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The Impact of Testing Protocol on Recorded Gait Speed

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Abstract

Background—Gait speed predicts disability, cognitive decline, hospitalization, nursing home admission and mortality. Although gait speed is often measured in clinical practice and research, testing protocols vary widely and their impact on recorded gait speed has yet to be explored.

Objectives—Our purpose is to describe and compare gait speeds obtained from different testing protocols in the same individuals.

Design—Cross-sectional.

Setting—University research setting.

Participants—Subjects were 104 community-dwelling older adults who could ambulate household distances independently (mean age=77.2±6.1).

Measurements—Gait speed was recorded over 4 meters using the protocols: 1) standing start, usual pace over ground, 2) walking start, usual pace over ground with an optokinetic device, 3) walking start, usual pace over ground with a stop watch 4) walking start, usual pace on a computerized walkway, and 5) walking start, fast pace on a computerized walkway. A linear mixed model and pairwise comparisons was used to compare gait speeds within individuals across different protocols.

Results—Mean±SD gait speed for each condition was: standing start, usual pace over ground 0.97±0.23 m/s; walking start, usual pace over ground 1.14±0.25 m/s; walking start, usual pace on walkway 1.01±0.26 m/s; and walking start, fast pace on walkway 1.31±0.34 m/s. On average, the determined gait speed was 0.17 m/s faster during the walking compared to the standing start (p<.001), 0.07 m/s slower on the computerized walkway compared to over ground (p<.001), and 0.25 m/s faster during the fast pace compared to the usual pace walk (p<.001).

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Conclusion—Starting protocol (standing vs. walking), testing surface (over ground vs. computerized walkway), and walking pace (usual vs. fast) impact recorded gait speed in older adults. Care should be taken when comparing gait speeds from studies with different testing protocols.

Keywords

gait speed; testing protocol

Gait speed, a significant predictor of important health outcomes,[1–3] is frequently used in clinical and epidemiological research studies. However, there is currently no consensus on the ideal testing procedure; therefore testing protocols vary widely, making comparisons difficult.[4, 5] Others examining the implications of testing protocol conducted literature reviews comparing protocols between different studies and subjects.[4, 5] Because the comparisons were not made between the same subjects, it is difficult to determine if differences in gait speed were due to testing protocol or differences in study sample. Also when evaluating the differences, researchers focused on statistically significant and not clinically significant values (i.e. differences that are clinically noticeable).

Therefore, the purpose of this study is to compare gait speeds obtained from different testing protocols in the same individuals. More specifically, the impact of starting protocol (standing start versus walking start), testing condition (computerized walkway versus over ground walking), measurement method (automatic timing system versus manual stopwatch), and pace (usual pace versus fast pace) on measured gait speed will be investigated taking into account the clinical meaningfulness of the differences in recorded gait speeds.

METHODS

Subjects

The study included 120 older adults, who were recruited from the University of Pittsburgh Pepper Center research registry, a database of older adults who have previously consented to be contacted for studies of this nature. Subjects were community-dwelling adults age 65 and older who could ambulate household distances (50 feet) independently, and who self-reported the ability to tolerate 5 hours of testing. Participants were included in the present analyses if they had completed gait speed measurements for each of the five testing protocols (N =104). The 16 excluded subjects with incomplete data did not differ from the sample on age, gender, self-reported fear of falling, self-reported rating of mobility, or over ground gait speed. The University of Pittsburgh institutional review board approved the study and all participants provided written informed consent.

Measures

Assessments included demographic information, self-report questions of health, mobility, and fear of falling, and measurements of gait speed using five different testing protocols (described below).

Standing Start, Usual Pace, Over Ground (SPPB)—Standing start, usual pace, over ground gait speed was assessed as part of the Short Physical Performance Battery (SPPB).[6, 7] Time to complete the 4 meter walk was measured using a stopwatch, and the tester started the time when the participant stepped over the starting line and stopped when the participant had completely crossed the end line.

Walking Start, Usual Pace, Over Ground (Optokinetic)—Gait speed was measured over a 4-meter distance by a motion sensitive light beam system that triggers activation and inactivation of a stopwatch. Participants started walking several steps before the first light beam and continued walking after the final light beam, allowing time to accelerate and decelerate.

