The effects of whole-body vibration on upper- and lower-body EMG during static and dynamic contractions

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Abstract: Whole-body vibration (WBV) training uses a vertically oscillating platform and reports suggest that this perturbation elicits reflexive muscle contractions that augment muscle activity and contribute to increased strength. No WBV study has measured both upper- and lower-body muscle activation. The purpose of this study was to determine the optimal WBV stimulus (frequency x amplitude) to increase electromyography (EMG) in upper- and lower-body muscles for three distinctive unloaded actions: isometric semi-squat, dynamic leg squats, and static and dynamic bilateral bicep curls. Surface EMG was measured for the vastus lateralis (VL), biceps femoris (BF), biceps brachii (BB), and triceps brachii (TB) in 10 recreationally active male university students (24.4 ± 2.0 years; mean ± SD) when WBV was administered at 2 and 4 mm and at 25, 30, 35, 40, and 45 Hz. EMG changes are reported as the difference between WBV and no WBV EMG root mean square expressed as a percentage of maximum voluntary exertion (%MVE). In static semi-squat, WBV increased muscle activity 2.9%-6.7% in the VL and 0.8%-1.2% in the BF. During dynamic squatting, WBV increased muscle activity in the VL by 3.7%-8.7% and in the BF by 0.4%-2.0%. In a static biceps curl, WBV had no effect on BB EMG, but did increase TB activity 0.3%-0.7%. During dynamic biceps curls, WBV increased BB EMG activity by 0.6%-0.8% and TB activity by 0.2%-1.0%. The higher WBV amplitude (4 mm) and frequencies (35, 40, 45 Hz) resulted in the greatest increases in EMG activity.

Key words: vibration training, frequency, amplitude, EMG, whole-body vibration.

Introduction

Whole-body vibration (WBV) training without the addition of an external load for repeated exposures has been reported to result in improvements in muscle strength.
(Delecluse et al. 2003; Roelants et al. 2004a, 2004b; Torvinen et al. 2002b; Verschueren et al. 2004) and muscle power (Delecluse et al. 2003; Roelants et al. 2004b; Torvinen et al. 2002b, 2003). However, several WBV studies have also reported no beneficial adaptation subsequent to repeated WBV exposures (Cochrane et al. 2004; Delecluse et al. 2005; de Ruiter et al. 2003b; Kvorning et al. 2006). Similar to the longer-duration exposure studies, acute unloaded WBV investigations are also equivocal, whereby some studies report increases in muscle strength and power (Bosco et al. 1999b; Cochrane and Stannard 2005; Cormie et al. 2006; Torvinen et al. 2002a), yet others have conferred no benefit to performance (de Ruiter et al. 2003a; Torvinen et al. 2002c). These inconsistencies in the literature may be due to differences in the amplitude and frequency settings used to induce the WBV stimulus. The WBV stimulus is generated by a vertically oscillating platform based on one of two designs: reciprocating displacements (i) on both sides of a fulcrum (teeter totter) or (ii) uniformly up and down. The stimulus is characterized by a frequency, the number of deflections per second (Hz), and by an amplitude, the actual millimetres of vibration deflection (Griffin 1996). The combination of frequency and amplitude of vibration determines the intensity of the stimulus placed on the neuromuscular system (Mester et al. 2002). To date, WBV stimuli have utilized frequencies ranging from 15–50 Hz (Cardinale and Lim 2003; Torvinen et al. 2002a) and amplitudes varying from 1–105 mm (Delecluse et al. 2005; Rittweger et al. 2000).

Increases in muscle performance are theorized to be the result of WBV eliciting involuntary reflex contractions (Mester et al. 1999) via the tonic vibration reflex (TVR) (Hagbarth and Eklund 1966; Burke et al. 1976). The TVR is a spinal reflex responding from changes in muscle length caused by the frequency and (or) amplitude displacements generated by the WBV platform. These reflexive contractions might augment voluntary skeletal muscle activation, which has been reported to result in an increase in muscle performance (Cardinale and Lim 2003; Roelants et al. 2006).

