Investigating the Validity of the MVPA Feature
on the New Lifestyles 1000 Pedometer
in Children with Visual Impairments

by

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Abstract

Pedometer accuracy and validity during moderate to vigorous activity was examined in youth with visual impairment. Fourteen children (6 males, 8 females) with visual impairment were observed and recorded during six activities at a summer camp while wearing a New Lifestyles 1000 pedometer and an ActiGraph GT1M accelerometer. The accelerometer was worn on the small of the back and the pedometer was worn on the hip. Both devices recorded number of minutes spent in moderate to vigorous activity. The pedometer measurements were compared with those of the accelerometer. The correlation between the pedometer measurement and the accelerometer measurement was low (r = 0.23). These results indicate that there may be discrepancies in activity measurements of visually impaired youth when activity is measured with a pedometer versus an accelerometer.
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Chapter 1
Introduction

Physical activity is defined as all leisure and non-leisure body movements resulting in an increased energy output from the resting condition (Warburton et al., 2006). Physical activity cools off inflammatory processes and helps keep insulin and blood sugar at healthy levels. Extra weight negatively affects this balance. However, research has shown that it is possible to be “fit” and “fat” at the same time. Therefore, exercise could help in many ways even if it does not cause weight loss. The benefits of physical activity include prevention of cardiovascular disease, diabetes, cancer, and osteoporosis. Unfortunately not many people engage in physical activity or healthy lifestyles (Warburton et al., 2006).

High calorie diets and low-activity lifestyles have created health problems for many Americans in the 21st century. The Centers for Disease Control and Prevention listed obesity prevention as one of the nation’s top health concerns mostly due to the fact that the number of overweight children has tripled over the last twenty years. The American Alliance for Health, Physical Education, Recreation and Dance states that a lack of daily physical activity is a contributing factor to the adolescent obesity epidemic (2007). Several studies have shown that exercise could be the answer. For individuals with visual impairment or other disabilities, it is even more important to have adequate fitness levels in order to complete functional tasks (Ayvazoglu et al., 2006).

Children with visual impairments have much lower levels of fitness. The need for children with visual impairments to become physically fit is important because their daily activities demand more energy due to their impaired vision. Walking is one activity that
provides a realistic challenge for children with visual impairment. It has been shown that children who walk more have higher self-esteem. Talking pedometers can motivate children with visual impairment to be more active (Lieberman et al., 2006).

School settings have become predominant places in which to promote physical activity. Some of the more popular opportunities are school clubs and physical education (PE) classes. However, there is still a need for an accurate, practical, and affordable measure of physical activity that can be implemented within the school setting (Scruggs, 2007).

In previous studies, construct validity of pedometers in determining physical activity of youth has been determined using direct behavior observation. Direct behavior observations included heart rate monitoring, accelerometry, and oxygen uptake scaled for body mass. Correlations ranged from moderate to high (.50-.98). Unfortunately, correlation studies are not designed to determine whether step counts taken from a pedometer are accurate (steps recorded vs. steps taken). (Pitetti et al., 2009).

Step count is the most widely accepted measure of physical activity. A pedometer is the simplest device for measuring step count. A pedometer is easily stored and can be read without difficulty. An accelerometer can also act as a pedometer. Accelerometer based pedometers give more accurate measures of physical activity than simple pedometers (Le Masurier et al., 2003). Pedometers provide immediate, continuous feedback by detecting vertical movement with each step taken, while either walking or running, and pedometers produce less measurement error. Step counts from pedometers correlate strongly with other objective measures of physical activity. The use of pedometers is also related to an increase in physical activity. Overall, the pedometer has been found to be accurate and valid in the assessment of step count (Crouter, Schneider,
& Bassett Jr, 2005; Scruggs et al., 2003). A pedometer is also inexpensive, and its use requires minimal training (Pitetti, et al., 2009).

The New Lifestyles NL-1000 is a new and affordable (≈ $50 per unit) motion sensor, based on a piezoelectric accelerometer mechanism. The NL-1000 has a function that is able to record the accumulated time spent in physical activity of at least moderate intensity; it has been suggested that moderate intensity is more beneficial to health than light intensity activity (American College of Sports Medicine, 2000; United States Department for Health and Human Services, 1996). This function is in addition to the standard function of recording steps. If valid evidence can be provided for the NL-1000 for measuring time spent in moderate to vigorous activity (MVPA), it may prove useful for measuring physical activity in school settings; which will promote healthy lifestyles.

**Purpose of Study**

The purpose of this study was to determine if the NL 1000 pedometer provides a valid measure of moderate to vigorous physical activity in children with visual impairment (VI). Measurements provided by an ActiGraph accelerometer were used as the criterion to establish validity of the NL 1000 measurements.

**Hypothesis**

It was hypothesized that the activity measures from the NL1000 pedometer were significantly correlated to the ActiGraph GT1M accelerometer measurements. The alternative hypothesis was that the activity measures from the NL 1000 pedometer were not significantly correlated to the ActiGraph GT1M accelerometer measurements.
Delimitations

In order to evaluate the results of the pedometer and accelerometer measures, certain limitations were set. The delimitations for this study were:

1. Participants had to be present for each of the testing periods.
2. The variety of physical activities was limited to those common in children with VI.

