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ABSTRACT

This report explores the potential of a simple pedometer for physical activity measurement and motivation, explaining that physical inactivity is one factor that has contributed to the recent obesity epidemic. After a brief history of the pedometer, the report discusses measurement, focusing on how to measure physical activity in free-living populations; what pedometers measure; the best type of pedometer to use; how to collect pedometer data (what unit of measure to use, how long the pedometer must be worn, and how to record step counts); and how many steps people take per day. Finally, the report discusses issues related to motivation, including how many steps people should take, how pedometers can be used to motivate and promote physical activity, and basing programs on theory. It notes that the essential elements of a program theory are problem definition, critical inputs, mediating processes, expected outcomes, extraneous factors, and implementation issues. The report concludes that pedometers are practical, accurate, and acceptable tools for measuring and motivation in physical activity and may be of practical importance in the war on obesity. (Contains 92 references.) (SM)

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Taking Steps Toward Increased Physical Activity: Using Pedometers to Measure and Motivate

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Introduction

The U.S. Surgeon General ended 2001 with a call to action focused on preventing and decreasing the growing epidemic of overweight and obesity that threatens the health and welfare of our nation (U.S. Department of Health and Human Services, 2001). The prevalence of obesity (defined for adults as a body mass index ≥ 30 kg/m^2) increased from 12.0% in 1991 to 17.9% in 1998 (Mokdad, Serdula, & Dietz, 1999). In 2000 the prevalence of obesity was 19.8%, providing additional evidence of a continuing epidemic trend (Mokdad et al., 2001). Overweight (defined for adults as a body mass index between 25 and 30 kg/m^2) and obesity are associated with a host of disabilities and chronic illnesses (including diabetes and cardiovascular diseases); approximately 300,000 annual deaths are attributable to obesity (Allison, Fontaine, Manson, Stevens, & VanItallie, 1999).

One of the factors that has contributed to the obesity epidemic is physical inactivity (i.e., a sedentary lifestyle). Physical activity is one of the ten Leading Health Indicators identified by Healthy People 2010 (U.S. Department of Health and Human Services, 2000), supporting its importance as a pressing public health issue. Recent national estimates of leisure-time physical activity (derived from the 1998 Behavioral Risk Factor Surveillance System; BRFSS) indicate that approximately 50% of American adults are not sufficiently active to achieve health benefits; 29% are not physically active at all (Centers for Disease Control and Prevention, 2001). Self-reported participation in leisure-time physical activity has remained relatively stable (Centers for Disease Control and Prevention, 2001) even amidst increasing trends for overweight and obesity of epidemic proportions. Regardless, there has been a noticeable transition in work-related physical activity demands (moving increasingly from physical labor to sedentary occupations) and also in short-distance transportation modes and patterns. For example, U.S. transportation surveys indicate that there has been an annual increase in the number of personal vehicles at the rate of approximately 1.5 times the population growth and that the average household traveled about 4,000 more miles in 1995 than in 1990 (U.S. Department of Transportation, 1999). Further, there was a 37% decline in the number of trips made by children by foot or by bicycle between 1977 and 1995 (McCann & DeLille, 2000). Together, the estimated direct costs of inactivity and obesity account for approximately 9.4% of U.S. health care expenditures (Colditz, 1999). Booth (2002) reported that the direct and indirect costs of sedentary living is $150 billion. In 1996 the U.S. Surgeon General (U.S. Department of Health and Human Services, 1996) endorsed public health recommendations (Pate et al., 1995) that individuals minimally strive to accumulate 30 minutes or more of moderate intensity activity (like brisk walking) on most, if not all, days of the week. Since that time researchers and practitioners have likewise been striving to implement this recommendation and practically evaluate it. The purpose of this article is to explore the potential of a simple pedometer for both measurement and motivation.

A Brief History of Pedometry

Although the invention of the pedometer is commonly attributed to U.S. President Thomas Jefferson, drawings from the 15th century indicate that Leonardo da Vinci was the conceptual originator (Gibbs-Smith, 1978). His early design appeared to be a gear-driven device with a pendulum arm designed to move back and forth with the swinging of the legs during walking. Thomas Jefferson did enjoy the use of a pedometer he purchased in France, however, and likely introduced it to America (Wilson & Stanton, 1999).

