ACUTE EFFECTS OF WHOLE-BODY VIBRATION ON ELASTIC CHARGE TIME IN TRAINED MALE ATHLETES

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Whole-body vibration (WBV) has been shown to increase jump height, power and strength but the mechanisms behind these changes are not fully understood. The aim of this study was to investigate the influence of WBV on elastic charge time, a surrogate measure of tendon and aponeurosis stiffness. 7 trained males were exposed to 10 vibrations at 30 Hz ± 4 mm with 60 seconds rest between each exposure. Pre and post-tests were conducted immediately, 5, 10, 15, 20, 30 and 40 minutes following vibration exposure. A significant increase in elastic charge times of both vibrated (p=0.004) and control (p=0.024) limbs suggest whole-body vibration decreases tendon and aponeurosis stiffness, possibly due to a warm-up effect of the lower limbs. Further study of the muscle stiffness response to vibration will improve understanding of the mechanisms behind performance improvements following vibration exposure.

KEYWORDS: electromechanical delay, tendon, aponeurosis, performance enhancement

INTRODUCTION: Whole-body vibration (WBV) is a novel training modality involving vibration of the body on a surface vibrating at a frequency between 20-50 Hz. It has gained popularity in recent years, due to reported acute and long-term improvements in performance. WBV has been shown to improve knee extensor strength and torque (Delecluse et al., 2003; Jacobs and Burns, 2009), jump height (Bosco et al., 1999; Cormie et al., 2006), acceleration, step length, step rate (Paradisis and Zacharogiannis, 2007) and power output during the back squat (Rhea and Kenn, 2009). The mechanisms explaining improvements following vibration exposure are not yet fully understood. The main neuromuscular mechanism stimulated is the tonic vibration reflex, which is a tonic contraction of the muscles as a result of sensitivity of the primary muscle spindle endings to stretch (Griffin, 1990). It is logical to assume however, that WBV also influences other musculoskeletal structures, such as tendon and aponeurosis. Improvements following WBV are particularly evident in outcome variables involving a stretch-shortening cycle (SSC), which has been shown to be related to muscle and tendon stiffness prior to the concentric phase of movement (Anderson, 1996). To date, the influence of WBV on these variables is unknown. Winter and Brookes (1990) proposed the stiffness of the musculotendinous structures can be estimated by determining electromechanical delay (EMD) in a simple heel raise movement. EMD is further subdivided into force development time (FDT), which represents the delay between muscle activation and force registration and elastic charge time (ECT) which describes the delay between the first registration of force and movement of the heel. ECT has therefore been proposed as a surrogate measure of tendon and aponeurosis stiffness (Winter and Brookes, 1991). There is a need to establish whether WBV produces acute changes in ECT of the triceps surae as it may explain more about the mechanism by which WBV affects performance in SSC activities. The purpose of this study was to improve understanding of the structures influenced by WBV. The aim of this study was to determine the acute effects of WBV on ECT in trained male athletes, as a possible mechanism for enhanced performance seen following vibration exposure.

METHODS: Data collection: Following university ethics committee approval, 7 trained males (mean ± SD: age: 22.1 ± 1.4 years; height: 1.84 ± 0.06 m; mass: 87.0 ± 7.5 kg) volunteered as subjects for this study. All competed at an elite/sub-elite level in their sport (sprinting=1, rugby=1, boxing=1, Gaelic football=2, hurling=2) and were injury free for at least 6 weeks prior to testing. Subjects completed a Physical Activity Readiness Questionnaire and signed an informed consent form prior to participation. None had previously used WBV as a regular training modality. ECT was determined using an adapted electromechanical delay technique (Winter and Brookes, 1991). Subjects sat on a plastic chair with the knee flexed at a 90° angle. The ball of the foot rested on a force plate (AMTI Technologies Inc., USA) sampling at 1000 Hz and the heel rested on a footswitch. The fixed position of the footswitch ensured the subject consistently placed their foot on the same place on the forceplate. A 3 cm x 6 cm piece of Perspex was taped to the heel to eliminate error from soft tissue movement over calcaneus. Following shaving and preparation of the skin with alcohol wipes (PDI Alcohol Prep Pads, Professional Disposables Inc., USA) two electrodes (Kendall Meditrace 100, Kendall Medical Supplies, USA) were placed on distal soleus, 2 cm apart at a point ⅔ of the distance between the lateral femoral condyle and lateral malleolus. EMG was recorded at 1000 Hz using a Powerlab system (ADI Instruments Powerlab 4/25T). After a '3, 2, 1' countdown, subjects were instructed to raise the heel as fast as possible.