Limitations

The limitations included:

1. The sample size was small.
2. There was no control group.
3. Sometimes children with VI have abnormal gait.

Assumptions

In order for this study to proceed, certain assumptions were made. It was assumed that:

1. The participants had no prior knowledge of the devices used.
2. Participants gave maximal effort
3. All equipment worked properly during testing.

Definition of Terms

Accelerometer- a device that measures the rate of change in velocity.

Body Mass Index (BMI)- A ratio of an individual’s body mass to their height squared. Used as a measure of body composition. Expressed in kilograms per meter squared (kg/m2).
**Criterion Validity**- evidence that a test has a statistically significant relationship with the trait being measured

**Concurrent Validity**- criterion is measured at approximately the same time as the alternative measure

**Moderate to Vigorous Physical Activity**- Any activity that burns 3 to 6 METs is considered moderate-intensity physical activity. Any activity that burns > 6 METs is considered vigorous-intensity physical activity.

**Pedometer**- a device that counts the number of steps taken by the wearer by responding to the impact of the wearer's steps.

**Reliability**- the degree to which repeated measurements of the same trait are reproducible under the same conditions; consistency

**Significance of the Study**

The purpose of this study was to determine if the NL 1000 pedometer provides a valid measure of moderate to vigorous physical activity in children with VI while collecting criterion-related validity evidence using an ActiGraph GT1M accelerometer as the reference method. The importance of physical Activity and school based interventions, along with the importance of physical activity in children with visual impairments will be considered. Along with measurements for physical activity and their reliability and validity, both with and without visual impairment.
Chapter 2

Review of Literature

Importance of Physical Activity and School Based interventions

According to McKenzie et al. (2004), current physical education recommendations call for at least an hour of moderate to vigorous physical activity daily for children. Physical education can provide children with a substantial proportion of the physical activity recommended for health purposes. Lack of physical activity can lead to many complications such as hypertension, chronic inflammation, increased blood-clotting tendency, diabetes, and sometimes even death (Ebbeling et al., 2002). These problems often carry over to adulthood. The incidence of overweight children has doubled for children in the United States aged 6-11 years over the past two years. Approximately 17% of children between the ages of 2-9 are considered overweight and 34% are at risk (Shaya et al., 2008). There are many factors that lead to obesity including prenatal over-nutrition, bottle-feeding, family life and physical activity levels (Ebbeling, 2002). However, it is possible to remain slightly overweight but to become physically active which in turn causes individuals to become more physically fit. One way to combat inactivity is to have school based interventions. School based interventions include healthier meal choices in the lunchroom, more knowledge given in the classroom, and more effective physical education classes.

Unfortunately, many physical education classes are not currently very effective. They are either too short, not frequent enough, or children do not work to their fullest potential.
McKenzie and colleagues, (2004), evaluated a two-year middle school physical education intervention program. Twenty-four middle schools with approximately 25,000 students participated in the study. Schools were assigned to intervention or control conditions and each school was the unit of analysis. The two-year physical education program consisted of curricular materials, staff development, and on-site follow up. The control group continued on with normal activity. Student activity and lessons were observed during baseline and intervention for both years. The results of this study showed significant improvement in student’s moderate to vigorous physical activity in physical education class by three minutes/lesson. Therefore, a standardized program increased moderate to vigorous physical activity in middle schools without requiring an increase in frequency or duration of physical education time.

In a similar study, Everhart and colleagues (1999) examined the effect of a curricular intervention on the heart rates of elementary physical education students. Sixty-four fourth grade and 83 fifth grade students were divided into an experimental and a control group. The experimental group was taught how to play basketball using the Fit-Sport Model. The Fit-Sport Model’s purpose is to teach children sport-skill related drill or activities in such a way so that cardiovascular endurance is emphasized more than in a traditional physical education class. The control group was taught as a traditional physical education class. A t-test showed a significant difference at the .05 alpha level between the heart rates of the experimental and control groups. The mean heart rate for the experimental group was 145.5 beats per minute while that of the control group was 126.7 beats per minute \( (t=.44) \). The results showed no significant difference between skill tests for basketball shooting between groups.
Dishman et al. (2004) performed another study that involved intervention. This study evaluated the effect of the Lifestyle Education for Activity Program (LEAP)-intervention on changes in enjoyment, self-efficacy and physical activity among adolescent girls. It was shown that the LEAP intervention had positive effects of increased physical enjoyment on increased physical activity.