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Pedometers have been used in Japan to assess physical activity and increase walking behaviors for over 30 years (Hatano, 1993). Hatano (Hatano & Tudor-Locke, 2001) reported that a pedometer came onto the commercial market in 1965 under the name of manpo-meter (manpo in Japanese means 10,000 steps). Both the slogan and the pedometer were widely accepted by the public and organized walking clubs seized the concept. Hatano reported that surveys conducted at walking events in Japan indicate that >90% of respondents have been aware of the slogan for more than five years and each household reports ownership of almost 2 pedometers! At least 10 Japanese-language articles are currently listed in PubMed (an electronic search engine). Using other search strategies (communicating with Japanese collaborators, translating reference sections of held Japanese-language articles, translating references obtained through Japanese-language search engines) yields another 48 promising articles. Currently, Japanese-language literature about pedometer-assessed physical activity represents an untapped source of scientific and practical information. Unfortunately, without translation, the contents of these articles are inaccessible to most North American researchers and practitioners. Support for the translation and review of previously inaccessible Japanese-language literature will likely contribute much to our understanding and use of the pedometer for multiple practical purposes.

Early English-language research studies used mechanical pedometers (Bassett et al., 1996) that were subject to large error making them unsuitable as precise research instruments (Blair, 1984). Further, researchers were quick to dismiss the utility of pedometers based on the poor performance of single brands (Tryon, Pinto, & Morrison, 1991). The new generation of electronic pedometers is more accurate for recording walking-related activity (Bassett et al., 1996). Set against the backdrop of a continuing obesity epidemic, and combined with the increased emphasis on accumulated moderate activity (Pate et al., 1995) as endorsed by the U.S. Surgeon General (U.S. Department of Health and Human Services, 1996), the stage has been set for rapid acceptance of the pedometer for both measurement and motivation applications.

Measurement

How do we measure physical activity in free-living populations?

Assessment of physical activity in free-living conditions (i.e., in the real world) is important to researchers and practitioners interested in surveillance, screening, program evaluation and intervention. Typically, self-report questionnaires, diaries and logs have been used to assess physical activity. The limitations to self-report include recall bias (Ainsworth, Sternfeld, Slattery, Daguise, & Zahm, 1998; Sallis & Saelens, 2000), differential interpretations of terms (e.g., light, moderate, vigorous activity) (Wilcox et al., 2001), floor effects (the lowest score available is too high for some respondents) (Tudor-Locke & Myers, 2001a), and a lack of sensitivity to ambulatory activity or walking (Ainsworth, Leon, Richardson, Jacobs, & Paffenbarger, 1993; Kriska et al., 1990; Richardson, Leon, Jacobs, Ainsworth, & Serfass, 1994). Ironically, walking is perhaps the most important activity to accurately assess; it is fundamental to all our daily activities and is consistently reported as a preferred leisure-time activity choice (Tudor-Locke & Myers, 2001a).

Although self-report approaches to measuring physical activity are still considered important to understanding context and patterns, there is increasing interest in objective monitoring of daily physical activity using electronic motion sensors, including accelerometers (Westerterp, 1999a, 1999b) and pedometers (Rowlands, Eston, & Ingledew, 1997; Tudor-Locke & Myers, 2001a, 2001b). Both types of motion sensors are small, light-weight, unobtrusive instruments that are typically worn comfortably at the waist and count movement. Accelerometers can detect movement in one plane (uniaxial, typically the vertical plane) or up to three planes (triaxial). Uniaxial accelerometers typically contain a horizontal lever arm with an electronic sensor sensitive to distortions in the vertical (up and down) plane. The accelerometer records "activity counts" (raw or pure movement data) that are the product of frequency and intensity (inferred from velocity) of movement sampled at set intervals (e.g., over one minute). The results are then either displayed as an accumulated total or, more often, downloaded for computer analysis. In contrast, the pedometer is much simpler in design and requires no additional software or expertise to access or interpret data. The internal mechanism of a pedometer typically includes a horizontal, spring suspended lever arm that moves up and down with normal ambulation (e.g., walking, running). An electrical circuit closes with each movement detected and an accumulated step count is displayed digitally on a feedback screen. Pedometers do not, however, record velocity of movement, restricting their use to measures of total accumulated steps/day, or accumulated steps taken over a specific time frame (e.g., during physical education class). Some of the newest pedometers count "time in activity." Pedometers with a time feature have a clock that starts with the initiation of stepping and stops with inactivity. We must await research findings to determine the value of this feature.

