EFFECTS OF SEATED WHOLE-BODY VIBRATION ON SPINAL STABILITY CONTROL: STIFFNESS & REFLEX

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INTRODUCTION

Whole-body vibration (WBV) is a risk factor for low back disorders, but the neuromuscular, biomechanical, and/or physiological mechanisms responsible for this increased risk are unclear. The neuromusculoskeletal system that contributes to the control of spinal stability can be thought of as three subsystems: passive tissue stiffness, active muscular stiffness, and neuromuscular reflexes [1]. The purpose of this study was to measure the effect of seated whole-body vibration on these subsystems. By understanding the changes in these subsystems of spinal stability control simultaneously, the results can elucidate the link between WBV and LBDs.

METHODS

Twenty healthy subjects (10 males, 10 females, age 24.8±6.2 years, height 171.5±8.8 cm, mass 69.0±10.6 kg) provided informed consent and completed two experimental sessions approved by the Virginia Tech Institutional Review Board. Both sessions involved exposure to a series of pseudorandom force perturbations to flex the trunk (Figure 1a) before and after an intervention. The intervention for one session involved exposure to seated WBV (2–20 Hz bandwidth and 1.15 m/s² root-mean-squared amplitude) for 30 minutes (Figure 1b). The intervention for the other session involved quiet sitting (QS) for 30 minutes.

During force perturbations, data was sampled from a torque cell measuring the force of the perturbations, a digital encoder on the motor monitoring displacement, and bilateral pairs of electrodes on the erector spinae (ES) and the rectus abdominus (RA) muscles. These data were used with system identification techniques to quantify total trunk stiffness, ES reflex delay and gain, and RA activity (to assess co-contraction involvement) [2]. A two-way repeated measures ANOVA was used to investigate the effect of time (before an after intervention) and intervention (WBV and QS) on trunk stiffness, muscle reflex gain and delay, and muscle co-contraction.

RESULTS and DISCUSSION

Exposure to 30 minutes of seated WBV decreased trunk stiffness by 12.5±15.4% (P=0.005, Figure 2a), did not affect RA activity (P=0.983, Figure 2b), decreased reflex gain by 11.5±26.6% (P=0.033, Figure 2c), and did not affect reflex delay (P=0.999, Figure 2d). Exposure to 30 minutes of QS resulted in no significant changes in measures of trunk stiffness (P=0.776), RA activity (P=0.112), reflex gain (P=0.596), or reflex delay (P=0.617).

The results of this study found that 30 minutes of WBV exposure reduced trunk stiffness and reflex gain, suggesting that spinal stability control was impaired. The measured reduction in total trunk stiffness incorporated the combined effects of passive stiffness, active stiffness, and reflexes. Active stiffness is controlled through co-contraction of the trunk muscles, and was monitored by the activity of the RA muscles which were unchanged with WBV exposure. This indicates that co-contraction (and therefore active stiffness) was not affected by WBV and did not contribute to the reduction in total trunk stiffness. Reflex gain decreased after both interventions, but was not significant within either WBV or QS. This indicates that a decrease in reflex gain did not...
contribute significantly to the decrease in total stiffness with WBV. These results also suggest that the decrease in trunk stiffness was due, at least in part, to a decrease in passive stiffness. The passive tissues, such as intervertebral discs and paraspinal ligamentous tissues, may have experienced creep deformation with WBV, which can result in reduced stiffness [1]. This leads to the conclusion that the decrease in total trunk stiffness with seated WBV was due to the combination of reduced passive stiffness (due to vibration) and reduced muscle reflexes (due to sitting).

Two possibilities that can explain the changes in muscle utilization in stabilizing the spine are muscular fatigue or changes in the sensory information used in feedback control. It has been shown that seated WBV can cause fatigue in muscles [3], however, the findings of the current study showed no significant changes to muscle reflex delay, a common effect of fatigue, which may suggest that the muscles were not fatigued. While there were no significant changes to muscle reflex delay, the gain of the muscle reflex response was reduced after WBV exposure. This is likely a result of changes in the sensory organs which elicit muscle reflexes becoming impaired with WBV exposure. Consistent with this, changes in the system of proprioception were used to explain an increase in maximum torso flexion angle in response to sudden loadings [4]. This result was coupled with the analysis that the position sense error of the torso increased 1.58 fold after 5 Hz WBV exposure. Disruption of the proprioceptive system can create errors is position, velocity, and force control and is attributed to changes in muscle reflex behavior.

**CONCLUSIONS**

In conclusion, 30 minutes of seated WBV reduced the stiffness of the trunk and decreased reflex gain without compensation from increased reflex gain or co-contraction recruitment. These effects can impair spinal stability and increase the risk of a low back injury. By understanding the effects of WBV on the subsystems of spinal stability control, this information can contribute to the development of interventions to help prevent LBDs.

**REFERENCES**


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