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The Short-Term Effect of Whole-Body Vibration Training on Vertical Jump, Sprint, and Agility Performance

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ABSTRACT. Cochrane, D.J., S.J. Legg, and M.J. Hooker. The short-term effect of whole-body vibration training on vertical jump, sprint, and agility performance. *J. Strength Cond. Res. 18(4):000–000. 2004.*—Previous studies have suggested that short-term whole-body vibration (WBV) training produces neuromuscular improvement similar to that of power and strength training. However, it is yet to be determined whether short-term WBV exposure produces neurogenic enhancement for power, speed, and agility. The purpose of this study was to investigate the effect short-term WBV training had on vertical jump, sprint, and agility performance in nonelite athletes. Twenty-four sport science students (16 men and 8 women) were randomly assigned to 2 groups: WBV training or control. Each group included 8 men and 4 women. Countermovement jump (CMJ) height, squat jump (SJ) height, sprint speed over 5, 10, and 20 m, and agility (505, up and back) were performed by each participant before and after 9 days of either no training (control) or WBV training. Perceived discomfort of every participant was recorded after daily WBV exposure and nonexposure. There were no significant differences between WBV and control groups for CMJ, SJ, sprints, and agility. Perceived discomfort differed between the first and subsequent days of WBV training ($p < 0.05$); however, there was no difference between the WBV and control groups. It is concluded that short-term WBV training did not enhance performance in nonelite athletes.

KEY WORDS. stretch-shortening cycle, field-based tests, squat jump, power training, strength

Introduction

The use of whole-body vibration (WBV) has become increasingly common as a training method for enhancing sport performance (19). Conventional weight resistant and explosive power exercises have focused on fast and abrupt gravitational acceleration as a stimulus for strength and power adaptations (5). WBV has been described to produce gravitational acceleration changes similar to those of power and strength training (4), with single session to multiple sessions (10 days) reported to improve muscular power of upper and lower musculature (4, 6), changes to hormonal profile (7), and increases in cardiovascular responses (24). The specific training adaptations that occur with power, speed, and agility still require further research (4). However, the neuromuscular facilitation that arises from short-term WBV exposures maximizes muscle performance by producing gravitational changes elicited by mechanical vibrations (4, 6). The neural component is one of the purported mechanisms for explaining the increases in muscular performances, because the vibration is thought to produce an effect similar to that of explosive power training (5). However, the neuromyogenic components that are responsible for such improvements remain unclear. One possibility is that muscle length changes during vibration exposure, causing activation gamma fusimotor input that enhances the discharge of primary afferents to increase motoneuron activation, thereby causing powerful muscle contractions (6, 23).

Most short-term WBV studies have focused on fixed muscular performances (vertical jumping, elbow flexion, and isometric leg tests) that have produced favorable outcomes, with little attention being paid to rapid horizontal movements of sprinting and agility. Increased motoneuron excitability is regarded as integral to enhancing sprint performance (26) and is common to both WBV and power/strength training. However, there have been mixed reports of the relationship between strength and power on sprint performance. Some investigators have found significant correlations (1, 12, 16), whereas others have reported indifferent results (14). Nevertheless, sprinting requires a large force production in a short period (19), and it is likely that power and strength training contribute to developing sprint performance (11), but it is yet to be determined what influence short-term WBV has on sprint performance.

Similarly, the effect of WBV on agility performance is not known. Agility is of prime importance to many sports, and the 505, up and back test is considered a valid assessment of agility (15). However, agility has yielded poor correlations with strength, power, and speed qualities (33) that require specific motor and skill training. Therefore, it is unlikely that WBV training will enhance agility performance unless the neural component to agility is greater than we know.

Short-term WBV has been known to improve average power output in continuous jumping for 5 seconds (4), whereas reports differ on countermovement jump (CMJ) height after WBV exposure (4, 7); the performance of a concentric-only squat jump (SJ) after WBV training has not been examined. It is hypothesized that both CMJs and SJs will be enhanced from short-term WBV training due to the constant muscle stretching and stimulation of WBV.