Pedometers display good agreement with accelerometers (r=0.80-0.90) (Bassett et al., 2000; Kalscheuer, 2002; Leenders, Sherman, & Nagaraja, 2000), indicating that the two types of motion sensors measure approximately the same total accumulated daily activity. The cost of accelerometers ($50-400 per unit), costs for additional software and calibration hardware, and the associated demands of personnel expertise and time, make widespread use of accelerometers prohibitive outside the realm of research (Tudor-Locke & Myers, 2001a). More and more, researchers are beginning to acknowledge, that in terms of practicality, pedometers offer the better solution for a low cost ($10-30 per unit), objective monitoring tool that is accessible to both researchers and practitioners (Bassett, 2000; Freedson & Miller, 2000; Welk, Corbin, & Dale, 2000; Welk, et al., 2000). A common measurement tool and collection protocols would help bridge the gap between research and practice.

What do pedometers measure?

Most pedometers record and display movement as steps taken (a simple, raw or pure measure of ambulatory activity). Some also have features to estimate energy expended (kcals) and/or distance traveled (miles or kilometers). Typically the user must manually enter a number of variables (including any manufacturer-defined combination of gender, stride length, weight and/or age) into the pedometer's program in order to obtain a running estimate of caloric expenditure or distance traveled. The manufacturer's actual mathematical formula used is usually proprietary, meaning it is not readily available for public or scientific scrutiny. Further, this process of manipulating the raw step data introduces possible error. Individuals with shorter stride lengths appear to do less activity (for the same number of steps taken) if only their distance traveled is compared to that of individuals with longer stride lengths (Bassey, Dallosso, Fentem, Irving, & Patrick, 1987; Saris & Binkhorst, 1977). Similarly, reporting physical activity as energy expenditure makes it appear that obese people are more active than those who are normal weight (Tudor-Locke & Myers, 2001b). In agreement with this, studies have shown that pedometers are most accurate at measuring steps taken (Bassett et al., 1996; Hendelman, Miller, Baggett, Debold, & Freedson, 2000), less accurate at estimating distance traveled (Bassett et al., 1996; Hendelman et al., 2000), and even less accurate at estimating energy expenditure (Bassett et al., 2000). For these reasons, researchers (Rowlands et al., 1997; Tudor-Locke & Myers, 2001b) have recommended that steps taken, or steps/day be universally adopted as a standard unit of measurement for collecting, reporting, and interpreting pedometer data.

Pedometers are not perfect and there are a few potential threats to their validity. Although it has been suggested that riding in motorized transport may contribute to erroneously detected "steps" (Schonhofer, Ardes, Geibel, Kohler, & Jones, 1997), the magnitude of the error is approximately 2-3% of daily accumulated steps taken and therefore can be considered minor (Tudor-Locke, Jones, Myers, Paterson, & Ecclestone, in press). Pedometers consistently show more error during slow walking (Bassett et al., 1996; Hendelman et al., 2000). Specifically, research has shown that the Yamax pedometer underestimates (by approximately 25%) steps taken at walking speeds of < 60 meters/minute (Bassett et al., 1996; Hendelman et al., 2000). Hendelman et al. (2000) suggest that this speed of walking is much slower than normal self-selected walking speeds and should therefore not be considered an important source of error in free-living general populations. However, slow, shuffling, gaits characteristic of frail and/or institutionalized older adults may not be easily detected (Wilcox, Tudor-Locke, & Ainsworth, 2002); this is at least one population group for whom pedometers may prove to be inappropriate. A dissertation from the University of Waterloo provides preliminary evidence that this is true (Cyarto, 2001). Concern has also been raised about error related to increased obesity (Schmalzried et al., 1998; Shepherd, Toloza, McClung, & Schmalzried, 1999). In particular, abdominally-distributed adiposity may interfere with accurate detection of steps taken due to inappropriate placement (e.g., rotation of the pedometer horizontally), gait abnormalities associated with extreme obesity, and/or a dampening effect. This is an important research question that needs to be addressed: is there a BMI cut point above which pedometer error is unacceptable? Until such information is available, it would behoove researchers and practitioners to assess the pedometer's validity on each participant during a brief walking trial (McClung, Zahiri, Higa, Amstutz, & Schmalzried, 2000).

