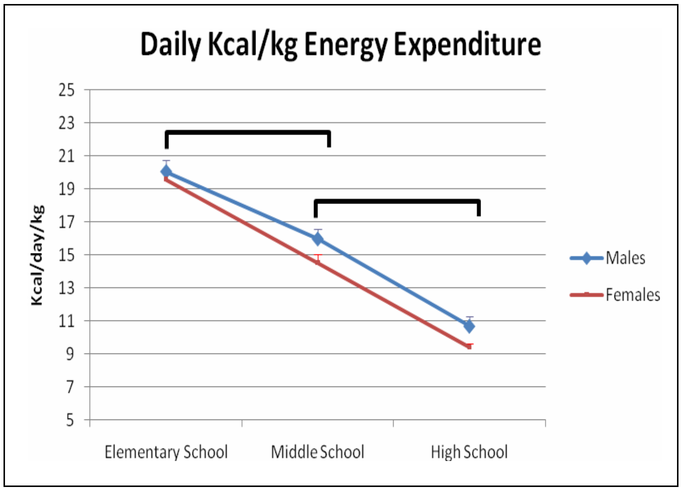

Figure 6. Kilocalories of AEE for all PA (light+moderate+vigorous) by each level of school. Horizontal bars represent a significant AEE drop across each school level with both genders combined (p<0.001). Vertical bars are SE.

PARENT INFORMATION AND CONSENT FORM

TITLE: Physical activity in Missoula County Public School students

PROJECT DIRECTOR(S): Steven Gaskill, Ph.D., Health and Human Performance Dept
104 McGill Hall, The University of Montana
Missoula, MT 59812
406-243-4268 steven.gaskill@umontana.edu
Laura Mohar, BS, Graduate Student, 503-680-7099
Carla Cox, Ph.D., 406-243-4291 carla.cox@mso.umt.edu
Arthur Miller, Ph.D., 406-243-5238 Arthur.miller@mso.umt.edu
Kelly Rice, Missoula Public Health 406-258-3895

This consent form may contain words that are new to you. If you read any words that are not clear to you, please ask the person who gave you this form to explain them to you.

Purpose:
You are being asked to give consent for your child to take part in a project to monitor and evaluate physical activity in Missoula County Public School (MCPS) students. Your child has been asked as they attend one of the schools selected for this project and are in one of the classes selected for assessment.

Procedures:
In general, if you agree to allow your child to take part in this research study they will be asked to wear an activity monitor (accelerometer) and a step counter (pedometer) for six days.

Specifics:
You are asked to sign this form if you give consent for your child to participate.
Your child will be asked to:

- Sign an informed consent.
- Have his/her age recorded and height and weight measured in a private location in the morning at their school.
- An activity monitor (about 1" x 1" x ¼") will be attached to one of their wrists using a non-removable band.
- They will also be given a step counter to wear on their waist.
- They will be given verbal and written instructions for the step counter and activity monitor.
- They will be asked to wear the activity monitor and step counter for 4 school days and 2 weekend days.
- After 4 school days (Tuesday-Friday) and 2 weekend days the activity monitor and step counter will be picked up at their school on Monday morning.
- Your child will also be asked to report times when they rode a bicycle during the week and the times when they participated in structured sport activities. If your child does not know these times, you may be asked to help us with this information.

This monitoring may be done on two separate weeks during the school term.

Risks/Discomforts: Your child will be asked to do normal activities during the week of monitoring. There are no interventions or required physically activity and thus no new health risks. There have been no reported problems wearing activity monitors or step counters. Students who experience any problems with the activity monitors or step counters should contact, or have their parent/guardian contact, one of the researchers: Carla Cox at home (626-5314) or work (243-4291), or Steven Gaskill at home (829-8978) or work (243-4289).

Benefits:
Little is currently know about the physical activity habits of youth in Missoula (or the United States). This data will help us determine current youth activity habits and will hopefully help the Missoula community to better evaluate the needs for accessible physical activity to promote healthy lives for our youth. Further, each participant will be given a copy of their individual data including: average school and leisure minutes in sedentary, light, moderate and vigorous physical activity.

Confidentiality:

- Records will be kept private and will not be released without the subject's consent except as required by law.
- Only the researchers will have access to subject files.
- Identities will be kept confidential, using only subject numbers on all forms.
- Informed consents including subject numbers will be kept in a locked cabinet in a locked room separate from all subject data files
- Subject data files will be kept in a locked cabinet in a separate room from consent forms.
- Results of this study, when reported in any form, will not include any names and only group data will be presented.

Compensation for Injury
Although we do not foresee any risk in taking part in this study, the following liability statement is required in all University of Montana consent forms.