Walking Start, Usual Pace, Over Ground (Stopwatch)—During the optokinetic gait speed protocol trials, a tester was simultaneously collecting the participant's gait speed using a stopwatch. The tester started the stopwatch when the participant crossed the starting line and stopped the time when the participant crossed the final optokinetic sensor.

Walking Start, Usual Pace on a Computerized Walkway—Gait speed was also measured using a computerized walkway, approximately 8 meters in length (GaitMat II). The walkway consists of a central 4-meter segment that collects data, with inactive segments before and after that allow for acceleration and deceleration. The participant walked at their usual pace.

Walking Start, Fast Pace on a Computerized Walkway—This protocol utilized the same setup as described above for walking start, usual pace walking on the computerized walkway. The participant completed additional fast pace trials on the walkway, with the following verbal instructions "walk as quickly as possible, without running or putting yourself at risk for falling".

Data Analysis

All Analyses were performed using SPSS® version 19.0 (SPSS, Inc., Chicago, IL) and SAS® version 9.3 (SAS Institute, Inc., Cary, North Carolina). We fit a linear mixed model for gait speed with protocol as the main fixed effect of interest, and a subject random effect to account for multiple measurements from each participant. Contrasts were estimated between: 1) standing start, usual pace and walking start, usual pace; 2) walking start, usual pace over ground and walking start, usual pace on the computerized walkway; 3) walking start, usual pace measured by the optokinetic light beam system and walking start, usual pace measures manually with a stop watch; and 4) walking start, usual pace on the computerized walkway and walking start, fast pace on the computerized walkway. Lastly, linear and quadratic regression models were used to create equations to estimate conversions for gait speeds obtained from different testing protocols.

RESULTS

Baseline characteristics of the sample (N = 104) and the average gait speed for each testing protocol are presented in Table 1. The slowest average gait speed was recorded using the standing start, usual pace over ground protocol (0.97 m/s; SD = .23) and the fastest average gait speed was recorded using the fast pace gait speed on the computer walkway (1.31 m/s; SD = .26).

Table 2 displays the mean difference between gait speeds obtained from the various testing protocols. On average, participants walked faster at their usual pace when starting with a walking start compared to a standing start. When comparing the computerized walkway to over ground, participants on average walked slower on the computerized walkway than over ground when instructed to walk at the same pace and starting protocol. These results were similar when measuring usual pace walking over ground with both the optokinetic system and the stopwatch. Walking start, usual pace gait speed over ground was similar when ($p>0.05$) when measured with the optokinetic system as compared to a stopwatch. Finally, on average, participants walked .25±.16 m/s faster ($p<.001$) when instructed to walk at their fastest pace than at their usual, comfortable pace.

Regression equations to convert gait speed between the various testing protocols are presented in Table 3. The R^2 of the equations ranged from 0.74-.83.

DISCUSSION

Based on findings of the current study, a small meaningful change in gait speed can be elicited simply by testing an individual’s gait speed over ground instead of on a computerized walkway. Furthermore, a substantial clinically meaningful change can be made by allowing an individual a walking start to accelerate to their true walking pace rather than using a standing start. For practical reasons, there may not be one ideal testing protocol. However, the ease of altering gait speed by clinically meaningful amounts simply by changing the protocol demonstrates the need for consistency in testing protocol and documentation of testing method when noting a gait speed measurement.

For example, gait speed assessment using a walking start may not be feasible in all clinical settings, particularly those that have limited space and would not allow for acceleration/ deceleration (i.e., home care, hospital rooms). Using the proper regression equation, standing start gait speed can be readily converted to walking start gait speed, facilitating more accurate comparison of gait speeds obtained with different testing protocols.

Conclusions

While consensus has yet to be reached on the optimal gait speed testing protocol, it is important that both clinicians and researchers are aware of the significant impact of altering aspects of testing protocol on measured gait speed.

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Research Findings

1. Although gait speed is often measured in clinical practice and research, testing protocols vary widely.
2. Starting protocol, testing surface, and walking pace all impact recorded gait speed.
3. Care should be taken when comparing gait speeds from studies with different testing protocols.
4. Regression equations to convert gait speed between various testing protocols are presented.

