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Assessing the Agreement Between 3-Meter and 6-Meter Walk Tests in 136 Community-Dwelling Older Adults

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Abstract

Objective—Walking speed is an important marker of functionality that is measured over courses of varying lengths, but it is unclear if course length affects measured pace.

Method—A total of 136 older adults completed two consecutive trials each of 3-m and 6-m walking courses, the order of which was randomly assigned. We calculated concordance correlation coefficients (CCC) and created Bland–Altman plots to evaluate the relationship between the two course distances.

Results—Average walking speed was faster for the 6-m course and the second trial of each course. There was high concordance between the first and second trials for both the 3-m and 6-m courses.

Discussion—The 3- and 6-m courses had excellent test–retest reliability and faster walking speed in later than earlier trials. Higher concordance between courses for later trials suggests the utility of practice trials and adjusting for course length when combining walking speed measurements between different course lengths.

Keywords

walking speed; concordance; course length

Introduction

In epidemiologic studies, walking speed is an important measure of functioning that strongly predicts mortality (Elbaz et al., 2013; Ostir, Kuo, Berges, Markides, & Ottenbacher, 2007; Studenski et al., 2011), functional decline (Brach, VanSwearingen, Newman, & Kriska, 2002; Onder et al., 2005), and hospitalization (Cesari et al., 2005). Walking speed is measured in both clinical and home-based settings over courses of different lengths (Kasper, Freedman, & Niefeld, 2012; Ostir et al., 2002; Wolinsky, Miller, Andresen, Malmstrom, & Miller, 2005), sometimes within a single study (Ashburner et al., 2011; Simonsick et al.,

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1997). However, it is uniformly presented as meters/second (m/s) regardless of the course length, despite the fact that courses are usually shorter in home settings due to limited space availability (Fredman, Doros, Ensrud, Hochberg, & Cauley, 2009; Fredman, Hawkes, Black, Bertrand, & Magaziner, 2006; Fredman et al., 2005). The course itself may influence walking speed measurements, which may in turn affect comparisons of pace between and within studies using different course lengths, as well as between measurements collected in home settings compared with clinical research settings, particularly if participant health status is the reason that walking speed is being measured in the home. The few studies that have examined whether course length affects measured walking speed were conducted on clinical populations (Peters, Fritz, & Krotish, 2013; Salbach et al., 2001). The present study compared walking course distances on measured pace in a sample of healthy community-dwelling older adults.

While course length differs due to space availability and location (Ashburner et al., 2011; Ostir et al., 2002; Simonsick et al., 1997), it may also be determined by participant health status (Graham, Ostir, Fisher, & Ottenbacher, 2008). Moreover, as walking speed among older adults varies with health status (Ashburner et al., 2011) and gender (Beavers et al., 2013), it is difficult to determine how much these differences in measured pace between studies were influenced by different course lengths or by differences in sample characteristics. Among community-dwelling older women with no notable disability, average walking speed was slower in assessments of combined 2-m, 3-m, and 6-m courses (Ashburner et al., 2011) than those in clinical research settings with single 4- or 20-m courses (Beavers et al., 2013; Brach et al., 2002). In particular, women who completed a 6-m course had faster walking speeds than those who completed shorter courses (Ashburner & Kloppel, 2011). Furthermore, in studies that included multiple trials of walking speed in older adults, faster speeds were documented in later trials than in earlier trials of the same course length (Fransen, Crosbie, & Edmonds, 1997; Green, Forster, & Young, 2002; Salbach et al., 2001) and in clinical settings compared with natural settings (Moseley et al., 2004). It is unclear whether these differences were due to differences in the courses or sample characteristics.

Several studies have assessed the reliability of walking speed among older adults (Adell, Wehmhorner, & Rydwik, 2013; Fransen et al., 1997; Green et al., 2002; Motyl, Driban, McAdams, Price, & McAlindon, 2013), but to our knowledge, only a few have examined the reliability over different course lengths or settings (Moseley et al., 2004; Peters et al., 2013; Salbach et al., 2001); of these, two were conducted in small samples of adults with stroke (Salbach et al., 2001) or traumatic brain injury (Moseley et al., 2004). Only Peters et al. (2013) evaluated older adults free of major impairment and concluded that the 4-m and 10-m course lengths were not interchangeable, as small differences in measured walking speed could have a significant impact on health and functional diagnoses. The current study assessed the agreement and comparability of two walking course lengths that are easily used in home settings in a sample of healthy, community-dwelling older adults.

