Concurrent validity of the GAITRite electronic walkway and the 10-m walk test for measurement of walking speed after stroke

Brice T. Cleland, Haris Arshad, Sangeetha Madhavan*

Brain Plasticity Lab, Department of Physical Therapy, College of Applied Health Sciences, University of Illinois at Chicago, Chicago, IL, USA

ABSTRACT

Background: Walking speed is used to assess functional status, predict recovery, prescribe exercise, and track functional progress after stroke. Determining concurrent validity ensures that results from different tests of walking speed can be compared or used interchangeably. The GAITRite electronic walkway and the 10-m walk test (10MWT) are popular measurement tools of walking speed in the laboratory and in clinical settings, respectively.

Research question: Do walking speeds in chronic stroke survivors measured with the 10-m walk test and GAITRite electronic walkway demonstrate concurrent validity?

Methods: 77 participants with chronic stroke performed four trials of 10MWT and four trials of GAITRite—two trials at comfortable walking speed and two trials at maximal walking speed. Intraclass correlations [ICC (3,1), absolute agreement] and Bland-Altman plots were used to assess the relationship between gait speed from these two measures.

Results: Walking speed showed poor to good absolute agreement between 10MWT and GAITRite for comfortable walking speed [ICC: 0.77 (95% CI: 0.46, 0.89; $P < 0.001$)] and excellent absolute agreement for maximal walking speed [ICC: 0.94 (95% CI: 0.91, 0.96; $P < 0.001$)]. Mean difference value (systematic bias) was different from 0 for comfortable walking [10MWT was faster; $P < 0.001$ (95% CI: 0.05, 0.10)] but not for maximal walking [$P = 0.16$ (95% CI: -0.01, 0.04)]. Limits of agreement were broad (comfortable walking speed, 0.43; maximal walking speed, 0.37), and there was proportional bias at both speeds whereby participants who walked faster tended to have a faster walking speed during 10MWT vs. GAITRite (comfortable walking speed, $R^2 = 0.22$, $P < 0.001$; maximal walking speed, $R^2 = 0.08$, $P = 0.01$).

Significance: Systematic bias, proportional bias, and broad limits of agreement suggest that caution should be used when comparing walking speeds from 10MWT and GAITRite. It may not be appropriate to use them interchangeably. Conducting 10MWT and GAITRite tests at maximal walking speeds may allow more accurate comparisons between measures.

1. Introduction

Walking speed is a robust measure that can predict constructs including life expectancy and response to rehabilitation [1]. Clinicians and researchers use walking speed to assess community ambulation status, prescribe exercise, and track functional progress after stroke [1,2]. To ensure that different tests of walking speed can be compared or used interchangeably, it is important to determine the concurrent validity of each measure. GAITRite is a popular laboratory measurement of spatiotemporal gait parameters. In stroke survivors, walking speed measured with GAITRite has concurrent validity with a motion capture system [3]. In clinical settings, many practitioners opt for walking tests that are easily administered without special equipment.

For example, a popular test of walking speed is the 10-m walk test (10MWT) [1]. Walking speed measured with 10MWT in chronic stroke survivors has concurrent validity with the 6-minute walk test and community walking speed [4,5]. Yet, no studies have evaluated the concurrent validity of walking speed measured with the 10MWT and GAITRite after stroke. The purpose of this study was to assess the concurrent validity of walking speeds measured with 10MWT and GAITRite in chronic stroke survivors.

2. Methods

Individuals with chronic hemiparesis (n = 77) performed walking trials during a single session as part of baseline measurements for an

---

Table 1
Demographics and walking speed.

Demographics, stroke (n = 77)	
Age (years)	59 ± 9; Range: 41, 80
Gender (male/female)	53/24
Height (meters)	1.71 ± 0.09; Range: 1.52, 1.88
Mass (kg)	83.6 ± 15.6; Range: 54.8, 119.5
Race/ethnicity (count)	
Black	39
White, not hispanic	27
White, hispanic	5
Asian	5
American Indian	1
Time since stroke (years)	5.8 ± 5.2; Range: 0.5, 32.8
Hemiparetic side (right/left)	42/35
Use of cane (yes/no)	4/73
Walking speed	
10MWT walking speed (m/s)	
Comfortable	0.75 ± 0.21; Range: 0.22, 1.17
Maximal	0.97 ± 0.29; Range: 0.30, 1.49
GAITRite walking speed (m/s)	
Comfortable	0.67 ± 0.16; Range: 0.22, 0.94
Maximal	0.95 ± 0.26; Range: 0.32, 1.50

Demographics (top) and walking speed (bottom) for all participants. Values are count or Mean ± SD. 10MWT: 10-m walk test.

ongoing randomized controlled trial evaluating motor priming and treadmill training (clinical trial registration: NCT03492229). Participants provided written informed consent, and the study was approved by the institutional review board. See Table 1 for demographics.