> *In the event that your child is injured as a result of this research, he/she should individually seek appropriate medical treatment. If the injury is caused by the negligence of the University or any of its employees, you may be entitled to reimbursement or compensation pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority of M.C.A., Title2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Claims representative or University Legal Counsel.@ (Reviewed by University Legal Counsel, July 6, 1993)*

Voluntary Participation/Withdrawal:

- Your decision to allow your child to take part in this research study is entirely voluntary.
- You may refuse to allow him/her to take part in or he/she may withdraw from the study at any time without penalty or loss of benefits to which they are normally entitled.
- Your child may leave the study for any reason.
- Your child may be asked to leave the study for any of the following reasons:
    1. Failure to follow the Project Director's instructions;
    2. Acute injury which limits his/her ability to do physical activity;
    3. The Project Director thinks it is in the best interest of his/her health and welfare; or
    4. The study is terminated.

Questions:
You may wish to discuss this with others before you agree to allow your child to take part in this study. If you have any questions about the research now or during the study contact: Carla Cox (243-4291), or Steven Gaskill (243-4289). If you have any questions regarding your child's rights as a research subject, you may contact the Chair of the IRB through The University of Montana Research Office at 243-6670.

Subject's Statement of Consent:
I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions I may have will also be answered by a member of the research team. I voluntarily agree to allow my child to take part in this study. I understand I will receive a copy of this consent form.

____
Printed Name of Student

____
Printed Name of Parent/Guardian

____________________________________ ______________________
Parent/Guardian's Signature Date

____
ID Number for subject (assigned by researchers)

If you agree to allow your child to participate in this study completing the screening form below will help us evaluate the data. The information below is optional. All information is confidential. Please check all that applies to your child.

HEALTH ISSUES

__ Your child currently has an acute injury that reduces their ability to do physical activity. Checking this box will exclude them from the current study.

__ You have concerns about the safety of exercise for your child. If yes, what are they?

____

__ Your child has a chronic physical disability that reduces their ability to do physical activity. (Your answer here has no bearing on participation in this program.) If yes, what type?

____

__ Your child has diabetes or take medicine to control their blood sugar. They may participate with your permission. Our reason for asking this question is to begin tracking the physical activity patterns of children with diabetes to help improve their activity patterns along with their peers.

SUBJECT INFORMATION AND CONSENT FORM

TITLE: Physical activity in Missoula County Public School students

PROJECT DIRECTOR(S): Steven Gaskill, Ph.D., Health and Human Performance Dept
104 McGill Hall, The University of Montana
Missoula, MT 59812
406-243-4268 steven.gaskill@umontana.edu
Laura Mohar, BS, HHP Graduate Student, 503-680-7099
Carla Cox, Ph.D., 406-243-4291 carla.cox@mso.umt.edu
Arthur Miller, Ph.D. 406-243-5238 Arthur.miller@mso.umt.edu
Kelly Rice, Missoula Public Health 406-258-3895

This consent form may contain words that are new to you. If you read any words that are not clear to you, please ask the person who gave you this form to explain them to you.

Purpose:
You are being asked to take part in a project to monitor and evaluate physical activity in Missoula County Public School (MCPS) students. You are being asked to participate as you are in a class that was chosen at your school in the grades that we are evaluating.

Procedures:
In general, if you agree to take part in this research study you will be asked to wear an activity monitor (accelerometer) and a step counter (pedometer) for six days.

Specifics:
You will be asked to:

- Sign this informed consent.
- Have your age recorded and your height and weight measured in a private location in the morning at your school.
- An activity monitor will be attached to one wrist.
- You will also be given a step counter to wear on your waist.
- You will be given verbal and written instructions for the step counter and activity monitor.
    - These measurements and placement of the activity monitor and step counter will require about 5 minutes.
- You will be asked to wear the activity monitor and step counter for 4 school days and 2 weekend days.
- After 4 school days (Tuesday-Friday) and 2 weekend days the activity monitor and step counter will be picked up at your school on Monday morning.
- At the time that the activity monitor and the step counter are picked up we will also ask how often and when you have ridden a bicycle during the past week.
- If you are involved in a sport program we will also ask you to report the time of day when you do this program.

This monitoring may be done on two separate weeks during the school term.

Risks/Discomforts: You are asked to only do only your normal activities during the week of monitoring. There are no interventions or additional required physically activity and thus no new health risks. There have been no reported problems wearing activity monitors or step counters. If you experience any problems during the study, you or your parent/guardian should contact one of the researchers: Steven Gaskill at home (829-8978) or work (243-4289) or Carla Cox at home (626-5314) or work (243-4291).

Benefits:
Your help with this study may help us to better evaluate the needs for physical activity to promote healthy lives within the MCSP students. Further, each participant will be given a copy of their individual data including: average school and leisure minutes in sedentary, light, moderate and vigorous physical activity.

