Case Report

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# Strategies to Achieve High Intensity Gait Training in a Clinical Setting: A Case Study

**Brian Wadsworth, PT, DPT[1*]**

*Rusk Rehabilitation, NYU Langone Health, Astoria, New York.*

**[*]Correspondence:**
Brian Wadsworth, Staff Physical Therapist, Rusk Rehabilitation, NYU Langone Health, Astoria, New York.

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## ABSTRACT

*Effectiveness of high intensity gait training (HIGT) is supported by the literature. HIGT is defined as 60-80% heart rate reserve for 30-40 minutes performed over ground or on the treadmill. Presently, there is limited evidence investigating clinically feasible treatment strategies to achieve HIGT. This case study's purpose is to identify clinically feasible interventions to achieve HIGT and promote efficient knowledge translation. The patient was a 23-year-old male with C5 incomplete spinal cord injury presenting with left hemiparesis. Interventions incorporated treadmill training (TT) and over ground training (OGT) for a maximum of 30mins each per session. Strategies included: varying speed; limb weighting; uneven surface gradients; and complex skills training. Results indicate that HIGT is clinically feasible. HIGT was achieved 90.9% of the time with TT vs. 66.7% of the time during OGT. HIGT OGT was accomplished with: running; resisted fast walking; ankle/trunk weighting; and stairs. TT achieved HIGT by: varying speed; increasing gradient; and limb weighting. Harness support would be recommended, as appropriate, to ensure safety and to maximize task demands with both OGT and TT. Future studies with larger sample sizes could provide evidence to identify the most effective training approaches for HIGT and give clearer guidelines to overcome potential clinical barriers to HIGT. To conclude, this case study provided examples of clinically feasible interventions to promote knowledge translation of HIGT.*

## Keywords

High Intensity Gait Training, Knowledge Translation, Locomotor Clinical Practice Guidelines.

## Introduction

Incomplete spinal cord injury (iSCI) is a chronic non-neurodegenerative condition that often leads to persistent gait impairment. As of 2016, it is estimated that there are approximately 17,000 new cases of SCI each year. In addition to this, there are an estimated 282,000 people living with SCI in the US and only 33% of patients with SCI are still employed 20 years following injury [1]. Associated lifetime costs of SCI range from 1.58-4.729 million [1]. The multifactorial costs of SCI increase the pressure to execute best practices when treating this population.

Commonly these patients seek physical therapy (PT) to address their walking [2]. PT is under greater pressure to maximize the efficiency of interventions as insurance covered visits continue to reduce. The locomotor clinical practice guidelines (CPG), by Hornby et al. (2018), expressed at American Physical Therapy Association's Combined Sections Meeting, seeks to address this [2]. They provided key suggestions for enhancing locomotor training in iSCI, stroke, and traumatic brain injury [2]. This CPG promotes high intensity gait training (HIGT) as a highly recommended intervention to improve gait speed and walking distance [2]. A literature review of HIGT by this author further supported the efficacy of HIGT to improve walking [3-6]. Despite the ample evidence of the benefits of HIGT, there remains a gap in the literature regarding its clinical feasibility. Training paradigms in the literature often span up to 40 visits across 10 weeks for 30-60 mins per session [4-6]. This is not consistent with typical clinical practice and lengths of stay. The purpose of this case study was to examine the clinical feasibility of HIGT and to provide examples of interventions that promote successful HIGT.

## Case Description

The patient in this case study was a 23-year-old male diagnosed with a C5 iSCI (see Table 1 for demographics and objective measures). He was initially diagnosed as an American Spinal Injury Association B SCI. Patient reported to outpatient neurological PT department 11 months post-injury. Impairments included: left extremities grossly 2-3/5 manual muscle test (MMT); right extremities grossly 4/5 MMT; light touch sensation intact with intermittent burning sensation in left hand; and range of motion was grossly within normal limits. Ambulation involved use of a straight cane and a left toe-off ankle foot orthosis. Gait kinematics included: left hip hike and circumduction; reduced left knee flexion during swing phase; decreased left step length; and left forefoot initial contact.