A contra-limb control leg design was used, with the preferred kicking leg being exposed to vibration. Control and vibrated leg performed 5 heel lifts each immediately prior to vibration exposure. Subjects were exposed to 10 vibrations at 30 Hz ± 4 mm with 60 seconds rest between each exposure using a Vibrogym platform (Vibrogym Inc., Haarlem, The Netherlands) located beside the force plate. The knee of the vibrated leg was flexed to 110° and the knee of the control leg was flexed so it did not touch the vibration plate. Markings on the vibration plate ensured consistent foot placement. All vibrations were completed barefoot to remove confounding from footwear or socks. A post-test was conducted immediately after vibration exposure. Post-tests were also completed 5, 10, 15, 20, 30 and 40 minutes post-exposure and involved the vibrated and control leg performing 5 heel lifts each.

The instant of foot plantar flexion force was detected from force platform records and heel movement was detected by the footswitch. ECT was defined as the time interval between the registration of force on the force platform and initial movement of the heel and was determined by visual inspection of graphs in Microsoft Excel 2007 (Microsoft Inc., USA).

Data analysis: All statistical analysis was carried out in SPSS (Version 17, SPSS Inc., USA). A Shapiro-Wilk's test was used to check normality of data sets. ANOVA with repeated measures was used to determine if significant differences existed between pre-vibration ECT and maximum and minimum ECT post-vibration. Alpha was set at $p <0.05$.

RESULTS: All data satisfied the Shapiro-Wilk test for normality ($p>0.05$) with the exception of the control limb measures at 40 minutes ($p =0.025$). Figure 1 presents the results of the effects of WBV on ECT times in trained males in both the vibrated and control leg.

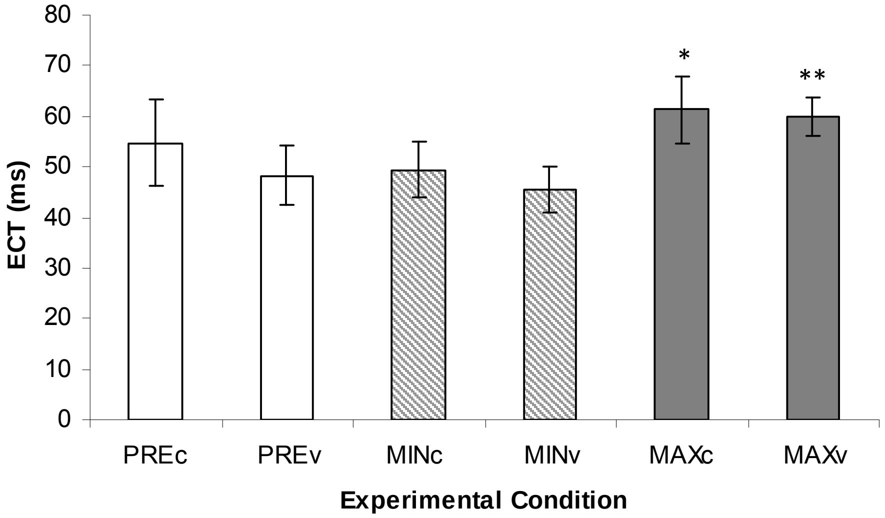

Figure 1: ECT in trained males in both the control and vibrated limb. ** indicates a significant difference compared with pre-test scores ($p < 0.01$); * indicates a significant difference compared with pre-test scores ($p < 0.05$)

DISCUSSION: The results of this experiment showed that following WBV, ECT increased significantly compared with pre-test ECT of both control (p=0.024) and vibrated (p=0.004) limbs. Increased ECT is thought to be indicative of decreased tendon and aponeurosis stiffness following vibration compared to ECT measures prior to vibration exposure, although it should be pointed out that ECT does not provide a direct measure of tendon stiffness and this limitation should be recognised. This provides a further explanation for the mechanisms behind performance improvements observed following WBV. Cochrane et al. (2008) reported an increase in muscle temperature and power output following WBV, suggesting a possible warm-up effect on the musculotendinous structures of the lower limbs which subsequently enhances performance. The warming effect of the test protocol was not measured in this study, but during vibration the subjects involved commented on feelings of increased warmth in the vibrated limb. Sweating was also observed, which suggests the protocol used here may have induced a warm-up effect on the vibrated limb. Due to the systemic nature of the body, this may also explain why a similar decrease in stiffness was seen in the control limb. The violation of the assumption of normality in data related to the control limb 40 minutes following vibration was considered trivial due to the robust nature of the statistical test used, and was not considered to influence overall study results.

CONCLUSIONS: The results of this study suggest WBV decreases tendon and aponeurosis stiffness in trained male athletes, possibly due to a warm-up effect. This may explain, in part, improvements in performance following WBV. Direct measurement of the tendon stiffness response and study of the muscle stiffness response to WBV will further enhance understanding of the mechanisms explaining performance improvements seen following WBV.

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