Self-Selected Walking Speed is Predictive of Daily Ambulatory Activity in Older Adults

Addie Middleton, George D. Fulk, Michael W. Beets, Troy M. Herter, and Stacy L. Fritz

Daily ambulatory activity is associated with health and functional status in older adults; however, assessment requires multiple days of activity monitoring. The objective of this study was to determine the relative capabilities of self-selected walking speed (SSWS), maximal walking speed (MWS), and walking speed reserve (WSR) to provide insight into daily ambulatory activity (steps per day) in community-dwelling older adults. Sixty-seven older adults completed testing and activity monitoring (age 80.39 [6.73] years). SSWS ($R^2 = .51$), MWS ($R^2 = .35$), and WSR calculated as a ratio ($R^2 = .06$) were significant predictors of daily ambulatory activity in unadjusted linear regression. Cutpoints for participants achieving ≤ 8,000 steps/day were identified for SSWS (≤ 0.97 m/s, 44.2% sensitivity, 95.7% specificity, 10.28 +LR, 0.58 –LR) and MWS (≤ 1.39 m/s, 60.5% sensitivity, 78.3% specificity, 2.79 +LR, 0.50 –LR). SSWS may be a feasible proxy for assessing and monitoring daily ambulatory activity in older adults.

Keywords: gait, mobility, elderly, assessment, steps per day

Clinical measures that identify older adults who would benefit from increased daily ambulatory activity are needed, as daily ambulatory activity is associated with health and functional status (de Melo, Menec, & Ready, 2014; Ewald, Attia, & Mc Elduff, 2014; Lee et al., 2013; Mosallanezhad, Salavati, Sotoudeh, Nilsson Wikmar, & Frandin, 2014; Petrella & Cress, 2004). Daily ambulatory activity can be quantified as steps per day. Higher average steps per day is associated with decreased cardiovascular and metabolic disease risk factors, improved hip bone mineral density, and better psychosocial health in older adults (Ewald et al., 2014; Ewald, McEvoy, & Attia, 2010; Foley, Quinn, & Jones, 2010; Newton et al., 2013; Park et al., 2008; Sisson et al., 2010; Tudor-Locke et al., 2008; Vallance, Euirch, Lavallee, & Johnson, 2013). Both normative data and daily step count recommendations are available in the literature, allowing clinicians and researchers to determine if an individual is meeting age norms and/or recommended thresholds to achieve health benefits (Ewald et al., 2014; Tudor-Locke et al., 2011; Tudor-Locke et al., 2013). Although recommendations on steps per day varies for older adults, achieving an average of 8,000 steps per day is associated with reduced risk of metabolic syndrome and is above the threshold for receiving at least 80% of the benefit steps per day confers on body mass index (BMI), waist-to-hip ratio, insulin sensitivity, high-density lipoprotein (HDL) levels, white cell count, and fibrinogen levels in this population (Ewald et al., 2014; Park et al., 2008). In addition, 8,000 steps has been recommended as a goal for older adults on days they are attempting to achieve 30 min of moderate to vigorous physical activity (Tudor-Locke et al., 2011).

Measurement of steps per day requires activity monitoring via a pedometer or accelerometer. The device must be worn for several days to get an accurate reflection of average ambulatory behavior.

In previous studies on older adults, activity monitoring has ranged in length from four to eight days, with the majority of monitoring taking place for seven days (Boyer, Andriacchi, & Beaupre, 2012; Brach, VanSwearingen, Newman, & Kriska, 2002; Garcia-Ortiz et al., 2014; Lee et al., 2013; Schimpfl et al., 2011; Wanner, Martin, Meier, Probst-Hensch, & Kriemler, 2013). The utility of activity monitoring is limited by the time required. However, it is plausible that a more efficient measure may provide insight. An individual’s performance on clinical measures of gait and mobility may be indicative of their daily ambulatory activity.

