The Acute Effect of Whole-Body Vibration on the Vertical Jump Height

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Abstract

Armstrong, WJ, Grinnell, DC, and Warren, GS. The acute effect of whole-body vibration on the vertical jump height. *J Strength Cond Res* 24(10): 2835–2839, 2010—To determine the effectiveness of a single, 1-minute bout of whole-body vibration (WBV) as a viable warm-up activity, 90 subjects (30 men; 60 women, mean age = 19 ± 1 years) were recruited and randomly assigned to either a nonvibration control group or 1 of 8 WBV treatments (4 frequencies × 2 AMplitudes). Subjects stood with the feet shoulder width apart and the knees flexed 10° on a Next Generation Power Plate for 1 minute with the frequency (30, 35, 40, or 50 Hz) and amplitude (2–4 or 4–6 mm) settings at the assigned levels. Before, 1, 5, 10, 15, 20, 25, and 30 minutes after the WBV or control treatment, subjects performed a series of countermovement vertical jumps (CMJs) measured using a Vertec™ vertical jump tester. Comparisons were made of changes in the countermovement vertical jump height (CMJH) over time and between groups, frequencies, and amplitudes using repeated measures analysis of variance ($\alpha \leq 0.05$). There were significant differences in CMJH over time ($p = 0.008$); however, these were similar for all groups, frequencies, and amplitudes ($p > 0.88$). Some athletes may benefit from using WBV as a warm-up activity, if the timing of WBV is optimized. The effect of WBV on performance is likely variable and minimal, with a small window of effectiveness. Gender differences were not examined, and the optimal duration, intensity, and postural position are still unclear and warrant further study.

Key Words performance, warm-up, vibratory exercise

Introduction

The use of whole-body vibration (WBV) in rehabilitation and sport training is an issue of growing interest in sport physiology (1,3–5,11–14). Although the vibration may be applied using a variety of mechanical stimuli (e.g., plates, cables, belts), vibration platforms are popular devices finding their way into exercise facilities and rehabilitation clinics worldwide. Vibration platforms generally produce an oscillatory motion by either oscillating up and down or producing reciprocal vertical displacement on the right or left side of a fulcrum (4). The superiority of 1 method over the other has yet to be demonstrated. Whole-body vibration platforms oscillate over a range of frequencies (15–60 Hz) and amplitudes or displacements (<1–10 mm) (3,4), which vary among products (3,4). The vibration generates a perturbation of the gravitational field in the range of 3.5–15g (1g = 9.81 m·s^{-2} or the equivalent of the Earth's gravitational field) (3,4). This increased gravitational load disrupts posture and activates the muscles surrounding the involved joints. Refer to Cardinale and Wakeling (4) for a review of the complex neuromuscular response to vibration.

Investigators have noted improvements in response to WBV training in physiological measures such as neuromuscular performance (2), force output (6,7,10,15), flexibility (16), and hormone concentrations (2). Not all investigators, however, have noted positive benefits (5,8,9,12), particularly in the short term. Research exploring the effectiveness of WBV is in its infancy, and protocols vary largely because of the variety of available devices and stimulus intensities. Additionally, the duration of stimulation varies among the literature. For these reasons, it is difficult to interpret the effectiveness of WBV.

For the present study, a single performance variable–countermovement vertical jump height (CMJH)–was examined. Cormie et al. (6) noted a slight increase in CMJH after a 30-second vibration treatment at 30 Hz and 2.5-mm amplitude carried out in a half-squat position (100° knee flexion) using a body vibration platform (Power Plate North America, Inc., Northbrook, IL, USA). Jump heights were significantly greater immediately post-WBV, compared to the sham treatment, but it was not reported whether this was significantly greater than baseline. Comparable changes were not observed in muscle activity (i.e., electromyography or peak power), and no mechanism for the transient increase in CMJH could be noted.

The purpose of the present study was to gain further insight into the effectiveness of a single, 1-minute bout of WBV as

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24(10)/2835–2839

Journal of Strength and Conditioning Research

Figure 1. Postural position for whole-body vibration (Next Generation Power Plate, Power Plate North America).

a viable warm-up activity. Because the available WBV platform (Next Generation Power Plate, Power Plate North America, Inc.) allows 8 possible intensity combinations, each was examined. Because previous investigations using the Hoffmann reflex (H-reflex) as an outcome measure have demonstrate variable levels of neuromuscular facilitation over a 30-minute period post-WBV (1), possible changes in CMJH were observed over a prolonged period (30 minutes).

