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ORIGINAL ARTICLE

An acute bout of whole-body vibration on skeleton start and 30-m sprint performance

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Abstract

Maximal 30-m upright sprinting and bent over, skeleton push performance were examined in five female national team skeleton athletes before and 10 min after an acute bout of whole-body vibration or no vibration. The whole-body vibration was applied at a frequency of 45 Hz with 4-mm displacement for 3 × 1-min treatments separated by 1 min. All changes in 30-m sprint and skeleton push times before and after whole-body vibration were small or trivial and within the tests' typical variation (~3.7% for the skeleton push and ~3.2% for the upright sprint). Athletes were able to achieve 75–79% of their 30-m upright sprinting velocities when pushing a skeleton sled. These results question the effectiveness of whole-body vibration as an ergogenic aid immediately before performing a maximal upright sprint or skeleton push following a comprehensive warm-up.

Keywords: Acceleration, skeleton, sprint running, warm-up, winter sport

Introduction

The positive benefit of whole-body vibration to athletes for performance enhancement is controversial. A dichotomy of evidence in jumping performance exists following an acute bout of whole-body vibration. Countermovement jump height has been shown to increase by 8% (Cochrane & Stannard, 2005) and 1% (Cormie, Deane, Triplett, & McBride, 2006) following whole-body vibration, whereas no changes were reported by other authors (Rittweger, Mutschelknauss, & Felsenberg, 2003; Torvinen *et al.*, 2002). Evidence supporting the use of whole-body vibration to facilitate muscle function during power-based movements in athletes is lacking (Nordlund & Thorstensson, 2007). Moreover, there is a paucity of data using acute whole-body vibration in highly trained athletes in a sport performance setting using a competition warm-up.

Skeleton is an individual sliding sport performed on an iced bobsleigh track. The skeleton run starts with the athlete sprinting in a bent-over position pushing a sled for 20–35 m on the track before loading on the sled in a prone head-first position. Under normal competition conditions, skeleton athletes are able to achieve 70–85% of upright sprint times in a bent-over running position while pushing a “dry-land sled” (Sands *et al.*, 2005) and a fast start time in skeleton has been suggested to be a prerequisite for an excellent overall performance (Zanoletti, La Torre, Merati, Rampinini, & Impelizzeri, 2006).

Countries seeking international success in skeleton are placing greater emphasis on the start through identification of faster athletes (OWIA, 2006; BBSA, 2007; BCS, 2007). However, the relationship between upright sprinting and on-ice push performance has not been well documented. In the present

study, we investigated skeleton push performance following an acute bout of whole-body vibration in conjunction with a standard competition warm-up to replicate practices seen in World Cup competition to determine whether bent-over sprint running times could be improved.

Methods

Participants

Five female national team skeleton athletes (mean \pm s: age 22 ± 3 years; height 1.6 ± 0.05 m; body mass 61.0 ± 9.8 kg) volunteered to participate in this study. Two of the athletes were ranked in the top-10 in the world. All athletes received a clear explanation of the study, including the risks and benefits of participation. Approval was obtained from the Australian Institute of Sport Research Ethics Committee.

Procedures

Athletes attended four test sessions each separated by 24 h, which included a warm-up, maximal sprint effort, intervention, and finished with a second maximal sprint effort. No formal familiarization sessions were completed because the athletes in this study had participated in this type of testing regularly over the previous 2 years. The 30-m upright sprints were performed (from a stationary two-point standing start 1 m before the start line) indoors on a synthetic running surface. Skeleton pushes were performed in an indoor ice-house facility. Athletes completed a competition-specific sprint warm-up before the first sprint effort, which was replicated before all test sessions and has previously been described (Bullock *et al.*, 2008). Thirty minutes following the initial 30-m sprint or skeleton push, athletes received whole-body vibration or no treatment (control). Ten minutes after the final bout of whole-body vibration (45 min after the first performance test), all athletes (whole-body vibration and control) repeated the performance tests (Figure 1). The timing for applying the intervention was designed to replicate the standard times between competitive slides at a World Cup event.

Vibration treatment

Three bouts of 60 s vertical sinusoidal vibration of approximately 45 Hz and 4 mm displacement (according to the manufactures instructions) was used (NEMES LC, Rome, Italy) with a 1:1 work to relief ratio. The whole-body vibration was performed with the athletes' heels slightly elevated off the platform, the knee at 110° flexion and leaning slightly forward, with their hand on the vibration plate's handle to support their upper body. During the control trial, the same posture was employed but no vibration was applied.

