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Mini Review

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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 range of motion, 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].

Significant ill effects from WBV have not been reported. But regardless of central nervous system (CNS) and/or peripheral nervous system (PNS) deficits, headaches, dizziness and nausea have been reported especially when standing with weight bearing heels on the platform at higher amplitudes [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, subcute 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.

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