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ORIGINAL ARTICLE

Effect of Overground Training Augmented by Mental Practice on Gait Velocity in Chronic, Incomplete Spinal Cord Injury

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Abstract

Objective: To compare the efficacy of a regimen combining mental practice (MP) with overground training (OT) with the efficacy of a regimen consisting of OT only on gait velocity and lower extremity motor outcomes in individuals with chronic (>12mo postinjury), incomplete spinal cord injury (SCI).

Design: Randomized, controlled, single-blinded study.

Setting: Outpatient rehabilitation laboratories.

Participants: Subjects with chronic, incomplete SCI (N=18).

Interventions: Subjects were randomly assigned to receive (1) OT only, occurring 3d/wk for 8 weeks; or (2) OT augmented by MP (MP + OT), during which randomly assigned subjects listened to an MP audio recording directly after OT sessions.

Main Outcome Measures: Subjects were administered a test of gait velocity as well as the Tinetti Performance Oriented Mobility Assessment, Spinal Cord Injury Independence Measure, and Satisfaction With Life Scale on 2 occasions before intervention, 1 week after intervention, and 12 weeks after intervention.

Results: A significant increase in gait velocity was exhibited across subjects at both 1 week posttherapy ($P=.005$) and at 12 weeks posttherapy ($P=.006$). However, no differences were seen in intervention response at either 1 or 12 weeks postintervention among subjects in the MP + OT group versus the OT-only group.

Conclusions: OT was associated with significant gains in gait velocity, and these gains were not augmented by further addition of MP.

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Approximately 25% of patients with incomplete spinal cord injury (SCI) remain unable to ambulate independently.[1] Muscular and cardiovascular deconditioning, spasticity, and decreased bone density are commonly associated with compromised ambulation in this group.[2-5] As a result, increased ambulation quality and speed are frequent rehabilitative goals.[6]

It is believed that patients with SCI exhibit cortical plasticity in response to repetitive activity.[7,8] Vertebrate spinal cords also house "central pattern generators" activated by repetitive locomotor activity.[9-11] These mechanisms contribute to the increased walking speed observed after overground training (OT).[12-15] Whereas compensatory strategies (eg, braces) increase independence but not active movement, OT-based strategies attempt to restore walking through repetitive, motor learning–based physical practice. However, it remains unclear which strategies should be used to best augment or maximize the efficacy of OT. One plausible approach is mental practice (MP), a noninvasive technique during which physical skills are repetitively, cognitively rehearsed. For decades, studies[16,17] have reported improved motor function when MP is combined with physical practice of the same

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Table 1 Description of OT regimen components

Gait Training Sessions	Description	Progressions of the Activity
Timed speed sessions	Subject walks ~10m at self-selected speed (as fast as comfortable). Parameters of gait are evaluated qualitatively (visual) and quantitatively (GAITRite).	Speed and distance were augmented based on individuals' ambulation abilities.
Dynamic balance training	Focuses on dynamic balance training. A full-length mirror was used during the exercise as a source of visual feedback.	Static bipedal standing → static unipedal standing → bipedal/unipedal standing on degraded surface. Gradual reduction in base of support, reduction of upper extremity support, and increased duration of each stance were implemented.
Stride and step length	Based on the subject's natural step/stride length ascertained at baseline, tape was used to cue where each subject should step in gait training sessions. Parallel bars and lower extremity assistance were used as needed.	Progression was implemented by increasing the distance between steps. Parallel bars were used as assistance to upper extremity if needed.
Cadence	Subjects were asked to match this cadence with help of a metronome. Treatment stressed accuracy of cadence and increased speed of footfalls. Speed expectations and amount of rest were tailored based on each subject's impairment level and cardiovascular and muscular status.	Once the subject was able to ambulate at this cadence with 80% accuracy (8/10 trials), metronome speed was incrementally increased by 3 beats/min.
Individual ankle joint movements	Exercises were performed as passive, active assist, or active, as appropriate, and were intended to improve strength and coordination of the triceps surae, tibialis anterior, peroneals, digitorum, and hallucis muscles.	Reducing assistance, increasing effective gravity, and increasing executed range of motion were used to escalate difficulty over sessions. To address the variance in subjects' abilities, platform height, degree of extremity support, and velocity of motion were varied.
Stepping up	Subjects stepped up and down onto a firm and vertical surface at least 15.24cm in height. The task was varied depending on ability. Subjects viewed a mirror while performing the exercise.	To address the variance in subjects' abilities, step height, degree of extremity support, and velocity of motion were varied.
Gait velocity	Combined all components practiced in earlier sessions into a coherent gait cycle using velocity as a metric.	Speed, distance walked, and level of cueing were individually graded according to the subject's ability.

activity. The application of MP to neurorehabilitation is supported by evidence suggesting that its use activates the same neural areas as physical practice of the same tasks.[18-20] Preserved supraspinal influences after incomplete SCI[21,22] would likely allow for similar neural activations and adaptive plasticity to occur. Furthermore, MP can be useful when physical practice is difficult (eg, ambulation),[23-25] and was successfully applied to rehabilitative training in stroke,[26,27] including several studies[26,28-30] targeting ambulation and lower extremity movement. Thus, this pilot study compared the efficacy of an OT regimen incorporating MP with the efficacy of a regimen composed only of OT on gait velocity in chronic (>12mo postinjury), incomplete SCI. We hypothesized that the addition of MP to OT would cause significantly larger gait velocity changes. To our knowledge, this is the first study examining MP application to individuals with incomplete SCI.

List of abbreviations:

CI confidence interval
MP mental practice
OT overground training
POMA Tinetti Performance Oriented Mobility Assessment
SCI spinal cord injury
SCIM Spinal Cord Injury Independence Measure
SWLS Satisfaction With Life Scale

Methods

Participants

Volunteers were recruited using advertisements and inservices provided to rehabilitative clinics and SCI support groups in the midwestern and western United States. The following inclusion criteria were applied: (1) age ≥18 years; (2) incomplete SCI experienced >12 months before enrollment; (3) manual muscle test score of ≥1 and ≤3 in the quadriceps, hamstrings, and hip flexors, and the ability to ambulate with at least a minimal assist; (4) range of motion in the lower limbs within functional limits; (5) motor function in at least half of the American Spinal Injury Association's key lower extremity muscles with strength >3/5; (6) able to ambulate at least 10m with 1 person assistance or with an assistive device, or both; (7) medically stable; and (8) stable dosage of antispasticity medications for the study duration. Exclusion criteria were as follows: (1) score of ≥3 on the Modified Ashworth Spasticity Scale in the lower extremities; (2)