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Influence of stroke-related impairments on performance in 6-minute walk test

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Abstract—The 6-minute walk test is a clinical measure of endurance, but it is not known if it is useful for individuals with mobility impairments secondary to stroke. Purposes of this study were to assess which stroke-related physical impairments influence performance in the 6-minute walk test and to evaluate if this test provides a measure of functional walking endurance after stroke. Seventy-two adults poststroke completed the 6-minute walk as part of baseline testing for a randomized intervention clinical trial. Pulse and blood pressure were taken before and after the walk. Subjects walked an average of 216 m in 6 minutes. The Fugl-Meyer lower-limb motor score and the Berg Balance score explained 45 percent of the variance in distance walked. Pulse and systolic blood pressure increased significantly with the 6-minute walk. Neuromuscular impairments poststroke contribute to diminished performance in the 6-minute walk test. Pulse and blood pressure pre- and posttesting can indicate cardiovascular stress.

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INTRODUCTION

Walking is a common goal after stroke, and many stroke survivors attain some ability to walk in the months after onset [1]. Walking ability, however, is markedly compromised. The vast majority of stroke survivors who regain walking ability in the months following stroke fail to achieve the normal walking speed of 1.2 m/s, the speed demonstrated by healthy elderly adults [2–7]. Decreased endurance also contributes to compromised functional walking after stroke [6]. It has been demonstrated that stroke survivors are not physically fit, and this affects their functional abilities [8]. If interventions for those poststroke are to include endurance training, a clinical measure of fitness is necessary. Recently, it has been suggested that the 6-minute walk test be used as a clinical measure of cardiovascular endurance for adults with stroke [2,5].

The 6-minute walk test requires a subject to walk as far as he or she can in 6 minutes, with rests as needed. This test is particularly appealing for clinicians, because it is relatively quick and easy to implement and can be completed by many patients. A suggestion has been made that the 6-minute walk test is a measure of conditioning and that performance is hampered by the presence of cardiac, respiratory, or peripheral circulation pathology [9–21].

The 6-minute walk test recently has been used to assess endurance in community-dwelling adults [22]. Basic individual demographics are important factors in predicting how far a healthy adult can walk in 6 minutes. Gender-specific reference equations that include the factors of age, weight, and height predict 42 percent of the variance in the distance walked in 6 minutes for men and 38 percent for women [23]. These equations were not designed to account for mobility deficits related to pathology. To our knowledge, only one report has been published on the use of the 6-minute walk test for adults with central nervous system damage. The report evaluated the effects of a pulmonary rehabilitation program in adults with Parkinson's disease [24]. Stroke survivors are often left with physical impairments that limit functional abilities. One can reasonably suggest that, for those individuals with stroke, performance in the 6-minute walk test may be limited by stroke-related physical impairments, as well as cardiovascular endurance.

The purpose of the present study was to assess which stroke-related physical impairments influence functional walking endurance as measured by the 6-minute walk test. We hypothesized that measures of lower-limb motor function, lower-limb sensory function, and balance would be powerful modifiers in predicting 6-minute walk distance. A second purpose of this study was to evaluate if, in the presence of existing mobility impairments, the 6-minute walk test did stress the cardiovascular system.

METHOD

Study Design

Data in this study are a subset of baseline data from a randomized clinical trial of a therapist-supervised 12-week therapeutic exercise program delivered in the home. The larger parent study is designed to determine if an exercise program, focused on upper- and lower-limb strength, balance, endurance, and upper-limb use, can improve key impairments and functional performance in individuals poststroke.

Subjects

The 72 stroke survivors in the present sample were participants in the parent study. Subjects for the parent study were recruited from the Kansas City Stroke Registry, an ongoing registry of adults who are recruited within the first 28 days after their stroke (principal investigator, S. Lai, PhD). We used the Orpington Prognostic score to assess stroke severity at the time of entry into the registry [25]. The Orpington Prognostic score is a reliable and valid screening assessment that evaluates the motor function of the arm, upper-limb proprioception, balance, and cognition [25,26]. Scores can range from a 1.6 to a 6.8, with less than 3.2 considered a mild stroke, 3.2 to 5.2 a moderate stroke, and greater than 5.2 a severe stroke. To be included in the registry, subjects had to be older than 50 years of age, reside within 60 miles of an inpatient hospital in the greater Kansas City area, and have suffered an ischemic or hemorrhagic stroke.

To enter the clinical trial, subjects were required to have been independent in basic activities of daily living before their stroke, to be free of poststroke complications, and to be able to walk for 25 ft without supervision, with or without an assistive device. We excluded subjects from the clinical trial if they had a comorbid condition that would have prevented their participation in a home-based intervention that included strengthening, balance, and endurance training. Specific exclusionary conditions included—

- Cardiac surgery or a myocardial infarction within the last 3 months.
- A diagnosis of severe aortic stenosis or hypertrophic cardiomyopathy.
- A pulmonary embolus or infarction in the last 6 months.
- Parkinson's disease.
- Amyotrophic lateral sclerosis.
- Multiple sclerosis.
- Hospitalization in the last 6 months for a psychiatric illness.
- Use of oxygen at home for 24 hours/day.

