Accumulating 10,000 Steps: Does This Meet Current Physical Activity Guidelines?

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The purpose of this study was to determine whether taking 10,000 steps in a day is equivalent to meeting the current national physical activity guidelines of accumulating at least 30 min of moderate physical activity (MPA). Fifty-nine women ages 20–65 years wore a pedometer and accelerometer concurrently on their right hip for 1 day. There were no differences in the age, body mass index, or the amount of time the pedometers and accelerometers were worn between the 10K+ and the <10K groups. The 10K+ group accumulated significantly more steps and minutes of MPA than the <10K group (M = 13,084 steps, SD = 2,603 vs. M = 7,518 steps, SD = 1,955; and M = 62.1 min, SD = 27.7 vs. M = 38.9 min, SD = 18.9, p < .05). A 2 x 2 chi-square analysis demonstrated no difference between the proportions of 10K and <10K participants who met the step goal, when all minutes of MPA accumulated throughout the day were considered (x² = 1.8, df = 1, p = .175). When only continuous bouts of MPA lasting >5 min and >10 min were considered, a significantly greater proportion of 10K participants met the current physical activity guidelines than the <10K participants (x² = 11.5, df = 1, p = .001, and x² = 5.9, df = 1, p = .015, respectively). Our findings suggest that individuals who accumulate 10,000 steps/day are more likely to meet the current physical activity guidelines by engaging in the length of bouts promoted by the Centers for Disease Control and Prevention and the American College of Sports Medicine (Pate et al., 1995) and the U.S. Surgeon General (U.S. Department of Health and Human Services, 1996). However, the data also reveal that accumulating 10,000 steps/day does not guarantee meeting the guidelines in the bout lengths documented to confer the health benefits of physical activity.

Key words: accelerometer, pedometers, steps/day

A pedometer-based target of 10,000 steps/day has been promoted in the popular press as a way for adults to meet the current national physical activity guidelines (Fleury, 2000; Hellmich, 1999; Quitmier, 2000; Wahlberg, 2003). The current national physical activity guidelines are based on empirical evidence and recommend that every U.S. adult accumulate 30 min of moderate physical activity (MPA) equivalent to brisk walking on most, if not all, days per week (American College of Sports Medicine, 1995; Pate et al., 1995; U.S. Department of Health and Human Services, 1996). No research has directly assessed whether the 10,000 steps/day target is equivalent to the empirically set guidelines and, in the few studies that have indirectly examined the 10,000 steps/day target as a way of meeting these guidelines (Hatano, 1993; Welk et al., 2000; Wilde, Sidman, & Corbin, 2001), limited support for or against the step target has been provided. Because pedometers do not measure the intensity or patterns of physical activity, research attempting to validate the 10,000 steps target will require the combined use of a pedometer with a tool that can provide additional information about the intensity and patterns of physical activity.

The Computer Science and Applications (CSA) accelerometer (model 7164; MTI Health Services, Fort Walton Beach, FL) is a uniaxial accelerometer capable...
of objectively measuring physical activity over user-specified time intervals for several days. The CSA accelerometer enables researchers to obtain estimates of the intensity and pattern of physical activity. When calibrated, the accelerometer is both a reliable and valid tool to objectively measure physical activity (Freedson, Melanson, & Sirard, 1998; Melanson & Freedson, 1995). Both the pedometer and accelerometer are small, lightweight, and unobtrusive and can be worn together with comfort. Concurrent use of these instruments has been used in previous research (Basset et al., 2000; Leenders, Sherman, & Nagaraja, 2000) and allows for measuring steps taken as well as the patterns and intensity of physical activity. The purpose of the present study was to determine whether accumulating 10,000 steps/day, as commonly reported in the popular press, is equivalent to meeting the current national physical activity guideline of accumulating at least 30 min of MPA.

Method

Participants

From a total of 121 sedentary women participating in a 4-week pedometer-based study designed to increase physical activity levels, 59 women were randomly selected to wear an accelerometer in addition to the pedometer for the 1 day during the fourth week of the study. The day was the same for all participants. The body mass index (BMI) data used in the present study were gathered prior to the 4-week intervention. All participants read and signed a letter of written informed consent to take part in the study voluntarily. This study was reviewed and approved by the Institutional Review Board at Arizona State University.

