

Reliability and Validity Testing of the MotionWatch 8 in Older Adults

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Background and Purpose: The purpose of this pilot study was to test the reliability and validity of the MotionWatch 8 with older adults. **Methods:** Participants wore the MotionWatch 8 for 3 days, completed a diary of activities and the Borg Rating of Perceived Exertion (RPE) scale. **Results:** Evidence of reliability and validity was supported because there was no difference in daily level of activity and that recorded physical activity matched the activity counts. There was a significant difference in Borg RPE scale scores between the sedentary group (Borg RPE scale = 8.6, $SD = 3.0$) and those with some level of activity (Borg RPE scale = 9.9, $SD = 2.3$; $F = 5.72$, $p = .02$). **Conclusion:** The findings provide preliminary support for the reliability and validity of the MotionWatch 8 when used with older adults.

Keywords: MotionWatch 8; physical activity; older adults; validity; reliability

Limited physical activity and subsequent disability and dependency are commonly observed among older adults and are associated with adverse health outcomes (Buchman et al., 2014; Fried, Bandeen-Roche, Chaves, & Johnson, 2000; Hardy, Kang, Studenski, & Degenholtz, 2011; Pahor et al., 2014). *Physical activity* is defined as behavior that involves movement of the body resulting in the expenditure of energy. Current guidelines for older adults recommend at least 150 min weekly of moderate-level physical activity, preferably in bouts of 10 min or more at any time during the day (Centers for Disease Control and Prevention, n.d.-b). Moderate-intensity activity burns 3.5–7 kcal/min and includes such things as walking briskly (3–4 mph), climbing up the stairs, heavy housework (vacuuming, cleaning widows or floors), swimming, or dancing. Alternatively, the guidelines recommend 75 min weekly of vigorous-intensity activity weekly. Vigorous activity burns more than 7 kcal/min (Centers for Disease Control and Prevention, n.d.-a) and includes such things as running (6–8 mph) or cycling (12–14 mph; Centers for Disease Control and Prevention, n.d.-b; Nelson et al., 2007).

MEASURES OF PHYSICAL ACTIVITY

Measurement of physical activity includes the frequency, duration, and types of behaviors performed during a period of time and is generally evaluated based on subjective survey data, objective monitoring (e.g., actigraphy, pedometers), or via physiological measures (e.g., heart rate). Subjective physical activity surveys are the most frequently used measures

and include administration of questionnaires, completion of detailed diaries or brief logs. Specific surveys developed for older adults include the Community Health Activities Model Program for Seniors physical activity questionnaire (Stewart et al., 2001), the Yale Physical Activity Survey (YPAS; Dipietro, Caspersen, Ostfeld, & Nadel, 1993), and the Physical Activity Scale for the Elderly (PASE; Washburn, McAuley, Katula, Mihalko, & Boileau, 1999). Surveys have the advantage of ease of administration, low cost, and they provide the subjective perceptions of the participant in terms of the type and amount of physical activity he or she performs. Disadvantages include recall challenges and risk of bias, response burden, and limited reliability and validity of surveys because they tend to overestimate activity (Brown & Werner, 2008; Fjeldsoe, Winkler, Marshall, Eakin, & Reeves, 2013; Gennuso, Matthews, & Colbert, 2015; Hekler et al., 2012).

Conversely, objective measures of physical activity tend to be less biased. Disadvantages of objective measures include the reliance on preset algorithms for estimates of intensity of physical activity (e.g., Freedson calculations), lack of sensitivity particularly regarding light-intensity activities, inability to detect nonambulatory activities (e.g., cycling, weight lifting), or to differentiate activity (e.g., transfers, toileting, resistance exercise vs. ambulation; Resnick, Galik, Gruber-Baldini, & Zimmerman, 2010). Preset algorithms for physical activity can result in biased findings because energy expenditure in older adults is not equivalent to that of young adult men and women (Ainsworth, 2009). Consequently, the Freedson calculation (Freedson, Melanson, & Sirard, 1998), which was developed based on activity among young adults, underestimates the amount of energy expended by older individuals. Several different methods have been recommended to overcome this bias. These include the establishment of arbitrary cutoff points (Gerthel, Dencker, Ringsberg, & Akesson, 2008), setting individualized levels (Pruitt et al., 2008), or calculating threshold count values specifically for older adults that represent moderate-intensity physical activity (Copeland & Eslinger, 2009). None of these, however, has been established as a gold standard. Similarly, the inability to capture different types of activity, particularly lower level activity, has also been a major challenge in measurement of physical activity when working with older adults. Moreover, the intensity of routine activities for these individuals such as ambulating to the bathroom has not been established.