What is the best pedometer to use?

A number of electronic pedometers are commercially available; one has only to type in the keyword "pedometer" on any internet search engine to view a variety of instruments. Unfortunately, only one study has conducted a head-to-head comparison of different brands (Bassett et al., 1996). The most accurate brand in that study, the Yamax Corporation (Model SW-500, Tokyo, Japan) recorded within 1% of all steps taken under controlled conditions (walking on a 4.88km sidewalk course). Unfortunately, as is often the case with consumer items, this particular model has been discontinued (Bassett, 2000). It appears that identifying a single brand and model for standard use is futile since access to specific models is governed by distribution channels and we can anticipate continual product development. Therefore, before using any particular brand or model of pedometer, researchers and practitioners should quickly validate their units against the obvious field criterion standard of observed steps taken (Tudor-Locke & Myers, 2001b). Simply walk a short distance at a normal walking pace wearing the pedometer as specified by the manufacturer and simultaneously count actual steps taken. Vincent and Sidman (in press) conducted a 100-step walk test and also a "shake test." The shake test involved shaking the pedometers in the manufacturer's shipping box 100 times and then recording the counts on each pedometer. These researchers reported that the percent error for the walk test was <2% and for the shake test was <1%. No pedometer exceeded 5% error (i.e., 5 steps out of 100) on any of the tests. Researchers and practitioners should expect similar error when validating their own pedometers using similar methods.

How do you collect pedometer data?

Both researchers and practitioners will be interested in collecting pedometer data for screening and evaluation purposes. The universal adoption of standardized data collection methods and protocols is necessary to bridge the gap between research and practice. These methods must not only be based on empirical research but must also be feasible and acceptable under free-living conditions to researchers, practitioners, and their participants. An initial attempt has been made to assemble these methods and protocols (Tudor-Locke & Myers, 2001b) and they are summarized here with some updated information.

What unit of measure should be used? As previously discussed, steps taken (over a defined time period), or steps/day is the most appropriate unit of measure. This format (rather than energy expenditure or distance traveled) will facilitate comparisons between studies and with existing programs.

How long must the pedometer be worn? In the case of estimating habitual or customary activity, the monitoring frame is the necessarily minimum amount of time that participants must wear the pedometer. This has not been well established yet and may vary depending upon the characteristics of the target population under study. To date, monitoring frames have ranged from one day (Kashiwazaki, Inaoka, Suzuki, & Tamada, 1985) to 14 consecutive days (Tryon, Goldberg, & Morrison, 1992). Meager reliability evidence has been put forth as yet. Gretebeck and Montoye (1992) are often cited to support a monitoring frame of five to six days (including weekend days) of pedometer data collection with less than 5% error. That study was conducted with a sample of young males purposefully recruited on the basis of their varied physical activity pursuits. This length of monitoring frame may not be necessary in all populations especially those considered to be typically sedentary. For example, a couple days may be all that is necessary to obtain a reliable estimate of habitual activity in individuals living with chronic illness or who otherwise participate in few and relatively unvaried physical activities (Schonhofer et al., 1997; Tudor-Locke, 2001). Until better information is available, it is prudent to conduct pilot work in the intended population (Tudor-Locke & Myers, 2001b). However, if the purpose of the study is to examine cyclical patterns of daily physical activity (e.g., associated with day of the week), or to promote individual awareness of personal patterns of daily physical activity as part of a behavior modification program, then a full week (or more in the case of intervention) of continuous monitoring may be most effective.

