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Neuromuscular and Hormonal Effects of a Single Session of Whole Body Vibration

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Significant alterations in musculo-skeletal structures, predominantly a reduction in muscle and bone mass, occur following prolonged exposure to microgravity. Recent evidence suggests that mechanical vibrations applied to the body can produce changes in the gravitational conditions (Bosco et al, 1999c) and these have recently been reported to induce physiological adaptations similar to those occurring after a period of resistance or explosive power training (Bosco et al, 1998; 1999; 2000; Cardinale and Bosco, 2003). Vibration exercise then, may be an alternative to heavy resistance training for stimulating musculo-skeletal structures; and may represent an effective countermeasure against the adverse physiological effects experienced during spaceflight. The purpose of the present study was to therefore compare the neuromuscular and hormonal responses following a single session of isometric half-squat exercise with and without the superimposition of whole body vibrations (WBV).

With ethical approval, seven healthy male subjects aged between 19 and 26 years voluntarily participated in this study. They performed ten sets of one min isometric exercise in the half-squat position followed by one min rest. This was conducted on two separate occasions with vertical sinusoidal WBV (frequency 30 Hz; magnitude 3.5 G) or no vibration (Control) applied using a randomised cross-over design. Maximal isometric unilateral knee extensions were performed before and immediately following the treatment (WBV or Control). A doublet was superimposed when the subjects reached their MVC via percutaneous electrical stimulation (50 µs square wave pulses). Maximum isometric torque-generating capacity (MVC), rate of torque development in the first 200 ms (RTD_{200ms}) and voluntary activation were used as measures of performance in repeated trials. Voluntary activation was derived from the following formula: voluntary activation = 100(1-interpolated twitch/control twitch in a relaxed muscle) (Gandevia, 2001). Saliva samples were collected both before and immediately following the treatment, and analysed for testosterone (T) and cortisol (C) concentrations.

Statistically significant decreases in MVC were observed following both WBV and Control ($p < 0.05$). The magnitudes of these reductions in MVC were similar, being 9 % and 8 % for WBV and Control respectively. There was no statistically significant difference ($p > 0.05$) in RTD_{200ms} either between treatments (WBV vs Control) or across time (Pre vs Post). However following WBV only, RFD_{200ms} tended to be lower post-WBV (889.5 Nm/s vs 825.1 Nm/s; $p = 0.06$). Voluntary activation was unaffected following both WBV and Control. There was also no statistically significant difference ($p > 0.05$) in salivary T and C concentrations. However, T concentration tended to be lower following exposure to WBV only (1040.2 pmol/l vs 866.9 pmol/l; $p = 0.08$).

The observed neuromuscular and hormonal impairments demonstrate that both treatments represented a stressful stimulus to the subjects. The exact mechanism(s) of the observed neuromuscular fatigue, demonstrated by the reduction in MVC and RTD_{200ms} in the case of WBV, remain to be elucidated; but may reside at a central and/or peripheral level being multifactorial in nature. It has been suggested impaired performance may be associated with vibration-induced reduction in Ia afferent function (Turner and Jackson, 2003).

According to the General Adaptation Syndrome (G.A.S.; Selye, 1936), a training session of adequate volume and intensity will induce a transient reduction in performance followed by a period of recovery and subsequent supercompensation. Therefore the observed neuromuscular and hormonal responses are in accordance with the initial phase of the G.A.S. This suggests that WBV is a strong stimulus for the neuromuscular system and one that can induce similar adaptive responses to those previously observed with resistance exercise (re the work of Kraemer).