The ActiGraph has been the most commonly studied objective measure of physical activity among older adults. It provides a noninvasive method of monitoring daily periods of activity or rest over an extended amount of time. A major limitation with the use of the ActiGraph, however, is that the calculation of activity intensity is based on use of the Freedson calculation, which, as noted earlier, may be biased regarding activity intensity performed by older adults. Other limitations to the ActiGraph are that to assure accuracy of results it should be worn on the participant's waist, which can be challenging with some individuals (Ainsworth, Cahalin, Buman, & Ross, 2015; Grap, Borchers, Munro, Elswick, & Sessler, 2005; Jacobi et al., 2009; Matthews, Ainsworth, Thompson, & Bassett, 2002; Warms & Belza, 2004). Furthermore, the ActiGraph does not identify the type of activity performed (e.g., resistance exercise, bathing, and dressing; Ainsworth et al., 2015; Grap et al., 2005; Jacobi et al., 2009; Matthews et al., 2002; Warms & Belza, 2004).

The MotionWatch 8 is a newer type of accelerometer and referred to as the next generation of actigraphy from CamNtech (n.d.). The MotionWatch 8 uses a triaxial accelerometer, has a built in ambient light sensor and event marker, and provides an option for long-term recording with no interruptions for battery charging. The device,

which looks like a watch, is lightweight (9.1 g) and monitors limb or body movements during daily living and sleep. The data obtained from the MotionWatch 8 provides a multiple-day, single- or double-plotted motion graph (actogram) to graphically display daily activity.

A major advantage of the MotionWatch 8 is that individual set points for intensity of physical activity can be established. The analysis function uses a calibration to derive reference levels for vigorous, moderate, low, and sedentary activity types based on individual gait speed. To establish these individual reference levels, the participant is asked to perform a brisk walk (3–4 mph) for at least 5 min as soon as the device is initiated. An average of the activity counts found within this 5-min period is used to produce the moderate threshold level. This value is then used to determine vigorous and sedentary thresholds. Given the advantages of the MotionWatch 8 over other objective measures of physical activity used with older adults, the purpose of this pilot study was to test the reliability and validity of the MotionWatch 8.

METHOD

Design

This was a pilot study testing the reliability and validity of the MotionWatch 8 among a group of 14 older adults living in a single continuing care retirement community (CCRC). The study was approved by a university institutional review board, and all participants were required to complete written consent.

Subjects

Older adults living in the CCRC were invited to participate in this study. Eligibility was based on living in the setting, being 65 years of age and older, and being able to recall at least two out of three words on the Mini-Cog. Participants were excluded if they were unable to pass the Evaluation to Sign Consent which is a 5-item questionnaire evaluating the individual's understanding of participation in the research project (Resnick et al., 2007). Potentially eligible participants were identified by the nursing staff in the primary care outpatient office. Seventeen individuals were approached and invited to participate, 15 provided written consent, 2 refused and 1 of the consented individuals refused to wear the MotionWatch 8 following consent.