Unlike the previous researchers who looked at intervention, Boyle and colleagues (2007) examined the relationship between physical activity and body composition in adolescents to determine if physical activity differs between adolescents with normal BMI compared to at risk or overweight adolescents. Thirty-five children were included in this study. Each child was given an accelerometer to wear during all waking hours for seven days. Height and weight were assessed to determine BMI and percent body fat was measured using air-displacement plethysmography. Participants were split into two groups; one whose participants had normal BMI for age and one whose participants were at risk. The participants averaged 312,015.42(+ or -) 141, 589.34 total counts/day. Percentage of body fat did not differ between the boys and girls but BMI differences were statistically significant (p = .03). The correlations between physical activity and body composition variables ranged from -0.35 to .11 for boys and -0.21 to 0.14 for girls. Counts per minute and counts per day did not change between group one or group two. Therefore, ambulatory physical activity during the summer months may not differ between boys and girls or normal and at risk adolescents. However, even though correlations between physical activity and body composition were low, the results suggest that relationships may vary between boys and girls.
**Measures of Physical Activity**

Intervention is necessary to increase physical activity levels in inactive individuals. However, methods for assessing those who are inactive or under-active must first be validated and deemed reliable.

McQuinn and colleagues (2010) researched the validity of the New lifestyles NL-1000 accelerometer for measuring time spent in moderate-to-vigorous physical activity in school settings. Data were collected during a cross-country run (n = 12), physical education (n = 18), and classroom-based physical activities (n = 42). Significant correlations between methods were found, and NL-1000 estimates of moderate-to-vigorous physical activity were not significantly different from GT1M-estimated moderate- to-vigorous physical activity. The NL-1000 therefore shows promising validity evidence as an inexpensive, convenient method of measuring moderate-to-vigorous physical activity in school settings.

Allor and Pivarnik (2001) examined the stability and convergent validity of heart rate monitoring, Caltrac accelerometer, and physical activity recall in sixth grade girls during normal weekday activities. 46 sixth grade girls took part in the study. They wore heart rate monitors and accelerometers for three days. Results showed that heart rate and physical activity recall were stable across two days. Physical activity recall underestimated caloric expenditure by approximately 14%. The accelerometer showed the least utility in both reliability and validity.

In order to evaluate the reliability of the Tritrac-R3D activity monitor during physical activity of children Welk and Corbin (1995) performed experiments with the Tritac-R3D and two other devices to see the difference. The other two devices were the
Caltrac Activity monitor and the telemetry-based polar Vantage XL heart rate monitor. Thirty-five children ages 9-11 were monitored on 3 different school days. It was shown that the Tritac was moderately correlated with the heart rate monitor and highly correlated with the Caltrac. Correlations between these two instruments were higher during free play situations and lower during limited or structured activity times.

Schneider and colleagues (2003), tried to show the accuracy and reliability of ten different pedometers for measuring steps over a 400m walk. Ten males and ten females took part in the study. They walked around a 400m outdoor track while wearing two pedometers of the same model, one on the right side and one on the left side of the body. A researcher tallied the actual steps. The types of pedometers were as follows: Freestyle Pacer Pro (FR), Kenz Lifecorder(KZ), New Lifestyles NL-2000(NL) Omron HJ-105(OM), Oregon Scientific PE316CA(OR), Sportline 330(SL330) and 335(SL335), Walk4life LS2525(WL), Ymax Skeletone Em180(SK) and the Ymax Digi-Walker SW701(DW). The results showed that KZ, NL, and DW were the most accurate in counting steps and the SL330 and OM were least accurate. Not all pedometers count steps accurately.

Pfeiffer et al. (2006) evaluated the validity of the Actical accelerometer in preschool children. Eighteen 3-5 year old children wore an Actical accelerometer and a Cosmed portable metabolic system during a resting period, while performing three different activities in a structured laboratory setting, and twenty minutes of unstructured indoor and outdoor activities with their teachers. Expired respiratory gases were collected and oxygen consumption was measured. The correlation between VO2 and Actical
measurement was $r = .89$ for every activity. Therefore the Actical accelerometer is a valid tool for use in measuring physical activity in preschool children.

Puyau and colleagues (2002) completed another study to examine the validity of physical activity monitors used by children. They found that two types of monitors, the Computer Science Applications ActiGraph and Mini-Mitter Actiwatch, were useful and valid devices used for the assessment of physical activity in children. The researchers used 26 children aged 6-16 over a period of 6 hours to validate accelerometer-based activity monitors against energy expenditure in children; to compare monitor placement sites; to field test the monitors and to establish sedentary, light, moderate and vigorous threshold counts. The children performed a variety of structured activities such as resting metabolic rate, Nintendo, arts and crafts, aerobic warm up, Tae Bo, treadmill walking, running and games. The mean correlations between energy expenditure were slightly higher for Mini-Mitter (MM) than Computer Science Applications ActiGraph (CSA).

Puyau and colleagues (2004) also validated two accelerometer-based activity monitors as measures of children’s physical activity using energy expenditure as a criterion. The Actiwatch (AW) and Actical (AC) activity monitors were validated against continuous 4-h measurements of energy expenditure in a respiratory room calorimeter and 1-h measurements in an exercise laboratory using a portable calorimeter and treadmill in 32 children ages 7-18 years old. Both accelerometer based activity monitors provided valid measures of physical activity.