Four trials of 10MWT and four trials of walking across the GAITRite electronic walkway (classic 14′ (4.27 m) model, CIR Systems Inc., NJ, USA) were performed—two trials at self-selected comfortable speed and two trials at maximal speed. Participants were asked to walk at their "normal comfortable" speed for comfortable trials and as fast as they could safely walk for maximal trials. For 10MWT, cones marked the walking area, and a stopwatch was used to manually record the time from when the leg crossed the beginning marker to when it crossed the end marker for each trial. Walking speed was computed from the mean time across trials. During GAITRite trials, walking speed was computed as the distance between the centroid of the first and last footfalls (typically 3–4 m) divided by the elapsed time between these footfalls. The mean speed across trials was used. For all walking trials, there was a ~2 m acceleration and deceleration zone. No practice trials were performed. The 10MWT was performed first, and both 10MWT and GAITRite were performed before other walking tests or baseline measures involving physical exertion. To minimize the effects of fatigue, rest was given between trials as needed. Participants wore their typical footwear.

Absolute agreement between walking speeds from 10MWT and GAITRite was tested with intraclass correlations [two-way mixed, single measures, i.e. ICC (3,1)]. Linear Bland-Altman plots also were constructed to evaluate the relationship between 10MWT and GAITRite. The difference value was computed as: 10MWT speed – GAITRite speed. Linear limits of agreement were calculated as the mean difference value ± 1.96*SD. Mean difference values were compared with 0 using one-sample t-tests (systematic bias). Regression-based Bland-Altman plots were also constructed. Mean proportional bias (relationship between difference and mean values) was determined with a linear regression. Regression-based limits of agreement were determined as the linear regression line ± SD of residuals. Statistical tests were performed with SPSS Statistics 25 (IBM, NY, USA). $P < 0.05$ was statistically significant.

3. Results

Most participants (73 out of 77 total participants) performed walking tests without an assistive device. Comfortable and maximal walking speeds from 10MWT and GAITRite are shown in Table 1. Absolute agreement of walking speeds from 10MWT and GAITRite was poor to good for comfortable walking speed [ICC = 0.77 (95% CI: 0.46, 0.89; $P < 0.001$)] and excellent for maximal walking speed [ICC = 0.94 (95% CI: 0.91, 0.96; $P < 0.001$)].

Linear Bland-Altman plots (Fig. 1A, C) demonstrate that the mean difference value was different from 0 for comfortable walking [10MWT was faster than GAITRite, $P < 0.001$ (95% CI: 0.05, 0.10)] but not for maximal walking [$P = 0.16$ (95% CI: −0.01, 0.04)]. The linear limits of agreement show that the relationship between measures was diverse, with a range of 0.43 for comfortable speeds and 0.37 for maximal speeds. Regression-based Bland-Altman plots (Fig. 1B, D) demonstrate a weak but significant relationship between difference and mean values (proportional bias) for comfortable walking speed ($R^2 = 0.22$, $P < 0.001$) and maximal walking speed ($R^2 = 0.08$, $P = 0.01$);
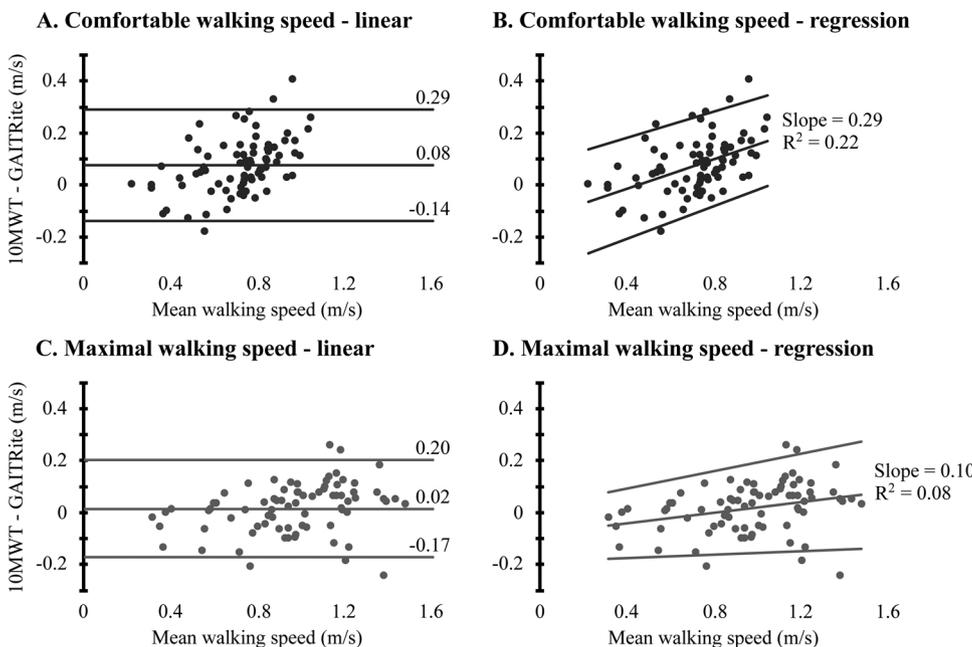