How should step count results be recorded? When it comes down to the specifics of actual data recording, there are two obvious choices: either the researcher/practitioner records the data (implying the pedometer is sealed and no feedback is accessible to the participant) or the participant does (implying the pedometer is unsealed and feedback is accessible). Regardless of the data recording specifics, there is always a concern that participants will alter their behavior simply because they are being monitored (also know as reactivity). Vincent and Pangrazi (2002) recently ruled out reactivity in children wearing sealed pedometers. The potential for reactivity using unsealed pedometers has not been well explored yet. A thesis at Arizona State University focused on this problem found preliminary evidence that children did not alter their behavior when monitored by unsealed pedometers compared to sealed ones (Ozdoba, 2002). At this time we do not know if reactivity is a problem with adults, regardless of whether or not the pedometer is sealed. Additional research is needed to address these niggling issues.

Reactivity aside, a number of recent studies have been conducted where the pedometer was unsealed and participants took an active role in recording data (Moreau et al., 2001; Speck & Looney, 2001; Sugiura, Kajima, Mirbod, Iwata, & Matsuoka, 2002; Tudor-Locke, 2001; C. Tudor-Locke et al., 2001; Tudor-Locke, Jones, et al., in press; Wilde, Sidman, & Corbin, 2001). The practical appeal of this process is undeniable; successful self-monitoring opens up additional possibilities including surveillance that capitalizes on the existing postal system. At least two studies have relied on participants returning self-monitored pedometer data in this manner (Sequeira, Rickenbach, Wietlisbach, Tullen, & Schutz, 1995; Tudor-Locke et al., 2002). On the whole, it appears that (given simple instructions), few adults have problems recording their total daily steps on a calendar and re-setting the pedometer to zero in preparation for a subsequent day of data collection. Although it seems likely (especially with supervision), less information is available on children's ability to take part in their own data collection.

How many steps do people take?

To date, no single study has yet been conducted to obtain representative data on a random population sample. Normative data for expected values of steps/day has necessarily been assembled from original studies scattered throughout the published literature. A systematic review (Tudor-Locke & Myers, 2001b) of these studies (32 in total) suggests that we can expect between 12,000-16,000 steps/day in 8-10 year old children (lower for girls than boys); between 7,000-13,000 steps/day in healthy younger adult samples (lower for women than for men); between 6,000-8,500 steps/day in healthy older adult samples; and between 3,500-5,500 steps/day in individuals with disabilities and chronic diseases. Since that time a number of additional studies have been conducted. A study of 700+ 6-12 year old children reported that girls took between 10,479-11,274 steps/day and boys took 12,300-13,989 steps/day (Vincent & Pangrazi, in press). Another study of 600+ adolescents (14-16 year old) also reported values of 11,000-12,000 steps/day (again, lower for girls than boys) (Wilde, 2002). Although the evidence is currently fragmented, patterns of pedometer-determined physical activity are discernable. Figure 1 presents a summary of these expected values. Expected values of steps/day can serve as benchmarks for interpreting change and comparison purposes but should not be misinterpreted as recommendations for appropriate activity levels since we may discover that optimal indices associated with important health outcomes are higher! Recommendations can only be made once the totality of accumulated evidence supports specific health-related cut points or indices. This last point will be discussed in more detail later.

Motivation

How many steps should we take?