Crouter et al. (2005) examined the effects of BMI, waist circumference, and pedometer tilt on the accuracy of a spring levered pedometer (Yamax Digiwalker SW-200) and a piezio-electric pedometer (New Lifestyles 2000, NL) during a 24-hour
treadmill walking period in overweight and obese adults. Forty participants walked on a treadmill at five different speeds (54, 67, 80, 94, 107 m-min-1) for three minute stages. Using a hand counter, actual steps were also measured. Height, weight, pedometer tilt angle and circumference were also measured. The results showed that the SW became less accurate with increasing BMI, increasing waist circumference and greater pedometer tilt. The NL however was not affected by these variables. On average the NL recorded 1030 +/- 1414 (16.5 +/- 22.7%) more steps than the SW during the 24-hour trial. Therefore, a piezo-electric pedometer (NL) is more accurate than a spring levered pedometer (SW) in overweight and obese individuals.

Beets et al. (2005) determined the accuracy of pedometer step counts and time in self-paced walking and treadmill walking in children aged 5-11. Two pedometers were used during the self-paced walk; the Digiwalker SW-200 (DW200) and the Walk4Life 2505 (WL). Four pedometers were used during treadmill walking, the DW200, WL, Digiwalker Sw-701 (DW701) and the Sun Trek LINQ (SUN). Ten boys and ten girls walked three laps around an outdoor track. Treadmill walking was performed at five different speeds; 40, 54, 67, 80, and 94 m-min-1. Pedometer and observed steps and times were recorded. A high correlation was observed between steps and time for both the DW200 and WL. For treadmill walking low agreement between pedometer steps and treadmill steps was shown. For pedometer time the WL showed a high level of agreement with the observed during SPW. During treadmill walking the WL was within 5.3% of actual time and time with SUN did not come within 5% agreement until 80 m-min-1.
The findings are consistent with adult studies with step count underestimation during slow walking. The accuracy of time (WL) suggests that time might be used in addition to steps to quantify the physical activity behavior of children.

Clemes et al. (2009) investigated the presence of reactivity to wearing sealed and unsealed pedometers, with and without step count recording. Sixty-three participants were given a sealed pedometer (NL 1000) and were not told the purpose of the study. Participants wore the pedometer for 1 week while awake. They were then told that it was a pedometer and wore it under three conditions; sealed, unsealed and unsealed plus logging daily steps in an activity diary for one week. Mean daily step counts were recorded and compared using a repeated-measures ANOVA. The results showed that reactivity to pedometers was greatest when participants were requested to wear an unsealed pedometer and record their step counts. Therefore short term pedometer studies may have validity implications.

Clemes et al. (2009) also performed a study to evaluate the accuracy of a Silva pedometer currently being used as part of a national program to promote physical activity in the UK. In a lab study, sixty-eight participants wore two Silva pedometers, one on each hip, while walking on a treadmill at 2, 2.5, 3, 3.5 and 4 mph. Pedometer step counts were compared to actual step counts. In the free-living study 134 participants wore one Silva pedometer, one NL 1000, and an ActiGraph GT1M accelerometer as the criterion during waking hours for one day. Step counts taken by the Silva and NL 1000 were compared to ActiGraph step counts. Percent of error was measured across normal weight, obese and overweight participants. The results show that the Silva pedometer was inaccurate for inactivity promotion purposes especially in overweight and obese adults.
Energy expenditure, economy and pedometer counts between normal weight and overweight or obese women during a walking and jogging activity was compared by LeChemninant and colleagues (2009). 13 normal weight (BMI 22.2 ± 2.0 kg m\(^{-2}\)) and 13 obese (BMI 27.2 ± 2.1 kg m\(^{-2}\)) women all of which were non-smokers, not regularly active, and able to run 1.609 km continuously at 2.23 m s\(^{-1}\). Each participant reported to the laboratory on three separate days within a one week period. During the first visit, tests for resting metabolic rate via indirect calorimetry, anthropometric measures, and VO2max were completed. During the remaining two visits, participants randomly performed either a 1.609-km walk at 1.34 m s\(^{-1}\) or a 1.609-km jog at 2.23 m s\(^{-1}\). All participants wore a pedometer to assess steps taken. Energy expenditure during the 1.609-km walk was 280 ± 29 kJ for the normal weight and 356 ± 42 kJ for the overweight/obese women and during the 1.609-km jog was 393 ± 46 kJ for the normal weight and 490 ± 59 kJ for the overweight/obese women. In both trials, Energy expenditure (EE) was statistically greater in the overweight/obese women. Economy of movement was not statistically different between the normal weight and overweight/obese women during the walk or jog. In both groups, pedometer counts were lower during the jog than the walk (P < 0.05). During both a walking and jogging activity, the data indicates significant differences in EE between normal weight and overweight/obese women.

