Short Communication

Annals of Behavioral Neuroscience

Walker vs. Wheelchair User: Expected Gains from Lower Extremity Eccentric Resistance Training after Incomplete Spinal Cord Injury

Stone WJ^{1*} and Stevens SL²

¹School of Nutrition, Kinesiology and Psychological Sciences, University of Central Missouri, USA

²Health and Human Performance, Middle Tennessee State University, Murfreesboro, Tennessee, USA

***Correspondence:** Whitley Jo Stone, School of Nutrition, Kinesiology, and Psychological Sciences, University of Central Missouri, Warrensburg, MO 64093, USA, Tel: 660-543-4148; Fax: 660-543-8847; E-mail: whstone@ucmo.edu

Received: August 21, 2018; Accepted: September 25, 2018; Published: September 30, 2018

Abstract

Individuals post Incomplete Spinal Cord Injury (iSCI) experience mitigated physical function relative to the degree of injury. Prolonged therapeutic interventions may include strengthening of the affected musculature below the lesion. Eccentric resistance training has shown to positively impact strength and function inferior to the iSCI. It has yet to be determined if the severity of injury impacts sensitivity to such exercise interventions. A 12-week lower extremity, eccentrically-biased resistance training program was implemented in a mixed sample of walkers ($n = 4$) and wheelchair users ($n = 7$) with iSCI. Strength, walking speed, mobility, and daily step activity were analyzed using multiple 1 way ANOVAs with percent improvement from pre- to post-test as the dependent variable and community traversing style as the independent-between factors. Traversing style made no impact on strength gained (eccentric and isometric) nor increase in daily step activity ($p > 0.05$). Chair users experienced greater improvement in walking speed ($p = 0.03$) and mobility ($p = 0.025$) when compared to the walkers, respectively. These preliminary data may represent a ceiling effect for community ambulators in respect to walking function without formal gait training. Alternatively, those using chairs may attain walking improvement in the absence of structured walking therapy. Further support is provided for implementation of lower extremity exercise training regardless of severity of iSCI as the trajectory of improvement in strength and step activity was similar between groups.

Keywords: Leg strengthening, Ambulator, Eccentric exercise, Spinal cord injury

Abbreviations: iSCI: Incomplete Spinal Cord Injury; ERT: Eccentric Resistance Training

Introduction

It was estimated that approximately 280,000 individuals are living with a spinal cord injury in the United States [1]. Damage to the cord leads to impaired neuromuscular coordination, at home function, and mental health [2][3] [4]. The Rate of depression post injury at (22%) averages substantially higher than the general population at (8.1%) [5][6]. Ample evidence is available to prescribe exercise as a prophylactic and treatment of depression in able

bodied [7] and neurologically impaired [8]. Improving quality of life and reducing depression through physical activity can be attributed to reduction in pain [9], lowered stress, and increased satisfaction with physical function [10]. Purposeful physical activity, or exercise, may pronounce improvements in physical function, reduction in pain, and overall satisfaction.

Eccentric resistance training (ERT) is a popular exercise training style in athletes and rehabilitative ventures. The

eccentric muscle action (generation of tension as the muscle lengthens) consumes less oxygen per unit of work, thus allowing individuals with low cardiovascular ceilings to exercise at higher volumes compared to traditional eccentric + concentric repetitions. Those with incomplete spinal cord injury (iSCI) [11][12][13] and other neurological conditions [14][15] have safely performed ERT in adjunct to traditional therapeutic interventions. Outcomes from these studies include improved eccentric and isometric strength, walking function, quality of life, cardiovascular fitness, and muscle volume. However, there appears to be no data evaluating the impact mobility status has on training outcomes. With that, this initial investigation compared a sample of individuals completing an ERT program post iSCI who used wheelchairs (WC) as their primary mode of traversing to those who were primarily ambulatory (WALK).

Methods

Eleven individuals post iSCI completed a 12 week ERT program twice per week. See Table 1 for group descriptive statistics. The ERT followed a previously described progressive protocol after a two-week familiarization [12] [13]. Participants trained twice per week, where sets and reps schemes mirrored those for strength on day one (2-6 sets, < 6 repetitions at > 85% one repetition maximum [RM]) and hypertrophy/endurance on day two (3-6 sets, 6-10 repetitions at 67-75% 1RM).