Laser data collection

Athlete velocity data were collected at 100 Hz with an infra-red laser (LaVeg, 300c, Jenoptick, Germany). The athlete's lower back and the rear of the sled were targeted by laser for upright sprints and skeleton pushes respectively. The laser instrument was raised such that the line of sight of the laser to the sled beyond the 15-m interval was parallel to the (2%) slope. The laser gun height, true distance of laser to start and sled, and angle of slope through the initial 15 m were used with the cosine rule to determine distances, and therefore speeds, to the first 15 m. Splits beyond 25 m in the skeleton push were not analysed, as some athletes had already mounted their sleds. A 99-point average filter was used to smooth the skeleton push data because of the increased noise from the vibrations of the sled target.

Statistical analysis

A repeated-measures counterbalanced crossover design was employed. The velocity interval splits were fitted with a logarithmic curve and a regression analysis was used. The changes between pre- and post-velocity splits were calculated and expressed as a percentage change $\pm 90\%$ confidence limits. These differences were assessed using *a priori* planned contrasts (paired *t*-tests). Intraclass correlation coefficients (ICC) and the coefficient of variation (CV) were established to assess reliability and test-retest. Magnitudes of differences and changes are expressed as an effect size using the following criteria:

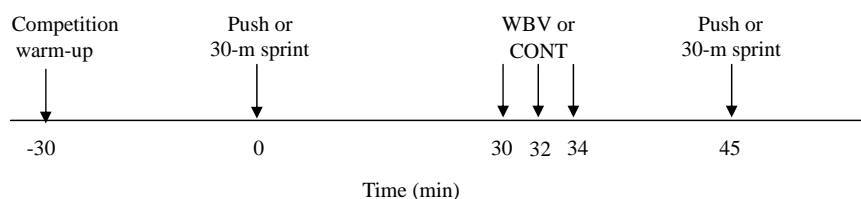


Figure 1. Schematic representation of the experimental protocol. WBV = whole-body vibration, CONT = control.

0.0 = “trivial”, 0.2 = “small”, 0.6 = “moderate”, 1.2 = “large”, and >2.0 = “very large” (Liow & Hopkins, 2003). Statistical significance was set at $P < 0.05$.

Results

One athlete did not participate in one of the four sprint trials. The 0–5 m interval data were discarded due to the high variability. No significant differences were observed for any of the skeleton push and 30-m sprints ($P > 0.05$). The data for the whole-body vibration and control groups were collapsed and mean velocity for each split is shown in Table I. The coefficients of variation and intraclass correlations are shown in Table II. In the skeleton push, the effects were small for the 5–10 and 20–25 m splits (0.50 and 0.48 respectively) and trivial for the 10–15 and 15–20 m splits (0.18 and 0.17 respectively). In the upright sprint, the effects were small for the 5–10 m split (0.41) and trivial for the 10–15, 15–20, 20–25, and 25–30 m splits (0.04, 0.03, 0.13, and 0.00 respectively). At the 5–10 m split, the athletes were able to push $75 \pm 3\%$ of their 30-m upright sprinting velocity. By 10–15 m, this value was $79 \pm 4\%$ and at 15–20 m it had increased to $84 \pm 3\%$.

Discussion

The results of this study do not support the use of whole-body vibration as an acute ergogenic aid for a second maximal skeleton push or a second 30-m upright sprint in highly trained skeleton athletes. The present participants were able to achieve 75–85% of their upright running velocity while performing an on-ice skeleton push, which is similar to previous study (Sands *et al.*, 2005). The 10-min interval (the most realistic for the practical application in a competitive skeleton setting) between the last bout of whole-body vibration and the performance task may have been too long or the competition sprint specific warm-up may have

Table I. Collapsed mean velocities for each individual split for the skeleton push and sprint data (m s^{-1})

| | Skeleton push | 30-m sprint |
|---------|-----------------|-----------------|
| 5–10 m | 4.56 ± 0.17 | 6.15 ± 0.19 |
| 10–15 m | 5.74 ± 0.22 | 7.23 ± 0.27 |
| 15–20 m | 6.47 ± 0.22 | 7.74 ± 0.28 |
| 20–25 m | 7.10 ± 0.32 | 7.96 ± 0.26 |
| 25–30 m | * | 8.11 ± 0.23 |

*No data presented, as some athletes had already loaded the sled.

Individual trends for the skeleton push and 30-m sprint in both the control and whole body vibration trials are shown in Figures 1 and 2.