Field and laboratory tests for assessing strength, power, and speed performances are well established (10, 32). However, laboratory equipment can be costly and restrict replication of the specificity of the action and mode of the activity. Field-based tests can measure performances such as jumping, sprinting, and agility with a high degree of reliability (22, 27) and commonly include CMJs and SJs performed on a contact mat system (4) and sprint and agility maneuvers timed by electronically infrared photocells (1, 33). Therefore, the high degree of specificity and replication of the above movements warrants the use of field-based tests.

To date, most short-term WBV training studies have focused on muscular power aspects that involve stationary explosive movements in well-trained or elite athletes (3, 5) using laboratory outcomes (5, 6), with little attention given to dynamic field-based sporting performances. Therefore, the purpose of this study was to examine the effect of short-term WBV exposure on vertical jump, sprint, and agility in nonelite athletes.

METHODS

Experimental Approach to the Problem

Short-term WBV exposure is able to elicit significant neural changes to improve performances in muscular power. Recent research has shown that single and short-term (10 days) WBV exposure increases muscular power in vertical jump, dynamic forearm flexion (5), and isometric knee strength (29). However, the effects of short-term WBV on concentric SJ, sprint, and agility components have yet to be determined.

Participants

Twenty-four healthy participants (16 men and 8 women; mean ± *SD* age, 23.9 ± 5.9 years; mean ± *SD* height, 1.75 ± 0.09 m; mean ± *SD* weight, 75.5 ± 12.0 kg) from noncompetitive team sports with a training frequency of at least once a week and little experience in power, speed, and agility training provided informed consent and volunteered to participate in the study, which was approved by the Massey University Human Ethics Committee. During the study, participants were not permitted to undertake any power, speed, and strength training.

Each participant performed 2 familiarization sessions of all of the performance tests indicated below. These were conducted on 2 separate consecutive days before the commencement of the study. A standardized 10-minute warm-up and cool down that incorporated light jogging and whole-body stretching was administered before all testing and physical activity. The performance tests were conducted on a vinyl surface in an indoor stadium. The pretreatment performance tests were performed a day after the last familiarization test, whereas the posttreatment performance tests were performed 2 days after the last WBV training.

All the participants were individually ranked (highest to lowest height jumped and fastest to slowest sprint time) according to their pretreatment CMJ, SJ, and 5-, 10-, and 20-m sprint times. In a random balanced order, every man and woman were allocated to either the WBV or control group, which included 8 men and 4 women each.

Performance Tests

Vertical Jump Tests. Three CMJs and concentric SJs were performed according to the protocol of Cronin and McLean (8). The participants were instructed to keep their hands on their hips for the duration of the jumps. Each

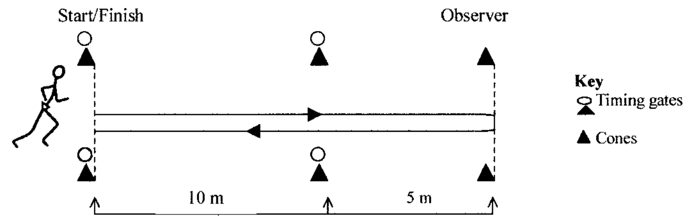

FIGURE 1. Diagrammatic representation of the agility test.

jump was recorded to 0.1 cm and averaged. Every jump was separated by a rest period of 20 seconds. The vertical jump test measurement system consisted of a portable hand-held computer unit connected to a contact mat (Swift Performance, New South Wales, Australia). It has been previously reported that that the system is reliable compared with a force platform (9).

Sprint Tests. Four sprints of 5, 10, and 20 m were performed and recorded to the nearest 0.01 second with a 2-minute rest separating each trial. The mean of the 4 sprints was computed. Each sprint test was started in a stationary position from a line 30 cm before the start line. Time measurement was recorded using a dual-beam, modulated, visible red light system with polarized filters (Swift Performance).