Physical Activity Measures

Participants wore the Yamax SW-200 pedometer (PED; Tokyo, Japan) to measure the number of steps taken. The PED is an electronic pedometer that operates on a horizontal, spring-suspended lever arm that moves up and down with vertical accelerations at the hip. When vertical accelerations reach ≥ .35 Gs, the lever arm makes an electrical contact, and records one event (Bassett et al., 1996). The accuracy of PEDs has been demonstrated in comparison to other brands (Bassett et al., 1996), and evidence of the PED as an objective indicator of physical activity has been provided (Dillerding, Welk, Hart, Abate, & Symington, 1998; Eston, Rowlands, & Ingledeuw, 1998; Tudor-Locke & Myers, 2001a, 2001b).

In addition to the PED, participants wore the CSA accelerometer, which measures activity counts used to infer the intensity of physical activity (Freedson et al., 1998). This accelerometer is designed to detect vertical acceleration ranging in magnitude from 0.05 to 2.00 Gs with frequency response of 0.25-2.50Hz. The filtered acceleration signal is digitized, and the magnitude is summed over a user-specified time interval. For the current study, a 1-min time interval (epoch) was used. At the end of each interval, the summed function of cycles and their acceleration (activity count) is stored in memory, and the integrator is reset (Computer Science and Applications, 1995).

Procedure

Each accelerometer was checked for calibration using the manufacturer's calibrator prior to use and distributed to participants the day before they wore it concurrently with the pedometer. The PEDs were checked for accuracy using a walking test and a manual shake test (Vincent & Sidman, 2003). Participants were instructed to wear the accelerometer and PED the following day from the time they woke until they were in bed, excluding water activities (e.g., bathing and swimming). Participants were required to record their steps/day throughout the 4-week study and hand deliver or fax their progress weekly. The accelerometer was mounted on an adjustable strap, and participants wore the strap with the accelerometer aligned with the midline of their right thigh. The PED was attached to the strap immediately right of the accelerometer. At the time of distribution, a date and time for the accelerometer collection was established, and participants were asked to bring their daily step log so that steps/day for the concurrent PED and accelerometer day could be recorded.

Data Treatment

Minute-by-minute activity counts were uploaded to manufacturer's recommended day-by-day reduction software to determine time spent in MPA (3–5.99 METS) and vigorous physical activity (≥ 6 METS). These MET ranges for defining moderate and vigorous physical activity have been used in previous research (Leenders et al., 2000; Masse et al., 1999) and correspond to count ranges established by Freedson et al. (1998) for moderate and vigorous physical activity using the following regression equation:

\[ \text{METs} = 1.439 + (0.000795 \text{- counts-min}^2) \]

Moderate and vigorous physical activity count ranges were 1,952–5,724 counts/min and ≥ 5,724 counts/min, respectively. The total min/day spent in MPA were calculated by summing the minutes above the 1,952 count/
min cut point. Minutes in vigorous physical activity (VPA) were added to the total min/day of MPA, because so few participants (<10%) engaged in VPA.

To determine the amount of continuous MPA, the data were further analyzed to include only bouts lasting ≥5 min or ≥10 min. To be considered continuous bouts, 100% of the minutes in a bout of ≥5 min were required to be above the count/min cut point for MPA. For the 10-min bouts, 90% of the minutes were required to be above the age-related cut point. For example, if a bout lasted 20 min, 18 or more of those minutes were required to be above the count/min cut point for MPA. This data treatment has been used in previous research (Trost et al., 2002).

**Statistical Analysis**

Participants were stratified by those who accumulated 10,000 steps (10K+) and those who did not (<10K). Independent t-tests were used to determine differences in PED, and accelerometer determined physical activity between the two strata. The Levene's statistic (Norusis, 2000) was used to test the equality of variances between groups and, when significant, a t-test, assuming unequal variances was used. Significance was set at the .05 level. A 2 x 2 chi-square analysis with an adjustment for continuity (Norusis, 2000) was used to determine if there was a difference between the proportions of participants in the 10K and <10K group meeting the current physical activity guidelines. The analysis was run considering all minutes of accumulated MPA, accumulated MPA in bouts of >5 min, and accumulated MPA in bouts of >10 min.