Confidentiality:

- Records will be kept private and will not be released without your consent except as required by law.
- Only the researchers will have access to subject files.
- Identities will be kept confidential, using only subject numbers on all forms.
- Informed consents including subject numbers will be kept in a locked cabinet in a locked room separate from all subject data files.
- Subject data files will be kept in a locked cabinet in a separate room from consent forms.
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Compensation for Injury
Although we do not foresee any risk in taking part in this study, the following liability statement is required in all University of Montana consent forms.

In the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by the negligence of the University or any of its employees, you may be entitled to reimbursement or compensation pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority of M.C.A., Title2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Claims representative or University Legal Counsel.@ (Reviewed by University Legal Counsel, July 6, 1993)

Voluntary Participation/Withdrawal:

- Your decision to take part in this research study is entirely voluntary.
- You may refuse to take part in or you may withdraw from the study at any time without penalty or loss of benefits to which you are normally entitled.
- You may leave the study for any reason.
- You may be asked to leave the study for any of the following reasons:
    1. Failure to follow the Project Director's instructions;
    2. Acute injury which limits your ability to do physical activity;
    3. The Project Director thinks it is in the best interest of your health and welfare; or
    4. The study is terminated.

Questions:
You may wish to discuss this with others before you agree to take part in this study.
If you have any questions about the research now or during the study contact: Steven Gaskill (243-4289) or Carla Cox (243-4291). If you have any questions regarding your rights as a research subject, you may contact the Chair of the IRB through The University of Montana Research Office at 243-6670.

Subject's Statement of Consent:
I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions I may have will also be answered by a member of the research team. I voluntarily agree to take part in this study. I understand I will receive a copy of this consent form.

____
Printed Name of Subject

____________________________________ ______________________
Subject's Signature Date

____
ID Number for subject

Physical Activity in Missoula County Public School Students

Student Assent Form:

You are being asked to participate in a simple project to monitor physical activity for six days. You will be asked to wear a small activity monitor, about the size of a wristwatch, on your wrist from Tuesday (today) through next Monday (six days). When we put the monitors on, we will measure your height and your weight. Nobody else will see your height or weight, and we will not tell anyone.

During this week we ask that you do the same activities that you normally would do. Next Monday your teacher will remove the monitor. Later in the school year, you and your parent will receive a copy of your results.

____ ***assents to participate in this project.***

Student Name

Subject ID #____________________

Detach Here

Subject #______________________

Actical Start Date & Time____________

School____________________________

School Grade__________

Contact Teacher________________________

Age___________

Gender____________

Height____________(cm)

Weight____________(kg)

Right or Left Handed___________

Times for PE & Recess/Lunch

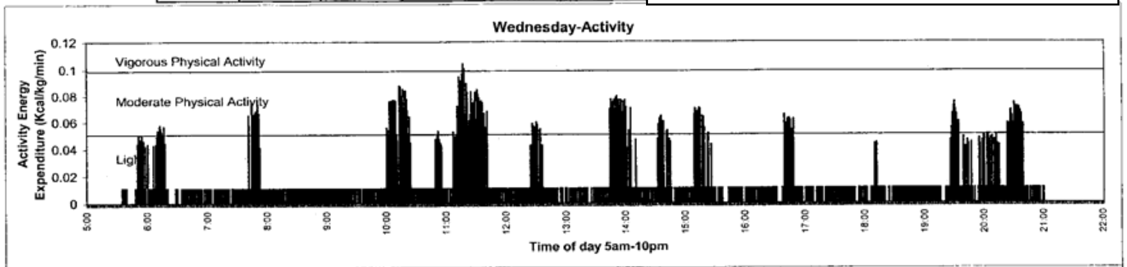
	PE	Recess/Lunch
WED	______to______	_____to______
THURS	______to______	_____to______
FRI	______to______	_____to______

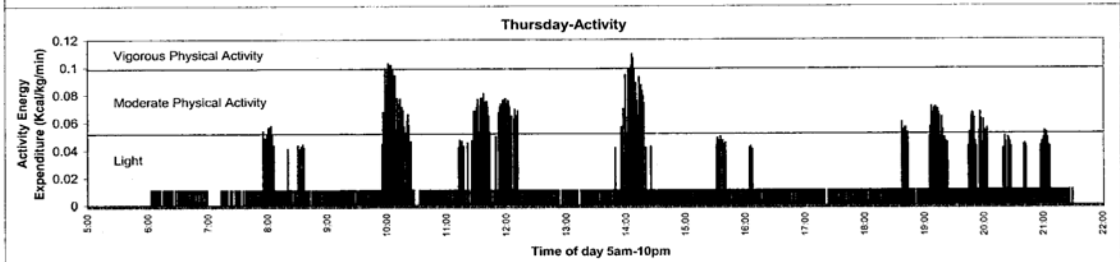
Sport practice & game times **for this week**