To indirectly examine the effects of WBV, electromyography (EMG) has been used to examine changes in neuromuscular activity (Griffin 1996). In isometrically active lower-body muscle groups, Cardinale and Lim (2003) used a reciprocating displacement stimulus to examine a static half squat (knee angle 100°) and measured the EMG activity in the vastus lateralis muscle during a 1 min vibration session and reported a 34% increase in EMG root mean square (RMS) to a 30 Hz, 10 mm signal. A recent study by Roelants et al. (2006) used a vertical stimulus to examine the effect of a 20 s exposure of a 35 Hz, 2.5 mm vibration stimulus for 3 static positions (high squat, low squat, and one-legged squat). The knee angle during the high squat and one-legged squat was 125° and was 90° during the low squat. Muscle activity was measured from the rectus femoris, vastus medialis, vastus lateralis, and gastrocnemius muscles. The results of this study demonstrated that WBV led to significant increases in EMG RMS in all muscles during all positions. During the high squat, WBV resulted in increases between 92.5% and 301% when compared with the control condition. In the low squat position, WBV increased muscle activity in the range of 49%–134% compared with control, and increases of 115%–360% during the one-legged squat. While being exposed to the whole-body vibration stimulus, the leg muscles measured were activated between 12.6% and 82.4% of their maximal activation.

Collectively, the lower-body skeletal muscle EMG data during WBV suggest increases in muscle activity compared with no WBV; however, there is no data on the influence of WBV on upper-limb muscle EMG activity and there is no consensus on the optimal WBV frequency and (or) amplitude to apply. Determining the optimal combination of frequency and amplitude to be used with static and dynamic movements will aid in understanding the effect of WBV on muscle performance and inevitably contribute to the design of WBV training protocols. Furthermore, there is no indication of the effect that WBV has on EMG activity during standard unloaded dynamic movements of upper- or lower-body skeletal muscles. The objectives of this investigation were to assess which frequency and (or) amplitude combination results in the maximal skeletal muscle EMG activity of lower- and upper-body skeletal muscles during static and dynamic muscle contractions.

Materials and methods

Ten recreationally active male university students (age, 24.4 ± 2.0 years; height, 177 ± 7.3 cm; mass, 81.47 ± 11.6 kg) having passed a PAR-Q health survey and having no contraindications to WBV according to the manufacturer’s criteria (i.e., diabetes, epilepsy, gallstones, kidney stones, acute inflammations, joint problems, cardiovascular diseases, joint implants, recent thrombosis, back problems such as hernia, tumors, recent operative wounds, or intense migraines) were recruited as participants. This study was approved by the University of Windsor Human Research Ethics Board and subjects gave their informed written consent prior to participation.

Prior to the experimental protocol subjects underwent a familiarization session to acclimate to the sensation of WBV. This session consisted of standing with feet shoulder width apart on the vibration platform in a comfortable static semi-squat (~120°) with their arms flexed (~90°). Subjects were given a demonstration of proper technique for the squat position and were allowed to practice until they performed the squats correctly and verbal instruction was provided to complete the squats at a constant pace of 1 s down and 1 s up. Placement of surface EMG electrodes on the vastus lateralis (VL), biceps femoris (BF), biceps brachii (BB), and triceps brachi (TB), as well as the goniometer (joint angle) on the knee, was demonstrated. These muscles were selected because they are primary agonist and (or) antagonist muscles for the dynamic squat and bicep curl. Joint angle measurements were collected with a goniometer to ensure subjects maintained the required position; joint angles were not used in the analytical measurements. However, subjects were provided verbal feedback for the joint position throughout the protocol and movement position was self-corrected. Generally, subjects were consistent in maintaining the required joint angle.

The vibration stimulus of the platform used in this study consisted of uniform vertical oscillations (WAVE™, Can-
ada) During both testing sessions (separated by one week) subjects were randomly exposed to 10 WBV conditions comprising five frequencies, 25, 30, 35, 40, and 45 Hz, and two amplitudes, 2 and 4 mm deflection. All experimental conditions were 45 s in length and started with the subject in a comfortable static semi-squat position or squatting dynamically on the platform for 15 s with no WBV, followed by 30 s with WBV. A 5 min rest period between conditions was used to eliminate any potential fatigue and subjects were blinded to the WBV frequency and amplitude. Platform foot position was marked on the first trial of each experimental session and subjects were required to maintain that foot position for all trials.