Method

Sample

The sample was drawn from the Health Pathways Study, an ongoing longitudinal cohort study of older community-dwelling caregivers and non-caregivers from the Boston, Massachusetts metropolitan area, as described elsewhere (Fredman, Gordon, Heeren, & Stuver, 2013). Participants were aged 60 years or above, English-speaking, and free of cognitive impairment. Caregivers were recruited from Boston University's (BU) Alzheimer's Disease Center and Parkinson's Disease Center and needed to be assisting their care recipient with at least one basic or instrumental activity of daily living; non-caregivers were recruited through announcements placed in local newspapers, the Harvard Cooperative Program on Aging (HCPOA) newsletter, and direct mailings to HCPOA members.

The sample for the current study consisted of both caregivers and non-caregivers whose second follow-up interview took place at the BU General Clinical Research Unit.

Data Collection

Trained interviewers conducted face-to-face interviews with participants at annual intervals. They collected data on sociodemographic characteristics, self-reported physical and psychological health status, and medications taken over the past month, and administered physical performance tests. Participants received a US\$20 honorarium for completing the interview. Written informed consent was obtained from all participants. BU Medical Center's Institutional Review Board has approved the study.

Walking speed—Participants' usual walking speed was assessed using 3-m and 6-m walk tests. Each participant completed two trials of each walking test with a standing start, for a total of four trials. Participants were instructed to stand with their toes touching the taped start line and walk at their usual pace to a few steps beyond the taped finish line. Trained interviewers walking alongside the participants recorded the time to complete the course from the start line to the stop line using a hand-held stop watch following standardized procedures (Nelson, Nevitt, Scott, Stone, & Cummings, 1994). Participants were timed from the moment their foot crossed the start line to the moment their foot crossed the stop line. If participants did not follow the instructions, the interviewer stopped the trial to review the instructions and prompted the participant to try again. All walking tests were conducted at a single location by interviewers who were trained in administering the walking tests and who gave walking instructions using a standard script. Total course time was converted to meters/second (m/s). Participants were randomly assigned to complete either the 3-m or the 6-m walk test first to detect potential differences related to the order of the tests.

Sociodemographic and health variables—Respondents reported their age, marital status, race, gender, and highest level of education. The 14-item Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) measured general stress experienced in the past month, with higher scores indicating more stress (range = 0–56). Medical conditions were based on self-report of ever being diagnosed with any of nine conditions (arthritis, emphysema, high blood pressure, myocardial infarction, diabetes, cancer, stroke,

Parkinson's disease, and Alzheimer's disease; range = 0–9). Trained nurses measured the respondents' height in inches and weight in pounds.

Statistical Analyses

To examine order effects, we compared characteristics of the group who walked the 3-m course first with those who walked the 6-m course first using *t*-tests for continuous covariables and analysis of variance (ANOVA) for categorical variables. Intraclass correlation coefficients (ICC) and Lin's Concordance Correlation Coefficients (CCC) were calculated to evaluate reproducibility and validity of the first and second trials for each walking test and between the mean walking speed for the 3-m and 6-m courses (Lin, 1989). The CCC was developed specifically to describe agreement between single measures from each of two instruments, and agrees closely with the ICC, which describes agreement in more general situations as well (Nickerson, 1997). We created Bland–Altman plots of differences between mean 3-m and mean 6-m walking speeds, as well as between the first and second trials over each course length (Bland & Altman, 1986).

Results

The sample included 136 males and females who were interviewed between May 2012 and October 2013. Participants were aged 62 to 91 years ($M = 76.44$, $SD = 7.45$), 83.82% were White, and 63.68% were female. Sociodemographic and health characteristics did not differ by whether the participant performed the 3-m or the 6-m course first, demonstrating that randomization was successful (Table 1).

