ORIGINAL ARTICLE

The Effect of Environment and Task on Gait Parameters After Stroke: A Randomized Comparison of Measurement Conditions

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ABSTRACT. Lord SE, Rochester L, Weatherall M, McPherson KM, McNaughton HK. The effect of environment and task on gait parameters after stroke: a randomized comparison of measurement conditions. Arch Phys Med Rehabil 2006;87: 967-73.

Objectives: To assess the effect of environment and a secondary task on gait parameters in community ambulant stroke survivors and to assess the contribution of clinical symptoms to gait performance.

Design: A 2×3 randomized factorial design with 2 main factors: task (no task, motor task, cognitive task) and environment (clinic, suburban street, shopping mall).

Setting: Subjects were assessed in 1 of 3 settings: 2 in the community (a suburban street and shopping mall) and 1 clinical environment.

Participants: Twenty-seven people with stroke (mean age, 61±11.6y; mean time since stroke onset, 45.8±34.2mo), living at home, were recruited from community stroke groups and from a local rehabilitation unit. Selection criteria included the following: ability to give informed consent, unilateral first ever or recurrent stroke at least 6 months previously, walking independently in the community, a gait speed between 24 and 50m/min, Mini-Mental State Examination score of 24 or higher, and no severe comorbidity.

Interventions: Not applicable.

Main Outcome Measures: Gait speed (in m/min), cadence, and step length were assessed by using an accelerometer with adjustable thresholds. Clinical measures hypothesized to influence gait parameters in community environments were also assessed including fatigue, anxiety and depression, and attentional deficit.

Results: Twenty-seven people with a mean baseline gait speed of 42.2±5.9m/min were randomly allocated to 1 of 9 conditions in which the setting and distraction were manipulated. Analysis of variance showed a significant main effect for environment (P=.046) but not for task (P=.37). The interaction between task and environment was not significant (P=.73). Adjusting for baseline gait speed, people walked on average 8.8m/min faster in the clinic (95% confidence interval, 0.3−17.3m/min) than in the mall. Scores for fatigue, anxiety and depression, and attentional deficit were higher than normative values but did not influence gait performance.

Conclusions: This study suggests that people with chronic stroke cope well with the challenges of varied environments and can maintain their gait speed while performing a secondary task. Despite moderate levels of gait impairment, gait automaticity may be restored over time to a functional level.

Key Words: Cerebrovascular accident; Gait; Rehabilitation; Task performance and analysis.

REINTEGRATION INTO COMMUNITY life contributes to improved quality of life after stroke and attainment of community mobility is an important part of that process. However, full, independent community mobility is not always achievable and instead variable levels of community mobility are attained.[1-3] Stroke survivors have reported dissatisfaction with their ability to ambulate outdoors and to access their communities.[4]

The skills required to achieve community mobility include the ability to walk at a given speed for a minimum requisite distance.[5] The role of attention in gait has been the focus of recent research, with evidence that cortical input demands vary with the difficulty of the task, the environment in which it is performed, and the type of task being performed. By using a dual-task paradigm, decrements in performance have been observed for both healthy and balance-impaired older adults and for people with specific types of neurologic disorder.[6,7] For example, decrements in gait performance and postural control have been identified when participants have carried out a secondary task such as talking,[8,9] carrying a tray or tumbler,[10,11] stepping over virtual and real obstacles,[12,13] responding verbally to auditory tones,[14,15] and performing cognitive tasks.[16]

A number of studies have reported changes in gait performance in people with stroke during dual-task testing in a clinical environment. Bowen et al[17] noted a significant decrease in gait speed (4m/min) and a significant increase in double-support time when a cognitive activity was added to a walking test for 11 people with stroke. Haggard and Cockburn[18] reported a 7% decrement in stride duration and a simultaneous 4% decrement in cognitive task performance under dual-task conditions for 50 people undergoing neurologic rehabilitation that included 11 people with stroke. Gait decrement improved in 7 of 10 people with stroke who were reassessed 1 to 9 months later, and cognitive decrement improved in 3 people.[19] Changes in gait performance under motor and cognitive dual-task conditions may be explained by a loss of central capacity to perform more

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than 1 task simultaneously, which occurs either because gait is less automatic and more reliant on central cognitive processing and use of attentional resources,[18,20] or because cognitive acuity is diminished, both of which result in "cognitive-motor interference."[19] Research[21,22] suggests that people who have had a stroke experience attention deficits, even late after the stroke event, and the importance of sustained attention in particular to motor recovery and motor performance has been reported. However, the research to date has been conducted in laboratory or clinic and hospital settings, and the real-world relevance of the findings for community mobility can only be estimated. The changes in gait speed and stride duration noted previously do not exceed the bounds of measurement error for people with stroke,[23] and the findings to date do not necessarily reflect a meaningful decline in functional performance.