**Experimental session no. 1: lower body**

In the lower-body session, subjects performed an EMG noise trial to determine the amount of baseline interference in the spectrum. Subjects were then asked to perform maximal voluntary exertion (MVE) tests for the muscle groups being evaluated. All MVEs were isometric and were performed three times against resistance provided by a nylon strap attached to an immovable object for the leg muscles and against resistance provided by the investigator for the upper body muscles. During all MVE tests joint angles were kept constant at 90°. The peak EMG muscle activity obtained from the 3 trials was used to normalize all data. The MVE trials obtained a maximal EMG profile rather than force output measures; dynamometers were not available for all muscles studied. Subjects first completed all 10 WBV conditions in the static semi-squat position (knee angle 120° ± 10°), followed by dynamic squatting for all WBV conditions (frequency and amplitude combinations).

**Experimental session no. 2: upper body**

The upper-body sessions followed the same protocol as the lower-body sessions, with subjects first performing a noise trial, followed by MVE tests for all muscle groups being evaluated. Subjects then performed all 10 WBV conditions while maintaining an elbow angle of 90° ± 5° in a static semi-squat (knee angle 120° ± 10°) for the static condition, followed by performing dynamic bicep curls in the same semi-squat position for the dynamic condition. Subjects were instructed to simulate the action of a typical bicep curl.

**EMG analysis**

The EMG signals from the four muscle groups (vastus lateralis, biceps femoris, biceps brachii, triceps brachii) were recorded with surface EMG electrodes (inter-electrode distance = 10 mm) fixed over the muscle bellies (Saitou et al. 2000). Inter-electrode distance was fixed within the prefabricated electrode bar and placement between sessions was ensured by outlining the position with an indelible marker. Subjects were instructed to maintain this outline. All markings were visible for the second session, ensuring the same electrode placement for both experimental trials. The EMG signal was sampled at 1000 Hz and was pre-amplified by a gain of 1000 (DataLOG, Biometrics Ltd., Gwent, UK). The EMG was post processed using customized software (Labview, National Instruments, Austin, Tex.); the EMG data was extracted and the start and end points of the pre-vibration and vibration conditions were marked. Baseline muscle activation was measured for the middle 10 s of the pre vibration period and for the middle 20 s of the vibration period. The interference EMG for both periods was dual passed 6th order Butterworth filtered between 100 and 450 Hz, which removed any noise caused by the frequency of the vibration platform (Potvin and Brown 2004). The data was then full-wave rectified and smoothed with a low-pass filter at 1.5 Hz. The noise was then subtracted and the data was divided by the MVE and multiplied by 100 for normalization. The EMG RMS was then calculated and expressed as a percentage of maximum muscle activity (%MVE). The EMG RMS values are based on the differences between WBV and no WBV EMG RMS, not as the percent increase in muscle activity during WBV.

**Statistical analysis**

One-way analyses of variance (ANOVAs) were used to investigate whether vibration resulted in significant increases in muscle activity over the no vibration condition (baseline). To assess muscle activity between the no vibration and vibration conditions, the EMG RMS value from the 30 s vibration period was compared with the 15 s baseline no vibration period and a 5 × 2 (frequency x amplitude) repeated measures ANOVA was used to determine the effect of frequency and amplitude on muscle activity. Post hoc tests were performed using Tukey’s HSD tests. All data are presented as means ± standard error (SE) and the level of statistical significance was set at p < 0.05.

**Results**

**Whole-body vibration effect on lower-body muscles**

### Static semi-squat

During the static semi-squat condition, muscle activity for the vastus lateralis (VL) was 34.5% ± 3.9% maximal voluntary exertion (MVE) and was 1.5% ± 0.47% MVE for the biceps femoris (BF). WBV exposure resulted in increases in VL muscle activity ranging from 0.6%–6.7% MVE compared with no WBV, and only the higher frequency and amplitude combinations resulted in statistically significant increases (p < 0.05) (Fig. 1a). It is important to note that for all statistical comparisons each WBV stimuli was compared with the immediately preceding “no vibration” condition. There was a significant frequency main effect where the 40 and 45 Hz frequencies resulted in significantly greater muscle activity than did the 25 and 30 Hz frequencies (Fig. 1b).

In the BF, WBV also led to increases in muscle activity, as compared with no vibration, ranging from 0.3% to 1.2% MVE with the higher frequencies and amplitudes resulting in statistically significant increases (p < 0.05) (Fig. 2a). There were significant frequency and amplitude main effects, which revealed that the 45 Hz frequency elicited significantly greater muscle activity than did the 25 Hz frequency (Fig. 2b) and that the 4 mm amplitude resulted in significantly greater muscle activity than the 2 mm amplitude for the BF when collapsed across all frequencies.