**Results**

The descriptive data for the 10K+ and <10K groups are shown in Table 1. The average BMI for the two groups was not significantly different prior to beginning the intervention. There was no significant difference between the heights of the 10K and <10K groups, ruling out differences in step counts based on participant height. Both groups wore the accelerometer and PED for an average of 15 ± 1.5 hr. The 10K+ group had a significantly (p < .05) higher average PED steps and accelerometer counts/min/day compared to the <10K group.

When all minutes of MPA were considered, regardless of continuity, the 10K+ group accumulated significantly more minutes of total MPA than the <10K group (M = 62.1 min, SD = 27.7, vs. M = 38.8 min, SD = 18.9, p < .05). With respect to continuous MPA, the 10K+ group accumulated significantly more minutes of total continuous MPA (see Table 2). Analysis of the percentage of participants in each strata accumulating at least 30 min of MPA demonstrated that, of the 35 participants in the 10K+ group, 32 (91%) accumulated more than 30 min of MPA. In the <10K group, 18 (75%) participants accumulated more than 30 min of MPA. When continuous bouts of ≥5 min were considered, 27 (77%) 10K+ participants and 7 (29%) <10K participants accumulated more than 30 min in MPA. When bouts of ≥10 min were considered, 18 (51%) 10K+ participants and 4 (17%) <10K participants accumulated 30 min of MPA.

When all minutes of MPA were considered, there was no significant difference in the proportion of 10K

| Table 1. Descriptive variables, pedometer steps and accelerometer data for 10K+ and <10K groups |
|--------------------------------------------------|---------------------------------|---------------------------------|
| 10,000+ (N = 35)                                 | <10,000 (N = 24)                |
| Age (years)                                      | 43.4                            | 43.9                            |
|                                                   | 11.5                            | 11.1                            |
|                                                   | (39.5–47.4)                     | (39.2–48.6)                     |
| BMI (kg/m²)                                      | 28.3                            | 30.0                            |
|                                                   | 5.5                             | 8.2                             |
|                                                   | (26.3–30.2)                     | (26.5–33.5)                     |
| PED (steps/day)                                  | 13,084                          | 7,518                           |
|                                                   | 2,603*                          | 1,956                           |
|                                                   | (12,191–13,979)                 | (6,692–8,344)                   |
| CSA (hours worn)                                 | 15.3                            | 15.1                            |
|                                                   | 1.5                             | 1.6                             |
|                                                   | (14.7–15.8)                     | (14.2–16.0)                     |
| CSA (counts/min/day)                             | 494                             | 326                             |
|                                                   | 153*                            | 88                             |
|                                                   | (442–547)                       | (289–363)                       |

*Note. BMI = body mass index; PED = pedometer; CSA = accelerometer.
*Significantly greater than the <10K group (p < .05).

| Table 2. Minutes spent in total moderate physical activity and total continuous moderate physical activity for 10K+ and <10K groups |
|--------------------------------------------------|---------------------------------|---------------------------------|
| Group                                            | Total MPA (min)                | Continuous MPA in ≥5 min bouts (min) | Continuous MPA in ≥10 min bouts (min) |
| MPb                                              | 10,000+                        | <10,000                          |
|                                                   | (N = 35)                       | (N = 24)                        |
| MPA                                              | (52.5–71.6)                    | (32.5–49.2)                     | (22.9–37.4)                     |
|                                                   | 62.1                            | 40.8                            | 30.1                            |
|                                                   | 27.7*                           | 24.2*                           | 21.0*                           |
|                                                   | (38.8)                          | (18.9)                          | (15.8)                          |
|                                                   | (30.8–46.7)                     | (14.7–30.0)                     | (6.3–19.7)                      |

*Note. MPA = moderate physical activity.
*Significantly greater than the <10K group (p < .05).
and < 10 K participants meeting the current physical activity guidelines \((\chi^2 = 1.8, df = 1, p = .175)\). When continuous bouts of \(\geq 5\) min and \(\geq 10\) min were considered, a significantly greater proportion of 10 K participants met the current physical activity guidelines than the < 10 K participants \((\chi^2 = 11.5, df = 1, p = .001, \text{ and } \chi^2 = 5.9, df = 1, p = .015, \text{ respectively})\).