Among the total sample, the average walking speed was 0.82 ($SD = 0.23$) m/s over the 3-m course and 0.94 ($SD = 0.21$) m/s over the 6-m course. Within the 3-m course, 83 (61.0%) of all participants were faster in the second trial, with an average increase in speed of 11%; among those who walked the 3-m course first, 48 (65.8%) were faster in the second trial. For the 6-m course, 69 (50.7%) of all participants were faster in the second trial, with an average increase of 8%; among those who walked the 6-m course first, 38 (60.3%) had faster speeds in the second trial. A higher proportion of participants were classified as walking less than 1 m/s, a clinically meaningful prognostic value (Cesari et al., 2005) using the 3-m course (78.7%) than the 6-m course (64.0%; $p < .01$; Table 1). The two 3-m course trials differed significantly in participants who walked the 3-m course first ($p < .01$) but not in participants who walked the 6-m course first ($p = .37$). Similarly, the two 6-m course trials differed significantly in participants who walked the 6-m course first ($p = .03$), but not in those who walked the 3-m course first ($p = .70$).

Lin's CCC indicated high concordance comparing first and second trials for both the 3-m and 6-m courses (CCC = 0.91 and 0.92, respectively), similar to the ICCs (Table 2) (Figures 1a–1c). We found moderate concordance between the second trials of the 3-m and 6-m courses (CCC = 0.78, 95% CI [0.78, 0.83]) and the lowest concordance between the first trials over each course (CCC = 0.69, 95% CI [0.61, 0.76]). Using the less conservative ICC measure, concordance was excellent between the second trials of the 3-m and 6-m courses (ICC = 0.88, 95% CI [0.83, 0.91]). Both measures of agreement showed slightly higher concordance between average 3-m and 6-m pace (CCC = 0.77, ICC = 0.88) than the fastest

3-m and 6-m pace (CCC = 0.74, ICC = 0.86). A sensitivity analysis excluding three outliers with a large difference (>0.23 m/s) between the first and second trials of either length course resulted in no significant impact on these findings.

There were significant differences in average difference in walking speed between the first and second trials by interviewer for the 6-m course ($p < .01$) but not the 3-m course ($p = .19$). Additional analyses excluding the three interviewers with outlier data yielded a non-significant difference by interviewer ($p = .74$) but reduced the total sample size to 88. Given the size of the sample for these analyses and the wide range of walking speed among participants, we cannot conclude that these differences were solely due to interviewer effects.

Discussion

In this sample of older, community-dwelling adults, we found strong agreement in walking speed within the 3-m and 6-m courses, but values below the cut point of 0.8 for good concordance between the two courses. These results are consistent with a comparison of 4-m and 10-m courses in older adults (Peters et al., 2013) and with that study's conclusion that walking speed measurements between different course lengths may not be comparable. Therefore, it may be beneficial to utilize a conversion factor, as has been applied previously to adjust for courses of different lengths (Guralnik et al., 2000; Studenski et al., 2011), or sample-based adjustment when comparing walking speed over different length courses in older adults.

We also found that participants walked faster at the second trial than the first trial of both courses, similar to findings of previous studies (Fransen et al., 1997; Green et al., 2002; Salbach et al., 2001). This practice effect was also observed for the total number of trials: The second trial within a single course was faster than the first trial, and those who walked the 6-m course first had faster 3-m walking speeds than those who walked the 3-m course first, and vice versa. We did not find that the difference between the first and second trials of either course length were significantly different ($p = .23$), indicating that practice effects are similar for the shorter course as the longer course. This suggests that averaging several trials, or conducting practice trials, would increase the reliability of walking speed measures, as has been recommended for longer courses (Motyl et al., 2013). However, another approach used by studies that measured walking speed across multiple trials of the same course length is to use the fastest of two (Cesari et al., 2005; Guralnik et al., 2000; Onder et al., 2005; Ostir et al., 2002) or three (Elbaz et al., 2013) trials.

This study adds to the limited literature comparing different length of walking courses in older adults. Previous studies were conducted among disabled older adults (Moseley et al., 2004; Salbach et al., 2001), or in community-based samples of 50 participants or fewer (Peters et al., 2013; Salbach et al., 2001). Compared with these studies, our results are generalizable to older community-dwelling adults, and our sample was larger. Moreover, we randomly assigned walking course length order, thereby removing potential order effects that could affect the validity of our results.