Agility—505, Up and Back Test. This test was administered according to Lancaster and Draper (13). A dual-beam, modulated, visible red light system with polarized filters (Swift Performance) was set at 0 and 10 m (Figure 1) to record the time taken to sprint to the first 10-m mark (AG 10), time to complete the turn (2 × 5 m) (505), and time taken to sprint up and back (2 × 15 m) (UAB). Each participant started in a stationary position from a line marked 30 cm before the start line. The participants were required to sprint and place 1 foot on the line at the end of the 15-m track before returning to the finish. An observer visually checked this. Two trials were performed with a 3-minute rest between each bout. The average of both trials was used in the statistical analysis.

WBV Treatment

Each participant underwent 9 days of either WBV or control treatment, composed of 5 consecutive days separated by 2 days of recovery followed by another 4 consecutive days of treatment. WBV was conducted according to the procedure described by Bosco et al. (4). The WBV treatment was performed on a commercialized Galileo 2000 machine (Novotec, Pforzheim, Germany). The participants stood and positioned their feet around the center of the oscillating platform, which equated to a peak-to-peak amplitude of 11 mm of vertical vibration. The frequency was set at 26 Hz. Two-minute exposures separated by 40 seconds of rest of 5 different body positions were administered. These positions were 1) standing upright, 2) squatting at a knee angle of 90°, 3) squatting at knee angle of 90° with feet rotated externally, 4) single right leg standing at a knee angle of 90°, and 5) single left leg standing at a knee angle of 90°. With the use of a handrail, the participants were allowed to maintain balance for positions 4 and 5.

For the control treatment, each participant stood on the floor to the side of the Galileo 2000 machine (0 Hz, amplitude = 0 mm) and performed the exact 5 body positions and time constructs as the WBV group. All partic-

TABLE 1. Intraclass correlation coefficients for retest reliability of vertical jump, sprint, and agility of the familiarization trials.

Variable†	Retest reliability
CMJ	0.969*
SJ	0.977*
5-m sprint	0.894*
10-m sprint	0.893*
20-m sprint	0.897*
505	0.780*
AG 10	0.862*
UAB	0.731*

* $p = 0.01$.
† CMJ = countermovement jump; SJ = squat jump; 505 = time to complete turn (2 × 5 m); AG 10 = time taken to sprint to the first 10-m mark; UAB = time taken to sprint up and back (2 × 15 m).

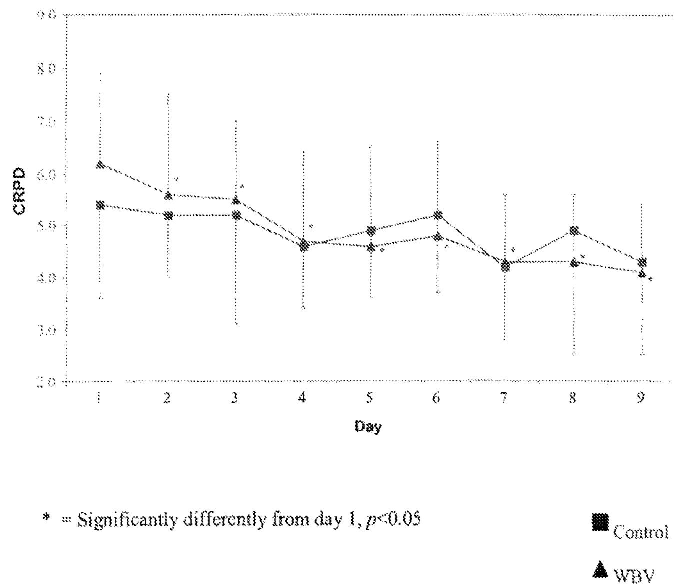

FIGURE 2. Mean (*SD*) daily rating of perceived discomfort using the category-ratio scale of the whole-body vibration and control groups.

ipants from both groups were instructed to wear sport-type shoes, especially those in the vibration group, to prevent bruising (6).

