ACUTE EFFECT OF WHOLE-BODY VIBRATION ON SPRINT AND JUMPING PERFORMANCE IN ELITE SKELETON ATHLETES

NICOLA BULLOCK,[1,2] DAVID T. MARTIN,[1] ANGUS ROSS,[3] C. DOUG ROSEMOND,[4] MATTHEW J. JORDAN,[5] AND FRANK E. MARINO[2]

[1]Department of Physiology, Australian Institute of Sport, Belconnen, Australia; [2]School of Human Movement Studies, Charles Sturt University, Bathurst, Australia; [3]New Zealand Academy of Sport, South Island, Dunedin, New Zealand; [4]Department of Biomechanics, Australian Institute of Sport, Belconnen, Australia; [5]Canadian Sport Centre–Calgary, University of Calgary, Calgary, Alberta, Canada

ABSTRACT

Bullock, N, Martin, DT, Ross, A, Rosemond, CD, Jordan, MJ, and Marino, FE. Acute effect of whole-body vibration on sprint and jumping performance in elite skeleton athletes. *J Strength Cond Res* 22: 1371–1374, 2008—The winter sliding sport known as skeleton requires athletes to produce a maximal sprint followed by high speed sliding down a bobsled track. Athletes are required to complete the course twice in 1 hour and total time for the 2 runs determines overall ranking. The purpose of this investigation was to examine the effect of whole-body vibration (WBV) on lower body power to explore the utility of WBV as an ergogenic aid for skeleton competition. Elite skeleton athletes (1 male and 6 females) completed an unloaded squat jump (SQJ) immediately followed by 2 countermovement jumps (CMJs) and a maximal 30-m sprint before and after WBV or no vibration (CON) using a crossover design. The second 30-m sprint was slower following both CON (1.4% decrement; $p = 0.05$) and WBV (0.7% decrement; $p = 0.03$). Mean vertical velocity was maintained following WBV in the SQJ but decreased following CON ($p = 0.03$). There was a trend for athletes to commence the SQJ from a higher starting stance post-WBV compared to CON ($p = 0.08$). WBV decreased total vertical distance traveled compared to CON in the SQJ ($p = 0.006$). WBV had little effect on peak velocity, jump height, dip, and peak acceleration or any CMJ parameters. When sprint athletes' warm up and perform maximal jumps and a 30-m sprint with 15–20 minutes of recovery before repeating the sequence, the second series of performances tend to be compromised. However, when WBV is used before the second series of efforts, some aspects of maximal jumping and sprinting appear to be influenced in a beneficial manner. Further research is required to explore whether WBV can improve the second sprint for athletes in actual competition and/or what sort of WBV protocol is optimal for these populations.

KEY WORDS warm-up, neural potentiation, ergogenic aid, recovery

INTRODUCTION

Vibration is a mechanical stimulus characterized by an oscillatory motion which determines the amplitude (mm) while the repetition rate of oscillation determines the frequency (Hz) (2). A recent review highlighted the potential effects of an acute bout of whole-body vibration (WBV) as a neuromuscular warm-up in preparation for explosive athletic events (8). Improvement in physical performance after vibration has been primarily attributed to neural factors, such as increased motor unit synchronization (10), stretch reflex potentiation (8), increased synergist muscle activity, and increased inhibition of the antagonist muscle (1,3). Whether WBV can be used to enhance actual sport performance remains unclear.

A skeleton run begins with a push start where an athlete sprints for ~30 m in a bent-over running position while pushing a sled. During elite competition, the top 20 sliders will perform 2 explosive starts within an hour of each other. Start time has been shown to correlate with overall finish time in World Cup skeleton competition for both male ($r = 0.48$) and female ($r = 0.63$) athletes. Thus, a fast start time has been suggested to be a prerequisite for a successful overall performance (15).

