Utilization of Whole-Body Vibration Intervention for Improving Mobility in Spinal Cord Injury

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Mini Review

Suffering a spinal cord injury (SCI) constitutes numerous neurologic, vascular and muscular problems below the level of injury. Neurologic problems can include sensation and motor impairments which can limit effective and efficient mobility and jeopardize safety. Vascular problems can include reductions in thigh blood flow, femoral artery diameter, vascular reactivity and capillary alterations [1]. Muscular problem alterations have included atrophy, particularly of type 2 fibers and eventually a shift from type 1 to type 2B [1]. These skeletal-muscle changes seemingly paralleling vascular reductions, over time, increase the risk of secondary clinical conditions such as pressure ulcers and cardiovascular disease [1]. Bone mineral density reductions and architecture due to lack of mechanical loading have been observed within 12 months post SCI [2]. Skeletal-muscle atrophy, bone density decreases and vascular insufficiencies, coupled with motor impairments can lead to subsequent mobility and gait problems.

Mobility interventions for SCI have included conventional physical therapy. The neurally intact muscle mass that remains for a person with SCI is generally the focus of acute and chronic rehabilitative techniques. While conventional physical therapy, such as electro-stimulation, passive and active assistant and resistive rehabilitation techniques have been featured in reducing dependency with a SCI, these therapies have not offered consistent and significant results in improving motor impairments or mobility and gait [3].

Whole body vibration (WBV) is an intervention which has a person seated or standing on a metal platform which vibrates at various amplitudes and frequencies. Vibration is transmitted to the feet by a typically 2’ by 2’ flat metal surface. Amplitudes of the WBV range from 1 to 6 mm displacement and frequencies range from 20-120 Hz [3].

WBV has generally demonstrated positive and beneficial skeletal-muscle and vascular changes in SCI [1,3,4]. Muscle strength increases for the lower extremities have been reported in single session application for motor incomplete SCI, likely due to enhanced neuromuscular circuit activation [5].

Increased skeletal muscle contraction may improve both blood flow and arterial diameter [1]. The ability to enhance muscle contraction could result in greater long term muscle mass which would increase metabolism. Increased metabolism has been demonstrated with higher oxygen consumption [1,6]. Bone density increases in the pelvis and lower extremities have also been documented [3,7].

Safe and effective mobility and gait can be facilitated by physiological enhancements such as increased muscle strength, bone density, and oxygen consumption. Decreased neuromuscular spasticity, which could facilitate greater gait control, has also been demonstrated through the use of WBV [8,9]. Only one investigation has shown gait to improve in SCI, with incomplete transection [10]. However, this study did not measure or associate physiological measures with gait improvements. Thus, mechanisms and explanations for increased cadence, speed and overall gait function were unclear.

The physical benefits highlighted have been reported in both animal and human models. Eliciting positive physical changes through WBV occurred through manipulation of vibration intensity, frequency, and duration. It is not clear what combination of platform amplitude displacement, frequency, duration in minutes of intensity and duration per intervention session are needed to capture the physiological benefits of WBV. How many intervention sessions per week and the length of the inventions in weeks, are also in question concerning the amount of WBV needed to deliver an optimal physiological benefit. These WBV intervention variables need to be considered for efficacy and safety whether the SCI is acute, subacute or chronic. Other physical considerations needing review before determining effective and safe WBV workloads.
include age, health and fitness status, and cardiopulmonary risk factors.

Most animal and human investigations on WBV in SCI thus far have shown that higher frequencies over 30 Hz and amplitude-displacement of 2 mm or more have exhibited the best results regardless of variable measured [11-15]. Human studies have shown WBV to be economical and convenient compared to more costly and/or more cumbersome techniques of eliciting positive physical changes in SCI [3,16].

WBV mechanisms and explanations at the spinal cord level could be made clearer by imaging techniques [17]. Reliability issues have plagued investigations with high resolution such as with the 5 Tesla. The 5 Tesla in prior experiences, has not demonstrated consistent images over time at the lesion regardless of posture and positioning. DWI may offer the most accurate way to learn what occurs at the lesion site when an intervention such as WBV is applied, both acutely and chronically [17]. Whether neurogenesis occurs in the injured spinal cord could also be gleaned.