After each treatment session, every participant from the WBV and control group gave a rating of their perceived discomfort using the category-ratio scale (CRPD) (2). Each participant was retested on CMJs, SJs, sprints, and agility performance tests 2 days after the last WBV treatment.

Statistical Analyses

The mean and *SD* pretraining and posttraining dependent variables (CMJ; SJ; 5-, 10-, and 20-m sprints; and agility [505, UAB, and AG 10]) were calculated and compared by repeated-measures analysis of variance. Factor interaction of sex and treatment (control and vibration) groups on the pretraining and posttraining scores were performed using a least significant difference confidence interval of adjustment. From the 2 familiarization trials, the intraclass correlation coefficients were calculated for each dependent variable to determine test-retest reliability. The CRPD daily scores were analyzed by Student's paired *t*-test. For all analysis, the level of statistical significance was set at $p \leq 0.05$.

RESULTS

The reliability of the dependent variables indicates there was very little variability between the familiarization trials, giving a high degree of consistency between the 2 sessions (Table 1). There were no significant differences between the performance variables for pretraining and posttraining control and vibration scores (Table 2). There were no differences in pretraining and posttraining performance scores for both the control and WBV groups for men and women.

The results of the CRPD are displayed in Figure 2. For the WBV group, there was a significant difference in day 1 vs. the following 8 days. The control group members had no statistical change in the way they perceived their treatment. There were no differences between groups.

DISCUSSION

Single and multiple (10 days) exposures of short-term WBV have been shown to improve neuromuscular improvements in power and strength (4, 5). Little research has been conducted on whether 9 days of short-term WBV exposure produces neurogenic enhancement for power, speed, and agility. This study revealed that 9 days of WBV training did not statistically influence vertical jump, sprint, or agility performance. This is not the first reporting of negative findings; Torvinen et al. (30) found

TABLE 2. Mean (± *SD*) pretraining and posttraining jump (CMJ, SJ), sprint (5, 10, 20 m), and agility (505, UAB, AG 10) scores for control and WBV groups.*

	Control group ($n = 12$)		WBV group ($n = 12$)	
	Pretraining	Posttraining	Pretraining	Posttraining
CMJ (cm)	30 ± 0.05	29 ± 0.05	26 ± 0.05	27 ± 0.05
SJ (cm)	26 ± 0.05	24 ± 0.04	23 ± 0.05	24 ± 0.05
5-m sprint (s)	1.11 ± 0.09	1.11 ± 0.08	1.12 ± 0.10	1.13 ± 0.08
10-m sprint (s)	1.92 ± 0.16	1.90 ± 0.15	1.91 ± 0.16	1.92 ± 0.15
20-m sprint (s)	3.33 ± 0.30	3.31 ± 0.27	3.32 ± 0.29	3.33 ± 0.29
505 (s)	2.60 ± 0.22	2.64 ± 0.22	2.50 ± 0.26	2.54 ± 0.28
AG 10 (s)	1.93 ± 0.15	1.94 ± 0.15	1.90 ± 0.15	1.92 ± 0.16
UAB (s)	6.13 ± 0.49	6.15 ± 0.46	5.99 ± 0.48	6.01 ± 0.46

* CMJ = countermovement jump; SJ = squat jump; 505 = time to complete turn (2 × 5 m); AG 10 = time taken to sprint to the first 10-m mark; UAB = time taken to sprint up and back (2 × 15 m); WBV = whole-body vibration.

no changes to strength and stability performances after 4 minutes of WBV treatment.

For this study, all external variables and internal validity issues were accounted for, and it is unlikely that they contributed to the negative findings. The short duration (9 days) potentially could have contributed to the lack of significance for this sample population. However, this study confirmed the findings of Bosco et al. (4) of no statistical improvement of CMJ after WBV but has also extended these negative findings by showing SJ also responded similarly. A possible explanation is that the slow stretching speed and large angular displacement in CMJ may cause little excitation of the concurrent gamma fibers to enhancing the afferent discharge (4, 16). Likewise, the elastic stored energy in the tissue components and the magnitude of muscle stretched in the SJ is likely to be less than the CMJ. Hence, the stored muscle energy is dissipated and instantaneous motor unit recruitment dwindles; therefore, a potentiated jump is unlikely to occur.