**Physical Activity and the Visually Impaired**

Physical activity and physical education for children with visual impairments may be problematic for a few reasons. One is that children with visual impairments have unique motor needs due to limited sight and that perceived or actual barriers may hamper physical education instruction (Lieberman, Wilson, & Kozub, 2002).
Lieberman, Wilson, and Kozub (2002), examined barriers perceived by teachers when including students with visual impairments in physical education classes. A questionnaire was developed to determine which barriers physical educators might perceive when including children with VI into their general physical education classes. Content validity was determined from reviews by three adapted physical education teachers. Ten barriers were listed and participants were asked to check which barriers they believed applied to them. Participants filled in the questionnaire and then participated in a workshop designated to provide training on inclusion for students with disabilities. Data were analyzed to determine the most frequent barriers. Professional preparation, appropriate equipment, curriculum and time in schedule were the most common barriers reported.

Stuart et al (2006), completed a similar study using a survey of 25 visually impaired children aged 10-12 and their parents to investigate the value the parents placed on their children’s physical activity levels and the barriers the children faced. The results showed that as vision loss increased, parents’ expectations for their children’s ability to be physically active decreased, as well as the children’s feeling that physical activity is important.

In addition to gathering information from surveys and questionnaires, Longmuir and Or (2000) also reanalyzed the data using ANOVA and chi square statistics to provide new information. They examined gender, disability type, age and specific diagnostic category in relation to habitual physical activity levels, perceived fitness and perceived participation limitations of youth aged 6-20. It was shown that activity levels, perceived fitness, and perceived participation limitations varied by type of disability and specific
diagnostic category. The influence of age and gender was similar to previous findings. Youths with visual impairments had significantly lower activity levels. The findings show that new ideas are required to develop effective intervention strategies for youths with disabilities.

Houwen and colleagues (2009) studied the relationship between motor skill level and the physical activity patterns of children with and without visual impairments. The study used 96 children ages 6-12. The children’s body composition was measured. The Actical GT1M accelerometer was used to gauge the children’s physical activity and the Test of Gross Motor Development-2 was used to measure motor skill performance. The results showed that the total activity count in children without visual impairment is significantly higher than that of the children with visual impairment.

Ayvazoglu and colleagues (2006) completed another study in which activity levels among children with visual impairments were the main focus. Six school age children with visual impairments, their siblings without impairments, and parents participated in the study. A mixed method research design was used to observe physical activity in children with visual impairments. The data were collected over a seven day period during summer vacation using triaxial accelerometers. Qualitative data were collected from interviews with the parents and children. Physical activity scores were the number of minutes that an individual was involved in bouts of moderate to vigorous physical activity. The amount of energy expenditure at rest was also calculated. This study shows some of the determinants for physical activity for children with visual impairments and the influences that parents and siblings may have on them. Older
children with visual impairment are prone to inactivity. More studies are needed to explain reasons for inactivity in people with visual impairment.

Lieberman and McHugh (2006) evaluated the health-related physical fitness of children at a summer camp who had visual impairments. Forty-six visually impaired children performed items from the Fitnessgram health-related fitness test. The test included the following: cardiovascular endurance, muscular strength and endurance, flexibility and body composition. The number of children who achieved the criterion for passing each item was determined. Passing percentage rates were then calculated. It was shown that the children with visual impairments have significantly lower physical activity levels.

**Pedometers/Accelerometers and the Visually Impaired**

Lieberman et al. (2006) investigated the walking behavior of children with visual impairment who used a talking pedometer before and during their stay at a summer sports camp for children with disabilities. They also examined the children’s views on the value of physical activity and their interest levels, and the importance of the talking pedometer to help increase their activity levels. This was done through interviews. The Brookstone talking pedometer was used for this study. Twenty- two boys and girls ranging in ages 9-13 attended the camp. The steps taken per day were recorded during the 7 days before camp started and 7 days at the camp. The average daily step count before camp was lower than the recommended level for healthy living but the average number of steps taken per day during camp was equal to or exceeded the recommended level.

Another study performed by Kozub et al. (2005) calculated the reliability and validity of the RT31 accelerometer when used by 19 school-aged children with visual
impairments. The accelerometers were worn during physical education class. Values from the RT3 monitor were compared to observational data from the Children’s Physical Activity Form. Reliability estimates were measured by putting two monitors on the participants during the data collection and then calculating intra-class correlations using repeated measures. Validity between RT3 monitors and the CPAF scores were high. Therefore the RT3 is a useful tool to measure short-term physical activity levels in children with visual impairments.

Mason et al. (2005) measured the variability of length and frequency of steps was measured for visually impaired and sighted walkers at three different paces. The three different paces were fast, slow and the participants preferred pace. A computer-readable pedometer (AME Micro) was clipped onto the participants waistband at the hip and connected to a laptop. It was shown that the variability was low for each group. Therefore, in conclusion, people who are visually impaired show no greater variability than sighted people when walking in a controlled indoor environment.