There appears to be sufficient evidence to suggest that WBV has potential to augment mobility and gait in persons with SCI. Determining the mechanisms that improve mobility and gait could increase the efficiency and effectiveness of WBV for different SCI populations. These findings could predict outcomes and whether WBV would be applicable for SCI in some cases.

References
1. Herrero AJ, Menendez H, Gil I, Martin J, Martin T, et al. (2011) Effects of whole-body vibration on blood flow and neuromuscular activity in spinal cord injury. Spinal Cord 49(4): 554-559.
2. Masani K, Alizadeh-Meghrazi M, Sayenko DG, Zariffa J, Moore C, et al. (2014) Muscle activity, cross sectional area, and density following passive standing and whole body vibration: A case series. Journal of Spinal Cord Med 37(5): 575-581.
3. Alizadeh-Meghrazi M, Masani K, Popovic MR, Craven BC (2012) Whole-body vibration during passive standing in individuals with spinal cord injury: Effects of plate choice, frequency, amplitude, and subject's posture on vibration propagation. Physical Medicine & Rehabil 4(12): 963-975.
4. Menendez H, Ferrero C, Martin-Hernandez J, Figueroa A, Marin PJ, et al. (2015) Acute effects of simultaneous electromyostimulation and vibration on leg blood flow in spinal cord injury. Spinal Cord 54(5): 383-389.
5. Bosweld R, Field-Fote EC (2015) Single-dose effects of whole body vibration on quadriceps strength in individuals with motor-incomplete spinal cord injury. J Spinal Cord Med 38(6): 784-791.
6. Birk TJ, Thornton W, Sheridan B (2013) Acute effects of whole body vibration on static and dynamic heel-rise in C5 incomplete spinal cord injury: A case report.
7. Davis R, Sanborn C, Nichols D, Bazett-Jones DM, Dugan EL (2010) The effects of whole body vibration on bone mineral density for a person with a spinal cord: a case study. Adapt Phys Act 9(1): 60-72.
8. Ness LL, Field-Fote EC (2009) Effect of whole-body vibration on quadriceps spasticity in individuals with spastic hypertonia due to spinal cord injury. Restor Neurol Neurosci 27(6): 621-361.
9. Sayenko DG, Masani K, Alizadeh-Meghrazi M, Popovic MR, Craven BC (2010) Acute effects of whole body vibration during passive standing on soleus H-reflex in subjects with and without spinal cord injury. Neuroscience Letters 482(1): 66-70.
10. Ness LL, Field-Fote EC (2009) Whole-body vibration improves walking function in individuals with spinal cord injury: a pilot study. Gait Posture 30(4): 436-440.
11. Wirth F, Schempf G, Stein G, Wellmann K, Manthou M, et al. (2013) Whole-body vibration improves functional recovery in spinal cord injured rats. J Neurotrauma 30(6): 453-468.
12. Manthou M, Nohmudi K, Moscarino S, Rehberg F, Stein G, et al. (2015) Functional recovery after experimental spinal cord compression and whole body vibration therapy requires a balanced revascularization of the injured site. Restor Neurol Neurosci 33(2): 233-249.
13. Schwarz A, Pick C, Harrach R, Stein G, Bendella H, et al. (2015) Reactions of the rat musculoskeletal system to compressive spinal cord injury (SCI) and whole body vibration (WBV) therapy. J Musculoskelet Neuronal Interact 15(2): 123-136.
14. Alizadeh-Meghrazi M, Masani K, Zariffa J, Sayenko DG, Popovic MR, et al. (2014) Effect of whole-body vibration on lower-limb EMG activity in subjects with and without spinal cord injury. The Journal of Spinal Cord Med 37(5): 525-536.
15. Yarar-Fisher C, Pascoe DD, Glidden LB, Quintry JC, Hudson J, et al. (2014) Acute physiological effects of whole body vibration (WBV) on central hemodynamics, muscle oxygenation and oxygen consumption in individuals with chronic spinal cord injury. Disabil Rehabil 36(2): 136-145.
16. Hadl SC, Delporte J, Hitzig SL, Craven BC (2012) Subjective experiences of men with and without spinal cord injury: Tolerability of the Juvant and WAVÉ whole body vibration plates. Physical Medicine & Rehabil 4: 954-962.
17. Skinner NP, Kurpad SN, Schmit BD, Burde MD (2015) Detection of acute nervous system injury with advanced diffusion-weighted MRI: a simulation and sensitivity analysis. NMR Biomed 28(11): 1489-1506.