Fig. 1. Bland-Altman plots. Relationship between mean speed across 10MWT and GAITRite and the difference in speed between measures for comfortable walking speed (A and B) and maximal walking speed (C and D). In A and C, horizontal gray lines represent the mean difference value (middle line) and the linear limits of agreement (top and bottom line). Values to the right of each line represent the y-value of the respective line. In B and D, gray lines represent the regression-based line of best fit (middle line) and the regression-based limits of agreement as calculated from the standard deviation of residuals (top and bottom line). Values to the right of the regression lines represent the slope and R^2 value for the linear fit. Each data point represents a single participant.

individuals who walked faster tended to have a faster walking speed during 10MWT vs. GAITRite. Regression-based limits of agreement had a range of 0.34–0.4 m/s for comfortable walking speed and 0.26–0.41 m/s for maximal walking speed.

4. Discussion

Our results demonstrated poor to good agreement between 10MWT and GAITRite at comfortable walking speeds (ICC: 0.46, 0.89) and excellent agreement (ICC: 0.91, 0.96) at maximal walking speeds [6]. Although these initial findings suggest that walking speeds from these measures can be used interchangeably, several observations limit the concurrent validity of walking speed measured with 10MWT and GAITRite. At comfortable walking speeds, there was systematic bias whereby speeds were significantly faster during 10MWT than GAITRite. Additionally, for both walking speeds there was proportional bias, and the linear limits of agreement were large (0.43 for comfortable and 0.37 for maximal speeds). Hiengkaew, Jitaree [7] found that the minimal detectable change (MDC) for walking speed in chronic stroke survivors is 0.18 m/s and 0.13 m/s for comfortable and maximal speeds, respectively. Because our limits of agreement exceed these values, we cannot be confident that differences between tests, even those that reach MDC, are because of differences in walking speed and not systematic bias. A recent study measured self-selected walking speed in chronic stroke with the 3-m walk test (3MWT) and GAITRite [8]. They also found large limits of agreement (0.19–0.46), indicating a lack of concurrent validity between these tests.

In our study, walking speed was faster during 10MWT compared to GAITRite, which may reflect differences in the distance covered for each test. Walking speed is measured over 10 m for 10MWT but only 3–4 m for the GAITRite walkway, depending on the distance between the first and last footfalls. Walking speed measured from 10MWT may be more valid because it is measured over a longer distance. Additionally, fear of falling could have led to slower speeds during GAITRite compared to 10MWT [9]. Specifically, the required foot clearance and narrower path of GAITRite could have resulted in slower speeds, as seen in old adults [10,11]. Unlike our study, Peters, Middleton [8] found that walking speed was faster during GAITRite compared to 3MWT. For both that study and our current study, the walking test with a longer distance (GAITRite for Peters, Middleton [8] and 10MWT for our current study) yielded a faster walking speed. Walking tests with longer distances may reduce the proportion of the timed distance that involves acceleration or deceleration. Overall, our findings suggest that clinicians and researchers should use caution when comparing walking speeds from 10MWT and GAITRite, and it may not be appropriate to use them interchangeably. References to normative data should rely on data collected with the same test of walking speed.