Methods

Experimental Approach to the Problem

This investigation was designed to assess the time course of changes in CMJH after a single bout of WBV. The vibration platform (Next Generation Power Plate, Power Plate North America, Inc.) provides 8 intensity levels based on a combination of frequency (30, 35, 40, and 50 Hz) and amplitude (2–4 vs. 4–6 mm). All intensities were examined, in addition to a nonvibration control, to gain an insight into the effect of intensity on CMJH and to determine optimal intensities for future studies.

Subjects

Ninety subjects (30 men and 60 women, mean age = 19 ± 1 years [range: 18–27 years]) were recruited from the student population at Hope College by word of mouth. The subjects had no indicated neurological defects, no history of lower extremity surgery, and no lower extremity injury for 12 months before the start of the study as reported by the medical history questionnaire. Informed consent was obtained and the Hope College Human Subjects Review Board approved all procedures.

Procedures

WBV Treatment. Participants were randomly assigned to either the control group ($n = 9$; 6 men, 3 women) or 1 of 7 treatments (30–low [$n = 11$; 1 man, 10 women], 30–high [$n = 9$; 6 men, 3 women], 35–low [$n = 12$; 6 men, 6 women], 35–high [$n = 8$; 1 man, 7 women], 40–low [$n = 11$; 2 men, 9 women], 40–high [$n = 10$; 3 men, 7 women], 50–low [$n = 10$; 2 men, 8 women], or 50–high [$n = 10$; 3 men, 7 women]) of varying vibration frequency (30, 35, 40, or 50 Hz) and amplitude (low–2–4 mm or high–4–6 mm). Subjects stood with the feet shoulder width apart and the knees flexed approximately 10° (Figure 1) on a Next Generation Power Plate (Power Plate North America, Inc.) for 1 minute with the frequency and amplitude settings at the appropriate levels. The control subjects stood on the same Power Plate in the same posture for 1 minute with no vibration and were otherwise treated identically to the treatment subjects.

Vertical Jump. Before and after the 1-minute WBV or control treatment, subjects performed a series of countermovement vertical jumps for CMJH measured using a Vertec™ vertical jump tester (Sports Imports, Columbus, OH, USA). For the vertical jump, subjects were instructed to stand with the feet shoulder width apart, bend at the knees and jump as high as possible with the arm and hand overhead. The CMJH was attempted 5 times before WBV and 3 times every 5 minutes for 30 minutes after WBV. The maximum CMJH was recorded at each time. If at any time point CMJH increased on the final jump, additional jumps were allowed until there was no improvement. With similar subjects, this protocol demonstrated an intraclass correlation coefficient = 0.98.

Statistical Analyses

Comparisons were made of changes in the CMJH over time and between groups, frequencies, and amplitudes using repeated-measures ANOVA. The level of significance was set at $\alpha \leq 0.05$. Paired t-tests were also performed using pooled data from all groups to determine where significant changes from baseline occurred. For these, a Bonferroni correction was used, and significance was determined at $\alpha \leq 0.007$. All statistical analyses were performed using the SPSS, 13.0 (SPSS, Inc., Chicago, IL, USA) statistical software package.

Results

There was a significant effect for time ($p = 0.008$); however, there was no significant difference between groups (Figure 2, $p = 0.932$) and no significant effect of group by time ($p = 0.175$). Likewise, there were no significant differences when the data were compared by frequency and amplitude ($p = 0.902$ and 0.883, respectively).