Procedures

The MotionWatch 8 was placed on each participant on a Monday morning and removed on Friday morning at a time that was convenient for the participant. The 3 full days of data obtained on Tuesday, Wednesday, and Thursday were used for analysis. Participants were instructed to continue to wear the MotionWatch 8 at all times including showering, bathing or swimming, and when sleeping. In addition, participants were given a paper diary to record their activities (e.g., bathing, dressing, walking, piano playing) in hour blocks and to rate the intensity of their activity based on the Borg Rating of Perceived Exertion (RPE) scale (Borg, 1970) using the 6–20 scale described in the following text. To facilitate completion of the Borg RPE scale, participants were given a written sheet to visualize the numbers and anchors (Appendix). We also reviewed the Borg RPE scale with participants

indicating that a level of 9 corresponds to *very light* exercise which for a healthy individual is like walking slowly at his or her own pace for some minutes. A rating of 13 is *somewhat hard* exercise, but it still feels okay to continue. A level of 17 is *very hard* exercise, and at this level, a healthy person can still go on, but he or she really has to push him or herself. Lastly, a level of 19 on the scale is an extremely strenuous exercise level. For most people, this is the most strenuous exercise they have ever performed.

Measures

Descriptive data included age, gender, comorbidities, and use of an assistive device.

In addition, as noted earlier, an hourly activity diary was completed for the 3 days of wear, and participants were also asked to rate the intensity of that activity at hourly intervals based on the Borg RPE scale. The recorded activities from the participants' diaries were recoded as sedentary or involving some level of activity. Sedentary activities (e.g., activities done in a sitting position) included such things as reading, knitting, working on the computer, and sleeping. Some level of activity (e.g., activities that require more energy expenditure than sitting or lying) included walking, bathing and dressing, pool exercises, and cleaning the apartment or making the bed.

Borg Rating of Perceived Exertion. The Borg RPE scale (Borg, 1970) is a measure of perceived exertion during physical activity, and it contains both verbal anchors and numerical anchors ranging from 6 to 20. The verbal anchors start at 6 which is the *least effort* and proceed upward to 7 which is *very light*, 9 which is *very light*, 11 which is *fairly light*, 13 which is *somewhat hard*, 15 which is *hard*, and 20 which is labeled *maximum effort*. Prior research has supported the reliability and validity of this measure although it is acknowledged that the validity of perceived exertion when compared to objective measures is not strongly correlated in all situations. In particular, women and those who do not engage in much physical activity are more likely to overestimate their exertion (Resnick et al., 2010).

The MotionWatch 8. The MotionWatch 8 is a compact, lightweight, body-worn activity monitoring device that is used to measure physical movement. The device is intended to monitor limb or body movements during daily living and sleep. The MotionWatch 8 contains a miniature accelerometer to allow measurement and recording of physical movement of the wrist which provides a close correlation to whole body movement. The data are sampled at 50 Hz and processed into "epochs" of user-selectable length (e.g., every minute). These data are stored into an internal nonvolatile memory and then downloaded for analysis at the end of the study period. The participants in our study were unable to walk at a moderate level of activity for 5 min so that individual reference levels could not be accurately calculated. Consequently, previously established reference levels for the MotionWatch 8 when worn by older adults were used based on a study that included 23 community-dwelling healthy older adults evaluated during 10 different activities of daily living (Dederling, Gnospelius, & Elfving, 2010; Resnick et al., 2010; Resnick et al., 2008). The mean age of these 23 participants was 69.96 years ($SD = 6.57$), they reported few comorbidities and 4% used assistive devices. The cut points established were used with all individuals in this study (sedentary <178 counts per minute, light 179–561 counts per minute, moderate >562 counts per minute, and vigorous $>1,020$ counts per minute; Landry, Falck, Beets, & Liu-Ambrose, 2015). Counts are the unit of measurement used to evaluate activity when calculated by any type of ActiGraph. The device counts the number of times the waveform crosses 0 for each period being evaluated.

Data Analysis and Reliability and Validity Testing

Descriptive statistics were done using SPSS Version 23. Reliability testing was based on the consistency in time spent in active, inactive, vigorous, moderate, or sedentary physical activity among the participants across the 3 full days in which the MotionWatch 8 was worn: Tuesday, Wednesday, and Thursday. Validity testing was based on evidence that the activity diary recordings matched the counts of activity on the MotionWatch 8 and that the participant's Borg RPE scale scores correlated with the counts of activity. In addition, an analysis of variance was done comparing Borg RPE scale scores between those who reported engaging in only sedentary activity during the day and those that engaged in some activity.