A reliable, responsive measure of gait and mobility is walking speed (WS) (Goldberg & Schepens, 2011; Peters, Fritz, & Krotish, 2013). Due to the wealth of information the measure provides and the ease of administration (i.e., minimal space, time, and equipment requirements), WS has earned recognition as the “sixth vital sign” and is recommended in comprehensive geriatric assessment (Fritz & Lusardi, 2009; Middleton, Fritz, & Lusardi, 2015; Peel, Kuys, & Klein, 2013). WS can be measured at either an individual’s self-selected walking speed (SSWS) or maximal walking speed (MWS) and is appropriate for use with a wide range of populations, including older adults (Bowden, Balasubramanian, Behran, & Kautz, 2008; Cesari et al., 2005; Paltamaa, Sarasoja, Leskinen, Wikstrom, & Malkia, 2008; Quinn et al., 2013; Ries, Echternach, Hof, & Gagnon Blodgett, 2009; Williams, Schache, & Morris, 2013). SSWS provides insight into an older adult’s current and future health and function (Elbaz et al., 2013; Rosano, Newman, Katz, Hirsch, & Kuller, 2008; Shimada et al., 2013), and is associated with risk of adverse outcomes such as fracture, stroke, dementia, hospitalization and institutionalization, and mortality (Cesari et al., 2005; Cooper et al., 2011; Elbaz et al., 2013). Whether SSWS provides insight into daily ambulatory activity (steps per day) in this population has not been determined. The measure shows promise, though, as it is predictive of ambulatory activity in individuals with stroke (Bowden et al., 2008; Perry, Garrett, Gronley, & Mulroy, 1995) and incomplete spinal cord injury (Stevens, Fuller, & Morgan, 2013).

MWS may also be reflective of daily ambulatory activity in older adults, as MWS is associated with physical health status and level of physical activity in this population (Sallinen et al., 2011; Sartor-Glittenberg et al., 2014).
Although WS provides insight into health and functional status, meeting steps per day guidelines is how one can maintain or improve health and functional status (Fox et al., 2015; Tudor-Locke et al., 2011). Individuals not meeting recommended daily step counts may benefit from increased ambulatory activity. The gold standard for assessing daily ambulatory activity is activity monitoring. Although, to get an accurate reflection of average ambulatory activity, multiple days of monitoring are required. At screening events, when goal-setting in clinical practice, or when an individual is self-assessing, waiting multiple days for results is not always practical. Reliable, responsive, easily administered measures that provide insight into daily ambulatory activity are needed. WS meets these criteria and demonstrates potential in this capacity.

It is unknown whether an older adult’s SSWS or MWS is more predictive of their daily ambulatory activity, or whether a combination of these two values may be the most informative. SSWS and MWS can be combined to quantify an individual’s ability to adapt their WS. Adaptability of WS may be tied to outcomes, independent of the ones associated with SSWS or MWS, as changing speed is more challenging than maintaining steady-state WS (Peterson, Kautz, & Neptune, 2011). Termed “walking speed reserve” (WSR), this value can be calculated as either a difference (MWS – SSWS) or a ratio (MWS/SSWS). The primary objective of this study was to determine if SSWS, MWS, and WSR are significant predictors of daily ambulatory activity, quantified as steps per day, in community-dwelling older adults, and if so, which measure is the most informative. Findings from the primary objective were used to inform the secondary objective, which was to establish WS cutpoints that distinguish those meeting a steps per day threshold (8,000 steps) relevant to this population from those not meeting the threshold. The cutpoints established can be used to identify individuals who would benefit from increased daily ambulatory activity and to set objective, easily measurable WS goals.

Methods

A cross-sectional study design was used to investigate the relationship between SSWS, MWS, and WSR and daily ambulatory activity in community-dwelling older adults. All study procedures were approved by the University of South Carolina’s Institutional Review Board, and all participants signed an approved informed consent form before participation. Data collection was performed by a single investigator—a physical therapist trained on the standardized procedures.

Participants

A convenience sample of community-dwelling older adults was recruited via flyer and word of mouth from local retirement communities and senior centers. To be eligible, participants had to be 65 years of age or older and able to complete the WS assessments. Individuals who presented with unresolved, but temporary, musculoskeletal problems that affected ambulation (e.g., recent sprain or fracture); history of a neurologic condition (e.g., stroke, traumatic brain injury, Parkinson’s disease); or required a prosthetic device of any sort for ambulation were excluded. Results from a power analysis indicated that a sample size of 60 would provide 87% power to determine the relationship between SSWS and steps per day (α = .05) using linear regression (Bohannon, 2007; Cesari et al., 2005).

