Research Report

Validation of a Talking Pedometer for Adolescents with Visual Impairments in Free-Living Conditions

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Regular physical activity can lead to decreases in health-related conditions such as obesity, diabetes, coronary heart disease, hypertension, anxiety, and depression (Centers for Disease Control [CDC], 2011; Pate et al., 1995). Developing a physically active lifestyle at an early age decreases the chances of developing those health-related conditions (CDC, 2011; Sothern, Loftin, Suskind, Udall, & Blecker, 1999). Unfortunately, less than half of all school-aged individuals (that is, those aged 4 to 18 years) report regular participation in vigorous physical activity (CDC, 2011). Compared to peers without visual impairments, school-aged individuals with visual impairments report even less physical activity (Haegele & Porretta, 2015; Kozub & Oh, 2004). Because school-aged individuals with visual impairments are less physically active than peers without visual impairments, they are at greater risk for developing health-related conditions (Haegele & Porretta, 2015).

Previous research suggests that physical activity for school-aged individuals with visual impairments can be increased (Cervantes & Porretta, 2013). However, a recent literature review found few physical activity intervention studies (Haegele & Porretta, 2015). A challenge for those involved in physical activity research that includes individuals with visual impairments is obtaining objective measures (Schneider, Crouter, & Basset, 2004).

One instrument that provides an objective, cost-effective measure of physical activity by counting the total number of steps taken is the pedometer (Albright & Jerome, 2011). According to Clemes and Biddle (2013), pedometers are commonly used to assess the physical activity of school-aged individuals. Contemporary pedometers are small devices that can be worn unobtrusively on a belt or waistband. Typically, they provide feedback via a digital screen that displays the user's accumulated step count. For people with visual impairments, talking pedometers provide auditory as well as visual feedback. Research suggests that talking pedometers can motivate school-aged individuals with visual impairments to set goals for increasing daily physical activity (Lieberman, Stuart, Hand, & Robinson, 2006). But in order to conduct physical activity interventions, obtaining valid measures under free-living conditions is necessary (Barreira et al., 2013; Holbrook, Kang, & Morgan, 2013). *Free-living conditions,* as contrasted to clinical settings, are those in which participants are asked to maintain their typical physical activity patterns throughout the duration of a typical day (Wilde, Corbin, & Le Masurier, 2004). Talking pedometers have been validated for step-count accuracy for all walking speeds and environmental conditions (Holbrook, Stevens, Kang, & Morgan, 2011) compared to nonaudio pedometers (Albright & Jerome, 2011), and they have also been compared to steps that have been video recorded (Beets, Foley, Tindall, & Lieberman, 2007). Unfortunately, although previous talking pedometer validation research has been conducted, those studies either used talking pedometers that are no longer commercially available (Albright & Jerome, 2011) or gathered data in clinical settings (Beets et al., 2007; Holbrook et al., 2011). Therefore, the purpose of this study was to determine the validity of a commercially available talking pedometer for adolescents with visual impairments in free-living conditions.

Methods

Participants

Seven adolescents with visual impairments (one female and six males, aged 14–17) were recruited from a Midwestern school for blind students. All participants were Caucasian Americans. Visual impairment was categorized as *blind* (B1, $n = 1$), *travel vision,* (B2, $n = 5$), or *legal blindness* (B3, $n = 1$), in keeping with the sport classification system of the United States Association of Blind Athletes (2013). Four of the seven participants used long canes for mobility. A purposive sampling method was employed for this study. Participants were selected based on the following criteria: (a) full-time residency at a Midwestern school for the blind, (b) willingness to wear two pedometers at one time, and (c) having no ambulation-related disability. The Institutional Review Board of The Ohio State University approved all study procedures. Written consent was obtained, and each participant provided verbal assent.

Talking pedometer

The Centrios (Orbyx Electronics, model 6310620, Concord, Canada) was the talking pedometer chosen for this study. It is a spring-levered device that includes an automatic voice-announcement feature with announcement options such as number of steps taken, distance traveled, calories burned, and time elapsed. The voice-announcement feature makes the pedometer larger than other spring-levered pedometers (Holbrook et al., 2013). Additional features include intelligent counting, which identifies false steps and movements not related to exercise, and a panic alarm. The panic alarm is activated when a small pin is detached from the pedometer.

Some validation evidence is already available for the Centrios talking pedometer in settings other than free living. Holbrook and colleagues (2011) found the Centrios to accurately record steps taken for adults with visual impairments in both familiar and unfamiliar clinical settings such as walking on a track when it was mounted on the hip opposite a mobility device such as a long cane or dog guide. Beets and colleagues (2007) found similar results for adolescents with visual impairments, with the Centrios recording steps taken in a closed-circuit course. However, validation information for the Centrios in free-living conditions is currently unavailable.

Criterion pedometer

The Digiwalker SW200 (Yamax, Tokyo, Japan) was chosen as the criterion pedometer as it is considered the "gold standard" instrument for measuring physical activity in field settings (Brusseau et al., 2011). The Digiwalker SW200 functions with a horizontal, spring-suspended level arm that moves up and down with vertical hip accelerations (Hart, Brusseau, Kulinna, McClain, & Tudor-Locke, 2011). It records and visually displays the number of steps taken, and also includes a reset button and a display cover that decreases the likelihood of accidently resetting the device.