Because elite skeleton athletes have to produce 2 maximal pushes within a short time frame, there is a need to use strategies that will maintain lower body power between the 2 push starts. The purpose of this study was to examine the

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Address correspondence to Nicola Bullock, nicola.bullock@ausport.gov.au

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effect of acute WBV exposure on repeated lower body power traits in elite skeleton athletes. Testing was completed in the off-season when access to iced tracks is limited. We used upright 30-m sprint running as a performance measure because a substantial proportion of normal training load involves sprint running and a strong correlation has been demonstrated between upright running and skeleton push performance (14).

METHODS

Experimental Approach to the Problem

To assess the possible beneficial effects of WBV in repeat sprint performance, elite skeleton athletes performed squat jumps (SQJs), countermovement jumps (CMJs), and a 30-m sprint before and after either WBV or no vibration (CON).

Subjects

Seven (6 females and 1 male) internationally competitive skeleton athletes (including 2 Olympians, 1 of whom is a former World Champion, 1 is Under-23 World Champion, and 2 World Cup athletes) (mean ± *SD* age, 24.9 ± 4.7 years; height, 168.4 ± 7.7 cm; mass, 67.1 ± 8.5 kg) volunteered as subjects. All athletes were familiar with the sprint and jump tests as these tests were routinely used for both training and to monitor fitness. Before participating, athletes gave their written informed consent. All procedures used in this study had been approved by the Australian Institute of Sport (AIS) ethics committee.

Procedures

Athletes attended 2 testing sessions (all performed indoors on a synthetic surface) on consecutive days (Figure 1). The competition-specific sprint warm-up was replicated for both testing sessions and involved aerobic activity to elevate muscle temperature followed by stretching, bounding, jumping, and 90% accelerations. WBV was administered in a random fashion using a repeated-measures counterbalanced crossover design.

Jump Testing

The athletes adopted a static 110° position that was held for ~3 seconds. The difference between the height of the waist in the standing upright and the height of the waist in the 110° knee position was defined as the "dip." The SQJ was performed by jumping straight upward with as little countermovement as possible and was immediately followed by the 2 CMJs. Twenty seconds after the last CMJ jump, a second set of 3 jumps was performed (Figure 1). Mean and peak velocity, height, dip, and peak acceleration were measured using GymAware (Kinetic, Mitchell, Australia), which consists of a linear encoder placed between the athletes feet and secured to the floor with a cord attached to a belt tied firmly around the athlete's waist. An infrared transceiver picked up the signal from the linear encoder that saved the data on a palm top and was subsequently downloaded to a computer.

Sprint Testing

One 30-m sprint was performed 4 minutes after the final CMJ was completed. Splits were measured at 5, 10, 15, 20, 25, and 30 m and recorded to the nearest 0.01 second using a laser device focused on the bottom of the athletes back by an experienced operator (LaVeg, 300c, Jenoptick, Jena, Germany). Each sprint was done using a 2-point start where athletes started in a stationary position from a line 1-m before the "start" line.

Vibration Treatment

Athletes were exposed to vertical sinusoidal WBV of 30 Hz with a ±4 mm amplitude (NEMES LC, Rome, Italy). The WBV exposure was 3 × 60 seconds with a 1:3 work relief ratio. After the final bout of WBV the athletes had a 5-minute rest before commencing the final series of jumps and the sprint. For the WBV treatment, athletes stood with heel elevated and only their toes on the vibration platform, the knee at 110° flexion and leaning slightly forward. Those who did not undergo WBV stood on the vibration plate in an upright position with no vibration. This protocol was used to allow 4 athletes (maximum allowed on the World Cup) to undergo WBV in a realistic time frame between the completion of the warm-up and time of competition.

Statistical Analyses

Change scores are expressed as the mean effect (%) ± 90% confidence limits (CL) between pre- and postvibration trials. Differences between the overall sprint time, individual split times, and jump parameters were assessed using a priori planned contrasts (paired *t*-tests). Intraclass correlation (ICC) and the percentage within-subject *SD* (SD_{within}) between the 2 pretesting sessions were established to assess reliability and test-retest reliability. The SD_{within} was calculated as follows ($\%SD_{\text{within}} = \{SD\,\Delta/\sqrt{2})/[(\text{mean pre }1 + \text{mean pre }2)/2] \times 100\}$ (7). Magnitudes of differences and changes were calculated as (effect size = WBV change − CON change/*SD*) and expressed as an effect size using the following criteria: 0.0, trivial; 0.2, small; 0.6, moderate; 1.2, large; and >2.0, very large (9) All data are presented as mean ± 90% CI; significance was set at $p \leq 0.05$.