Questionnaires

Information regarding exercise frequency, fall history, and pain was collected from each participant. Participants self-reported exercise frequency by answering the following questions: “Do you exercise regularly? If yes, how often (times/week) and for how long (minutes/session)? What type of activities do you engage in?” To determine fall history, participants were asked: “Have you fallen in the last 12 months? A fall is an unplanned, unexpected contact with a supporting surface. If yes, please describe each fall.” Finally, pain was assessed by asking participants: “Do you currently have pain anywhere? If yes, where is your pain located? List all areas where you experience pain along with cause of pain, if known.”

Walking Speed

To determine SSWS and MWS, participants performed two trials of the 10-m walk test under two different conditions (four trials total) (Peters et al., 2013). For assessment of SSWS, participants were instructed to walk at their “usual, comfortable speed”. For MWS, the instructions were to walk as “quickly, but safely as possible, for example, as if you are hurrying to get somewhere.” The two trials under each condition were then averaged to determine SSWS and MWS (m/s), respectively. A stopwatch was used to time participants over the 10-m path. Timing started when the participant’s lead leg broke the plane of the marker at the beginning of the path and stopped when their lead leg broke the plane of the marker at the end of the 10-m path. Five meters were provided before and following the timed portion to allow acceleration and deceleration to occur outside the timed region and ensure that steady-state SSWS and MWS were captured for analyses (Graham, Ostir, Fisher, & Ottenbacher, 2008; Lindemann et al., 2008). Assistive devices and/or orthoses typically used during community ambulation were permitted during testing.

Daily Ambulatory Activity (Steps per Day)

To determine steps per day, participants wore an ActiGraph GT3X+ triaxial accelerometer (Pensacola, FL) on their right ankle for seven consecutive days, except during water-based activities (Korpan, Schafer, Wilson, & Webber, 2015). Ankle placement has been validated for collecting step count data in this population (Korpan et al., 2015). Participants were instructed to record time along with reasons the activity monitor was removed on an activity monitoring log. To improve compliance, participants were contacted on day 2 and day 4 of activity monitoring to answer any questions and/or address any concerns. Participants were also encouraged to contact the investigator at any time during the seven days if questions arose. ActiLife 6.0 software (ActiGraph, Pensacola, FL) was used to initialize the devices before distribution to participants and to download and process data once the devices were returned. Sampling frequency was set at 30 Hz, and data were collected in 60-s epochs (Garcia-Ortiz et al., 2014). Sixty consecutive epochs with no activity counts was classified as nonwear time (Hart, Swartz, Cashin, & Strath, 2011). To be considered a “complete day”, at least 600 min of wear time had to be recorded (Barreira, Brouillette, Foil, Keller, & Tudor-Locke, 2013). Participants with less than five complete days of activity monitoring were excluded from data analysis (Hart et al., 2011).

Data Analysis

Descriptive statistics were calculated for all variables, and normality was assessed using the Shapiro-Wilk test. Correlation coefficients were calculated to determine the level of association between each WS measure and steps per day. Linear regression analyses were performed to determine if SSWS, MWS, and/or WSR (difference...
and ratio) could be used as predictors of daily ambulatory activity (steps per day as continuous variable). Before performing regression, a between-sex comparison (male versus female) of steps per day was performed. If steps per day differed between sexes, all regression analyses would be performed separately for males and females. Unadjusted models were constructed first, using each WS measure (SSWS, MWS, WSRdiff, or WSRatio) as the independent variable. Age-adjusted models were then constructed for each WS measure. Comparison of the amount of variability in steps per day ($R^2$) explained by the regression models was used to identify which of the WS measures provided the greatest value (highest $R^2$) as a predictor of daily ambulatory activity.

