Lower Limb, Balance and Walking Following Spinal Cord Injury

1.0 Executive Summary

What Lower Limb, Balance, and Walking problems occur after injury?

- Loss of function in the lower limbs due to SCI can extend from complete paralysis to varying levels of voluntary muscle activation. The rehabilitation of lower extremity function after SCI has generally focused on the recovery of gait. Even when functional ambulation may not be possible (e.g. in complete tetraplegia), lower limb interventions can be targeted to maintain muscle health as well as reduce other complications, such as decreased cardiovascular health, osteoporosis, or wounds. Minimizing the risk of these complications would ease health costs related to the treatment of these sequelae and also could promote participation in society and/or the workforce.

What are the chances of recovering from Lower Limb, Balance and Walking problems after Spinal Cord Injury?

- Most patients classified with an AIS A (complete motor and sensory) spinal cord injury have very slim chances of walking independently in the community again compared to the other AIS grading levels[1]
- Those who regain some community walking function usually have lower levels of injuries (T12-L3) [1]
- Overall ambulation recovery for AIS B (motor complete, sensory incomplete) patients is at around 33%[1]
- AIS C and AIS D patients generally have a very good prognosis for regaining ambulatory/walking function[1]
- However, the ability to recover walking function from a spinal cord injury decreases as one ages[1]

What management options are there for lower limb, balance, and walking following spinal cord injury?

Non-Pharmacological Options

- **Sitting, Standing and Balance Training:**
  - There are relatively few studies that provide information on balance as an outcome (of an intervention) in people with SCI. Early balance training does not appear to enhance the effects of standard physical therapy in either sitting or standing balance, but people that engaged in overground or BWSTT *and* were able to walk showed improvements in their balance scores.[2,9,10,11,12]
  - Visual field feedback training leads to substantial improvements in static and dynamic standing (eyes open and closed scores), and improvements in balance performance during training-irrelevant tasks.[3,4] Results from 1 RCT found that task-specific sitting balance exercises for an additional 3 weeks in acute SCI had no effect on balance outcomes.
  - In people with chronic SCI who cannot stand, sitting balance can be improved with both static and dynamic task specific training. For people with lower severity

injuries (e.g., AIS C and D), BWS over ground training combined with physiotherapist-led task-specific exercises and feedback appear to be more effective to improve standing function than BWSTT alone.[5,6,7,8]

   - In studying the effects of task-specific balance exercises in acute SCI, 1 RCT showed no difference in balance outcomes after an additional 3 weeks of training.[49]

- **Strengthening Lower Limb Function:**
   - Typically, studies to improve walking focus on individuals with incomplete SCI and look at walking-related outcomes (e.g., walking speed or distance). However, some investigators have also examined the relationship between changes in lower limb strength and walking ability. For the most part, these therapies include a form of body-weight supported treadmill training, and the patient's limb movements may be assisted by any (or a combination) of: therapist, electrical stimulation (i.e., FES) or a robotically controlled servo-mechanism.[13,14,15,16,17,18,19]
   - In general, investigators have noted significant increases of lower limb strength following locomotor training, despite variations between training protocols and specific methods employed. [13,14,15,16,18,19]
   - Despite all investigators reporting some increases in lower limb muscle strength following locomotor training (in individuals with chronic SCI, and in 1 study with subacute SCI),[20] enhanced walking capability was not necessarily associated with parallel increases in strength, nor do we know the clinical relevance of strength gains found. [15,16,17,18,19]
   - However, a study that examined the effects of a 12-week resistance and plyometric training program, improvements in knee extensor and ankle plantarflexor torque production were accompanied by >30% improvement in gait speed.[21] There is also weak evidence (from 1 study, n = 3) that significant improvements in muscle strength may be realized when locomotor training is combined with conventional therapy.[14]
- **Gait Re-training Strategies**
   - Overground training can only be undertaken with higher functioning individuals with incomplete SCI. However, overground training provides an important mode of exercise for improving walking function, and likely other physical and mental functions (e.g., muscle strength, balance, bone health, cardiovascular function, depression symptoms) shown to be positively affected by exercise in the general population. Oh and Park (2013)[22] found that an intensive 6X/week, 4 week training program resulted in effects at 1 year follow-up and demonstrate the positive benefits of exercise.
      - There is evidence from 1 RCT and multiple pre-post-studies that BWSTT can improve gait outcomes in chronic, incomplete SCI, and most body weight-support strategies (overground, treadmill, with FES) are equally effective at improving walking speed. Robotic training was the least effective at improving walking speed.[9-12, 15,17,18,23,24,25,26]
- **Orthoses/Braces**
   - Two studies[27,28] examined the immediate effects of an ankle-foot-orthosis after randomizing different brace conditions. Positive effects consisted of increased gait speed, step length, cadence and improved performance on the 6 Minute

Walk test. It is generally recognized in the field that effects from an AFO are attained immediately, although it is likely that practice over a few sessions may improve a participant's confidence, learning and function.

  - The Reciprocating Gait Orthosis (RGO) (or variants of it) is the most common bilateral HKAFO for people with thoracic injuries, as it permits ambulation and in some cases, stairs to be performed.
  - Most studies showed that HKAFOs may facilitate the ability of people with subacute or chronic complete paraplegia to stand independently and to achieve some functional walking skills, such as stepping up on curbs or climbing stairs.
  - It has been recommended that orthoses or braces are best for people who are well-motivated, with complete SCI at T9 or below or incomplete SCI at any level, with good postural control and good level of fitness.[29,30,31]

- **Functional Stimulation, PES, and Walking**
  - The functional benefits derived from FES are also quite variable. For instance, one study showed[32] that most people showed a modest improvement in gait speed (average: 4 m/min), with greater gains for the more severely disabled participants. Higher-functioning participants felt that this small benefit in gait speed did not warrant the daily use of FES.
  - Other research[33] reported that there was a tendency for people with initially faster gait speed to have greater absolute improvements. Thus, outcomes from FES-use also seem to be quite variable in terms of walking speed[32, 33] or distance.[34]

  - 1 RCT in people with either complete or incomplete SCI found that PES-assisted exercise increased voluntary quads strength over those with no intervention (though we don't know if strength increases were clinically important).[36]

  - PES exercise to ankle flexor muscles found stimulated leg could generate significantly higher torque and simulated muscle forces than on the untrained leg.[35, 37,38,39]

  - FES-assisted walking can enable walking or enhance walking speed in incomplete SCI or complete (T4-T11) SCI. Regular use of FES in gait training or activities of daily living can lead to improvement in walking even when the stimulator is not in use.[33,34,40,41,42,43,44]

  - There is also evidence that electrical stimulation can have increased benefits over manual assistance or braces (driven gait orthosis)[45] and that BWSTT <u>combined</u> with FES to the quadriceps and hamstrings muscles can enhance functional ambulation.

Pharmacological Options

- The studies on clonidine (oral or intrathecal), cyproheptadine and baclofen demonstrate improvements in various aspects of gait (i.e. walking speed, posture, spasticity), but no improvements led to significant functional changes in walking.
- The greatest improvements have been found in more severely disabled participants and in many cases, and the effects were retained following washout of clonidine.[46] Bradycardia and hypotension, common side-effects of oral clonidine can be lessened with intrathecal injection of clonidine (150-450µg).[47]

- One high-quality randomized, placebo-controlled, double-blinded crossover study[48] (N=9) provided level 1 evidence that a combination of physical therapy (including gait training) and GM-1 ganglioside improved motor scores, walking distance, and walking speed in chronic SCI participants compared to physical therapy plus placebo.

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