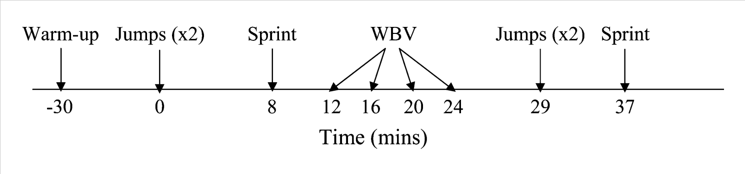

Figure 1. Timeline of the protocol. Jumps = squat jumps and countermovement jumps; WBV = whole-body vibration; sprint = 30-m sprint.

RESULTS

30-M Sprint

In the CON condition, the second 30-m sprint was 0.06 seconds slower (change score % ± 90% CI; 1.4 ± 0.8%; $p = 0.05$). After WBV, the decrement in 30-m sprint time was 0.03 seconds (0.7 ± 0.4%; $p = 0.03$) (Figure 2). There was a nonsignificant trend ($p = 0.25$) for the second sprint to be faster following WBV. The SD_{within} was 0.8% and the ICC = 0.98. The effect size was small in the second sprint (0.31) but larger than the first sprint effect size of trivial (−0.17).

The 0- to 5-m segment was discarded from this analysis due to the high variability between athletes' running styles (changes in the position of the upper body during the start) and was deemed as unreliable. The 5- to 10-m split was significantly slower after the CON condition (1.8 ± 0.4%) compared to the WBV treatment (0.4 ± 1.0%; $p = 0.04$). No statistically significant differences were found between any of the other splits. The SD_{within} was 0.9% and the ICC was 0.99 for the 5- to 10-m sprint interval. The effect size was small for the post 5- to 10-m interval (0.41) and trivial for the first sprint 5- to 10-m interval (0.14).

Squat and Countermovement Jumps

In the CON condition, the mean velocity of the second SQJ was 0.05 $\text{m}\cdot\text{s}^{-1}$ lower (−2.8 ± 2.3%; $p = 0.09$), yet after WBV, the mean velocity was enhanced by 0.03 $\text{m}\cdot\text{s}^{-1}$ (1.7 ± 4.2%; $p = 0.53$). The SD_{within} was 4.0%, the ICC was 0.72, and the effect size was small in the post-jumps (0.41) compared to the trivial findings in the pre-jumps (−0.14). Dip post-CON conditions was 0.01 m lower (−4.7 ± 3.5%; $p = 0.08$), but after WBV, the dip increased 0.02 m (7.1 ± 7.0%; $p = 0.15$), resulting in a nonsignificant difference in change scores of 11.8%. The SD_{within} was 7.6%, the ICC was 0.56, and the effect size was between small in both the second set of jumps (0.48) and the first set of jumps (0.35). Vertical distance remained identical during the second SQJ in CON conditions (0.1 ± 4.0%; $p = 0.95$), but after WBV, it decreased 0.04 m (−5.5 ± 4.4%; $p = 0.08$). The SD_{within} was 5.6%, the ICC was 0.67, and the effect size was trivial post-conditions (0.11) compared to small in the precondition (0.57). No changes were found for peak velocity, height, or peak acceleration in the SQJ, and no significant differences were found in all parameters measured for the CMJs.