**Discussion**

The 10,000 steps/day goal, like the current national physical activity guidelines, is based on increasing people's daily energy expenditure (Hatano, 1993). Hatano (1993) estimated the energy expenditure for walking at various speeds and extrapolated to suggest that walking 10,000 steps/day at a "fairly fast" pace was equivalent to expending 350-400 kcal, which is greater than the increases in daily energy expenditure promoted by the American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention (CDC; = 200 kcal) as necessary for health risk reduction (Pate et al., 1995). However, lay articles and the media promoting the 10,000 steps/day target have failed to acknowledge the intensity factor, which is a necessary component of the 10,000 steps/day target and current national physical activity guidelines.

In the present study, use of the accelerometer concurrently with the PED made it possible to examine the patterns and intensity of physical activity performed by adult women. When all minutes of MPA were considered toward total MPA, the majority of participants from the 10K+ (91%) and < 10K groups (77%) accumulated 30 min of MPA, and both groups averaged over 30 min of MPA (see Table 2). In addition, when all minutes of accumulated MPA were considered there was no statistical difference in the proportions of participants from the 10K and < 10K groups that met the current physical activity guidelines. In previous research, Wilde et al. (2001) demonstrated that sedentary women (2,000-5,000 steps/day) can add a 30-min walk to their day and still not reach 10,000 steps. Current research (Tudor-Locke, Ainsworth, Thompson, & Matthews, 2002) reported a correspondence between 8,000 and \(\approx 33\) min of all accumulated MPA as measured by the CSA accelerometer. In support of the studies by Wilde et al. (2001) and Tudor-Locke et al. (2002), our results iterate the fact that one does not have to achieve 10,000 steps to accumulate the recommended 30 min of MPA.

In the original ACSM and CDC report (Pate et al., 1995), accumulating MPA in short bouts is suggested as an effective way to accumulate 30 min of MPA and meet the physical activity guidelines. In fact, this strategy is particularly effective for beginners and those who do not engage in regular physical activity. First, it is assumed that lower doses of physical activity (i.e., intensity and duration) are more enjoyable for the average person, thus, leading to higher involvement and adherence rates (Ekkekakis & Petruzzello, 1999). Second, a gradual buildup to 30 min of MPA may prevent musculoskeletal problems incurred from doing too much too soon. Pedometer based interventions (Sidman, 2002; Tudor-Locke, Myers, & Rodger, 2000) and the research to support them (Tudor-Locke, 2002; Wilde et al., 2001) have identified the importance of selecting personally relevant incremental goals anchored by individual baseline step counts. However, there may be a required stimulus for the proposed health benefits of physical activity (Haskell, 1994) and the health benefits of engaging in short (1-4 min), intermittent bouts of physical activity not been directly researched.

Research demonstrating the health benefits of accumulating 30 min of MPA in 5- (Coleman et al., 1999) and 10-min bouts exists (Fulton et al., 2001; Manson et al., 2002; Manson et al., 1999; Murphy, Nevill, Neville, Biddle, & Hardman, 2002; Staffileno, Braun, & Rosenson, 2001; Thomas, Lewis, McCas, & Adams, 2001). Accumulating 30 min of MPA in 5-min bouts, 6 days/week for 16 weeks has been shown to significantly increase aerobic fitness and significantly reduce systolic blood pressure in previously sedentary 18-55-year-old adults (Coleman et al., 1999). In studies examining the accumulation of 30 min of MPA in 10-min bouts, significantly increased aerobic fitness (Murphy et al., 2002) reduced skinfold measures (Murphy et al., 2002), and reduced systolic blood pressure (Staffileno et al., 2001) resulted from 5 days/week walking for 6-8 weeks. Thomas et al. (2001) showed that walking 30 min on 3 days/week for 12 weeks was sufficient to maintain the aerobic fitness of college-aged participants.