An Orpington score of less than 5.2 and a Fugl-Meyer score between 27 and 90 were required [27]. The Fugl-Meyer Assessment is a scale of recovery after stroke, which includes items of upper- and lower-limb sensation and motor control [27]. The maximum score for the Fugl-Meyer is 124, and it has been shown to be valid and reliable [27,28].

A Mini-Mental Status Examination score of 16 or greater out of a possible 30 was required as part of the parent study to accept self-reported data [29]. We included subjects if any of the following applied:

- A medical condition that would interfere with outcomes assessments or limit participation in a submaximal endurance exercise program.

- Major receptive aphasia and/or inability to follow a two-step command.
- Life expectancy less than 1 year.
- Coma.
- Obtunded.
- Poorly controlled diabetes.
- Amputation.
- Legal blindness.
- Diagnosis of a progressive neurological disease.
- Current participation in inpatient rehabilitation.

Procedure

Before testing, each subject provided oral and written informed consent. After passing a bicycle ergometry stress test, subjects returned to the medical center within a week to complete a battery of laboratory and clinical performance testing and questionnaires for baseline assessment. Total testing time was 4 to 6 hours, with a lunch break.

The first test given in the day was a 10-m walk test consisting of two successive 10-m walks without a rest in between. We took resting pulses and blood pressures before the 10-m walk test. A short rest was provided after the completion of the 10-m walk test, and then subjects completed the 6-minute walk test. The 6-minute walk test was completed in a 100 ft-long testing corridor. Subjects wore their own shoes except when their shoes had a heel-height greater than 0.5 in.; in which case, they were provided with canvas tennis shoes. We instructed subjects to walk with any assistive device or orthotic they would use to walk for 6 minutes.

From a standing start, subjects were instructed to walk continuously for 6 minutes, at the fastest pace they felt they could maintain for the duration of the test. They were told that their goal was to cover as much ground as possible in 6 minutes so that at the end of the test, they would feel that they could go no further. At each minute, standardized verbal encouragement was given, and subjects were told how much time had elapsed or was left to complete the test (e.g., "You are doing a good job and have a minute left to go."). Subjects were allowed to stop and stand or sit in a chair if they expressed a desire to rest, and they were instructed to begin again when they felt able. At the end of the 6 minutes, we took their heart rate and blood pressure and recorded the distance walked.

We assessed sensory-motor impairments with the Fugl-Meyer Assessment [27]. The lower-limb sensory score and motor score were incorporated into the present study as measures of lower-limb sensory-motor impairment. We assessed balance with the Berg Balance Test, a functional measure of balance that includes items ranging from sitting without back support to standing on one leg [30]. The validity and reliability of the Berg Balance Test has been established [30,31].

Data Analysis

To evaluate our assumption that the equation for healthy adults was not appropriate for use with stroke survivors, we fit a regression using the published equation for males and females with age, height, and weight included as predictors to determine the amount of variance accounted for in our sample by these variables [23]. To test our first hypothesis, we fit a stepwise regression model with the lower-limb Fugl-Meyer motor score, lower-limb Fugl-Meyer sensory score, and Berg Balance score as predictors to determine the most predictive clinical variables, explaining the distance walked in the 6-minute test. To test our second hypothesis, we used paired t-tests to compare pre- and posttest pulse and systolic and diastolic blood pressure. Data from subjects who were on beta-blockers or had rate-limiting pacemakers were not included in the analyses of changes in pulse and blood pressure.

RESULTS

Subjects had a mean age of 72.1 ± 10.2 years, and 40 of the 72 subjects were male. The mean time since stroke for all subjects was 73.3 ± 26.8 days. Twenty-four subjects had a mild stroke, forty-six had a moderate stroke, and one a severe stroke. The side of the brain damage was the right for 35 subjects and the left for 29 subjects. Of the remaining seven subjects, two had a bilateral stroke and five had a brain stem stroke. Out of a possible 34, subjects had a mean ± standard deviation lower-limb Fugl-Meyer motor score of 24.0 ± 3.8. Out of a possible 12, subjects had a sensory score of 10.9 ± 1.5, and out of a possible 56, they had a Berg Balance score of 42.1 ± 8.4. Most subjects (n = 54) used an assistive device for ambulation and 11 subjects used an ankle-foot orthosis.

The average distance walked was 215.8 ± 91.6 m. The regression analyses for males and females using age, height, and weight revealed that none of these factors was a significant predictor of the distance walked in the 6-minute walk test. The combination of all of these factors explained only 7 percent of the variance in distance walked.

In a stepwise regression analysis with lower-limb Fugl-Meyer motor and sensory scores and Berg Balance score, only the lower-limb Fugl-Meyer motor score and the Berg Balance score were significant predictors of the distance walked ($p < 0.0001$). Together, these factors explained 45 percent of the variance in distance walked (see **Table**).