It is foolish to surmise that if we distributed enough

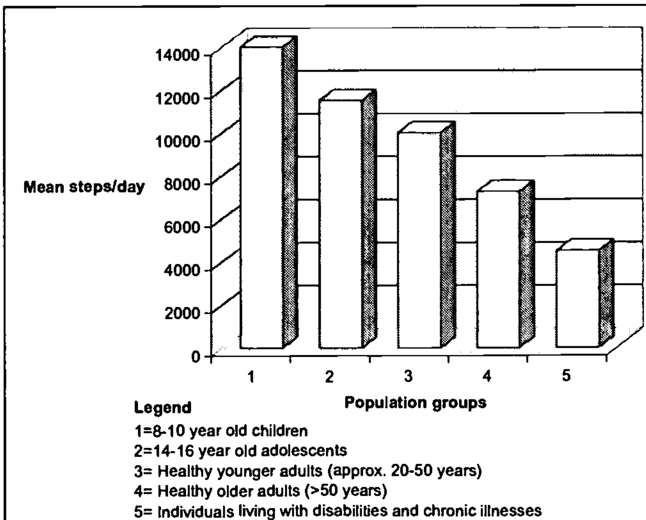

Figure 1. Expected values of steps/day for different populations

Adapted in part from Tudor-Locke and Myers (2001b) pedometers to each household in the nation our work as physical activity promoters would be done. Without software (e.g., guidelines, programs, etc.) the hardware (i.e., the pedometer) is useless. Researchers and practitioners require practice guidelines (Tudor-Locke & Myers, 2001b), including step indices associated with important health-related outcomes (e.g., obesity, hypertension). As stated previously, Japanese health promotion efforts recommend a goal of 10,000 steps/day (Hatano, 1993; Yamanouchi et al., 1995). According to Hatano (1997) 10,000 steps/day is approximately equal to an energy expenditure of 300-400 kcal/day (depending on walking speed and body size). This is double the amount (150 kcal/day) that the U.S. Surgeon General indicates is related to health benefits (U.S. Department of Health and Human Services, 1996). Compared to assembled expected values (Tudor-Locke & Myers, 2001b), 10,000 steps seems a reasonable estimate for ostensibly healthy adults, but there is currently little empirical evidence (i.e., linked to important health-related outcomes) to support such a threshold. Specifically, neither the appropriateness nor the sustainability of a universal goal of 10,000 steps/day has been thoroughly examined. Although body composition has been consistently related to pedometer-determined steps taken in adults (McClung et al., 2000; Tryon et al., 1992; C. Tudor-Locke et al., 2001; Tudor-Locke et al., 2002) and children (Rowlands, Eston, & Ingledew, 1999), few have attempted to link specific step cut points to indicators of body fatness. A single cross-sectional study has reported that individuals who take >9,000 steps/day are more frequently classified as normal weight (defined by BMI cut points) and those who take <5,000 steps/day are more frequently classified as obese; there were, however, exceptions to this rule (Tudor-Locke et al., 2001). Some experts have suggested that at least 15,000 steps/day is necessary to achieve weight loss goals (Leermakers, Dunn, & Blair, 2000).

With regards to appropriateness as a universal goal, 10,000 steps/day is likely too low for children; expected values for 8-10 year old U.K. children currently range 12,000-16,000 steps/day (Rowlands et al., 1999) while U.S. adolescents (14-16 years old) 600+ adolescents take 11,000-12,000 steps (Wilde, 2002). Further, a Japanese study (Suzuki et al., 1991) of handicapped youth ranging from 3 to 22 years reported that mentally retarded, blind, and deaf youth took an average of 14,500 steps/day, 12,700 steps/day, and 17,400 steps/day, respectively, compared to physically handicapped youth who took 8,050 steps/day. A recent study of 6-12 year old U.S. children reported 10,479-11,274 and 12,300-13,989 steps/day for girls and boys respectively (Vincent & Pangrazi, in press). The 2001-2002 President's Challenge Physical Activity and Fitness Awards Program (President's Council on Physical Fitness and Sports, 2001) recommends that children accumulate 11,000 steps/day at least 5 days a week for a standard healthy base.