### Dynamic squats

During dynamic squats, VL muscle activity with no vibra-
tion was 52.5% ± 3.7% MVE and 4.5% ± 1.0% MVE for the BF. The addition of WBV resulted in increases in VL muscle activity ranging from 3.7% to 8.7% MVE as compared with no vibration and all increases were statistically significant ($p < 0.05$) (Fig. 3a); in the BF, only 2 WBV stimuli resulted in significant increases in muscle activity, as compared with no vibration (0.4%–2.0% MVE; $p < 0.05$) (Table 1). There were significant frequency and amplitude main effects, in which the 45 Hz frequency elicited significantly greater muscle activity than all other frequencies (25, 30, 35, and 40 Hz) (Table 1), and the 4 mm amplitude resulted in significantly greater muscle activity than did the 2 mm amplitude when collapsed across all frequencies.

**Whole-body vibration effects on upper-body muscles**

**Static arm condition**

In the static arm condition, biceps brachii (BB) muscle activity with no vibration was 2.5% ± 0.5% MVE and 0.8% ± 0.1% MVE in the triceps brachii (TB). Exposure to WBV did not result in any significant increases in muscle activity in the BB when compared with no vibration (Table 1). In the TB, all but one WBV condition resulted in significant increases in muscle activity when compared with no vibration (0.3%–0.7% MVE; $p < 0.05$; Table 1). There were significant frequency and amplitude main effects, in which the 45 Hz frequency elicited significantly greater muscle activity than all other frequencies (25, 30, 35, and 40 Hz) (Table 1), and the 4 mm amplitude resulted in significantly greater muscle activity than did the 2 mm amplitude when collapsed across all frequencies.

**Dynamic bicep curl condition**

During dynamic bicep curls, the average muscle activity for the BB was 4.3% ± 0.7% MVE and was 3.6% ± 0.4% MVE for the TB. The addition of WBV resulted in increases in muscle activity in the BB when compared with no vibra-
tion ranging from 0.2% to 0.8% MVE. Statistical significance were observed for only 4 of the 10 conditions ($p < 0.05$) (Table 1). There was a significant amplitude main effect in the BB in which the 4 mm amplitude resulted in more muscle activity than the 2 mm amplitude when collapsed across all frequencies. In the TB, WBV led to increases in muscle activity over no vibration ranging from 0.2% to 1.0% MVE with most WBV stimuli resulting in significant increases ($p < 0.05$) (Table 1). There was a significant amplitude main effect, in which the 4 mm amplitude resulted in significantly greater muscle activity than the 2 mm amplitude when collapsed across all frequencies.

### Discussion

#### Static semi-squat condition

The main finding was that the WBV stimulus resulted in statistically significant increases in static semi-squat muscle activity in the VL and BF as the frequency (Hz) and amplitude (mm) of the WBV stimulus intensified. More specifically, static semi-squat muscle activity displayed an average increase of 4% MVE in the VL and 0.7% in the BF during WBV.

In contrast to our 4% increase in VL muscle activity, Roelants et al. (2006) reported a vertical vibration stimulus of 35 Hz, 2.5 mm resulting in a 92.5% increase in muscle activity of the VL. Although this increase in muscle activity appears to be dramatically different from the average increase of 4% observed in this study, it is important to note that our results are reported as the difference between the WBV and no WBV EMG RMS values expressed as a percentage of MVE (%MVE), whereas others have reported absolute changes (Roelants et al. 2006).

Additionally, EMG responses might be less in this investigation owing to differences in data processing. During pre-testing, it was determined that it was imperative to band-pass filter the EMG signal between 100 and 450 Hz to ensure the signal output generated by the WBV platform was eliminated, yet still retain the major portion of the required EMG muscle activity for analysis (Potvin and Brown 2004). This is important, as the frequency (Hz) component of the oscillating platform would have induced mechanical contributions to the physiological increases in EMG muscle activation had filtering not been employed.