Investigators measured eccentric and isometric strength, daily step activity, walking speed, and mobility by way of the BTE Eccentron (BTETech, Hanover, MD), hand-held dynamometry (JTech Commander PowerTrack II, Midvale, UT), Modus Step Activity Monitor (Modus, Oklahoma City, Oklahoma), 10 Meter Walk Test, and Timed Up and Go, respectively. Collection of these data followed guidelines established in previously published works [12] [13]. Eccentric strength was assessed using a 3RM on the training ergometer and converted to a 1RM value for prescription. Isometric strength was a cumulative score representing performance on flexors and extensors at the knees, hips, and ankles when at joint angles of 90°. Performance on the 10 Meter Walk Test and Timed Up and Go followed standardized procedures. Data were converted into percent change scores from baseline assessments to post-assessments for the subsequent 1 way ANOVA analyses. These ANOVAs compared the percent change for each independent variable between WC and WALK groups.

Results

There were no differences in eccentric strength [$F(1,10) = 0.03$, $p > 0.05$], isometric strength [$F(1,10) = 0.79$, $p > 0.05$] improvement or daily step activity [$F(1,10) = 0.74$, $p > 0.05$] between groups (Figure 1). The magnitude of improvement for walking speed [$F(1,10) = 6.42$, $p = 0.032$] and mobility [$F(1,10) = 7.23$, $p = 0.025$] was greater in participants who primarily used wheelchairs when compared to daily ambulators, respectively (Figure 2).

Figure 1: Individual participant step data from pre- to post-test.

Table 1: Group descriptive statistics.

	Age (years)	Age of Injury (years)	Height (inches)	Mass (pounds)
Walkers (n = 4)	53.0 + 14.26	10.23 + 7.29	61.82 + 2.19	139.1 + 13.16
Wheelchair Users (n = 7)	31.14 + 10.74	9.17 + 3.25	67.71 + 6.07	183.17 + 54.41

Steps represent the number of steps taken by the less impaired limb. Part A represents the WALK group and B the WC group. Percent change for the WALK group averaged $40.13 \pm 58.46\%$ and WC group averaged $2859.48 \pm 6389.22\%$. Participant 5 and 10 averaged 0 and 4.5 steps per day at baseline, respectively.

Figure 2: Graphical representation of percent change data for independent study variables.

Conclusion

The purpose of this analysis was to determine the impact of mobility status on improvements observed following ERT of the lower extremities for individuals with gait impairments following iSCI. Results from this study indicate that the primary method of mobility did not determine the impact of training for measures of strength or daily step activity. This indicates that ERT provides resistance appropriate for training the lower extremities of both walkers and wheelchair users. In addition, it was observed that the improvements were demonstrated in isometric as well as eccentric measures of strength. Increases were also seen in the number of steps taken per day in the natural environment of the participants. The observed increases were similar in both ambulators as well as wheelchair users.

With regard to walking performance measures, specifically, walking speed and mobility, the impact of ERT of the lower extremities following iSCI was influenced by primary method of mobility. While both groups demonstrated improvements, those who used wheelchairs for mobility demonstrated significantly greater improvements than those who walked. This

may be related to the level of deconditioning of the lower extremities observed following iSCI. While wheelchairs greatly improve independence and users demonstrate similar metabolic demands to walking, they do not provide the opportunity to strengthen the lower extremities or facilitate neural adaptations to ameliorate the loss of muscle structure and function experienced post SCI [16]. Alterations in muscle physiology and metabolic function are secondary to the changes in muscle composition related to the denervation post SCI. Immediately following SCI muscle denervation, muscle cells experience conversions, favoring a transition from type I muscle fibers to Type II fibers [17]. This transition limits endurance, increases fatigability, and reduces exercise tolerance. These factors contribute to weakness beyond the degree of paralysis experienced as a result of neurological deficits [18]. The combined effect of these factors, results in deconditioning which can potentially be altered with eccentric exercise.

While this investigation explored the use ERT on those with iSCI, little is known regarding the effect of this training on gait impairments related to other conditions. Future research could explore the use of this technology on gait impairments associated with cerebral vascular accidents, head trauma, and cerebral palsy, as well as a variety of orthopedic and metabolic disorders.

Given the efficacy and the safety associated with implementing ERT for those with iSCI, it may be possible to improve the accessibility of this treatment option. The equipment is not complex, nor is it expensive to operate. Clients wishing to take advantage of this type of training can easily transfer and operate the equipment with little or no assistance, making it an option for gyms community centers and clinical facilities. If publicly available, it has the potential to be used across the life span for people with gait impairments working to improve lower extremity strength and function.

In summary, these analyses demonstrated that regardless of method of mobility, ERT is a safe and effective intervention for improving strength and mobility following iSCI. In addition, those with greater degrees of impairment may experience the greatest benefits in terms of walking speed and mobility.