Table 1

Baseline Characteristics of the Sample

Characteristic	Study sample (n=104)	Excluded Sample (n=16)
Age, mean ± SD	77.1 ± 6.1	79.8 ± 4.1
Female, n (%)	76 (73.1%)	10 (62.5%)
White, n (%)	91 (87.5%)	14 (87.5%)
≥High school education, n (%)	97 (93.2%)	15 (93.8%)
Global mobility fair or poor, n (%)	25 (24%)	1 (6.3%)
Global health fair or poor, n (%)	10 (9.6%)	0 (0%)
Afraid of falling, n (%)	45 (43.3%)	7 (43.8%)
Gait Speed Measures		
Standing start, usual pace over ground (SPPB[†]), mean ± SD	0.97 ± .23	0.97 ± .25
Walking start, usual pace over ground (optokinetic), mean ± SD	1.14 ± .25	--
Walking start, usual pace over ground (stopwatch), mean ± SD	1.13 ± .25	--
Walking start, usual pace on computerized walkway, mean ± SD	1.06 ± .26	--
Walking start, fast pace on computerized walkway, mean ± SD	1.31 ± .34	--

SD = standard deviation.

[†]4-meter SPPB

Table 2

Mean Differences Between Gait Speeds Obtained from the Different Testing Protocols

Measures	Estimated Difference	95% Confidence Interval	p-Value
Walking Start vs. Standing Start			
Optokinetic vs. SPPB†	0.17	(0.14, 0.20)	<.0001
Stopwatch vs. SPPB†	0.16	(0.14, 0.19)	<.0001
Computerized Walkway vs. SPPB†	0.10	(0.07, 0.12)	<.0001
Computerized Walkway vs. Over Ground			
Walkway vs. Optokinetic	−0.07	(−0.10, −0.04)	<.0001
Walkway vs. Stopwatch	−0.07	(−0.09, −0.04)	<.0001
Over Ground measures			
Optokinetic vs. Stopwatch	0.01	(−0.02–0.03)	0.7174
Fast Pace vs. Usual Pace			
Fast vs. Usual Computerized Walkway	0.25	(0.22–0.27)	<.0001

† 4-meter gait speed from Short Physical Performance Battery (SPPB)

Table 3

Conversion Equations for Gait Speeds Obtained from Different Protocols with Linear and Quadratic Models, and [Proportion of Explained Variability R^2]

		Convert to (Y)				
		Optokinetic	**Stopwatch**	**SPPB**	**Walkway Usual**	**Walkway Fast**
Convert from (X)	Optokinetic	----	Y=0.006+0.990X [94%] Y=−0.025+1.053X −0.030X^2 [94%]	Y=0.074+0.786X [70%] Y=−0.008+0.953X −0.079X^2 [70%]	Y=−0.020+0.954X [83%] Y=−0.022+1.353X −0.190X^2 [83%]	Y=−0.045+1.192X [74%] Y=−0.602+2.323X −0.539X^2 [76%]
	Stopwatch	Y=0.061+0.951X [94%] Y=−0.229+1.530X −0.272X^2 [95%]	----	Y=0.068+0.795X [75%] Y=0.081+0.771X +0.012X^2 [75%]	Y=−0.009+0.949X [85%] Y=−0.185+1.300X −0.165X^2 [86%]	Y=0.014+1.145X [71%] Y=−0.757+2.686X −0.723X^2 [74%]
	SPPB	Y=0.273+0.892X [70%] Y=−0.318+2.237X −0.718X^2 [74%]	Y=0.222+0.939X [75%] Y=−0.106+1.686X −0.399X^2 [76%]	----	Y=0.090+1.006X [81%] Y=−0.217+1.706X −0.374X^2 [82%]	Y=0.099+1.251X [72%] Y=−0.792+3.279X −1.082X^2 [76%]
	Walkway Usual	Y=0.213+0.867X [83%] Y=−0.052+1.445X −0.0291X^2 [84%]	Y=0.175+0.898X [85%] Y=0.072+1.122X −0.113X^2 [85%]	Y=0.110+0.806X [81%] Y=0.204+0.601X +0.104X^2 [81%]	----	Y=0.042+1.191X [82%] Y=−0.385+2.120X −0.467X^2 [83%]
	Walkway Fast	Y=0.321+0.622X [74%] Y=0.034+1.151X −0.221X^2 [76%]	Y=0.316+0.622X [71%] Y=0.022+1.163X −0.226X^2 [73%]	Y=0.214+0.576X [72%] Y=0.118+0.753X −0.074X^2 [72%]	Y=0.168+0.684X [82%] Y=−0.040+1.066X −0.160X^2 [82%]	----