The Digiwalker SW200 is one of the most widely used pedometers in research and practice due to its accuracy and low price (Barreira et al., 2013). It has been used extensively in research as a criterion pedometer to compare the accuracy of other pedometers (Schneider et al., 2004) or when a hand-tally count is not feasible (Albright & Jerome, 2011). Research supports the accuracy of the Digiwalker SW200 in applied settings for participants across various age ranges (McKee, Boreham, Murphy, & Nevill, 2005; Schneider et al., 2004).

Procedures

Both pedometers were attached to an elastic belt that participants wore along their waistbands, and devices were placed on the anterior midline of the thigh across from any mobility devices the participants used (Holbrook et al., 2011). Data were collected over two three-and-a-half-hour (210-minute) sessions. Data was collected at morning and afternoon sessions that took place on the same day. Participants were free to participate in activities that were typical to a normal school day while wearing the pedometers. Five participants wore the pedometers during both sessions, whereas two participants wore the pedometers for one session. Therefore, 12 data points were obtained.

After participants secured the belt around their waistbands, they were instructed to walk 20 steps to verify that their pedometers were functioning accurately (Barreira et al., 2013). If an error was detected in either pedometer (if it was over or under by one step), the placement of the pedometer was adjusted until satisfactory readings were achieved. Most participants needed at least one adjustment. The 20-step test was completed prior to both the morning and afternoon data-collection sessions.

Data analysis

Two types of percent calculations, as used in the Beets et al. (2007) study, were used to determine differences in steps between the talking and criterion pedometers; percent difference scores and absolute percent difference scores. *Percent difference scores* are used to verify the direction of error (over- or underestimation). *Positive percent difference scores* indicate that the criterion pedometer possesses a higher step count than the talking pedometer, whereas *negative percent difference scores* indicate the opposite. Percent difference scores are calculated using the following equation: percent difference = ([criterion pedometer − talking pedometer/talking pedometer] x 100). *Absolute percent difference scores* are calculated using the same equation, but the direction of scores (positive or negative) is disregarded. As used in the Holbrook et al. (2011) study, absolute percent difference scores determine the magnitude of error between both pedometers, with a smaller absolute percent difference score representing better accuracy. As recommended by Schneider and colleagues (2004) for free-living conditions, the maximum acceptable threshold for absolute percent difference scores was set at 10%, which translates into an error of plus or minus 10 registered steps out of 100. A Pearson correlation coefficient was calculated to further evaluate the magnitude of the relationship between the steps of both pedometers across sessions. Statistical significance was established at $p < 0.01$.

Table 1
Absolute percent difference (APD) scores for each participant, by session.

Participant	Morning session APD	Afternoon session APD	Total APD[c]	Mean APD[d]
1	2.3	—	2.3*	2.3*
2	8.2	9.2	8.8	8.7
3	—	9.2	9.2*	9.2*
4	8.4	9.7	9.3	9.1
5	7.2	6.9	7.0	7.1
6	5.9	1.9	2.7	3.9
7	0.8	3.0	2.2	1.9
Mean total	6.1	5.8	5.9[a]	6.1[b]

[a] APD for total steps counted across all sessions and participants; [b] mean APD across 12 data points; [c] APD scores for total steps across sessions; [d] mean APD scores across session; * one session completed.

Results

Talking pedometer step counts ranged from 710 to 9,414 per session (M = 3,714). Criterion pedometer step counts ranged from 645 to 9,234 (M = 3,495). All percent difference scores were negative, indicating that the Centrios overestimated step counts. However, the step counts were overestimated by an average of only 6.1% (range: 0.8–9.7%) for the 12 data points. Absolute percent difference scores for all participants and sessions are provided in Table 1. A Pearson bivariate correlation on actual step counts determined that the pedometers were highly correlated, $r(10) = .998$, $p < .01$.

Discussion

The results of this study indicate that the Centrios talking pedometer is a valid instrument to use when measuring physical activity (step count) of adolescents with visual impairments under daily-living conditions. The Centrios does overestimate steps, but the resulting overestimation is consistent with previous findings (Beets et al., 2007; Holbrook et al., 2011). There are at least two explanations for the range in absolute percent difference scores found in this study. They include variations in walking speeds and gait patterns (Beets et al., 2007; Crouter, Schneider, & Bassett, 2005). Because of the study's free-living condition, walking speeds and gait patterns were not monitored. However, it is reasonable to assume that participants moved with different walking speeds or gait patterns. Nonetheless, all absolute percent difference scores were within the threshold recommended by Schneider and colleagues (2004). Further, our results suggest that the Centrios has greater accuracy than the other talking pedometers under free-living conditions used in the Albright & Jerome (2011) study. Thus, the Centrios provides an accurate account of step-based physical activity for adolescents with visual impairments during free-living conditions when compared to a commonly used criterion pedometer.

The use of talking pedometers to measure and promote physical activity can contribute to at least four components of the expanded core curriculum (ECC). These components consist of self-determination, independence, compensatory and access skills, and independent living skills. For example, audio feedback can contribute to independence (Lieberman et al., 2006) and self-determination skills by motivating students to set and work toward physical activity goals (Lieberman, Haegele, Columna, & Conroy, 2014). In summary, talking pedometers like the Centrios are becoming popular for measuring the physical activity of individuals with visual impairments (Foley, Lieberman, & Wood, 2008).

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