Nonetheless, this study had several limitations. Although we selected course lengths based on epidemiologic studies that conducted walking speed measures in both home-based and clinic-based settings (Ashburner et al., 2011; Ashburner & Kloppel, 2011), we did not include a longer course (e.g., 10-m) as a reference as in one other study (Peters et al., 2013), nor did we include additional space for acceleration or deceleration. Future studies with these features may further clarify the validity of shorter courses.

In summary, both the 3-m and 6-m walking tests showed excellent test–retest reliability. We found only moderate concordance between the two tests, with better concordance for the second trial than the first trial. While longer courses, such as a 10-m course, may provide more valid assessments of walking speed in clinical settings, this distance may not be feasible in home-based settings or with populations with disabilities. Shorter courses may be used without hesitation, as they are also valid. However, combining walking speeds from different length courses without adjusting for the course distance may lead to incorrect assessment of walking speed.

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Figure 1. Bland–Altman agreement analyses showing limits of agreement and mean difference for 136 participants who completed both the 3-m and 6-m walk courses.

Table 1

Characteristics of 136 Participants in the Health Pathways Study Who Completed the 3-Meter and 6-Meter Walking Courses.

	<u>Total sample (n = 136)</u>	<u>3-m first (n = 73)</u>	<u>6-m first (n = 63)</u>	
	<i>M (SD) or n (percentage)</i>	<i>M (SD) or n (percentage)</i>	<i>M (SD) or n (percentage)</i>	<i>p value</i>
Age: years	76.44 (7.45)	76.85 (6.97)	75.96 (8.00)	.49
Gender: female	93 (63.68)	54 (73.97)	39 (61.90)	.13
Education: college or higher	106 (77.94)	58 (79.45)	48 (76.19)	.65
Race: White	114 (83.82)	62 (84.93)	52 (82.54)	.73
Height (inches)	164.08 (9.66)	164.46 (1.13)	163.64 (1.22)	.62
Weight (pounds)	165.33 (39.18)	162.21 (4.59)	168.94 (4.94)	.32
Perceived stress	16.87 (7.91)	17.09 (0.93)	16.61 (1.00)	.73
Medical conditions	2.57 (1.59)	2.48 (0.19)	2.68 (0.20)	.46
3-m course				
Trial 1 (m/s)	0.81 (0.23)	0.77*** (0.24)	0.86* (0.21)	.03
Trial 2 (m/s)	0.84 (0.23)	0.81 (0.25)	0.87 (0.21)	.18
Average (m/s)	0.82 (0.23)	0.79 (0.03)	0.86 (0.03)	.07
Proportion with average walking speed < 1 m/s	107 (78.7)	58 (79.5)	49 (77.8)	.81
6-m course				
Trial 1 (m/s)	0.94 (0.22)	0.96* (0.24)	0.91** (0.19)	.20
Trial 2 (m/s)	0.95 (0.22)	0.96 (0.24)	0.93 (0.20)	.47
Average (m/s)	0.94 (0.21)	0.96 (0.03)	0.92 (0.03)	.31
Proportion with average walking speed < 1 m/s	87 (64.0)	46 (63.0)	41 (65.1)	.80

Comparisons of Trial 1 vs. Trial 2:

* p>0.05,

** p<0.05,

*** p<0.01.

Table 2

Lin's CCC Between Consecutive Walking Trials and Different Course Lengths.

	Agreement			
	Lin's CCC	95% CI	ICC	95% CI
6-m (m/s) first vs. second	0.92	[0.89, 0.94]	0.92	[0.89, 0.94]
3-m (m/s) first vs. second	0.91	[0.88, 0.94]	0.92	[0.89, 0.94]
First trial (m/s) 3 m vs. 6 m	0.69	[0.61, 0.76]	0.80	[0.73, 0.75]
Second trial (m/s) 3 m vs. 6 m	0.78	[0.72, 0.83]	0.88	[0.83, 0.91]
Average (m/s) 3 m vs. 6 m	0.76	[0.70, 0.82]	0.88	[0.83, 0.91]
Fastest (m/s) 3 m vs. 6 m	0.74	[0.67, 0.80]	0.86	[0.81, 0.90]

Note. CCC = concordance correlation coefficients; CI = confidence interval; ICC = intraclass correlation coefficients.