With regards to sustainability, the 10,000 steps/day is unrealistically too high for sedentary individuals or those living with chronic diseases who take between 3,500-5,500 steps/day (Tudor-Locke & Myers, 2001b). This would require a 2-3 fold increase in *daily* activity, setting up a high risk situation for failure and attrition. In support of this concern, a workplace walking program that prescribed 10,000 steps/day has reported a high attrition rate (88% over 12 weeks) (Iwane et al., 2000). In a study of healthy older adult exercisers (Tudor-Locke, Jones, et al., in press), half of the sample never achieved 10,000 steps on any single day of monitoring, despite the fact that they engaged in various forms of exercise (e.g., exercise class and informal walking for exercise) most days of the week. Wilde et al. (2001) reported that, even with a 30 minute walk included, the proportion of women who achieved >10,000 steps/day only ranged between 38-50%. Preliminary evidence suggests that the effort required to achieve a 10,000 step/goal is associated with reduced adherence in women participating in a pedometer-based intervention (Sidman, 2002b).

Recommended levels of steps/day should not be determined from cross-sectional studies but should be inferred from longitudinal designs that allow step indices to emerge from the data related to important health outcomes. Until that time, a practical translation (in terms of pedometer-determined steps taken) of the public health recommendation would be useful to researchers interested in standardizing physical activity measures and practitioners charged with program evaluation and in motivating clientele to adopt healthful levels of physical activity. For example, it is possible to establish an index of steps taken in 30 minutes of brisk walking. Then we can compare this index to other activities of varying intensities and durations. We could also compare changes in steps/day due to intervention to this index to determine whether or not the public health recommendation was achieved. Welk et al. (2000) estimated that approximately 3,800-4,000 steps represented 30 minutes of moderate intensity walking. Wilde et al. (2001) reported that an unsupervised 30 minute walk included in a typical day of activity represented approximately 3,100 steps. Individuals with type 2 diabetes (mean age 53 years) took 2,198±282 steps during a self-paced 20 minute walk, equivalent to 3,297 steps in 30 minutes (Tudor-Locke, Myers, Bell, Harris, & Rodger, in press). Measured directly, older (59-80 years) healthy individuals took 3,411±577 steps in 30 minutes of continuous walking (Tudor-Locke, Jones, et al., in press). Collectively, 3,100-4,000 pedometer-determined steps taken appear to be equivalent to 30 minutes of moderate intensity walking. A simple study is warranted to directly establish a reliable index of pedometer-determined steps equivalent to 30 minutes of moderate intensity activity.

Another approach is to select personally relevant incremental goals anchored by individual baseline values. Any goal selected should be an improvement from baseline and should also be sustainable for the long term (Sidman, 2002a). Details are provided below on such an approach used in the First Step Program (Tudor-Locke, Myers, et al., in press; Tudor-Locke, Myers, & Rodger, 2000).

How can pedometers be used to motivate and promote physical activity?

A pedometer can be used as a tracking device (continuously collecting current activity), a feedback tool (providing immediate information on activity level), and as an environmental cue (reminder to be active). Used in combination with record keeping (e.g., calendars or diaries of daily progress), pedometers may be used in an effective way to increase daily physical activity. A number of implementation ideas have been suggested by Beighle et al. (2001) for use in school settings. Besides self-monitoring, however, a process of progressive goal-setting, reflection, and refinement should be put in place (Tudor-Locke, Myers, & Rodger, 2001).

Base programs on theory

An increasing number of intervention studies have used pedometers to track and/or motivate physical activity (Bassey, Patrick, Irving, Blecher, & Fentem, 1983; Fogelholm, Kukkonen-Harjula, & Oja, 1998; Iwane et al., 2000; Meshkinpour et al., 1998; Moreau et al., 2001; Puente-Maestu et al., 2000; Speck & Looney, 2001; Toda et al., 1998; Tudor-Locke, Myers, et al., in press; Yamanouchi et al., 1995). Project Active also used pedometers to increase lifestyle activity but did not provide details on pedometer use or outputs in the article (Dunn et al., 1999). With the exception of the First Step Program (Tudor-Locke, Myers, et al., in press; Tudor-Locke et al., 2000; Tudor-Locke et al., 2001), these studies provide few program details necessary to facilitate implementation and delivery in real-world settings. Program theory is used to systematically organize and explain what happens in the program and why (Myers, 1999; Sidani & Braden, 1998). Program theory drives program development, implementation, and evaluation. The essential elements of a program theory include: problem definition, critical inputs, mediating processes, expected outcomes, extraneous factors, and implementation issues (Lipsey, 1993; Sidani & Braden, 1998).