In the current study, when bouts of \(\geq 5\) min were considered toward total MPA, the 10K+ group averaged over 30 min of total MPA. Additionally, a larger percentage of participants in the 10K+ group (77%) compared to the < 10K group (29%) accumulated 30 min of MPA in bouts of \(\geq 5\) min. When bouts of \(\geq 10\) min were considered for total MPA, only half (51%) of the 10K+ and (17%) of the < 10K participants accumulated 30 min of MPA. The chi-square analysis revealed that when continuous MPA bouts of \(\geq 5\) min and \(\geq 10\) min are considered, a significantly larger proportion of the participants in the 10K group met the step goal compared to those who accumulated less than 10,000 steps. This finding suggests that individuals who accumulate at least 10,000 steps/day are more likely to meet the current physical activity guidelines by engaging in the length of bouts promoted by the CDC and ACSM (Pate et al., 1995) and the U.S. Surgeon General (U.S. Department of Health and Human Services, 1996). However, the data also re-
veal that accumulating 10,000 steps/day does not guarantee meeting the guidelines in the bout lengths documented to confer the health benefits of physical activity.

A systematic review of pedometer-based studies (Tudor-Locke & Myers, 2001b) suggests that we can expect higher (12,000–16,000) steps/day from children’s (8–10 years of age) samples, 7,000–13,000 steps/day in healthy younger adult samples, 6,000–8,500 steps/day in healthy older adult samples, and 3,500–5,500 steps/day in individuals with disabilities and chronic disease. Data from this review expose the inappropriateness of establishing a universal step goal. Depending on the population, the 10,000 step goal may be too low and inappropriate for youth and healthy adults, while too high for sedentary populations and those living with chronic disease, which creates a high-risk situation for failure and attrition (Tudor-Locke, 2002).

If we consider the 10,000 step threshold as a screening tool for determining whether individuals meet the current physical activity guidelines, we can assess its validity using two measures of screening—sensitivity and specificity (Hennegens & Burling, 1987). Sensitivity is defined as the probability of testing positive, if the condition is truly present (for calculations, see Hennegens and Burling, 1987, p. 332). In terms of sensitivity of the 10,000 steps goal, we want to know the probability of meeting the current physical activity guidelines when 10,000 steps have been accumulated. The sensitivity of the 10,000 steps goal was 65% when all minutes of MPA were considered and increased as the more specific criteria of continuous ≥ 5 min (79%) and ≥ 10 min (82%) MPA were used. The specificity of a test is defined as the probability of screening negative if the condition is truly absent (Hennegens & Burling, 1987). In terms of 10,000 steps, specificity would be the probability of not meeting the current physical activity guidelines when less than 10,000 steps were taken. The specificity of the 10,000 steps goal was 67% when all minutes of MPA were considered, 68% when continuous bouts of ≥ 5 min were considered, and 54% when continuous bouts of ≥ 10 min were considered. A desirable test is one that has both high sensitivity and high specificity (Hennegens & Burling, 1987). The validity of the 10,000 step goal is weak based on the fact that it is neither highly sensitive nor highly specific.

When all minutes of MPA accumulated throughout the day were considered, regardless of continuity, meeting the 10,000 steps criterion did not increase the likelihood of meeting the current physical activity guidelines. Previous research (Tudor-Locke et al., 2002) suggests that when all minutes of MPA are considered, current physical activity guidelines can be met by accumulating ≥ 8,000 steps/day. Our results demonstrate that participants accumulating at least 10,000 steps/day are more likely to meet the current physical activity guidelines in the bout lengths recommended by the ACSM and CDC and the U.S. Surgeon General (U.S. Department of Health and Human Services, 1996). The validity of the 10,000 step goal is not well supported due to a lack of sensitivity and specificity with regard to meeting current physical activity guidelines.

References


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Authors' Notes

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