Logistic regression was used to determine if SSWS, MWS, WSRdiff, and/or WSRatio could be used to distinguish between those averaging < 8,000 steps per day and those exceeding this threshold. Both unadjusted and adjusted analyses were performed. Receiver operating characteristic (ROC) curves were constructed for the WS measures found to be significant predictors in logistic regression. ROC curves were also used to identify a cutpoint which maximized combined sensitivity and specificity for the included measure. Positive and negative likelihood ratios ($+LR = \text{sensitivity}/[1 – \text{specificity}], \quad –LR = [1 – \text{sensitivity}]/\text{specificity}$) were calculated from the sensitivity and specificity at the selected cutpoint. The magnitude of the shifts in probability provided by positive and negative LR indicators how useful the diagnostic measure is to clinicians. The following guidelines can be used to interpret LR values: $+LRs > 10$ and $–LRs < 0.1$ result in shifts in probability that are “large and conclusive” $+LRs$ between 5 and 10 and $–LRs$ between 0.1 and 0.2 result in “moderate” shifts, $+LRs$ from 2 to 5 and $–LRs$ from 0.5 to 0.2 result in “small” shifts, and $+LRs$ from 1 to 2 – $–LRs$ from 0.5 to 1 result in shifts that are “rarely important” (Fagan, 1975). To determine posttest probabilities, $+LR$ and $–LR$ to the sample’s pretest probability and calculate posttest probability ($[1 – \text{specificity}], \quad –LR = [1 – \text{sensitivity}]/\text{specificity}$) were calculated using the DocNomo iPhone application (©Charles GB Caraguel) to ensure correct reporting of results. The DocNomo application is freely available to clinicians and offers an alternative to the paper and pencil nomogram. The shifts in probability from pre- to posttest for both positive (WS below identified cutpoint) and negative (WS above identified cutpoint) test results were calculated. The nomogram-derived posttest probabilities allowed comparison of the actual shifts in probabilities that the WS cutpoints provided. All data analyses were performed using IBM SPSS 22 (Armonk, NY) and SAS 9.3 (Cary, NC).

Results

Participants

Sixty-seven older adults meeting inclusion criteria enrolled in the study. Participants were recruited via flyer and word of mouth from four locations: three retirement communities and one senior center. Forty-eight participants lived in a retirement community; 14 were members of the wellness facility at a retirement community, but did not live in a home or apartment associated with the site; and five were recruited through a senior center. One participant returned the activity monitor with only four days of wear time and was excluded from data analysis ($n = 66$). Sixty-three (95.5%) participants self-reported regular engagement in exercise, with the majority reporting either participation in group fitness classes 59.1% or walking 63.6% as the mode. Sample characteristics are presented in Table 1.

### Table 1 Sample Characteristics

<table>
<thead>
<tr>
<th>Characteristic Mean (SD) or n (%)</th>
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</thead>
<tbody>
<tr>
<td>Age (years)</td>
</tr>
<tr>
<td>Female*</td>
</tr>
<tr>
<td>Assistive device*</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Single point cane</td>
</tr>
<tr>
<td>Four-wheeled rolling walker</td>
</tr>
<tr>
<td>Living in retirement community†</td>
</tr>
<tr>
<td>Number in household*</td>
</tr>
<tr>
<td>Alone</td>
</tr>
<tr>
<td>Spouse</td>
</tr>
<tr>
<td>Not reported</td>
</tr>
<tr>
<td>Exercise regularly*</td>
</tr>
<tr>
<td>Frequency (sessions/week)</td>
</tr>
<tr>
<td>Duration (minutes/session)</td>
</tr>
<tr>
<td>Report pain*</td>
</tr>
<tr>
<td>Fall over previous year*</td>
</tr>
<tr>
<td>No fall</td>
</tr>
<tr>
<td>1 fall</td>
</tr>
<tr>
<td>&gt; 1 fall</td>
</tr>
<tr>
<td>Self-selected walking speed (SSWS, m/s)</td>
</tr>
<tr>
<td>Maximal walking speed (MWS, m/s)</td>
</tr>
<tr>
<td>Walking speed reserve</td>
</tr>
<tr>
<td>Difference (MWS – SSWS, m/s)</td>
</tr>
<tr>
<td>Ratio (MWS/SSWS)</td>
</tr>
<tr>
<td>Days of activity monitoring (&gt; 10 hr)</td>
</tr>
<tr>
<td>Average steps/day</td>
</tr>
</tbody>
</table>