After we removed data from 26 subjects who were taking beta-blockers or had rate-limiting pacemakers, paired t-tests of pre- and posttest pulse and blood pressure data revealed that pulse and systolic blood pressure significantly increased from pre- to posttest (p's < 0.0001). Pulse and systolic blood pressure increased from 75.5 ± 11.2 beats/minute to 92.3 ± 15.7 beats/minute and 143.5 ± 19.4 mm/Hg to 150.1 ± 19.7 mm/Hg, respectively. In contrast, diastolic blood pressure did not change from 76.2 ± 10.7 mm/Hg before the walk to 77.1 ± 10.5 mm/Hg after the walk.

Table.
Results of regression.

$R^2 = 0.45$	Regular Coefficient	Standard Error	p Value
Intercept	–579.82	188.40	0.0030
Lower-Limb Motor Score	19.40	7.43	0.0110
Berg Balance Score	19.52	3.39	<0.0001

DISCUSSION

The results of this study demonstrate that performance in the 6-minute walk test for stroke survivors is influenced by the motor impairment of the affected lower limb and balance. Not surprisingly, the demographic data that can be used to predict the distance healthy adults can walk in 6 minutes cannot predict the distance achieved by adults with stroke. Further, the changes in pulse and systolic blood pressure suggest that the 6-minute walk test does provide a clinical measure of fitness for adults with stroke.

The need for cardiovascular endurance training as part of the rehabilitation program for adults poststroke has received increasing attention [5]. Endurance training, however, may need to progress concomitant with, and not in exclusion of, motor control and balance training. The limitations in the 6-minute walk test for adults with stroke do not purely reflect poor cardiovascular fitness. The results of the present study suggest that stroke-related motor and balance impairments restrict their abilities in endurance activities. This finding is congruent with those of Potempa and colleagues who found that even when individuals with stroke improved in stress test performance after intervention, improvement was related more to improvements in neuromuscular function than aerobic capacity [8].

The estimates of the coefficients were stable as lower-limb motor, sensory, and balance scores were added to the regression model as independent variables, indicating little or no multicollinearity. The correlations between lower-limb motor and sensory scores, between lower-limb motor and balance scores, and between sensory and balance scores were only 0.02, 0.34, and 0.29, respectively.

Only 14 percent of our subjects had a Fugl-Meyer sensory score less than 10 out of a possible 12. Possibly, a more severe lower-limb sensory deficit may contribute to decreased performance in the 6-minute walk test. The Fugl-Meyer sensory test is also a gross assessment of sensation; a more comprehensive measure of lower-limb sensation may be necessary to evaluate the impact of lower-limb sensory deficits on walking distance.

Even with stroke-related neuromuscular impairments, most adults with mild or moderate stroke with some ambulatory capability can complete the 6-minute walk test. Although some subjects took momentary pauses during ambulation, all of our subjects completed the test and none took a seated rest. Further, the 6-minute walk test does provide insight into the endurance of adults with stroke. Pulse rate and systolic blood pressure did increase from pre- to posttest, suggesting that subjects experienced some cardiovascular stress. Clearly, the 6-minute walk test did not provide a maximal fitness test; on average, subjects reached only 63 percent of their predicted maximum heart rates (i.e., 220 – age) at the end of the test. Unfortunately, we do not have data on changes in blood pressure and pulse with the 6-minute walk for control subjects; a comparison with changes from those with stroke would provide greater insight into the level of fitness of the stroke survivors.

Poor cardiovascular endurance after stroke is well documented [32–35]. Although each of the subjects in the present study passed a bicycle ergometry cardiovascular stress test before inclusion in the clinical trial, fitness levels were predictably low. Cardiovascular stress tests to assess endurance have been incorporated into study designs in research with adults with stroke [2,8,36–40]. Adaptations have been made in standard bicycle ergometry [2,8,37,40] and treadmill protocols [38,39] to accommodate for the physical impairments of those with stroke. Cardiovascular stress tests are not, however, feasible for all clinical practices. Adding simple physiological measures, such as pulse and blood pressure, to 6-minute walk testing can provide the clinician with a measure of endurance. In addition, we strongly advocate the use of pulse and blood pressure before testing for safety reasons.

The results of the present study cannot be generalized to all individuals with stroke. Subjects in this study met numerous criteria for study inclusion and passed a cardiovascular bicycle ergometry stress test. In some sense, the results of this study present the best-case scenario; the general stroke population may be less fit and more impaired than the stroke population from which our study sample was obtained. Further, our subjects were at least 3 weeks post-onset but not greater than 5 months. Applying the results of this study to adults with acute or chronic stroke should be done with care. The protocol for the 6-minute walk has not been standardized across studies. For example, in the present study, subjects performed the 6-minute walk test only once; some have reported that practice trials are needed [41].

CONCLUSION

In conclusion, stroke-related impairments are powerful modifiers of performance in the 6-minute walk test. Motor deficits of the lower limb and decreased balance contribute to the distance an adult with stroke can walk in 6 minutes. Monitoring pulse and blood pressure before and after the walk can be helpful to assess the effectiveness and the safety of the 6-minute walk in evaluating functional walking endurance for individual patients poststroke.

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