We also found evidence that concurrent validity is higher for maximal vs. comfortable walking speeds. First, walking speeds were faster for 10MWT than GAITRite during comfortable but not maximal walking. Second, absolute agreement between 10MWT and GAITRite was lower and the linear limits of agreement were wider at comfortable vs. maximal walking speeds. Third, there was greater proportional bias at comfortable vs. maximal walking speeds; the regression slope was steeper, and the mean speed across measures explained a greater proportion of the variance in the differences between tests (higher R^2 value). Concurrent validity may have been higher for maximal walking speed because it is anchored to the maximal level, while comfortable walking speed may vary more depending on the environment. These findings suggest that if walking speeds from 10MWT and GAITRite must be compared, conducting these tests at maximal walking speeds may be more valid, albeit with the caveat that the limits of agreement still exceed MDC.

4.1. Study limitations

Concurrent validity assessments are limited to determining the agreement between measures and cannot provide information about which measure provides a value closer to the true value. This study was performed in chronic stroke survivors, most of whom could walk without an assistive device. The results should not be generalized to other populations, including those with greater walking impairment. Although there was evidence of systematic bias between 10MWT and GAITRite at comfortable walking speeds, differences in walking speed may be confounded by errors when using a stopwatch. For example, Youdas, Hollman [12] found that differences in walking speed measured by stopwatch and GAITRite software fell between -0.05 to 0.09 m/s. The mean difference between walking speeds from 10MWT and GAITRite in our study was 0.08 m/s, which falls within this range.

4.2. Conclusions

Caution should be used when comparing walking speeds from 10MWT and GAITRite. It may not be appropriate to use these measures interchangeably, and each measure should be referenced to normative data from the same measure of walking speed. Conducting 10MWT and GAITRite tests at maximal walking speeds may allow a more accurate comparison between measures.

Conflict of interest statement

None.

Acknowledgements

References

[1] A. Middleton, S.L. Fritz, M. Lusardi, Walking speed: the functional vital sign, J. Aging Phys. Act. 23 (2015) 314–322.

[2] J.E. Graham, G.V. Ostir, S.R. Fisher, K.J. Ottenbacher, Assessing walking speed in clinical research: a systematic review, J. Eval. Clin. Pract. 14 (2008) 552–562.

[3] D.S. Stokic, T.S. Horn, J.M. Ramshur, J.W. Chow, Agreement between temporospatial gait parameters of an electronic walkway and a motion capture system in healthy and chronic stroke populations, Am. J. Phys. Med. Rehabil. 88 (2009) 437–444.

[4] U. Dalgas, K. Severinsen, K. Overgaard, Relations between 6 minute walking distance and 10 meter walking speed in patients with multiple sclerosis and stroke, Arch. Phys. Med. Rehabil. 93 (2012) 1167–1172.

[5] D. Taylor, C.M. Stretton, S. Mudge, N. Garrett, Does clinic-measured gait speed differ from gait speed measured in the community in people with stroke? Clin. Rehabil. 20 (2006) 438–444.

[6] T.K. Koo, M.Y. Li, A guideline of selecting and reporting intraclass correlation coefficients for reliability research, J. Chiropr. Med. 15 (2016) 155–163.

[7] V. Hiengkaew, K. Jitaree, P. Chaiyawat, Minimal detectable changes of the Berg Balance Scale, Fugl-Meyer Assessment Scale, timed "up & go" test, gait speeds, and 2-minute walk test in individuals with chronic stroke with different degrees of ankle plantarflexor tone, Arch. Phys. Med. Rehabil. 93 (2012) 1201–1208.

[8] D.M. Peters, A. Middleton, J.W. Donley, E.L. Blanck, S.L. Fritz, Concurrent validity of walking speed values calculated via the GAITRite electronic walkway and 3 meter walk test in the chronic stroke population, Physiother. Theory Pract. 30 (2014) 183–188.

[9] J. Park, I. Yoo, Relationships of stroke patients' gait parameters with fear of falling, J. Phys. Ther. Sci. 26 (2014) 1883–1884.

[10] P. Dunlap, S. Perera, J.M. VanSwearingen, D. Wert, J.S. Brach, Transitioning to a narrow path: the impact of fear of falling in older adults, Gait Posture 35 (2012) 92–95.

[11] H.C. Chen, J.A. Ashton-Miller, N.B. Alexander, A.B. Schultz, Stepping over obstacles: gait patterns of healthy young and old adults, J. Gerontol. 46 (1991) M196–203.

[12] J.W. Youdas, J.H. Hollman, M.J. Aalbers, H.N. Ahrenholz, R.A. Aten, J.J. Cremers, Agreement between the GAITRite walkway system and a stopwatch-footfall count method for measurement of temporal and spatial gait parameters, Arch. Phys. Med. Rehabil. 87 (2006) 1648–1652.