*Values are n (%).
†Those not living in a retirement community lived in a home/apartment in general community.
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per day in the unadjusted models (Table 2). SSWS explained the greatest proportion of the variation in steps per day (51%), while the WSRatio model explained the least (6%). Residuals were not normally distributed for the unadjusted models predicting steps per day as a function of SSWS or WSRatio. To normalize residuals in the SSWS model, one outlier visually identified on a scatter plot of steps per day by SSWS was removed (14,608.86 steps per day and SSWS = 1.04 m/s), and steps per day were log transformed to normalize residuals for the WSRatio model.

Age-adjusted models were constructed for the WS measures found to be significant predictors of steps per day in unadjusted analyses: SSWS, MWS, and WSRatio. The only model in which age remained as a significant predictor \( (p = .02) \) was the model predicting steps per day as a function of MWS. The model including both MWS and age as predictors explained 5% more of the variability in steps per day than the model including only MWS \( (R^2 = .40 \text{ versus} .35) \). Of the models, the unadjusted model for SSWS best explained steps per day in our sample. The equation for this model was: 

\[
\text{steps per day} = -2,186.37 + (8,703.80 \times \text{SSWS})
\]

Logistic Regression

Both SSWS and MWS were significant predictors of not meeting the 8,000 steps per day threshold, while both WSRdiff and WSRatio were not. In unadjusted analysis, age was a significant predictor \( (p = .004) \) of steps per day, but sex \( (p = .261) \) was not. Therefore, age was the only covariate adjusted for in multivariate analyses. Age was a significant predictor in both the SSWS \( (p = .04) \) and MWS \( (p = .02) \) models. The logit equations for these models with exponentiated coefficients were:

\[
< 8,000 \text{ steps/day} = 0.07 + (0.02 \times \text{SSWS}) + (1.10 \times \text{age})
\]

\[
< 8,000 \text{ steps/day} = 0.03 + (0.06 \times \text{MWS}) + (1.11 \times \text{age}).
\]

The pretest probability of not achieving an average of 8,000 steps per day in the sample was 65.2% \( (43 \text{ with} < 8,000 \text{ steps/66 total}) \). The SSWS and MWS cutpoints maximizing sensitivity and specificity for identifying participants not meeting the threshold, along with the associated +LRs and –LRs, are presented in Table 3. Applying the associated +LR (10.28) for SSWS shifted the probability that a participant was not averaging at least 8,000 steps per day by 29.9% \( \text{(pretest probability 65.2%, posttest probability 95.1%)} \). The –LR (0.58) for SSWS shifted probability by 13.0% \( \text{(pretest probability 65.2%, posttest probability 52.2%)} \). The +LR (2.79) associated with the MWS cutpoint shifted the probability that a participant was not averaging at least 8,000 steps per day by 18.7% \( \text{(pretest probability 65.2%, posttest probability 83.9%)} \). The –LR for the cutpoint shifted probability by 16.6% \( \text{(pretest probability 65.2%, posttest probability 48.6%)} \). See Figure 2.

**Discussion**

Both SSWS and MWS provided insight into daily ambulatory activity in this sample of older adults. A relationship between SSWS and daily ambulatory activity was hypothesized given the measure’s association with ambulatory activity in individuals with stroke and incomplete spinal cord injury (Bowden et al., 2008; Perry et al.,

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**Figure 1** — Scatter plots of steps per day (vertical axes) by (a) self-selected walking speed (SSWS), (b) maximal walking speed (MWS), (c) walking speed reserve (WSR) calculated as a difference \( (\text{MWS} - \text{SSWS} = \text{WSRdiff}) \), and (d) walking speed reserve calculated as a ratio \( (\text{MWS/SSWS} = \text{WSRratio}) \).
Table 2 Unadjusted Linear Regression Models for Steps per Day

