Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2013;94:856-62

ORIGINAL ARTICLE

Locomotor Rehabilitation of Individuals With Chronic Stroke: Difference Between Responders and Nonresponders

Mark G. Bowden, PhD, PT,[a,b] Andrea L. Behrman, PhD, PT,[c] Richard R. Neptune, PhD,[d] Chris M. Gregory, PhD, PT,[a,b] Steven A. Kautz, PhD[a,b]

From [a]Ralph H. Johnson VA Medical Center, Charleston, SC; [b]Department of Health Science and Research and Division of Physical Therapy, Medical University of South Carolina, Charleston, SC; [c]Department of Physical Therapy, University of Florida, Gainesville, FL; and [d]Department of Mechanical Engineering, The University of Texas at Austin, Austin, TX.

Abstract

Objectives: To identify the clinical measures associated with improved walking speed after locomotor rehabilitation in individuals poststroke and how those who respond with clinically meaningful changes in walking speed differ from those with smaller speed increases.

Design: A single group pre-post intervention study. Participants were stratified on the basis of a walking speed change of greater than (responders) or less than (nonresponders) .16m/s. Paired sample *t* tests were run to assess changes in each group, and correlations were run between the change in each variable and change in walking speed.

Setting: Outpatient interdisciplinary rehabilitation research center.

Participants: Hemiparetic subjects (N=27) (17 left hemiparesis; 19 men; age: 58.74±12.97y; 22.70±16.38mo poststroke).

Intervention: A 12-week locomotor intervention incorporating training on a treadmill with body weight support and manual trainers accompanied by training overground walking.

Main Outcome Measures: Measures of motor control, balance, functional walking ability, and endurance were collected at pre- and postintervention assessments.

Results: Eighteen responders and 9 nonresponders differed by age (responders=63.6y, nonresponders=49.0y, $P=.001$) and the lower extremity Fugl-Meyer Assessment score (responders=24.7, nonresponders=19.9, $P=.003$). Responders demonstrated an average improvement of .27m/s in walking speed as well as significant gains in all variables except daily step activity and paretic step ratio. Conversely, nonresponders demonstrated statistically significant improvements only in walking speed and endurance. However, the walking speed increase of .10m/s was not clinically meaningful. Change in walking speed was negatively correlated with changes in motor control in the nonresponder group, implying that walking speed gains may have been accomplished via compensatory mechanisms.

Conclusions: This study is a step toward discerning the underlying factors contributing to improved walking performance.
Archives of Physical Medicine and Rehabilitation 2013;94:856-62

Cerebrovascular accident is the leading cause of long-term disability in the United States.[1] Approximately 795,000 cerebrovascular accidents occur each year in the United States, with 6.5 million current noninstitutionalized stroke survivors,[1] and this number is growing with increased survivorship due to improved interventions.[2] Only approximately 50% of the survivors regain independent ambulatory ability by the end of rehabilitation,[3] and 73% have some degree of long-term disability.[4] Returning to prior level of function, most importantly independent ambulation, is the top priority for individuals in the first year poststroke.[5] This desire from patients, as well as the fact that locomotor ability is an important factor in determining the level of disability,[6] has led to an increased focus on interventions to improve walking performance.

Many different types of locomotor rehabilitation for individuals poststroke have been examined recently: exercise therapy,[7] lower extremity strength training,[8,9] functional electrical stimulation,[10] treadmill walking,[11,12] and locomotor training with

Supported by VA Merit Review (grant no. B3983-R); VA Center of Excellence (grant no. F2182C) (Brain Rehabilitation Research Center); VA Career Development Award (Phase I): B7177; and K12 HD055929 National Institutes of Health – National Center for Medical and Rehabilitation Research (NICHD) and National Institute for Neurological Disorders & Stroke.

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit on the authors or on any organization with which the authors are associated.

0003-9993/13/$36 - see front matter © 2013 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2012.11.032

treadmill and body weight support (BWS).[13,14] A recent critical review,[15] however, demonstrated that the outcomes were very similar to each other with regard to increasing posttraining walking speed. Given that different rehabilitation approaches are targeted at different deficits prominent in the poststroke population, one might assume that different mechanisms of response for increasing gait speed are associated with each. However, while it appears that these interventions are fundamentally different, the results on improving walking speed are strikingly similar. To date, very little information is available describing those who respond well to a given intervention (eg, achieve a clinically meaningful change in walking speed) versus those who respond less well. The large majority of rehabilitation interventions measure only functional behavioral outcome measures, and it is impossible to discern the underlying factors contributing to performance or develop adequate models for determining who should receive what kind of therapy or combination of therapies.