| Patient Presentation | | |
|---|---|---|
| **Patient A** | Gender | Male |
| | Age | 23 |
| | Diagnosis | C5 Incomplete Spinal Cord Injury |
| | Time Since Injury | 11 months |
| | Target Heart Rate Range (60-85% Heart Rate Reserve) | 151bpm – 172bpm |
| **Initial Evaluation** | 6 Minute Walk Test | 244 meters |
| | 10 Meter Walk Test | 0.75m/s |
| | 5 Times Sit to Stand | 23.9 seconds |
| | Balance Assessment | Mini-Best Test: 14/28 |
| **10th Visit Reassessment** | 6 Minute Walk Test | 320 meters |
| | 10 Meter Walk test | 1.10m/s |
| | 5 Times Sit to Stand | 13.0 seconds |
| | Balance Assessment | Mini-Best Test: 20/28 |

**Table 1:** Patient demographics. Objective measures assessed at patient's initial evaluation and at subsequent reevaluation after 10 sessions of HIGT.

The following findings were obtained on initial evaluation: 10-meter-walk-test (10MWT) speed 0.75m/s; 6-minute-walk-test (6MWT) distance 244m; 5-time-sit-to-stand (5xSTS) 24 seconds (s); timed up and go (TUG) 15.5s; mini- BESTest 14/28; and high-level mobility assessment test (HiMAT) 9/54. He also demonstrated right step-too pattern on the stairs with supervision and use of right hand-rail to ascend and descend 10 steps. Patient goals included: "improve my walking" and "be able to return to living life like a typical 23-year-old."

## Intervention

This case study focused on the application of HIGT as defined by the locomotor CPG. HIGT was defined as achieving 60-80% heart rate reserve (HRR) for 30-40 minutes with over ground or treadmill-based training [2]. Heart rate (HR) was the primary determinate of successful HIGT and it was tracked at 5-minute increments during treatment sessions. Predicted maximal heart rate was determined by using Tanaka et al.'s (2001) equation, 208-(0.7 x age) [7]. Following this calculation, the Karvonen method was used to determine the patient's 60-80% HRR range. This range served as the basis to determine achievement of HIGT.

Over ground training (OGT) and treadmill training (TT) were used equally in this case study. OGT involved: fast walking; multidirectional walking; attempted running, bounding, hopping; continuous stair training; ankle or trunk weighting; PT resisted forward, backward, and lateral walking; and high knees walking. TT involved: increasing speed; adding weight or resistance bands to the distal aspect of the involved lower extremity; increasing gradient; increasing duration of active walking intervals; and combining these manipulations. An overhead harness was used during TT and OGT to maintain safety during treatment sessions. Harness support did not provide bodyweight support. Each mode was performed for a goal of 30 minutes each for a total of 60 minutes per session twice a week for 10 total sessions.

In this patient's case, TT was the most consistent way to achieve HIGT as evidenced by a success rate of 90.9% of the time as compared to 66.7% with OGT. In a 30min TT session, 22min were spent actively targeting HIGT and on average 20min were spent achieving it. In a 30min session targeting OGT based HIGT 24min were spent actively targeting it and an average 16min were spent achieving it. Differences in active time targeting HIGT between OGT and TT was likely related to the setup time required for the overhead harness that was used in every session during all TT and faded out of OGT by the sixth session.

Patient outcome measures were reassessed after ten sessions of HIGT. The following scores improved by a value of at least minimal detectable change (MDC) as defined for the SCI population: TUG to 7.75s (MDC = 30% reduction in time); 6MWT increased to 320m (MDC = Δ45.8m); and 10MWT improved to 1.10m/s (MDC = Δ0.13m/s) [8]. MDC scores are not available in this population for the: mini-BESTest, 5xSTS, or HiMAT. Patient's mini-BESTest improved to 20/28. His time on the 5xSTS decreased from 24s to 13s and no longer required upper extremity support. Mini-BESTest improved to 20/28. HiMAT score increased by three points to 12/54. HiMAT skills were still limited by weakness of the left ankle plantar flexors and his inability to achieve flight phase for running or jumping. Stairs progressed to step-over-step with right hand rail independently with reduced left hip circumduction. Gait kinematics also improved as evidenced by: reduced left hip circumduction; increased equalization of step-length; left heel first initial contact; and no longer requiring his cane. Additionally, floor-to-stand transfers were now independent without upper extremity assistance as compared to prior reported dependence on right upper extremity to pull himself into standing.