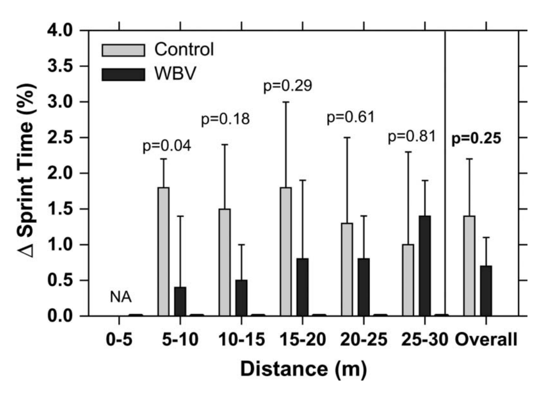

Figure 2. Mean changes (±90% CI) in interval time and overall 30-m sprint time between whole-body vibration and control.

DISCUSSION

This is one of the first studies to examine the effects of an acute bout of WBV on sprint performance in a group of highly sprint- trained athletes. Our study does not suggest large potentiation effects of WBV on 30-m sprint or vertical jump performance in elite skeleton athletes who are typically required to perform maximal efforts after a forced recovery period (e.g., multiple heats in 1 day). Elite sprint athletes have well-developed muscle strength, optimized motor neuron excitability, reflex sensitivity, and fast twitch fiber recruitment. Sprint running training uses the stretch shortening cycle while exploiting the qualities of the muscle tendon complex. Sprint training may also alter temporal sequencing patterns of muscle activation, for example, before ground contact, appropriate muscle cocontraction may allow greater stiffness of a given joint (13). Such an increase in muscle stiffness may help protect muscle fibers from damage due to impact vibrations during the landing phase (6) as well as enhancing performance by minimizing ground contact time. Hence, the muscle tendon complex of elite athletes (and control strategies for it) are already well developed to minimize changes in muscle length and to dampen vibrations (12) and resist high-impact loads (11). It is possible that the 30 Hz and 4-mm displacement used in our study may have been an insufficient stimulus for elite power athletes to achieve any potentiation.

To enhance ecological validity, we employed a full sprint competition warm-up replicated over both testing sessions. Aside from the small enhancement in the 5- to 10-m split time after WBV, we observed little evidence of vibration having a large positive effect on 30-m sprint or jumping performance over and above the normal warm-up of these athletes. Conversely, Cochrane and colleagues (4) found no changes in the CON or WBV (26 Hz, 6 mm) trials, but trivial changes were found in vertical jump after 5 minutes of seated cycling (50 W at 50 rpm). The authors postulated that if a greater number of athletes were tested, cycling alone may have provided a sufficient warm-up to enhance vertical jump performance compared to the CON conditions.

While jump height was not enhanced in this current investigation, it was of interest to note that some changes in the range of movement used in the jumps occurred. The reduced dip (amount of initial hip displacement) after WBV could have contributed to reduced mean velocity and vertical distance in the SQJ, although jump height remained similar throughout. It is plausible that the decreased dip after WBV may be due to disturbed proprioception. Tendon vibration has been shown to alter the afferent muscle spindle contribution to the sensations of dynamic position and velocity with reported biased perceptions of limb kinematics at 20, 40, and 60 Hz (5). No differences in biased perceptions were found at 30 Hz, although it is possible that the proprioception and kinesthetic awareness of perceived limb movement in our athletes was affected at 30 Hz due to the difference in vibration application (WBV versus tendon vibration). The change in proprioception awareness could in turn contribute to changes in overall performance.

In conclusion, when sprint athletes warm up and perform maximal jumps and a 30-m sprint twice with a 15- to 20-minute recovery, the second series of performances tend to be compromised. However, when WBV is used before the second series of efforts, some aspects of maximal jumping and sprinting appear to be influenced in a beneficial manner.

Practical Applications

If elite athletes already have well-developed muscle strength and recruitment strategies, optimized motor neuron excitability and reflex sensitivity (6), and a stiffer muscle tendon complex to minimize changes in muscle length and to dampen vibrations (12), then the accepted vibration frequency of ~30 Hz may not be optimal for this population. Further research is needed to see whether a higher frequency, greater amplitude, and/or longer exposure to the vibration stimuli have an additive effect in addition to a warm-up to maintain excitability or prolong the warm-up for skeleton or track and field athletes attempting multiple efforts within 1-day during actual competition.

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