REGIONAL CEREBRAL OXYGENATION AND BLOOD VOLUME RESPONSES IN HEALTHY WOMEN DURING SEATED WHOLE-BODY VIBRATION (WBV)

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Introduction

Landstrom et al. (1985) suggested the possibility of cortical activation during exposure to WBV, however, it is not known how cerebral physiology (oxygenation and blood volume) responds in healthy women during different vibration frequencies. This study examined the role of backrest support and handgrip work on cerebral oxygenation and blood volume responses, during exposure to seated WBV.

Methods

Fourteen women (age: 23.9 ± 3.5 years) were randomly exposed to three frequencies of WBV (3, 4.5 and 6 Hz at approximately $0.9g_{r.m.s}$ in the vertical direction) on a customized vibrating base (Advanced Therapy Products, Inc., USA) in a seated posture on three separate days. On the first day, the subjects completed an aerobic fitness test until volitional exhaustion on an arm cranking ergometer (Cybex, MET 300, USA).

Each WBV session lasted 30 min (6 min baseline without WBV, 8 min WBV 'with' or 'without' backrest support, and 4 min recovery from WBV, 8 min WBV with 'opposite' backrest condition, and 4 min recovery following WBV). During 8 min WBV exposure 'with' and 'without' backrest support, subjects performed maximal voluntary rhythmic handgrip contractions with their right hand for 1 min using a dynamometer. To obtain regional oxygenation and blood volume responses, a NIRS sensor (MicroRunman, NIM, Inc., PA, USA) was placed on the anterior right frontal lobe just below the hair and close to fronto-temporalis region (Maikala et al. 2005).

Results

Baseline oxygenation and blood volume values were recorded during recovery from each WBV session of 'with' and 'without' backrest support. The physiological change in oxygenation and blood volume during each frequency (3, 4.5, and 6 Hz) for both *backrest* ('with' and 'without' a backrest) and *workload* (WBV only and WBV combined with rhythmic handgrip contractions) was calculated as the difference between the maximum values identified for each WBV condition of *backrest* and *workload* and baseline values (Maikala et al. 2005).

Three-way analysis of covariance with repeated measures (*frequency, backrest, and workload*) with a fully crossed design was used to evaluate the differences in the oxygenation and blood volume responses (measured in optical density [od] units). Peak oxygen uptake during arm cranking was treated as the covariate. No three- or two-way interactions were significant ($P>0.05$). Only the main effects: *frequency* and *workload* reached statistical significance ($P<0.05$). Significant differences were observed in the oxygenation change between 3 and 6 Hz (0.0003 ± 0.04 od *versus* 0.065 ± 0.09 od, P=0.022), but not between 3 and 4.5 Hz (0.030 ± 0.06 od, P=0.102) and 4.5 and 6 Hz (P=0.206). Corresponding comparisons for the blood volume changes were significant: between 3 and 4.5 Hz (0.017 od ± 0.12 *versus* 0.07 ± 0.06 od, P=0.008) and 3 and 6 Hz (0.100 ± 0.09 od, P=0.004), but not between 4.5 and 6 Hz (P=0.247). Physiological changes were similar 'with' and 'without' backrest support (oxygenation: 0.031 ± 0.07 od *versus* 0.030 ± 0.07 od, P=0.79; blood volume: 0.063 ± 0.07 od *versus* 0.062 ± 0.12 od, P=0.80). Compared to WBV only condition, changes were higher during rhythmic handgrip contractions (oxygenation: 0.020 ± 0.07 od versus 0.042 ± 0.07 od, P=0.000; blood volume: (0.048 ± 0.06 od versus 0.078 ± 0.12 od, P=0.015)). Subjects' aerobic fitness influenced the oxygenation and blood volume responses during WBV ($P<0.05$).

Discussion

Compared to sitting without WBV, cerebral region showed increase in both oxygenation and blood volume responses at each frequency of WBV, implying an increase in neuronal activity due to WBV. Highest oxygenation and blood volume responses were observed during exposure to 6 Hz, suggesting women respond differently compared to men between the frequencies of 3 and 6 Hz (Maikala et al. 2005). An increase in response during handgrip contractions suggest that exposure to WBV in combination with physical activity might lead to much greater increase in cerebral activity due to functional motor stimulation. During vibration, Weinstein et al. (1988) suggested an increase in axonal transport due to direct stimulation of the brain, similar to the mechanism occurring during peripheral nerve injury, and the current evidence from exposure to WBV in different experimental conditions suggest that, increased neuronal activity subsequently results in increased perfusion to the pre-frontal cortex.

References

Landstrom, U., and Lundstrom, R. (1985). Changes in wakefulness during exposure to whole-body vibration. Electroencephalogr Clin Neurophysiol 61, 411-415.

Maikala, R.V., King, S., and Bhambhani, Y.N. (2005). Regional Cerebral oxygenation and blood volume responses to seated whole-body vibration. Eur J Appl Physiol. 95, 447-453.

Weinstein J., Pope M., Schmidt R., and Seroussi, R. (1988). Neuropharmacologic effects of vibration on the dorsal root ganglion – An Animal Model. *S*pine 13, 521-525.