



Neural and Functional Outcomes after Lower Extremity And Walking Activity-Based Interventions for Persons with Spinal Cord Injury: A Research Synthesis

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Introduction

Several lines of evidence suggest that intense activity, in the form of repeated active movement, often combined with sensory stimulation, can lead to neural or functional improvements, or both, in humans with any level or completeness of spinal cord injury (SCI). This has led to the development of activity-based programs around the globe, inviting persons with complete or incomplete SCI to participate in order to achieve their maximal potential. A careful review of the literature is imperative in order to examine the evidence related to this issue.

Purpose of the Review and Synthesis

To evaluate literature in between 1998 and 2008 related to the efficacy of activity-based interventions for improving neural activity and function in persons with SCI. Activity-based interventions (ABint) include any therapeutic activity focused on improving muscle function and sensory perception below the level of injury, and not simply compensating for paralysis and sensory loss, in order to improve neural recovery, i.e. a measurable change in neural circuitry or neuronal activity at any level of the neural axis in response to injury or learning, and function after SCI.

Methods

The lead reviewer located articles relevant to SCI, ABint, and neural and functional recovery. If the title appeared relevant, the abstract was reviewed; if it met inclusion criteria, the article was obtained. The article had to report on the use of at least one ABint, and at least one outcome measure for neural changes, functional ability, or both. Seven (7) trained reviewers evaluated each article for meaning and rigor, using guidelines set forth by Rogers and Farkas (2008). The lead reviewer tallied scores and determined overall meaning and rigor for each article. The articles deemed to be both rigorous and meaningful were then summarized for this review.

Results

- 27 of 40 articles were rated for rigor and meaning.
- 17 met the criteria for both meaning and rigor
- Only two studies used an experimental approach; most were descriptive (n=14); the remainder were quasi-experimental (n=1) designs.

Key findings from RCTs

Field-Fote et al. 2005

- Compared different body-weight supported (BWS) LT approaches: 1) Manual LT, 2) treadmill training with electrical stimulation (estim), 3) over-ground (OG) walking with stimulation, and 4) LT with robotic assistance in adults with chronic SCI (n=27);
- Participants had motor incomplete SCI (AIS C or D) and were randomly assigned, based on their pre-training lower extremity motor score (LEMS), to one of the four groups.

Findings:

- All participants improved in walking performance and speed; there was no significant difference between groups;
- Those with the most impairment in walking function showed the greatest improvements;
- Power analysis suggested more subjects are required in each group in order to detect a significant difference;
- HOWEVER, there was a trend for greater improvement in walking in the estim groups (OG and treadmill training);
- No participant was able to discard their wheelchairs and walk independently or in the community.

Dobkins et al. 2006

- Compared the efficacy of BWS manual LT with OG gait training (LT) to OG gait training (CONT) in adults with acute SCI (n=146);
- Participants had incomplete SCI (AIS B, C, or D) between C5 and L3, FIM locomotion score less than 4, and were within 8 weeks of their SCI when enrolled;

Findings:

- No significant differences between the LT and CONT groups for most outcome measures, specifically neural outcome measures;
- No significant change in Ashworth scores, or frequency of spasms in either group
- HOWEVER, in both groups:
 - The majority of persons with AIS C SCI, achieved independent walking;
 - Persons with AIS C and D SCI increased walking velocity, consistent with functional community ambulation, and speed continued to increase 3 to 6 months post-intervention.
 - Persons with AIS B SCI did not improve in OG walking. Only those enrolled as AIS B, who converted to AIS C during the intervention, improved in walking speed.

Key findings from quasi-experimental and descriptive studies

- Grasso et al 2004: Persons with acute SCI (C7 to L2; AIS A, B, C) (n=11) performed daily BWS manual LT. Persons with SCI improved the trajectory of the foot during stepping which progressed to the shape typically found in able-bodied persons. The majority (n = 8) also demonstrated a longer step length and greater foot clearance during stepping, and an increase in amplitude and decrease in variability, of the step trajectory, suggesting alterations in inter-segmental kinematic coordination. The LE EMG pattern in persons with SCI changed its distribution after training, but was different from the able-bodied population. Thus, neural plasticity was evident, but did not resemble that in able-bodied persons
- Behrman & Harkema 2000: Persons with SCI performed BWS manual LT. Those with AIS C SCI improved in ASIA LEMS, as well as stepping on the treadmill. Persons with AIS D SCI did not improve in LEMS, but did improve in OG walking, walking speed and distance. One person with AIS C SCI, not able to walk OG prior to training attained the ability to walk OG.
- Prosser 2007 & Behrman et al. 2008: Demonstrated improvements in OG walking, each in one child, (Prosser, acute SCI; Behrman chronic SCI) after BWS manual LT.
- Protas et al. 2001:

Conclusions

Although there is little evidence from RCTs related to the efficacy of lower extremity activity-based interventions, such as locomotor training, evidence from this systematic review suggests that further experimental design studies would be useful to gain a greater understanding of the efficacy of ABint for neural and functional outcomes in persons with SCI. Adults with motor incomplete SCI appear to be the best candidates for improving walking function following LE ABint, however, no one type of ABint has proven to be superior for facilitating neural and functional improvement for all persons with SCI. Neural improvements are possible in persons with SCI, however, neural recovery may not be *necessary, or sufficient*, to lead to functional changes in persons with SCI. Future studies should employ similar interventions and outcome measures to determine if there is functionally relevant neural benefit from ABint. Furthermore, future studies should use measures to characterize the injury of persons with SCI to determine for whom (i.e. level and extent of SCI) a given ABint, i.e. which LT approach, would be best for facilitating maximal outcomes.