Measurement of locomotor rehabilitation outcomes requires a broad-based evaluation examining the multiple contributors to functional recovery, particularly if the goal is to distinguish the targeted aspects of rehabilitation that are associated with statistically and clinically significant responses to interventions. This evaluation should not only include functional measures such as timed movement tasks, endurance, and balance testing but also measures that allow for an understanding of underlying coordination and walking-specific motor control. The concept of task-specific motor control is still emerging,[16] but many recognize the need to provide quantitative evidence to document baseline levels and alterations in motor control.[17] Measures of walking-specific motor control include paretic propulsion (PP, defined as the percentage of the total propulsion that is generated by the paretic leg)[18] and the paretic step ratio (PSR, defined as the percentage of the stride length accounted for by the paretic step length)[19] and have been used to document motor control responses to locomotor interventions.[20-22] We contend that in addition to functional measures, motor control measures will assist in elucidating the factors underlying patterns of response to a locomotor rehabilitation intervention.

Locomotor training (LT) is a rehabilitation intervention that includes stepping on a treadmill with BWS and therapist assistance as needed to generate appropriate stepping patterns. LT has generated much discussion and investigation in the past decade, including the recently completed Locomotor Experience Applied Post-stroke (LEAPS) randomized controlled trial.[23,24] In spite of these research efforts, little is understood regarding the difference between those individuals demonstrating clinically important improvements in walking speed and those who achieved minimal gains with LT. The purpose of this study was to demonstrate how those who respond with at least a minimally clinically important improvement in walking speed differ from those who do not. We hypothesized that individuals achieving clinically important changes in walking speed (ie, responders) would demonstrate significant increases in clinical gait, balance, and motor control and that changes in self-selected walking speed (SSWS) would be correlated with changes in these outcome measures. Furthermore, we hypothesize that responders will demonstrate significant improvements in measures of walking-specific motor control (PP and PSR), while those achieving minimal gains in walking speed (nonresponders) will do so without significant gains in motor control measures.

List of abbreviations:

ABC	**Activities-specific Balance Confidence Scale**
BBS	**Berg Balance Scale**
BWS	**body weight support**
DGI	**Dynamic Gait Index**
DSA	**daily step activity**
FCWS	**fastest comfortable walking speed**
FMA	**Fugl-Meyer Assessment**
FMA-S	**Fugl-Meyer Assessment−Synergy**
LEAPS	**Locomotor Experience Applied Post-stroke**
LT	**locomotor training**
MCID	**minimal clinically important difference**
MDC	**minimal detectable change**
PP	**paretic propulsion**
PSR	**paretic step ratio**
SSWS	**self-selected walking speed**
6MWT	**6-minute walk test**

Methods

Subjects

Twenty-seven individuals with hemiparesis (17 left hemiparesis; 19 men; age: 58.74±12.97y; 22.70±16.38mo poststroke) participated in a 12-week LT intervention. Inclusion criteria were stroke within the past 6 months to 5 years, residual hemiparesis in the lower extremity (Fugl-Meyer Assessment [FMA] lower extremity motor score of $<$34), ability to sit unsupported for 30 seconds, ability to walk at least 10 meters with maximum 1 person assist, self-selected 10-meter gait speed of $<$0.8m/s, and the ability to follow a 3-step command. All subjects passed an exercise tolerance test[25] to determine exercise safety prior to participation and provided written informed consent approved by the institutional review boards of the University of Florida and the Malcom Randall VA Medical Center.

Training intervention

Subjects participated in an LT program incorporating walking on a treadmill with BWS and manual trainers accompanied by training overground. The training program was developed concurrently with the recently completed LEAPS clinical trial, and it utilized a nearly identical protocol and clinical outcome measures.[23] The training of lab personnel and trainers was overseen by a LEAPS co-principal investigator (A.B.). The training sessions occurred 3 times a week for 12 weeks, mirroring the LEAPS protocol.[23] During each session, subjects participated in a total of 20 minutes of stepping on a treadmill with partial BWS.[26-28] Training began with a maximum of 40% BWS and progressed as tolerated to minimal BWS, while maintaining at least 5% BWS at all times. Step and postural training on the treadmill took place as close as possible to overground walking speeds that are normal for healthy age-matched controls (eg, 0.8−1.2m/s), with manual assistance provided by physical therapists at the hip and/or lower legs to approximate desired trunk, pelvis, and lower extremity kinematics and the spatiotemporal pattern of walking.[27]

Treadmill-based training was followed by 10 to 20 minutes of walking over ground to progress translation of newly trained skills to community environments. Overground walking trained dynamic balance and independence in walking, focusing on endurance, traversing various terrains, and negotiating obstacles.[23]