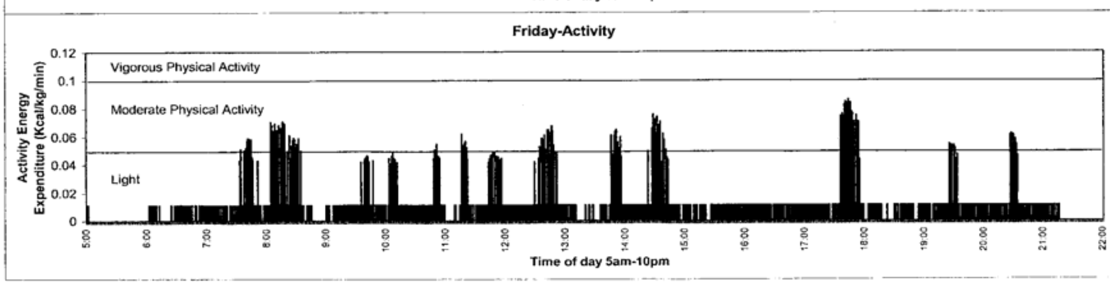
DAY	Start time	End Time	Sport
Wed	___am/pm	___am/pm	_____
Thurs	___am/pm	___am/pm	_____
Fri	___am/pm	___am/pm	_____
Sat	___am/pm	___am/pm	_____
Sun	___am/pm	___am/pm	_____

Physical Activity Feedback Example

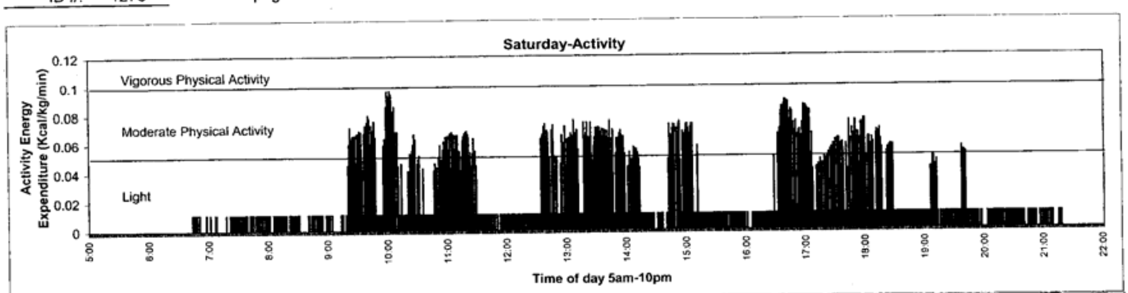
ID #	1278	Age	Gender	Height(in)	Weight(lb)	Grade	School	Average Minutes of Moderate to Vigorous Physical Activity
		8	female	55	72	2	FT	176 Min/day- Fabulous-Keep it up!!!

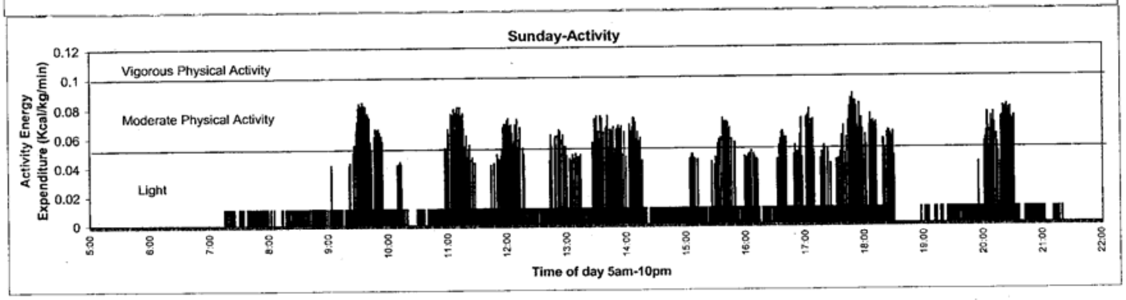






ID #: 1278 page 2





Time in Different Intensities of Activity During Specific Time periods

Whole Day	Wed	Thur	Fri	Sat	Sun	Average
Sedentary Minutes	629	598	662	676	709	654.8
Light Activity Minutes	656	713	673	500	506	609.6
Moderate Activity Minutes	153	123	105	264	225	174
Vigorous Activity Minutes	2	6	0	0	0	1.6

Goal is 90+Minutes of Mod + Vigorous Physical Activity Daily.