Increases in static semi-squat VL EMG RMS muscle activity of 34% has also been reported by Cardinale and Lim (2003) using a reciprocating displacement vibration platform with the peak increase in muscle activity at 30 Hz. Though these data are not directly comparable with our results owing to the differences in the vibration stimulus used, they indicate WBV increases EMG muscle activity. These studies by Cardinale and Lim (2003) and Roelants et al. (2006), as well as the present study, all demonstrate an increase in static semi-squat leg muscle activity during WBV.

In a recent review, Luo et al. (2005) recommend between 30 and 50 Hz as the most effective frequency to use with WBV. Furthermore, Mester et al. (2002) suggest that frequencies below 20 Hz are physiologically dangerous and frequencies above 50 Hz may result in an attenuation of the signal by the muscle tissue. In general, the present study indicates that the greatest increases in static muscle activity are in response to the 35, 40, and 45 Hz WBV frequencies, similar to those reported by Luo et al. (2005). Further examination of the various combinations of frequency and amplitude in this study reveals that amplitude has little effect at the low (25 Hz) and high (45 Hz) frequencies; however, the mid range frequency (30, 35, and 40 Hz) effects on static muscle activity are greatest when combined with a higher amplitude. The current results using no additional load with WBV are in agreement with Mester and colleagues (2006), who demonstrated that training with a 50% load of 1 RM a 4 mm displacement results in greater increases in strength and performance than a 2 mm amplitude.

#### Dynamic squat condition

As expected, dynamic activity without WBV significantly raised muscle activity over the static condition. When specific WBV stimuli were added to the dynamic activity there was a further increase in EMG activity. In general, the present data suggests that vertical oscillating frequencies of 35 Hz or greater with an amplitude of 4 mm seem to have the greatest ability to increase lower-body muscle activity during both dynamic and static contractions during WBV and therefore may potentially lead to improvements in muscle performance.

Previous studies using unloaded WBV training have used frequencies ranging from 25 to 40 Hz and reported improvements in vertical jump from 7.6% to 16% (Delecluse et al. 2003; Roelants et al. 2004a; Torvinen et al. 2002b, 2003), elevations of 1.9%–24.4% in isometric strength (Delecluse et al. 2003; Roelants et al. 2004a, 2004b; Torvinen et al. 2002a, 2003; Verschueren et al. 2004), and 9%–16.5% improvements in dynamic strength tests (Delecluse et al. 2003; Roelants et al. 2004b; Verschueren et al. 2004). Even acute exposure to WBV has resulted in significant increases in muscular strength and jump height (Cormie et al. 2006; Torvinen et al. 2002a). These improvements in muscle performance following acute WBV exposure and chronic WBV training are theorized as resulting from number of different mechanisms. The tonic vibration reflex produces involuntary

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### Table 1. Increases in upper-body muscle EMG RMS with WBV during the static and dynamic conditions.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Muscle</th>
<th>25 Hz, 2 mm</th>
<th>25 Hz, 4 mm</th>
<th>30 Hz, 2 mm</th>
<th>30 Hz, 4 mm</th>
<th>35 Hz, 2 mm</th>
<th>35 Hz, 4 mm</th>
<th>40 Hz, 2 mm</th>
<th>40 Hz, 4 mm</th>
<th>45 Hz, 2 mm</th>
<th>45 Hz, 4 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
<td>Biceps brachii</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td></td>
<td>Triceps brachii</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Dynamic</td>
<td>Biceps brachii</td>
<td>0.8</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0.2</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Triceps brachii</td>
<td>0.4</td>
<td>1.0</td>
<td>0.2</td>
<td>1.0</td>
<td>0.5</td>
<td>0.7</td>
<td>0.5</td>
<td>1.0</td>
<td>0.7</td>
<td>1.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significantly greater than no WBV ($p < 0.05$).
<sup>b</sup>Significantly greater than 25, 30, 35, and 40 Hz ($p < 0.05$).
rapid changes in muscle length, possibly enhancing muscle activation (Hagbarth and Eklund 1966) via the vibration perturbation. Alternatively, a decrease in the recruitment thresholds of motor units (Romaiguere et al. 1993) activating a larger portion of the motor unit pool (Issurin and Tenenbaum 1999) would augment EMG. Nazarov and Spivak (1987) theorized that WBV increases motor unit synchronization and augments strength, whereas Enoka and Fuglevand (2001) have reported that increases in motor unit synchronization do not translate into increases in muscle strength; however, an increase in such synchronization may cause the increase in muscle activity (Cardinale and Bosco 2003). Although the mechanism remains equivocal, EMG data from this study demonstrate that higher WBV frequencies and amplitudes elicit the greatest increases in muscle activity and emphasize that the selection of the correct frequency and amplitude is likely critical for optimal performance improvement. The identification of the optimal stimulus to result in the greatest increases in muscle activity should help in the development of WBV training protocols.