Beets and colleagues (2007) recruited 35 youths with visual impairments to walk four 100 m distances while wearing two voice announcement (VA) pedometers in order to examine the accuracy of the devices. There were three different brands of VAs used; the Centrios talking pedometer, TALKiNG Pedometer and Sportline Talking Calorie Pedometer. The participants each wore two different devices, one on each hip. It was shown that no VA pedometer met the minimum ICC inter-unit agreement and the registered steps were considerably different between each hip placement. However, it was shown that VA pedometers were acceptably accurate for right hip placement and should be used for individuals with visual impairment.
In 2006 Lieberman and colleagues studied the effects of using a talking pedometer on walking behavior and the value placed on walking for children who are visually impaired or deaf-blind. The Brookstone talking pedometer, which previously met the qualifications for accuracy, reliability, endurance and accessibility was used. Twenty-two children aged 9-13 participated in the study. The average number of steps taken per day was measured and an interview was given. It was shown that the number of steps taken per day was lower than the recommended amount for children in the age group.
Chapter 3

Research Manuscript

Introduction

Daily physical activity is essential in order to promote health and growth and to reduce cardiovascular disease especially in youth (Pitetti et al., 2009). Physical education can provide children with a substantial proportion of the physical activity recommended for health purposes. Lack of physical activity can lead to many complications such as hypertension, chronic inflammation, increased blood-clotting tendency, diabetes, and sometimes even death (Ebbeling et al., 2002). This is true for school-age youth (K-12) with and without disabilities. However, accurately quantifying or measuring physical activity remains a challenge to researchers and clinicians. Large-scale epidemiological studies and clinical trials have traditionally relied on subjective methods, such as questionnaires, self-report diaries and interviews. Such methods have proven inaccurate, with individuals tending to over-report time spent in physical activity (Sallis and Saelens, 2000). To accurately quantify physical activity and clarify the relationship between physical activity and health outcomes, researchers have turned to objective measurement tools.

Some of the methods used to measure physical activity are heart rate monitoring, self-report, direct observation, pedometers and accelerometers. Specifically, accelerometers have emerged as the device of choice to measure physical activity. Many studies have examined the reliability, validity, and ease of these methods. Although direct observations are considered the best, they are also time consuming, expensive, and reliant on observer precision (Oliver et al., 2007). Due to the fact that pedometers have been
shown to have a high correlation with other measures of physical activity, such as heart rate monitors and accelerometers, pedometers have become a popular method for measuring physical activity. Pedometers are also inexpensive, involve little training and allow for large population studies.

In previous studies using direct behavior observations, construct validity of pedometers in determining physical activity of youth has been determined. By comparing pedometer step counts with direct behavior observations including heart rate monitoring, accelerometry, and oxygen uptake scaled for body mass. Correlations ranged from moderate to high (.50-.98). Unfortunately, correlation studies are not designed to determine whether step counts taken from a pedometer are accurate (steps recorded vs steps taken). (Pitetti et al., 2009).

In recent years the interest to measure physical activity in children has increased due to the relationship between physical activity and lifestyle related morbidity in the pediatric population (Hayman et al., 2004). Because youths with disabilities tend to engage in less physical activity, there is also a need to increase physical activity of youth with disability (Pitetti et al., 2009). In order to determine activity levels in children who are disabled, reliable and valid methods for measuring activity level for children without disability must be developed. The Journal of Visual Impairment and Blindness (2001), lists the following goals for achieving high levels of physical activity in children with visual impairments:

1. Require involvement in an early intervention program. The groundwork for optimal motor development begins in infancy.
2. Teach children at an early age what they can do in the area of physical activity and sports. Research has shown that the effects of lower levels of physical activity surface as early as age 8 and may last a lifetime.

3. Promote activities that increase cardiovascular endurance, upper body strength and flexibility.

4. Educate parents, vision professionals, physical education teachers and community professionals about the abilities of children with visual impairments.

5. Promote athletes with visual impairments as role models for all children and promote involvement in recreational activities and sports for the lifetime.

For physical activity interventions in youth with visual impairments, a means of conveniently and inexpensively counting steps and measuring moderate to vigorous physical activity may motivate them have more active lifestyles. Establishing the validity of measurement devices is essential prior to utilizing the devices in intervention-based studies (Beets et al., 2007).

Due to delayed motor development, children with visual impairment (VI) have low self-esteem. Walking is one activity that provides a realistic challenge for children with VI. It has been shown that children who walk more have higher self-esteem. Talking pedometers can motivate children with VI to be more active (Lieberman et al., 2006). The concern of pedometer accuracy in school age children is based on the highly transitional and dynamic movement characteristics they have at their age. Physical activity of school age children may not only include walking but skipping, jumping, running, and other movements as well (Pitetti et al., 2009).
Methods

The purpose of this study was to determine if the NL 1000 pedometer provides a valid measure of moderate to vigorous physical activity in children with VI while collecting criterion-related validity evidence using an ActiGraph GT1M accelerometer as the reference method.

Participants.

Fourteen visually impaired children attending a summer camp during the summer of 2006 were the participants in this study. The 14 children included 6 males and 8 females ranging in age from 10-15 years old. Informed parental consent, voluntary participant assent, and IRB approval was obtained prior to data collection.