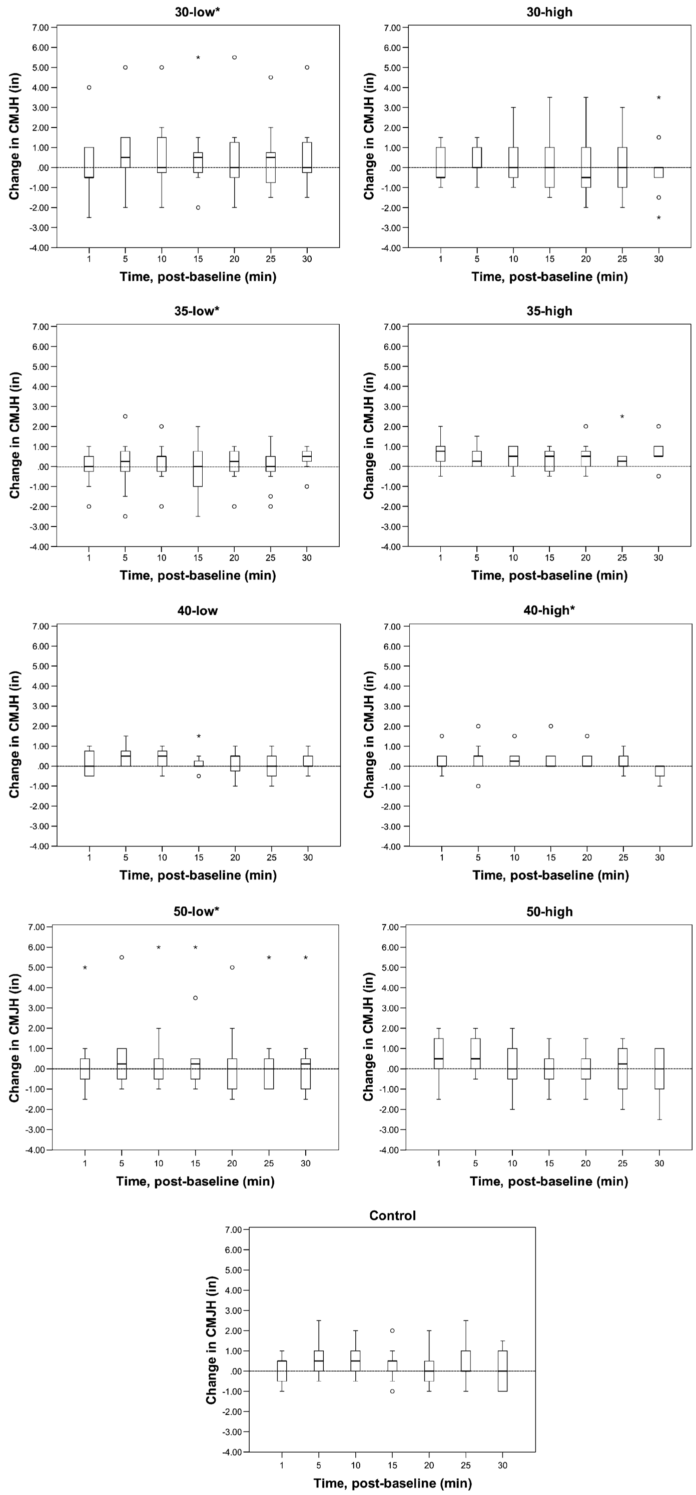

Figure 2. Box plots showing median, interquartiles, outliers (circles) and extreme values (stars) by group for changes in the countermovement vertical jump height (CMJH) in response to whole-body vibration. *Note the most extreme high values in 30–low, 40–high, and 50–low, and low values in 35–low represent a single subject in each group. Box plots showing median, interquartiles, outliers (circles), and extreme values (stars) by group for changes in the CMJH in response to whole-body vibration. *Note the most extreme high values in 30–low, 40–high, and 50–low, and the most extreme low values in 35–low represent a single subject in each group.

Table 1. Mean raw CMJHs.*

Time	CMJH (in.)	
	Mean ± *SD*	*SEM*
Pre-WBV	18.11 ± 4.67	0.49
Immediately post-WBV	18.38 ± 4.55	0.48
5-min Post-WBV†	18.58 ± 4.70	0.50
10-min Post-WBV†	18.52 ± 4.53	0.48
15-min Post-WBV	18.39 ± 4.43	0.47
20-min Post-WBV	18.36 ± 4.49	0.47
25-min Post-WBV	18.34 ± 4.51	0.48
30-min Post-WBV	18.32 ± 4.44	0.47

*CMJH = countermovement jump height.
†Significant ($p \leq 0.001$) difference from baseline.

After random assignment, groups were not balanced on gender. As a result, no comparisons could be made between men and women.

Paired *t*-tests were performed on the raw CMJH data for all subjects. Mean CMJH values for each time point are reported in Table 1. CMJH was higher than baseline at all time points, and peaked at 5 minutes post-WBV (Figure 3). These increases were significant at 5 and 10 minutes post-WBV ($p < 0.001$ and $p = 0.001$, respectively). There were no significant differences in CMJH between baseline and immediate, 15, 20, 25, and 30 minutes ($p = 0.018$, 0.043, 0.052, 0.066, and 0.100, respectively).

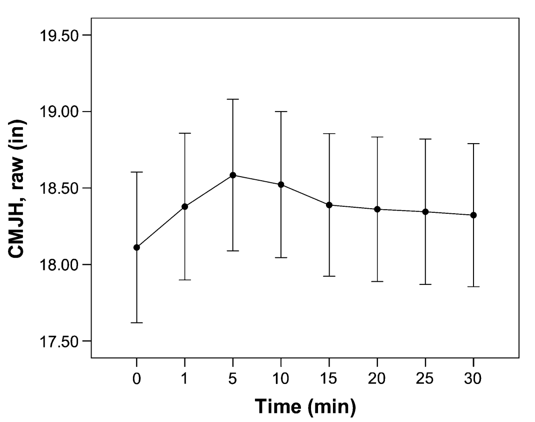

Figure 3. Change in vertical jump height in response to whole-body vibration; expressed as raw countermovement vertical jump height (CMJH) (mean ± *SE*). *Significant difference ($p \leq 0.001$) from baseline.