In the present study, there were no significant differences in sprint times at 5, 10, and 20 m from WBV training; therefore, a particular level of strength base may be required for nonelite athletes before undertaking vigorous WBV training. Furthermore, strength and power activities are highly specific in nature, and the transference to dynamic performance is often poor (28, 31). This is largely due to the training load, intensity, speed, and posture that elicit specific neural and muscular adaptations that reflect the type of training. Within these adaptations, some general and specific components have shown transference between power/strength and dynamic exercises (18, 21). Rohmert et al. (25) suggested that stretched muscle is likely to be more sensitive to vibration for enhancing neural and muscle components. Indeed, the body positions implemented in this study would have initiated muscle stretching. The WBV exercises used in the present study were identical to those used in the study by Bosco et al. (4), which found increased mechanical power output in continuous jump performance; however, the force-velocity range of jumping differs from that of sprinting (10). Moreover, it is possible that the WBV exercises used in the present study may have lacked the specific sprint positions and angular displacements required to induce the hypothesized neuromuscular effects. Hence, further investigation is required to determine if concurrent WBV and sprint training can assist the transference of the desired physiologic adaptations to improve sprint performance.

Traditionally, power and strength qualities have contributed little to agility performance (33). Likewise, in the present study, WBV training showed no significant changes in agility measures (505, UAB, and AG 10), which confirms our hypothesis that the WBV did not enhance agility performance. There are many aspects that characterize agility performance; for example, the UAB and AG 10 times are reliant on acceleration and maximal velocity, whereas the 505 is dependent on factors such as limb length, flexibility, stride length, concentric/eccentric limb strength, and ability to change velocity quickly while abruptly changing direction. Therefore, the interaction of all the perceptual and technical agility factors makes it difficult to identify the components that ultimately influence performance.

The participants in the study could not be described as elite athletes; therefore, those participants not accustomed to sprinting and agility movements may have shown lesser improvements when vibratory stimulus was applied. Issurin and Tenenbaum (17) support this view that elite athletes have a higher level of central nervous system and muscle receptor sensitivity, making them more receptive to vibration training. Indeed, it may be that the nonelite athletes in this study were not used to having their musculature stimulated in this manner and required a gradual increase in amplitude and frequency to produce an optimal loading effect on the neuromuscular properties.

It has been well documented that long-term exposure to WBV can cause discomfort and possible injury (20). In this study, the early exposures of the vibratory stimulus caused a heightened CRPD in the WBV group. As time progressed, the participants perceived significantly less discomfort as they became more familiar with the machine and muscle loading. Hence, like in any other exercise regimen, WBV training should be introduced slowly, because the effects of WBV can be underestimated.

For the control group, performing the isometric contractions (minus the vibration) was perceived as a stimulus to warrant discomfort but was not statistically different from that of the WBV group. No medical problems were evident from WBV training of 10 minutes a day for 9 days at a frequency of 26 Hz as supported by other studies (4, 7).

In conclusion, this study used field-based tests to examine the effect of WBV on vertical jump, sprint, and agility performance. The study failed to demonstrate any neuromuscular enhancements in these performance parameters after 9 days of WBV training in nonelite athletes. This contrasts to previous reports of increased power and strength due to WBV exposure in elite athletes tested on laboratory-based equipment (5, 7, 18).

PRACTICAL APPLICATIONS

Nine days of WBV for nonelite athletes does not produce the expected potential neuromuscular enhancements. WBV is not a simple procedure that can be used for complex strategies for power, sprint, and agility. A greater exposure duration and recovery time are required for WBV treatment of nonelite athletes.

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