ORIGINAL ARTICLE

An Intensive Intervention for Improving Gait, Balance, and Mobility in Individuals With Chronic Incomplete Spinal Cord Injury: A Pilot Study of Activity Tolerance and Benefits

Stacy L. Fritz, PhD, MSPT, Angela M. Merlo-Rains, PhD, DPT, MS, Erin D. Rivers, DPT, Denise M. Peters, DPT, Ashley Goodman, PhD, ATC, LAT, CPed, Erin T. Watson, DPT, Brooke M. Carmichael, DPT, Bruce A. McClenaghan, PED, PT

An audio podcast accompanies this article.
Listen at www.archives-pmr.org.

ABSTRACT. Fritz SL, Merlo-Rains AM, Rivers ED, Peters DM, Goodman A, Watson ET, Carmichael BM, McClenaghan BA. An intensive intervention for improving gait, balance, and mobility in individuals with chronic incomplete spinal cord injury: a pilot study of activity tolerance and benefits. Arch Phys Med Rehabil 2011;92:1776-84.

Objective: To determine the tolerance to and benefits of an intensive mobility training (IMT) approach for individuals with incomplete spinal cord injury (ISCI).

Design: Prospective pretest-posttest study with 6-month follow-up.

Setting: University research laboratory.

Participants: A volunteer sample of individuals with ISCI (N=15; >6mo postinjury and able to walk at least 3.05m with or without assistance). Follow-up data were collected for 10 of the participants.

Interventions: Participants received IMT for 3h/d for 10 weekdays, participating in activities that encouraged repetitive, task-specific training of their lower extremities in a massed practice schedule.

Main Outcome Measures: Amount of time spent in therapeutic activities and rest was used to assess participants' tolerance to the intervention. Treatment outcomes were assessed pretest, posttest, and 6 months after the intervention and included the Berg Balance Scale (BBS), Dynamic Gait Index (DGI), 6-minute walk test, gait speed, and Spinal Cord Injury Functional Ambulation Inventory.

Results: Individuals in the higher functioning ISCI group (BBS score ≥45 and gait speed ≥0.6m/s) spent more time in the intensive therapy on average than individuals in the lower functioning ISCI group. Effect sizes were comparable for changes in balance and mobility assessments between the lower and higher functioning groups, with the largest effect sizes observed for the DGI.

Conclusions: This dosage of IMT may be a more appropriate treatment approach for higher functioning ISCI individuals, as they were better able to tolerate the length of the session and demonstrated higher effect sizes postintervention.

Key Words: Gait; Mobility limitation; Postural balance; Rehabilitation; Spinal cord injuries.

IN THE UNITED STATES, there are approximately 262,000 individuals living with a spinal cord injury (SCI).[1] Of these, about 60% have an incomplete SCI (ISCI), and approximately 75% of patients with ISCI regain some type of ambulatory function.[2] Many of these individuals, however, tend to develop slow, inefficient, unbalanced, or uncoordinated gait patterns to compensate for impairments from the injury,[3-5] decreasing their ability to functionally ambulate.[6]

In the past, treating patients with SCI has often consisted of teaching compensatory strategies through modification of the environment or task because it was thought that the central nervous system was hardwired and nonmalleable.[4,7] Research now suggests that the central nervous system has the capability of activity-dependent plasticity.[4,7-9] This neuroplasticity capability, paired with theories supporting task-specific and intense practice, has led to the development of an intervention named intensive mobility training (IMT).

IMT is a treatment paradigm that merges body weight–supported treadmill training (BWSTT) and massed/intensive delivery of therapy similar to that of constraint-induced movement therapy (CIMT)[10] into one cohesive rehabilitative ap-

From the Department of Exercise Science, Physical Therapy Program, University of South Carolina, Columbia, SC (Fritz, Merlo-Rains, Rivers, Peters, Goodman, Watson, Carmichael, McClenaghan); and Department of Health, Leisure, and Exercise Science, Athletic Training Education Program, Appalachian State University, Boone, NC (Goodman).

Presented in part to the American Physical Therapy Association, February 11, 2010, San Diego, CA; February 11, 2009, Las Vegas, NV; February 8, 2008, Nashville, TN; and June 12, 2008, San Antonio, TX.

Supported by the South Carolina Spinal Cord Injury Research Fund (SCIRF 105).

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.

Reprint requests to Stacy L. Fritz, PhD, MSPT, Dept of Exercise Science, Physical Therapy Program, University of South Carolina, 921 Assembly St, 3rd Floor PHRC, Columbia, SC 29208, e-mail: *sfritz@mailbox.sc.edu.*

0003-9993/11/9211-01107$36.00/0
doi:10.1016/j.apmr.2011.05.006

List of Abbreviations

ASIA	American Spinal Injury Association
BBS	Berg Balance Scale
BWSTT	body weight–supported treadmill training
CIMT	constraint-induced movement therapy
DGI	Dynamic Gait Index
IMT	intensive mobility training
ISCI	incomplete spinal cord injury
LE	lower extremity
MDC	minimal detectable change
SCI	spinal cord injury
SCI-FAI	Spinal Cord Injury Functional Ambulation Inventory
6MWT	6-minute walk test

proach. IMT capitalizes on neuroplasticity by providing repetitive task-specific training delivered in a massed practice schedule, which is thought to stimulate specific neural pathways to reorganize and increase motor output.[9,11,12] BWSTT allows for the repetitive practice of walking/stepping in a controlled environment in which the individual's weight is partially unloaded and sensory input is provided that facilitates normal walking parameters.[3] Research has shown improvements in functional walking ability in both acute and chronic ISCI populations after locomotor training with BWSTT.[13-15] However, a Cochrane review[16] and a randomized control trial of locomotor training[17] stated that there is insufficient evidence to determine whether BWSTT is superior to other interventions to improve walking in a heterogeneous sample of individuals with SCI.