References

1. National Spinal Cord Injury Statistical Center. Facts and figures at a glance. Birmingham, AL: University of Alabama at Birmingham; 2016.
2. Ollivier-Lanvin K, Lemay MA, Tessler A, Burns AS. Neuromuscular transmission failure and muscle fatigue in ankle muscles of the adult rat after spinal cord injury. *J Appl Physiol*. 2009;107(4):1190-1194. doi: <https://doi.org/10.1152/jappphysiol.00282.2009>
3. Riley DA, Burns AS, Carrion-Jones M, Dillingham TR. Electrophysiological dysfunction in the peripheral nervous system following spinal cord injury. *Am Acad Phys Med Rehabil*. 2011;3(5):419-425. doi: <https://doi.org/10.1016/j.pmrj.2010.12.021>
4. Migliorini C, Tonge B, Taleporos G. Spinal cord injury and mental health. *Aust NZ J Psychiatry*. 2008;42(4):309-314. doi: <https://doi.org/10.1080/00048670801886080>
5. Williams R, Murray A. Prevalence of depression after spinal cord injury: a meta-analysis. *Arch Phys Med Rehabil*. 2015;96(1):133-140. doi: <https://doi.org/10.1016/j.apmr.2014.08.016>
6. Brody DJ, Pratt LA, Hughes JP. Prevalence of depression among adults aged 20 and over: United States, 2013-2016. *NCHS Data Brief*. 2018;(303):1-8.
7. Martinsen EW. Physical activity in the prevention and treatment of anxiety and depression. *Nord J Psychiatry*. 2008;62(sup47):25-29. doi: <https://doi.org/10.1080/08039480802315640>
8. Wu P-L, Lee M, Huang T-T. Effectiveness of physical activity on patients with depression and Parkinson's disease: A systematic review. *PLOS ONE*. 2017;12(7):e0181515. doi: <https://doi.org/10.1371/journal.pone.0181515>
9. Latimer AE, Martin-Ginis KA, Hicks AL, McCartney N. An examination of the mechanisms of exercise-induced change in psychological well-being among people with spinal cord injury. *J Rehabil Res Dev*. 2004;41(5):643-652. doi: <https://doi.org/10.1682/JRRD.2003.04.0043>
10. Hicks AL, Martin KA, Ditor DS, et al. Long-term exercise training in persons with spinal cord injury: effects on strength, arm ergometry performance and psychological well-being. *Spinal Cord*. 2003;41(1):34-43. doi: <https://doi.org/10.1038/sj.sc.3101389>
11. Stone WJ, Stevens SL, Fuller DK, Caputo JL. Eccentric resistance training in adults with and without spinal cord injuries. *Int J Ex Sci*. 2017;10(1):154-165.
12. Stone WJ, Stevens SL, Fuller DK, Caputo JL. Ambulation and physical function after eccentric resistance training in adults with incomplete spinal cord injury: A feasibility study. *J Spinal Cord Med*. 2018;1-8. doi: <https://doi.org/10.1080/10790268.2017.1417804>
13. Stone WJ, Stevens SL, Fuller DK, Caputo JL. Strength and step activity after eccentric resistance training in those with incomplete spinal cord injuries. *Top Spinal Cord Inj Rehabil*. August 2018. doi: <https://doi.org/10.1310/sci17-00052>
14. Dibble LE, Hale TF, Marcus RL, Gerber JP, LaStayo PC. High intensity eccentric resistance training decreases bradykinesia and improves quality of life in persons with Parkinson's disease: A preliminary study. *Parkinsonism Rel Disord*. 2009;15(10):752-757. doi: <https://doi.org/10.1016/j.parkreldis.2009.04.009>
15. Dibble LE, Hale TF, Marcus RL, Droge J, Gerber JP, LaStayo PC. High-intensity resistance training amplifies muscle hypertrophy and functional gains in persons with Parkinson's disease. *Mov Disord*. 2006;21(9):1444-1452. doi: <https://doi.org/10.1002/mds.20997>
16. Taghi MK. The physiological benefits and problems associated with using standing and walking orthoses in individuals with spinal cord injury-a meta-analytic review. *J Orthop Trauma Rehabil*. 2012;16(1):37-40. doi: <https://doi.org/10.1016/j.jotr.2011.07.008>
17. Boncompagni S. Severe muscle atrophy due to spinal cord injury can be reversed in complete absence of peripheral nerves. *Eur J Transl Myol*. 2012;22(4):161-200. doi: <https://doi.org/10.4081/ejtm.2012.1799>
18. Jayaraman A, Gregory CM, Bowden M, et al. Lower extremity skeletal muscle function in persons with incomplete spinal cord injury. *Spinal Cord*. 2006;44(11):680-687. doi: <https://doi.org/10.1038/sj.sc.3101892>

Copyright: © **Stone et al.** This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.