Discussion

The most significant finding in this study was that an acute bout of WBV might increase vertical jump height in some individuals regardless of intensity. Countermovement vertical jump height peaked at 5 minutes post-WBV and decreased to values that were not significantly greater than baseline after 15 minutes post-WBV. Thus, the use of WBV as a warm-up activity may involve a relatively small window of benefit. It also appears to affect individuals differently, benefiting some more than the others. There appear, however, to be no negative effects of a single 1-minute bout of WBV on CMJH.

The mean peak increase in CMJH at 5 minutes was <0.5 in. The Vertec™ is calibrated in increments of 0.5 in. It is, therefore, plausible that the device may underestimate CMJH between 0.5 and 1.0 in. The practical significance of these increases is likely sport specific.

The control group increased after the sham treatment, and the pattern of changes in CMJH for the control was similar to the overall pattern for all subjects. It is unlikely that 3 countermovement jumps every 5 minutes would be fatiguing. Although a learning effect for the vertical jump cannot be discounted, previous research in this laboratory (1) indicated that even without vibration the posture used in the present study might affect neuromuscular excitability, as measured using the H-reflex. Thus, even the control group may have benefited from the muscle contractions that result from the microperturbations of posture while standing in a flexed-knee position. When the H-reflex was measured for 30 minutes post-WBV, significant intrasubject variability was noted. For some subjects, there was potentiation of neuromuscular excitability. For others, there was a prolonged suppression of the H-reflex. It was proposed that these differences might be the result of muscle composition differences. This hypothesis, however, remains untested. The subjects in the present study were randomly assigned to groups and did not act as their own controls. It is possible that there was some level of selection bias, and the groups had different neuromuscular responses to WBV.

Cormie et al. (6) observed a potentiating effect of 30 seconds of WBV in a half-squat (100° knee flexion) at 30 Hz and 2.5-mm amplitude on a similar vibration platform. Bosco et al. (2) observed an increase in jump height using a similar protocol with longer (60-second) duration. Rittweger and others (12), however, reported equivocal results. The data presented here is, likewise, equivocal. Interestingly, both 30–low (the intensity used by Cormie et al. [6]) and 50–high–the 2 intensity extremes–displayed the greatest changes in CMJH.

The group sizes ($8 < n < 12$) in the present study were similar to the sample size ($n = 9$) in Cormie et al. (6). Likewise, the ages of the subjects are similar. Subjects in the present investigation, however, were of mixed gender and training status. Cormie et al. report using subjects who "were involved in resistance training and some type of recreational sporting activities" (pp. 258). The sample in the present study was one of convenience, including college students recruited primarily from a Human Anatomy course consisting of kinesiology, preprofessional (e.g., prephysical therapy, premedicine), and nursing students ranging from minimally active to intercollegiate (National Collegiate Athletic Association division-III) athlete. Thus, the subjects in this study represent a more heterogeneous sample and may be subject to greater variability.

Despite varying results, there appears to be no detrimental effect of a 1-minute acute bout of WBV on CMJH. Thus, WBV may be a useful warm-up activity for sport. The degree to which an athlete may benefit from WBV and the optimal dose remain unanswered. Cormie et al. (6) used subjects as their own controls and randomized the order of treatment. Groups in the present study were randomly assigned without control for gender. This negatively impacts the ability to interpret and generalize the results. For better comparison among dose intensities, the use of a larger sample used at all intensities including a control group that stands in an upright posture with no vibration is warranted. If possible, a gender-mixed sample that acts as its own control should be used to account for extraneous individual differences that have not been identified.

It should be noted that only 1 possible application of WBV as a warm-up was examined. Possible changes in flexibility, circulation, body temperature, etc., which may impact performance and reduce injury were not included in the present study. Further study in these areas is necessary.

Practical Applications

The present study indicates a possible benefit to using WBV as a warm-up activity in activities involving explosive motions, that is, jumping. The optimal duration, intensity, and postural position remain unclear and warrant further study. Coaches, however, might consider using this activity with some caution. The effect of WBV on performance is likely variable and minimal for most athletes. Some athletes, though, may benefit, if the timing of WBV is optimized. At best, the use of WBV as a warm-up activity should be determined on an individualized basis.

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