The intensive practice of CIMT distinguishes it from traditional therapeutic protocols, and this type of repetitive training has proved successful in the stroke population.[18-20] Recent studies[21-24] examining the application of CIMT concepts of massed practice to the lower extremity (LE) suggest that LE CIMT may be an efficacious method to improve balance and mobility in individuals with chronic stroke, and other studies[25,26] have investigated massed/intensive practice for individuals with ISCI. Overall, to provide a more complete therapeutic approach to mobility, the principles of intensive and task-specific training in a massed practice schedule will be used not only with gait but also balance and additional mobility tasks with IMT.

Currently, the most effective and efficient treatment frequency or dosage for individuals with motor impairments has not been defined. While widely accepted that more practice is better,[11,27,28] CIMT and locomotor training are the only continually reported interventions that have used and been effective in forcing massed practice in neurologic populations.[29-31] IMT, and the intensive nature of this therapeutic approach, is novel, so the participants' ability to tolerate the intervention needs to be established. The purpose of this study was to (1) examine whether the intensive nature of IMT is a rehabilitation strategy that individuals with chronic ISCI can tolerate, and (2) evaluate the effects of IMT on gait, balance, and mobility in individuals with chronic mobility deficits after ISCI.

METHODS

This study was approved by the University of South Carolina, Institutional Review Board. Before participation, all participants reviewed and signed an informed consent.

Participants

Fifteen participants were recruited on a voluntary basis via Internet postings, local radio announcements, and newspaper advertisements. Each participant was screened for eligibility based on predetermined inclusion and exclusion criteria. Inclusion criteria included (1) SCI categorized as American Spinal Injury Association (ASIA) C or D; (2) more than 6 months after ISCI; (3) able to sit independently without back or arm support for 5 minutes; (4) able to stand with support of an assistive device for 2 minutes; (5) able to walk 3.05 meters with or without assistance; and (6) passive range of motion at least half the normal range in the joints of the lower extremities. Participants were excluded if they had previously participated in BWSTT-related research, had health problems identified by their screening physician that would place the participant at significant risk of harm, had other neurologic conditions, or had pain scored greater than 5 on an 11-point numerical rating pain scale (0, no pain; 10, most severe pain).

Design

A prospective, repeated-measures, within-group design was used in this pilot study. Participants were evaluated 1 day before the 10-day intervention (pretest), 1 to 2 days after completion of the intervention (posttest), and at a 6-month follow-up to assess change.

Intervention

Participants received IMT 3h/d, 3 to 5d/wk for 10 days, for a total of 30 hours of intervention. The intervention was provided by physical therapists and senior level Doctor of Physical Therapy students. Each session devoted a third of the time to therapeutic interventions focused on improving balance, a third to locomotor training with a Robomedica StepGain GRF body weight support system,[a] and a third to activities designed to develop muscle coordination, strength, and range of motion within task-specific contexts of gait, balance, and mobility. The main goal of the entire intervention was to focus on improving mobility.

A task-oriented approach was implemented during the 2 hours of balance and mobility training that allowed for variability in practice. Participants were encouraged to repeatedly use their LEs in activities such as overground gait training with and without an assistive device, sit to stand, various balance activities (eg, tandem stance), targeted stretching and strengthening activities, and coordination tasks. When patients became fatigued, frustrated, or interests changed, adaptations were made to the therapy to create a more efficient intervention. When the participants improved, tasks were progressed to keep the therapy challenging; for example, changing the support surface on which the task was completed. The target goal for rest time was 30 minutes or less per 3-hour session. As with traditional CIMT, only the time of the intervention was standardized with a target goal of 50 minutes of gait, 50 minutes of balance, and 50 minutes of strength, range of motion, and coordination activities, for a total goal of 150 minutes spent in therapeutic activities per daily treatment session. An example log of daily activities can be found in appendix 1.

The protocol used for BWSTT was adapted from Behrman et al,[32] focusing on (1) approaching normal gait parameters; (2) maintaining an upright trunk; (3) approximating normal joint kinematics for LE joints; and (4) avoiding excessive weight-bearing on the upper extremities. If participants were unable to accomplish these goals independently, the percentage of body weight support was adjusted to achieve maximal bilateral limb loading without knee buckling so that the most "normal" walking kinematics were attained. If the participant was unable to generate kinematically appropriate stepping motions independently, manual facilitation was then used to assist the stepping motion. The primary goal during the 1-hour of BWSTT was to approach normal temporal parameters of gait (increasing walking speed on the treadmill) and to achieve near-normal joint kinematics through manual facilitation primarily applied at the hips, knees, and ankle. Once the "best" gait kinematics were achieved at the fastest pace the participant could tolerate, the therapy was advanced by decreasing the body weight support, further increasing speed, and/or reducing manual facilitation efforts.

Outcome Measures

The amount of rest time needed for each participant, as well as whether the participant was able to reach 90% of the target goal of 150 minutes of intervention, was used to assess participants' tolerance to the intervention. Rest breaks were determined as they would be in a clinical setting. The participants