Critical inputs are the key components or activities that must be present in successful physical activity interventions; these are informed by literature review, pilot work, consultation with program deliverers and recipients, and clinical understanding. Critical inputs in the First Step Program included initial group meetings with peers, flexibly scheduled moderate-intensity walking, self-monitoring and progressive individual goal-setting using a combination of a pedometer and calendar, training in accessing personal social support networks, and regular follow-up contact.

Mediating processes link critical inputs and expected outcomes. The First Step Program was informed by Social Cognitive Theory (Bandura, 1986, 1997), especially the important mediating processes of self-efficacy (or self-confidence with task performance) and social support.

Expected outcomes are expressed as short-, intermediate-, and long-term program outcomes (e.g., to increase steps/day and/or to achieve self-selected goals, to reduce waist girth, and to reduce cardiovascular disease risk, respectively).

Extraneous factors can affect participant outcomes either directly or indirectly (by moderating intervention effects) and include participant characteristics, intervener characteristics, program setting, and home/work environments. For example, the First Step Program includes program elements designed to enable participants to recognize and control extraneous factors where possible.

Implementation issues include resources and systems necessary for program delivery. In order to encourage widespread adoption, the First Step Program was developed to be simple enough to be delivered in a variety of settings, with minimal and inexpensive equipment demands, and intervener training requirements.

The First Step Program is an 8-week program designed to incrementally increase and sustain habitual physical activity levels in sedentary individuals with type 2 diabetes. The program is divided into two distinct phases directed at adoption and adherence. The adoption phase consists of four weekly group-based education and counseling meetings, combined with individual goal-setting and self-monitoring using a pedometer for feedback. The adherence phase occurs over a subsequent 4-week period with continued individual goal-setting and self-monitoring and limited telephone and/or postcard contact. The program theory underlying the First Step Program (Tudor-Locke et al., 2000) has been previously outlined (Tudor-Locke et al., 2001) and additional program details are also available (Tudor-Locke et al., 2000).

Association and Health Canada have contributed funds to evaluate the dissemination of the First Step Program across Canada including evaluation of the program as delivered by peer leaders. Evaluation of additional program models in varied populations and settings are necessary to inform the program theory underlying pedometer-based programs.

Summary and Conclusions

The evidence continues to accumulate that pedometers are practical, accurate, and acceptable tools for measurement and motivation in physical activity. The simple pedometer can be used equally well by both researchers and practitioners and therefore offers a simple opportunity to bridge the gap between research and practice. As acceptance continues to grow, accumulation of additional evidence will permit refinement of standardized measurement methods and protocols.

More definitive index values or cut points of steps/day for classifying sedentary populations and the optimal (based on appropriateness and sustainability) number of steps/day necessary to produce various health benefits requires additional empirical evidence. Although 10,000 steps/day appears to be readily accepted by the media (DeSa, 2001; Kosta, 2001; Krucoff, 1999; Spilner & Robertson, 2000) as a health-appropriate goal, the fact is that the scientific evidence is currently lacking and it is doubtful that any universal goal exists applicable to all populations. Such universal goals should be approached with caution. A better approach is to personalize step goals having considered baseline values, specific health goals, and sustainability of the goal in everyday living. Program theory will also be refined as new pedometer-based programs are developed, implemented and evaluated. Important studies are already in the planning stages. All in all, it is entertaining to ponder that such a seemingly insignificant gadget may be of practical importance in the war on obesity.

Pedometers are practical and accurate tools for measurement and motivation for physical activity.

The steps goals should be personalized considering baseline values, specific health goals, and sustainability of the goal in everyday living.

All in all, it is entertaining to ponder that such a seemingly insignificant gadget may be of practical importance in the war on obesity!

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