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>p-value for F</th>
<th>R²</th>
<th>β</th>
<th>95% CI for β</th>
<th>Standardized β</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSWS</td>
<td>65</td>
<td>&lt;.001</td>
<td>0.51</td>
<td>8703.80</td>
<td>(6558.84, 10848.76)</td>
<td>0.715</td>
</tr>
<tr>
<td>MWS</td>
<td>66</td>
<td>&lt;.001</td>
<td>0.35</td>
<td>5554.00</td>
<td>(3652.88, 7455.12)</td>
<td>0.589</td>
</tr>
<tr>
<td>WSRdiff</td>
<td>66</td>
<td>.14</td>
<td>0.03</td>
<td>3317.39</td>
<td>(−1104.30, 7739.09)</td>
<td>0.184</td>
</tr>
<tr>
<td>WSRatio</td>
<td>66</td>
<td>.04</td>
<td>0.06</td>
<td>0.54</td>
<td>(0.30, 0.98)</td>
<td>0.558</td>
</tr>
</tbody>
</table>

Abbreviations: CI = confidence interval; SSWS = self-selected walking speed; MWS = maximal walking speed; WSRdiff = walking speed reserve calculated as a difference (MWS – SSWS); WSRatio = walking speed reserve calculated as a ratio (MWS/SSWS).

* One outlier removed (14,608.86 steps per day and SSWS = 1.04 m/s) to normalize residuals for SSWS model.
† Steps per day log transformed to normalize residuals for WSRatio model.

Table 3 Sensitivity, Specificity, and Likelihood Ratios for < 8,000 Steps per Day

<table>
<thead>
<tr>
<th></th>
<th>SSWS</th>
<th>MWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUC</td>
<td>0.71 (0.58, 0.84)</td>
<td>0.72 (0.60, 0.85)</td>
</tr>
<tr>
<td>Cutpoint (m/s)</td>
<td>≤ 0.97</td>
<td>≤ 1.39</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>44.2% (29.4, 60.0)</td>
<td>60.5% (44.5, 74.6)</td>
</tr>
<tr>
<td>Specificity</td>
<td>95.7% (76.0, 100.0)</td>
<td>78.3% (55.8, 91.7)</td>
</tr>
<tr>
<td>+LR</td>
<td>10.28 (1.45, 71.15)</td>
<td>2.79 (1.23, 6.27)</td>
</tr>
<tr>
<td>−LR</td>
<td>0.58 (0.45, 0.76)</td>
<td>0.50 (0.34, 0.75)</td>
</tr>
</tbody>
</table>

Abbreviations: SSWS = self-selected walking speed; MWS = maximal walking speed; AUC = area under the receiver operating characteristic curve; m/s = meters per second; +LR = positive likelihood ratio; −LR = negative likelihood ratio.
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active older adults (> 7,500 steps per day) in a study investigating whether engaging in high levels of activity (steps per day) was protective against age-related declines in selected parameters of gait. Although cadence, step length, and joint kinematics differed between the “young” (age 29.0 [4.9] years) and active “older” (age 71.2 [4.4] years) samples, SSWS did not. The authors conclude that older adults who engage in “a high level of walking activity” maintain SSWSs similar to healthy, young individuals (Boyer et al., 2012). These active older adults also have faster SSWSs than would be predicted by normative data for their age. The SSWS of the “older” sample in the Boyer et al. (2012) study was 1.44 (0.03) m/s. Based on normative data, a SSWS of 1.1–1.3 m/s would be expected (Bohannon & Williams Andrews, 2011). This study provides further support for an association between SSWS and daily ambulatory activity in active older adults.

When using WS as a screening tool to identify clients who may benefit from increased ambulatory activity, both SSWS and MWS are informative. In our sample, both measures were significant predictors of whether a participant averaged < 8,000 steps per day. Averaging greater than 8,000 steps per day is associated with reduced risk of metabolic syndrome and is above the threshold for receiving at least 80% of the benefit steps per day confers on BMI, waist-to-hip ratio, insulin sensitivity, HDL levels, white cell count, and fibrinogen levels in individuals similar to the included sample (Ewald et al., 2014; Park et al., 2008). Since both SSWS and MWS were predictive, the clinical usefulness of these measures was compared.