Static and dynamic bicep curl condition

Although many have speculated that WBV confers no benefit to muscles of the upper body while standing on a ground-based platform, muscle activity via EMG measurements in the upper limbs have never been quantified until now. Previously, Rubin et al. (2003) used accelerometers and reported that a ground-based vibration platform (15–35 Hz) dampens the vibratory signal through the hips and spine to ~30% when standing with knees bent (20° flexion). This suggests substantial dampening of the floor-based signal prior to reaching the upper limbs. Furthermore, Mester et al. (2002) speculated that a WBV stimulus would be reduced in a non-linear fashion by the body’s soft tissues and Luo et al. (2005) also suggested a vibratory stimulus would be dramatically reduced as it travels up the body resulting in an insufficient stimulus to cause any appreciable increase in upper body muscle activity. Our EMG measures clearly add to the suggestion of muscle dampening by demonstrating that a vertically based floor vibration stimulus up to 45 Hz and 4 mm results in relatively small increases in upper-body muscle EMG activity relative to lower-body muscles for unloaded static and dynamic bicep curls. This would suggest that for a vertically oscillating vibration platform to potentially provide sufficient upper arm muscle benefits direct hand contact with the platform (ie. push-ups or triceps dips) might be required. A study using a weighted vibrating (30 Hz 6 mm) dumbbell designed for upper-body muscles substantiates this speculation, in that a significant increase in biceps brachii EMG RMS activity (225%) and muscle power (Bosco et al. 1999a) was observed with this device. Furthermore, Issurin et al. (1994) demonstrated a significant increase in strength as a result of performing loaded biceps curls with a bar attached to a vibrating cable assembly (40–60 Hz). To date, these data from the triceps and biceps brachii muscles are the first reports of EMG muscle responses in the upper-body musculature as a consequence of standing on a vertically displaced platform.

We speculate that contracting the upper-body muscles against a load may be a means of improving the transmission of the WBV stimulus to the upper body, possibly resulting in an increase in muscle performance. The body’s ability to transmit the WBV stimulus to all muscle groups may be increased with a load by increasing the amount of stiffness in a muscle or joint (Burke et al. 1976; Mester et al. 2002). Previous training studies using weights have demonstrated that WBV training seemingly results in significant muscular adaptations. Issurin et al. (1994) demonstrated that the combination of vibration applied through a vibrating cable can result in significant increases in muscle strength compared with the same exercise done without vibration stimulus. Rittweger et al. (2003) reported that dynamic squatting with an external load of 40% body mass with WBV resulted in significantly faster times to exhaustion than squatting without WBV. A further study by Rønnestad (2004) demonstrated that loaded squat training with and without WBV resulted in improvements in 1 RM, but that only the loaded WBV training increased vertical jump height. The author identified a trend that loaded WBV training may confer an additional benefit over loaded training without WBV. These studies demonstrate that lifting an external load while on a WBV platform may facilitate the transmission of the vibration stimulus to all muscle groups and contribute to the enhancement of muscle performance after WBV training. However, Kvorning et al. (2006) found no additional effects on muscle strength and mechanical performance after 8 weeks of training when comparing the combination of loaded squat and WBV with the loaded squat alone.

In both the WBV upper- and lower-muscle test conditions, our results demonstrated WBV increased muscle activity; however, whether these statistical changes translate into a functional benefit in strength and performance in young adult males was not evaluated. However, these small statistical increases in muscle activity may be very beneficial to an older population and translate into much larger performance changes.

Conclusion

Whole-body vibration stimuli of varying frequencies and amplitudes resulted in significant increases in EMG RMS muscle activity in the upper and lower body. The more intense vibration frequencies of 35–45 Hz with 4 mm amplitude elicited the greatest EMG responses in the upper- and lower-body muscles measured during both static and dynamic contractions. Furthermore, static and dynamic contractions in the upper body, compared with the lower body, are not as effected by a vertical vibration stimulus provided via a ground-based WBV platform.

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