This study set out to investigate the effect of environment and a secondary task on gait parameters for people with stroke to gain a better understanding of the skills required for effective community mobility. We hypothesized that study participants would experience greater difficulty walking in unpredictable, community environments or when performing a secondary task compared with walking in predictable clinical environments without these obstructions.

METHODS

Participants

Twenty-seven people with chronic stroke were studied. Participants who met the following criteria were recruited: a first-ever or recurrent stroke (World Health Organization Monitoring Trends and Determinants in Cardiovascular Disease [MONICA] definition)[24] at least 6 months previously, home-dwelling, walking independently outdoors without the need for close supervision; baseline 10-m timed walks between 24 and 50m/min, Mini-Mental State Examination score of 24 or higher,[25] and no severe comorbidity. The rationale for a restriction in gait speed was based on earlier work that categorized levels of community mobility according to gait speed.[1] In addition, we wished to engage participants who would find the testing procedure challenging rather than select those whose gait speed approached referent values. The participants came from a convenience sample of people who were recruited through community stroke groups, from newspaper and local advertising, and from physical therapists at 1 regional hospital. All participants gave written consent to enter the study, which was approved by the relevant regional ethics committee. Figure 1 describes the flow of participants through the trial.

Study Design

The study was a randomized factorial design, with 2 factors, task and environment, each at 3 levels. The 3 levels of task were no task, cognitive task, and motor task, and the 3 levels of environment were clinic, suburban street, and shopping mall. Participants were randomized to 1 of the different combinations of the 3 levels of each main experimental factor, task and environment (see fig 1). A factorial design was chosen for this exploratory study because we wanted to investigate the interaction effect between environment and task, which is not possible with a repeated-measures design. For example, a secondary task may be achieved in a predictable environment but not in a more challenging environment Also, there may have been a learning effect associated with the planned secondary cognitive and motor tasks even with randomization of testing order.

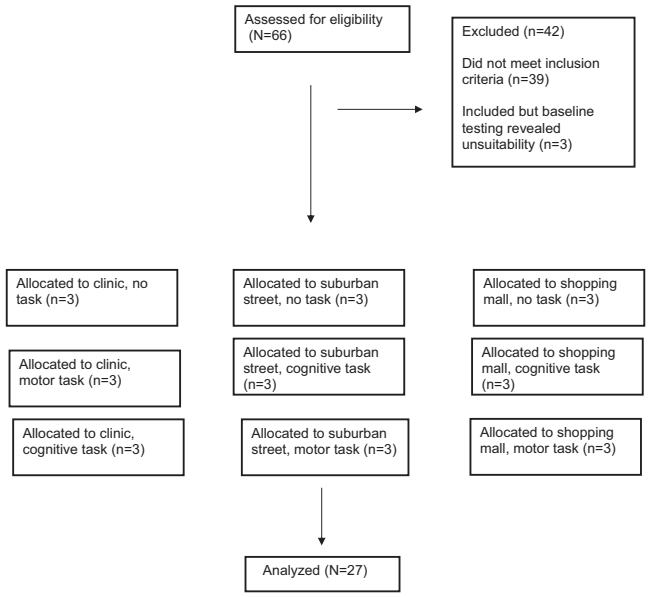

Fig 1. Flow of participants through the trial.

Experimental Protocol

Participants were screened in their homes and invited to participate in the study if they met the inclusion criteria. Baseline testing on standardized measures was performed in the clinic environment, and participants were randomly assigned to 1 of 9 testing conditions. Two researchers were required to implement the protocol. Each subject was then asked to perform a 6-minute walk test (6MWT) for the condition in which they were randomized. For both motor and cognitive tasks, the researcher used a stop watch to ensure accurate timing of tasks and also made a note of any inaccurate responses during the cognitive task. To measure distance walked during 6 minutes, the researcher walked several meters behind the participant wheeling an odometer (a measuring wheel). The researcher requested the participant to walk at his/her comfortable pace and to concentrate on both walking and the secondary task rather than focus on one. All tests were performed at a similar time of the day, between 10:00 AM and 3:00 PM.

Testing Conditions

For the single-task condition, participants were asked to walk at a comfortable walking pace for 6 minutes without talking in 1 of 3 selected environments: (1) the clinic environment was a quiet, wide hospital corridor, which necessitated a turn after approximately 150m; (2) the suburban street had a footpath with a slight camber on it, there was a small incline in the street and participants were asked to cross the street after walking on grass for 15m as well as negotiate a curb up and down; and (3) the shopping mall was a large, busy city mall with good ambient conditions, wide walkways, and moderate shopping crowds. The secondary tasks included the following. One was a motor task in which participants were asked to step over a wooden block that was placed approximately 2m in front of the participant on the anticipated route at 30-second intervals. The block measured 45cm long, 6.5cm high, and 6.5cm wide and had a nonstick cover wrapped around the central 30cm to ensure good contact with the ground. The second one was a cognitive task in which participants were asked to