Instruments.

**NL 1000 Pedometer.**

The pedometer used in this study is the New Lifestyles 1000, which has features to measure moderate to vigorous activity. The NL1000 uses a piezoelectric mechanism (a device that uses the piezoelectric effect to measure pressure, acceleration, strain or force by converting them to an electrical signal) that is similar to accelerometers, but it costs a fraction of the price.

The NL 1000 can be clipped onto a belt or waistband. It may be set to record at intensities above any one of nine discrete intensity levels, and it is delivered from the manufacturer set to record activity above 3.6 Metabolic Equivalents (METs) (Level 4). The most common definition of MVPA is activity that is at or above an intensity of 3 METs (American College of Sports Medicine, 2000). Therefore, the NL-1000 MVPA timers in this study were reset to record activity from 3-9 METS. Any activity performed
at an intensity in between the bounds will add time to the activity minutes. Steps and MVPA time are read from a digital display.

The pedometer mechanism in the NL 1000 is a medical-grade accelerometer that is more tolerant of placement on the body, so it will work better for a wider variety of body shapes. It has no moving parts, so no annoying clicking. The NL 1000 also costs an average of $55.00.

**GT1M ActiGraph Accelerometer.**

An ActiGraph GT1M was used in this study as the criterion to measure. The ActiGraph accelerometer (model GT1M) (ActiGraph, LLC, Fort Walton Beach, FL) is a uniaxial accelerometer that measures movement in the vertical plane. It is a acclerometer based activity monitor. The monitor is small in size and lightweight, 5.1 x 3.8 x 1.5 cm and 42.6 g, respectively. It is sensitive to accelerations from 0.05–2.0 G’s and has a band limited frequency of 0.25–2.5 Hz. The ActiGraph accelerometer samples at a rate of 10 Hz and the signal is digitized by an 8 bit A/D converter. Each signal is summed over a user specified time interval (epoch) and activity counts are stored. The ActiGraph accelerometer was initialized to collect data in 1-s epochs and the results were downloaded directly to a PC compatible computer using a USB cable. The ActiGraph can vary in cost between $250.00-$350.00.

**Design and procedure.**

The height and weight of each subject was measured at the beginning of the study. BMI was then computed for each subject from the height and weight measurements. The NL 1000 pedometer was worn at the small of the back and the ActiGraph GT1M accelerometer was worn on the hip while the participants engaged in
physical activity. The children were randomly assigned to one of five activities common among children with VI. The activities included gymnastics, beep ball, track and field, goal ball and Judo. Each child remained in that activity for approximately 30 minutes. Some of the children were engaged in an activity more than once resulting in 20 total data sets. The NL 1000 measured the intensity of movement at a 4 second epoch. Using the advanced settings, the bounds were adjusted to a threshold of 3-9 METS and any results within this range were considered moderate to vigorous activity. The ActiGraph accelerometer measured the accelerations during each cycle period. The ActiGraph measures acceleration 10 times each second, when one-minute cycles were used, 600 measurements were summed up and the value was written to memory. Activity counts represented a quantitative measure of activity over time. Counts in a given cycle were linearly related to the intensity of the subject’s physical activity during the interval of time. Moderate to vigorous physical activity is considered 1953-9498 counts or 3.0 to 8.99 METs.

**Data analysis.**

The results (number of minutes spent in MVPA) from the ActiGraph accelerometer and the NL 1000 pedometer were recorded and compared. Statistical analyses were conducted using Microsoft Excel. Differences in minutes in MVPA between the NL 1000 and the ActiGraph were calculated. Descriptive statistics and correlation were computed. A scatter plot was used to analyze the agreement between the results from the two instruments used. In this graphical method, the differences between the two techniques are plotted against the averages of the two techniques. The two methods of measurement (ActiGraph and NL 1000), each designed to measure the same
parameter, should have had a good correlation because the set of samples were chosen such that the property to be determined varied a lot between them.

Results

A validity coefficient represents the degree to which a measure correlates with a criterion. Statistical validity coefficients range from -1.00 to +1.00. A value of 0 indicates no validity, 1.00 represents perfect correlation with the criterion (Morrow et al., 2005). The results from the ActiGraph and the NL 1000 should have a direct linear relationship however the results indicate there is a low correlation (r= .23).

Investigation of the scatter plot (Figure 1) shows that by activity, with the exception of activity three, track and field, the NL 1000 underestimated MVPA, and therefore had more error. The results from the pedometer vary greatly from the accelerometer.

![Bland Altman Graph](image)

Figure 1. Difference between NL 1000 and ActiGraph versus activity
(Activity 1: gymnastics; Activity 2: beep ball; Activity 3: track and field; Activity 4: goal ball; Activity 5: Judo).
The graph below shows the relationship between NL 1000 activity measurement versus ActiGraph activity measurements.

![Graph showing relationship between NL 1000 and ActiGraph activity measurements.]

Figure 2. Plot of NL 1000 activity measurement versus ActiGraph activity measurement.