RESULTS

The mean age of the participants was 86.28 years ($SD = 5.90$) with a range of 77–95 years old, and there were nine females (64%) and five males (36%). Half of the participants used a walker during ambulation, and half of them did not. The mean number of comorbidities was 4.9 ($SD = 1.38$) with a range of 2–7. Two of the individuals had Parkinson's disease, and one individual had a prior cerebral vascular event, although there was no noted functional residual. All of the participants who wore the monitor wore it for the full testing period, and there were no complaints of discomfort. As noted, there was one consented individual who refused to wear the MotionWatch 8 following consent because he did not want to “bother with it.” With the exception of one participant, all of the participants completed diary recordings for the period in which the watch was worn, although the detail of the recordings varied among individuals with some being much more detailed than others. The one individual who stopped recording did so after 2 days and reported that she got tired of writing things down.

Reliability

As shown in Table 1, and as hypothesized, there was no difference in level of activity across the 3 full days in which the monitor was worn. Time spent inactive ranged from 674 ($SD = 196$) to 694 ($SD = 186$) min ($F = .31, p = .74$), time in sedentary activity ranged from 1,165 ($SD = 170$) to 1,193 ($SD = 213$) min ($F = .40, p = .68$), time in moderate-level activity ranged from 46 ($SD = 42$) to 54 ($SD = 47$) min ($F = 1.2, p = .35$), time in vigorous activity ranged from 7 ($SD = 10$) to 9.2 ($SD = 13$) min ($F = .51, p = .61$), and overall active time ranged from 766 ($SD = 196$) to 910 ($SD = 678$) min ($F = .39, p = .68$).

TABLE 1. Mean Time in Daily Activity for the Three Full Days of Testing and Repeated Measure Results

Activity	Day 1 <i>M (SD)</i>	Day 2 <i>M (SD)</i>	Day 3 <i>M (SD)</i>	Wilks's Lamda	<i>F (p)</i>
Inactive	674 (196)	694 (186)	686 (156)	.95	0.31 (.74)
Sedentary	1,182 (198)	1,165 (170)	1,193 (213)	.94	0.40 (.68)
Moderate	54 (47)	50 (46)	46 (42)	.84	1.2 (.35)
Vigorous	9.2 (13)	7.0 (10)	7.1 (13)	.92	0.51 (.61)
Active	766 (196)	910 (678)	793 (224)	.94	0.39 (.68)

Validity

Consistently, when participants recorded their activity, it matched changes in the activity counts. Reported activities included such things as walking to the dining room within the facility, making a bed, performing personal care, doing laundry, fixing a meal, playing the piano, knitting, watching television, or working on the computer. Likewise, documented periods of sleep were consistent with MotionWatch 8 counts. Among 14 participants, 99 activities by counts were recorded and rated using the Borg RPE scale ratings. Among the 99 activities rated, 41 (41%) were sedentary and 58 (58%) included some level of activity. There was a statistically significant difference in mean Borg RPE scale scores between these groups with sedentary activities having a mean Borg of 8.6 ($SD = 3.0$) and some activity having a mean Borg RPE scale of 9.9 ($SD = 2.3$), $F = 5.72$, $p = .02$.

DISCUSSION

This pilot work provides some preliminary evidence for the reliability and validity of the MotionWatch 8 when used with older adults. Reliability was supported in that the level of activity recorded was consistent across the 3 full days of testing (Tuesday, Wednesday, and Thursday). Consistency in activity among participants was expected because older adults in these types of institutional settings go to set meals and activities in the same location and thus walk the same distances daily and engage in routine activities of daily living and recreational activities. To strengthen the evidence of reliability of the MotionWatch 8, future reliability testing should include comparisons of a single 1-min walk completed 2 or 3 times by each participant.