Using LR guidelines, the LRs associated with the SSWS (0.97 m/s) and MWS (1.39 m/s) cutpoints were compared to determine which measure was more informative for predicting daily ambulatory activity in active older adult clients (Jaeschke et al., 1994). The -LRs associated with both measures were close to 0.5, corresponding to “small”/“rarely important” shifts in probability. The +LR associated with SSWS was greater than 10, and therefore, considered “large and conclusive”, while the +LR associated with MWS (2.79) resulted in only a “small” shift in probability. The +LRs indicate that SSWS provides greater insight than MWS into whether a client is achieving an average of at least 8,000 steps per day. Nomograms are valuable clinical tools, as they can be used in combination with LRs to determine a specific patient’s posttest probability of having the outcome of interest. To demonstrate the utility of the nomogram, consider the following example. If a client similar to those included in our sample presents with a SSWS ≤ 0.97 m/s, the probability that they are not meeting the 8,000 steps per day threshold is 95% (see Figure 2). These clients would benefit from increasing their ambulatory activity. As there is a dose–response relationship between steps per day and numerous health markers, any increase in walking activity may be beneficial (Ewald et al., 2014). Therefore, even if clients are falsely identified
as not averaging at least 8,000 steps per day, they may still benefit from additional walking.

Combining findings from all analyses indicates that SSWS provides the greatest insight into an older adult client’s daily ambulatory activity when compared with MWS and WSR. The measure demonstrates the strongest correlation with steps per day, explains the greatest variability in steps per day, and a cutpoint of 0.97 m/s provides “large and conclusive” shifts in the probability that the individual being assessed is averaging < 8,000 steps per day.

Strengths and Limitations

A strength of this study was the use of an objective measure of daily ambulatory activity, steps per day, rather than reliance on self-report. Although activity monitors collect data on multiple parameters, steps per day was chosen as the outcome of interest. A wealth of evidence supports the relationship between steps per day and health outcomes (Ewald et al., 2014; Tudor-Locke et al., 2011). Time spent engaged in various levels of activity intensity (e.g., sedentary, light, moderate, vigorous) is also captured via activity monitors; however, steps per day is a simple construct that can be easily understood and modified by a typical older adult. Another strength of the study was the monitoring of ambulatory activity over seven days, which captures all days of the week.

Limitations in study design must also be considered when interpreting results. In both linear and logistic regression analyses, covariates considered for entrance into the models were restricted to only a few (age, sex, assistive device use). The authors acknowledge that many other variables (e.g., comorbidities, socioeconomic status) could explain daily ambulatory activity. However, the purpose of this study was not to construct a complicated model that maximally explained variability in steps per day in this sample. Rather, the goal was to provide clinicians with insight into which WS measure may be most informative in regard to their client’s community walking behavior. Another limitation is the generalizability of results. The sample was recruited through retirement communities and senior centers. All sites provided members access to wellness centers with exercise equipment and group fitness classes. The sample of older adults included in this study was very active. Caution should be exerted when generalizing results to a less active group. The nature of activity monitoring prevents blinding of subjects, which may have resulted in participants increasing their daily activity levels because they knew they were being observed (Hawthorne effect). However, the device used for monitoring in this study had no display, so it did not provide the wearer with any feedback; this mitigated the impact that knowledge of performance may have had on outcomes. In addition, during instruction on the activity monitoring protocol, maintaining “normal” routines was emphasized.

Conclusions and Directions for Future Research

SSWS is regarded as a “vital sign” and is a recommended assessment tool for older adults. Findings from this study indicate that in addition to its current uses, SSWS also provides insight into daily ambulatory activity in this population. Ambulatory activity is an important construct to assess, but the utility of activity monitoring is limited by the time required. SSWS may be a feasible proxy for assessing and monitoring daily ambulatory activity in older adults. Future research in less active and lower functioning older adults is needed.

Acknowledgments

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References


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