**Discussion**

This study assessed the validity of pedometers using accelerometers as the criterion measure. The accelerometer-based activity monitor proved to be a valid and useful device for the assessment of visually impaired children’s physical activity level. The results of this study show that the NL 1000 pedometer may not be as valid a measure as the ActiGraph accelerometer. Unfortunately, pedometers that utilize the piezo-electric sensor have yet to include a voice-announcement feature, limiting their use in an
intervention setting with youth with visual impairments (Beets et al., 2007). Another reason for the discrepancy may include pedometer tilt (Crouter et al., 2005). Pedometer tilt is affected by adiposity that pushes the pedometer away from the waist which then causes the pedometer to deviate from its required vertical positioning. Placement of the pedometer, either right or left hip or middle back, has minimal influence on step count accuracy (Beets et al., 2007).

Previous studies using activity monitors with the same internal sensor as the NL-1000 have shown agreement with the ActiGraph accelerometer when measuring time spent in MVPA (McClain, Johnson, Brusseau, Washington, Tudor-Locke, & Darst, 2007a; McClain et al., 2007b). These studies used different ActiGraph epoch lengths (15 sec and 30 sec) than the current study and different cutpoints and equations to determine MVPA thresholds. Children’s physical activity patterns tend to be intermittent and varied, alternating between short bouts of only a few seconds of differing intensities (Bailey, Olson, Pepper, Porszasz, Barstow, & Cooper, 1995). Because of this, the use of longer epochs tends to produce lower estimates of MVPA time compared to shorter epochs (Mahar, Smith, Rowe, DuBose, & McCammon, 2008).

Prior studies of pedometer accuracy have primarily examined actual vs. registered step count during varying walking speeds (Beets et al., 2007). Differences in mean steps per day detected may be due to differences in set instrument sensitivity thresholds. Additional studies with different populations are needed to confirm a recommended number of steps per day associated with the duration and intensity of public health recommendations for ambulatory activity. But a large portion of movements in youths include transitory and dynamic movements such as skipping or jumping that are not
included in many studies (Beets et al. 2007). Therefore, the accuracy of pedometers for children involved in free play, has not been recognized for children with or without disability (Pitetti et al., 2007).

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Therefore, further studies may want to evaluate gait pattern and movement of the lower body in individuals with visual impairments to determine if this could be a cause for error. Also- when running, children are usually considerably and continuously above the moderate intensity threshold, regardless of what MVPA is defined as, therefore an agreement between instruments is relatively easy to achieve. However, testing the NL1000 under these conditions was a necessary prerequisite before testing it under more challenging conditions (i.e., where physical activity intensity varied and moderate intensity physical activity was intermittent). Activity during the different sports were more intermittent and varied in nature; including light, moderate, and vigorous intensity
activities. Therefore, any disparity in MVPA recording ability between instruments is more likely to be detected during these conditions.

The main focus of this study was to determine the accuracy of lower cost pedometers compared to accelerometers. For motivational purposes, a simple, low-cost step counter may work. However, if physical activity increase is a desired outcome, more sophisticated accelerometer-based devices have some advantages. Accelerometer-based devices provide several output variables (kilocalories, time spent in moderate and vigorous activity, monitor ‘wear time’, and steps), but not all of these devices contain a digital display that provides immediate feedback to the user. Physical activity monitors (even those worn on the ankle or arm) are generally well tolerated by clinical populations, including cardiac, pulmonary, kidney, muscular, or neurological diseases. However, further improvements are needed to enhance the accuracy of energy expenditure estimates for different types of activities, and assessment of energy expenditure (John, Tyo, & Bassett, 2010).

Researchers seeking to measure MVPA in the school setting should consider the positive and negative features of the NL1000 before selecting it over other instruments such as the GT1M accelerometer. Positive features of the NL1000 include the digital display that allows steps and MVPA time to be read directly from the screen, meaning that no downloading or cleaning of data is required. This offers an attractive advantage over the GT1M device, which requires often laborious downloading and cleaning of data. Further positive features of the NL1000 include the 7-day memory function and the relatively inexpensive price. Negative features of the NL1000 should also be highlighted. Although the digital display allows for ease of access to data, this feature may also
contribute to participant reactivity, particularly in children, who often shake pedometers in order to increase their step score. In addition to this, open access to the buttons that reset the device could lead to participants resetting their device, whether intentionally or by accident, impacting the reliability of data gathered; these are negative features not associated with the GT1M device that has no display or buttons. Before a device is selected for use in research, these positive and negative features should be considered based on individual study requirements.

Conclusion

Children with visual impairments have much lower levels of fitness. The need for children with visual impairment to become physically fit is important because due to their impaired vision, their daily activities demand more energy. Intervention is necessary to increase physical activity levels in inactive individuals. There is a need for an affordable activity monitor that can accurately measure time spent in MVPA. This would provide physical activity practitioners with a measurement tool that could be used in large groups to provide feedback on whether levels of activity intensity meet the minimum level for enhancing health.
References


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