## Discussion

The results of this case study indicate that HIGT can be clinically feasible within PT practice. No adverse reactions or injuries occurred at any point during treatment. TT was a more consistent method of achieving HIGT with this patient. Increasing belt-speed and gradient and adding limb resistance at the involved limb were all effective methods of intervention to increase treadmill-based training intensity. A likely factor of TT's success in this case is that, as previously indicated, it forced the patient to maintain continuous walking at speeds above selfselected pace.

Over ground training HIGT was achieved with this patient but at a lesser rate than TT. Successful OGT HIGT incorporated: repeated stair training; adding weight to the impaired limb or trunk; PT resisted fast forward walking; use of weight vest with stairs; and attempting to perform running. Although the patient could not achieve full running the effort exerted to try and accomplish this is a likely explanation for its success as an intervention. One potential barrier to HIGT via OGT is environmental set up. In this case, a challenge to maintaining continuous motion, was the 20m long hallway that was used to provide treatment. This led to frequent stopping and turning. Difficulty maintaining consistent motion made it harder to increase and maintain HR within the target HRR range. As the patient's mobility and stability levels improved, he was able to better maintain continuous motion over ground with more efficient turning, which led to more consistent HIGT. This suggests that one consideration for OGT HIGT is clinic space and the patient's ability to maintain adequate continuous motion to drive required intensities of training.

Another potential barrier to HIGT in this case study was fall risk and gait speed. As previously noted, use of an overhead harness to prevent falls was the most effective way to maintain safety. Body weight support (BWS) was discouraged by the locomotor CPG [2]. However, in this case study the harness was left slack to avoid providing BWS during OGT or TT. This allowed him to experience losses of balance and make attempts to regain his stability within a safer environment. During TT this was used with each session due to increased risk of harm if he were to fall on the treadmill. Harness support was gradually taken away during OGT and discontinued when fall risk was no longer considered a primary barrier to achieving HIGT. Harness support also helped to overcome this barrier from a treatment planning standpoint because it allowed me to maximally challenge him with reduced fear of potentially causing him harm.

Gait speed appeared to be another barrier to achieving HIGT. This was especially true during OGT. Patient's initial gait speed of 0.75m/s may have been predictive of a reduced likelihood of successful HIGT. This is assumed because he had difficulty maintaining continuous high-speed complex mobility interventions without stopping and starting during OGT due to difficulty with balance and mobility. His gait speed had less of an impact on his intensity with TT HIGT because he was immediately forced to walk well above his self-selected walking pace at a speed of ≥1.0m/s. It appears that this likely played a role in his more consistent achievement of HIGT on the treadmill as compared to over ground. According to Fritz and Lusardi (2009), slower gait speeds are predictive of increased fall risk and reduced functional mobility [9]. I therefore hypothesize that impaired gait speed may play a role in a patient's ability to achieve high intensities with locomotor training over ground. It may be indicated to initiate HIGT on the treadmill for patients at lower functional mobility levels and progress them to greater over ground time as they become better able to perform HIGT.

Additionally, HIGT appeared to promote reverse translation of skills in this case study. Improvements in his sit-to-stand and floor-to-stand transfers occurred without any direct interventions targeting them. In both cases he progressed to independent without upper extremity support. Functional balance also improved as indicated by his positive change in Mini-BESTest score. Balance specific exercises were not performed with this patient. Yet, by performing tasks required to achieve HIGT his balance was inevitably indirectly challenged and driven to improve. This was especially noted with OGT HIGT. Initially he required harness support to prevent falling but as he progressively improved his consistency with HIGT he eventually no longer needed the harness. Efficiency of HIGT as an intervention technique was further evidenced in this case study by these signs of reverse translation of skill acquisition.

Limitations of this case study are as follows: sample size of one patient limits the generalizability of findings; HR tracking every five minutes limits the determination of successful HIGT to intermittent snapshots throughout the session; and no blinding could be performed for patient or therapist which allows for risk of bias.

## Conclusion

In conclusion, this case study demonstrated that HIGT can be clinically feasible. It identified potential treatment strategies to promote the knowledge translation of the locomotor CPG into clinical practice. Additionally, it identified some potential clinical barriers and provides ideas for how to address these barriers and maximize successful HIGT. Further research should be done to continue to identify other clinical barriers to HIGT and provide more structured recommendations for how to overcome these barriers and maximize patient care. Additional research should also focus on determining potential objective characteristics (e.g. gait speed, etc.) that may have a predictive value in determining who may be more successful with OGT versus TT HIGT to improve the efficiency of clinical decision making.

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