There was some support for the validity of the MotionWatch 8 based on a relationship between participant reports of activity and number of counts on the MotionWatch 8 and a statistically significant difference between Borg RPE scale scores regarding sedentary activities (e.g., reading) versus activities that used at least some level of energy (e.g., walking, cleaning, bed making, bathing, and dressing). There may have been some bias in recordings in the diaries because we did not standardize or predefine activity for the participants. The activities that were reported, however, were consistent across the group (e.g., bathing and dressing, walking to the dining room, sleeping, reading, doing computer work, or knitting). We also cannot be certain that participants recorded all activities that were performed on a given day. In recognition of possible error, additional validity testing is needed with a larger sample and one in which direct observation of the participant and activity recording is included.

Given the consistency in daily actigraphy findings over 3 days, it may be possible to have institutionalized participants wear the MotionWatch 8 for 1 rather than 3 days to limit participant burden. Prior research using some type of actigraphy has recommended longer wear times from 3 to 7 days to ensure valid findings (Ainsworth et al., 2015; Matthews et al., 2002). It is possible that these longer wear times may be necessary among individuals in community settings because they may vary their activities more on a daily basis (e.g., going shopping, going to different restaurants) than those living in institutional settings where everything is available within the setting.

One of the known challenges in use of the MotionWatch 8 is that data may vary based on the wearing location of the device. Specifically, data from wearing the device on the

wrist will differ from that recorded at the waist or the ankle. All of our participants wore the device on their wrists, and it was clear in consideration of the diaries and counts of activity that activities in which the hands were involved resulted in a higher number of counts than otherwise might be expected. For example, piano playing and bed making were noted to be moderate levels of activity, whereas walking to the dining was not rated as a moderate level of activity.

Overall results showed activity levels among the participants were consistent with the level of activity recommended by the American College of Sports Medicine and the American Heart Association (see Nelson et al., 2007). Specifically, participants engaged in more than 30 min of moderate activity on the days of testing. It is possible, however, that moderate-level activity was overestimated because we used cut scores from a population that was younger and had fewer comorbidities and disabilities. Ongoing research is needed with the MotionWatch 8 to establish cut points with this type of sample.

The findings from this study provide some preliminary support for the reliability and validity of the MotionWatch 8 and suggest that this measure can be used as a way to measure objective physical activity among older adults. In so doing, it will be possible to accurately test interventions geared toward increasing time spent in physical activity among older adults and use these tested interventions in clinical practice.

Nursing Implications

Practice. It is currently recommended that older adults engage in 30 min of moderate level physical activity daily (Garber et al., 2011) to promote physiological health and prevent physical disability. Unfortunately, most of these individuals do not know what it feels like to engage in this level of activity. The use of the MotionWatch 8 in the clinical setting allows providers to teach older patients what moderate level of activity is by having them walk with the watch on and showing them what intensity of activity they achieve and how fast they need to walk to be working at a moderate level.

Research. The MotionWatch 8 provides objectively measured physical activity for us in research studies, either descriptive studies or intervention studies. Moreover, the MotionWatch 8 allows for individualization of calibration of exercise intensities. The calibration can be done by having the person perform a brisk walk (3–4 mph) for at least 5 min at the beginning of the MotionWatch 8 analysis. The calibration period is used automatically by the MotionWatch 8 to produce the moderate threshold which is then used to derive vigorous and sedentary thresholds (CamNtech, n.d.).

Education. Providing nursing students with information about the MotionWatch 8 will increase their awareness of such devices and provide them with an objective and accurate way in which to measure physical activity in patients.

Study Strengths and Limitations

This study was limited by the small sample size of older adults in a single setting. As noted earlier, we do not know if all activity was accurately recorded by participants and we used cut scores from a younger, healthier, and less disabled sample of older adults. Furthermore, we recognize that wearing the MotionWatch 8 on the wrist may bias the findings in that intensity of the activity may be overestimated because of the way in which the recordings are obtained. Despite these limitations, the study provides some preliminary support for the reliability and validity of the MotionWatch 8 and suggests the need for ongoing research to continue to support the value of this measure when used with older adults.

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APPENDIX**Borg RPE Scale**

The BORG

Look at the rating scale below while you are engaging in an activity; it ranges from 6 to 20, where 6 means “no exertion at all” and 20 means “maximal exertion.” Choose the number from below that best describes your level of exertion.

6	No exertion at all
7	Extremely light (7.5)
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion