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Comparison of the 2-, 6-, and 12-minute walk tests in patients with stroke

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Abstract—This study assessed inter- and intrarater reliability and sensitivity to change of the 2-, 6-, and 12-minute walk tests following stroke. A convenience sample of patients enrolled in an inpatient stroke rehabilitation program participated in the standardization protocol. The 2-, 6-, and 12-minute walk tests were performed and inter- and intrarater reliability and responsiveness to change assessed. The interrater intraclass correlation coefficients (ICCs) for the 2-, 6-, and 12-minute walk tests were, respectively, 0.85, 0.78, and 0.68 ($p < 0.0007$ for each). The intrarater ICCs were 0.85, 0.74, and 0.71 ($p < 0.0003$ for each). Responsiveness to change as measured by standardized response mean (SRM) scores was, respectively, 1.34, 1.52, and 1.90 ($F = 24.24$, $p < 0.001$). Pearson correlations for the 2-, 6-, and 12-minute walk tests by the same rater on the same day were 2 versus 6 minutes, $r = 0.997$; 2 versus 12 minutes, $r = 0.993$; and 6 versus 12 minutes, $r = 0.994$ ($p < 0.0001$ for each). The 2-, 6-, and 12-minute walk tests show acceptable inter- and intrarater reliability and high intertest correlations when they are used for the assessment of walking following stroke. The SRM statistic indicates that the 12-minute walk test is the most responsive to change.

Key words: cerebrovascular disorders, exercise, gait, outcomes assessment, rehabilitation, stroke, walking endurance, walking speed.

INTRODUCTION

Timed walk tests over 2-, 6-, and 12-minute intervals have been developed for use in evaluating patients with pulmonary disease [1–3]. The distance covered is used as a measure of cardiopulmonary and musculoskeletal adaptation to pulmonary impairment. Improvement in distance walked within the test interval is attributed to improvement in cardiac output, in mechanics of ventilation, or in muscular conditioning. The simplicity of these timed walk tests has led to their use in the assessment of patients with functional disability due to neurologic disorders [4–8]. Two studies have examined the effects of different neurologic impairments due to stroke on the 6-minute walk test [5,7]. Another has compared the change in 2- and 6-minute walk test scores to change in Functional Independence Measure (FIM) walking subscores during inpatient rehabilitation following stroke [6]. We have not found a published comparison of test reliability and sensitivity to change for all three versions of the timed walk test for patients with gait impairment due to stroke.

Walking speed following stroke has been standardized most commonly for the assessment of the time required to walk 10 meters [9–14]. Alternative test protocols have used 5- or 8-meter distances [7–8]. The major disadvantage of such scales is that they do not provide a continuous-scale assessment of gait recovery following stroke. Early during the rehabilitation phase, patients may not be able to walk 5 to 10 meters, and are therefore not testable. This “floor effect” is not seen with the 2-, 6-, and 12-minute walk tests.

Abbreviations: FIM = Functional Independence Measure, ICC = intraclass correlation coefficient, SD = standard deviation, SRM = standardized response mean.

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As patients improve, walking speed over 5 to 10 meters becomes a less credible measure of walking speed over more functionally relevant distances outside the home. The 2-, 6-, and 12-minute walk tests score distance as a continuous variable without floor or ceiling effects. Scores range from 0 meters for patients who are nonambulatory to the maximum biological limits for normal healthy controls. Walking speed is immediately derivable from the distance covered divided by the 2-, 6-, or 12-minute test interval used.

Standardization of the 2-, 6-, and 12-minute walk tests for patients with pulmonary disease allows for the patient to stop and rest as many times and for as long as needed during the test interval [15]. Rest periods are also considered appropriate during the assessment of gait following stroke. The 2-minute assessment, less encumbered by fatigue, could be considered a valid measure of self-selected walking speed [6]. The 6- and 12-minute walk tests, which may induce significant fatigue and need for rest stops, may be considered better measures of endurance than of speed [6]. The 2-, 6-, and 12-minute walk tests give a structured framework during which walking speed and endurance can be measured and the patient's progress followed over time.

Because of the simplicity and apparent utility of the 2-, 6-, and 12-minute walk tests, we sought to determine their interrater variability, intrarater variability, and responsiveness to change following stroke.

METHODS

Patients enrolled in an inpatient stroke rehabilitation program were asked to participate in the standardization protocol. The 2-, 6-, and 12-minute walk tests were performed as described by the American Association of Cardiovascular and Pulmonary Rehabilitation in its "Guidelines for pulmonary rehabilitation" [15], with the exception that Oxymetry, the Borg Dyspnea Scale, and vital signs were not monitored. Patients were asked to walk at what they considered to be their comfortable walking speed. Any brace, cane, or walker that had been previously shown to improve gait quality or safety was used. Therapist assistance was provided for balance, weight-shift, and leg advancement as needed. Timing was initiated once the patient was standing and ready to begin walking. The walking course was a 122-meter rectangular hallway around the periphery of the inpatient nursing unit. Distance was measured with a linear scale marked on the floor moldings. The walking tests were initiated at random points around the circuit from one day to the next so that distance cues from the walk test assessments would be masked. Patients were advised that they could rest, by sitting or standing, at any point during the course. Therapists attempted to base rest breaks on patient requests only. With patients requiring greater physical assistance, the therapist could request a short break if patients felt they could not continue without one. The 2-, 6-, and 12-minute walk tests were timed concurrently during a single 12-minute period. A physical therapy aide measured and recorded all times to keep the therapist blinded to distance cues, and to prevent interruption of the timed walk tests. The patient's primary therapist ambulated with the patient on day 1, day 3, and weekly thereafter. A second therapist ambulated with the patient on day 2 to allow for assessment of interrater reliability. Repeat exams each week allowed assessment of sensitivity to change.

Demographic, neuroimaging, neurologic examination, and FIM [16] scores were available for all patients as part of their computerized inpatient stroke rehabilitation admission record. The computerized stroke database was recorded by stroke team members unaware of this standardization protocol. Motor impairment was said to be present if the lower-limb Motricity Index score was 80 or less [17]. This standardized muscle strength score ranges from 1 (maximal deficit) to 100 (normal). Hemihypesthesia was said to be present based on the Limb Localization Test [18]. This test was scored as abnormal if the patients had a 6-inch or greater error in localizing their affected index finger as it was displaced randomly into all four spatial quadrants. Hemianopic visual field deficits were assessed based on confrontation visual field testing. Using these neurologic impairments, we classified patients as having pure motor impairment (M), motor plus sensory or motor plus visual impairments (MS/MV), or all three impairments (MSV).

We assessed interrater and intrarater variability using intraclass correlation coefficients (ICCs). Tests of the strength of association between other linear variables were assessed with Pearson correlations. Responsiveness of scores to change over time was assessed with the standardized response mean (SRM) defined as the mean change in scores divided by the standard deviation (SD) of the change in scores [8]. Statistical inferences were said to be significant if the two-tailed probability statistic was less than or equal to 0.05. All variances are listed as SDs. All statistical analyses were computed with SPSS version 10.0 for Windows (SPSS, Inc., Chicago, IL).

RESULTS

Eighteen patients (12 female, 6 male), with a mean age of 77 ± 11 years were assessed a mean of 28 ± 34 days following stroke. Eight patients had right hemispheric strokes, five had left, and five had involvement of other brainstem or cerebellar regions. Ten patients had pure motor strokes and eight had motor plus sensory or hemianopic visual impairments. The mean FIM total score was 68 ± 17 at the time of rehabilitation hospital admission. The mean admission FIM walking subscore was 3 ± 1.

Interrater ICCs for the 2-, 6-, and 12-minute walk tests were, respectively, 0.85, 0.78, and 0.68 ($p < 0.0007$ for each). The intrarater ICCs were 0.85, 0.74, and 0.71 ($p < 0.0003$ for each). Pearson correlations for the 2-, 6-, and 12-minute walk tests by the same rater on the same day were 2 versus 6 minutes, $r = 0.997$; 2 versus 12 minutes, $r = 0.993$; and 6 versus 12 minutes, $r = 0.994$ ($p < 0.0001$ for each).

Change in scores for the 2-, 6-, and 12-minute walk tests showed a 1.8-, 2.4-, and 2.9-fold increase for each test, respectively, over a mean of 3.9 ± 2 weeks of observation. The **Figure** shows the mean distance walked in meters for the 2-, 6-, and 12-minute walk tests over the course of observation. To allow for comparison of patients who had variable lengths of stay, we carried forward the last available weekly score for each patient to the fourth week of observation. Responsiveness to change for the 2-, 6-, and 12-minute timed walk tests as assessed with SRM scores was, respectively, 1.34, 1.52, and 1.90. A one-way analysis of variance with change in score as the dependent variable and timed walk test interval as the independent variable with Bonferoni correction for multiple comparisons showed $F = 24.24$, $p < 0.001$.

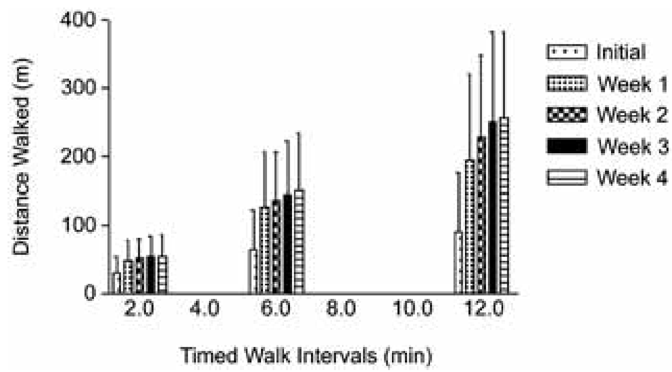

Figure.
Mean distance walked ± standard deviation in meters during 2-, 6-, and 12-minute walk tests initially and at weekly intervals thereafter. For comparison of patients who had variable lengths of stay, we carried forward last available weekly score for each patient to fourth week of observation.

DISCUSSION

Our results support the use of the 2-, 6-, and 12-minute walk tests for the assessment of walking distance following stroke. These tests are limited, however, by their inability to assess other important aspects of gait such as quality of movement, balance, use of assist devices, and amount of physical assistance needed.

The 2-minute walk test is the most time efficient of the three test durations. It is probably best for documenting the patient's self-selected walking speed, because it minimizes fatigue effects. The distance walked in 2 minutes also correlates well with the longer 6- and 12-minute walk distances. All Pearson correlations are >0.993. While highly correlated, the 6- and 12-minute walk distances are significantly overestimated based on the 2-minute assessment. This overestimation is probably due to fatigue, which was not specifically measured in this study. Others have also noted that gait speed measured over short distances (8 and 10 meters) overestimates actual 6-minute walking distance.

The 12-minute walk test showed the best sensitivity to change over the course of the inpatient rehabilitation hospital stay. There was a 2.9-fold increase in the 12-minute walk distance compared to 2.4-fold and 1.8-fold increases for the 6- and 2-minute walk distances, respectively. The SRM statistic (1.90), used to compare responsiveness to change over time, also indicates that the 12-minute walk test is the most sensitive to change. This is not merely an artifact of higher scale scores, because the scores are corrected for their variance.

FIM walking scores showed a 1.7-fold increase over the course of the inpatient rehabilitation hospital stay compared to 2.4-fold and 2.9-fold increases in the 6- and 12-minute walk test scores, respectively. This indicates that serial 6- and 12-minute walk tests are more sensitive to change and more useful in gait outcome documentation than FIM walking subscores.

Variability in test scores was minimized by test standardization, which specified that patients be tested after adapting to the standing position, that they be encouraged to self-select their comfortable walking speed, that they be given the chance to take either standing or seated rests during the test interval, and that the test course be as straight and unencumbered by turns as possible. The 122-meter rectangular course used in this study required only 90° turns. Effects of the dimensions and physical layout of the walking course are minimized within an institution by use of the same course for initial and follow-up assessments.

One might object to our research design, which assessed walking distance over 2, 6, and 12 minutes concurrently. This may have artificially enhanced intertest correlations. Patient motivation might also have been adversely affected, since the patient's "self-selected comfortable walking speed" may have differed if asked to walk for 2 minutes versus 12 minutes. These research design constraints were necessary for performance of this study as part of the patient's daily inpatient stroke rehabilitation program. Our correlation coefficients between 6- and 12-minute walking distances do not differ significantly from those reported by Eng et al., who performed each test on a separate day [7]. Others have also noted that "comfortable walking speed" measured over 10 meters overestimates 6-minute walking distance. Dean et al. attributed this overestimation to a reduction in walking speed due to fatigue over the 6-minute test interval [14]. This finding suggests that the 6- and 12-minute walking distances at "comfortable walking speed" are more constrained by fatigue than by initial motivation.

CONCLUSIONS

The 2-, 6-, and 12-minute walk tests show acceptable inter- and intrarater reliability and high intertest correlations when used for the assessment of walking following stroke. The SRM statistic indicates that the 12-minute walk test is the most responsive to change.

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REFERENCES

1. McGavin C, Gupta S, McHardy G. Twelve minute walking test for assessing disability in chronic bronchitis. Br Med J. 1976;1(6013):822–23.
2. Butland R, Pang J, Gross E, Woodcock A, Geddes D. Two, six, and 12 minute walking tests in respiratory disease. Br Med J. 1982;284:1607–8.
3. Guyatt G, Pugsley S, Sullivan M, Thompson P, Berman L, Jones N, Fallen E, Taylor D. Effect of encouragement on walking test performance. Thorax. 1984;39:818–22.
4. Koseoglu F, Inan L, Ozel S, Deviren SD, Karabiyikoglu G, Yorgancioglu R, Atasoy T, Ozturk A. The effects of a pulmonary rehabilitation program on pulmonary function tests and exercise tolerance in patients with Parkinson's disease. Funct Neurol. 1997;12:319–25.
5. Poh P, Duncan P, Perera S, Liu W, Lai S, Studenski S, Long J. The influence of stroke-related impairments on performance in the six-minute walk test. J Rehabil Res Dev. 2002;39:439–44.
6. Kosak M, Smith T. Comparison of the 2, 6, and 12 minute walking tests in patients with stroke [abstract]. J Stroke Cerebrovasc Dis. 2000;9:201.
7. Eng J, Chu K, Dawson A, Kim C, Hepburn K. Functional walk tests in individuals with stroke: relation to perceived exertion and myocardial exertion. Stroke. 2002;33:756–61.
8. Salbach N, Mayo N, Higgins J, Ahmed S, Finch L, Richards C. Responsiveness and predictability of gait speed and other disability measures in acute stroke. Arch Phys Med Rehabil. 2001;82:1204–12.
9. Holden M, Gill K, Magliozzi M, Nathan J, Piehl-Baker L. Clinical gait assessment in the neurologically impaired: validity and meaningfulness. Phys Ther. 1984;64:35–40.
10. Evans M, Goldie P, Hill K. Systematic and random error in repeated measurements of temporal and distance parameters of gait after stroke. Arch Phys Med Rehabil. 1997; 78:725–29.
11. VanHerk I, Arendzen J, Rispens P. Ten-metre walk, with or without a turn. Clin Rehabil. 1998;12:30–35.
12. Stephens J, Goldie P. Walking speed on parquetry and carpet after stroke: effect of surface and retest reliability. Clin Rehabil. 1999;13:171–81.
13. Suzuki K, Imada G, Iwaya T, Handa T, Kurogo H. Determinants and predictors of the maximum walking speed during computer-assisted gait training in hemiparetic stroke patients. Arch Phys Med Rehabil. 1999;80:179–82.
14. Dean C, Richards C, Malouin F. Walking speed over 10 metres overestimates locomotor capacity after stroke. Clin Rehabil. 2001;15:415–21.
15. American Association of Cardiovascular and Pulmonary Rehabilitation. Guidelines for pulmonary rehabilitation

programs, 2nd ed. Champaign (IL): Human Kinetics Publishing; 1998. p. 57–59.
16. Guide for the uniform data set for medical rehabilitation (Adult FIMTM), version 4.0. Buffalo (NY): State University of New York at Buffalo; 1993.
17. Demeurisse G, Demol O, Robaye E. Motor evaluation in vascular hemiplegia. Eur Neurol. 1980;19:328–29.
18. Yarnell P, Boutell-Friedman B. Left "hemi" ADL learning and outcome: limiting factors. J Neurol Rehabil. 1987; 1:125–30.

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