Table II. The coefficient of variation (CV) and intraclass correlation (ICC) for the skeleton push start and upright 30-m sprint

| | CV (%) | ICC |
|--------------------------|--------|------|
| Skeleton push | | |
| 5–10 m | 3.62 | 0.66 |
| 10–15 m | 4.36 | 0.75 |
| 15–20 m | 3.87 | 0.73 |
| 20–25 m | 3.10 | 0.86 |
| Upright sprinting | | |
| 5–10 m | 2.86 | 0.77 |
| 10–15 m | 3.57 | 0.97 |
| 15–20 m | 3.23 | 0.94 |
| 20–25 m | 3.20 | 0.98 |
| 25–30 m | 3.41 | 0.96 |

negated any potential performance gains from whole-body vibration. It has previously been reported that performance gains can be achieved directly following application of whole-body vibration (Cochrane & Stannard, 2005; Cormie *et al.*, 2006); however, Cormie and colleagues (2006) showed that all gains dissipated 5 min after whole-body vibration. Previously, we used an intervention at a lower frequency with the same amplitude (30 Hz) (Bullock *et al.*, 2008) in a similar population and we speculated that the use of the higher frequency (45 Hz) would result in a greater effect. It is conceivable that a full warm-up may already “fully potentiate” the stretch reflex response, motoneuron excitability, and fast-twitch fibre recruitment in these athletes. For sprint-trained athletes, it has been reported that their motor unit pool likely requires greater stimulation from the Ia afferents for a reflex to be elicited (Ross, Leveritt, & Riek, 2001). Thus, whole-body vibration may be a sufficient stimulus when warm-up procedures are compromised, but when a full warm-up is completed no further benefits accrue.

Due to the time delay necessary in this competition-specific protocol, it is possible that the frequency, amplitude, and/or duration of vibration could be inadequate and further research in this area is warranted. Highly trained athletes have the ability to produce a stiffer muscle–tendon complex through extensive training (Kubo, Kawakami, Kanehisa, & Fukunaga, 2002), which is positively related to sprinting speed (Ross *et al.*, 2001). These stiffer muscle–tendon complexes increase the ability to transmit force rapidly, resulting in a higher rate of force development (Wilson, Murphy, & Pryor, 1994) and shortening of the electromechanical delay (Kubo, Kanehisa, Ito, & Fukunaga, 2001), thus improving muscle performance during rapid movements. However, it would appear that the increased stiffness in elite sprint athletes is largely a function of the pre-contracted muscle rather than tendons, as

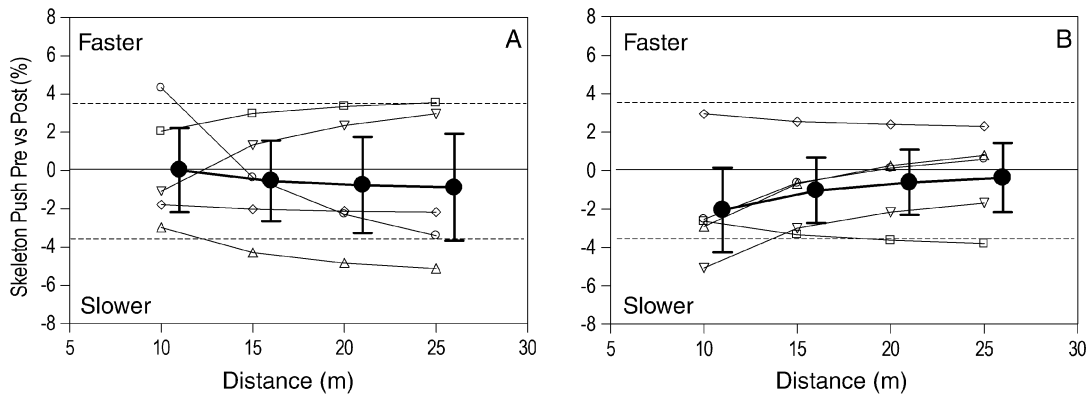


Figure 2. Individual changes for each of five athletes (open symbols) and the mean change (\pm 90% confidence limits; solid symbols) from pre- to post-test in the skeleton push for the control group (A) and whole-body vibration group (B).

Kubo and colleagues (Kubo, Kanehisa, Kawakami, & Fukunaga, 2000) report increasingly compliant tendons of highly trained sprint athletes that can act as a mechanical buffer and dampen vibration stimuli to protect the muscle from damage. Consequently, the vibration stimulus transmitted to the musculature and muscle spindles in elite athletes may be less than in their untrained counterparts, thus elite athletes may need a greater frequency, amplitude or duration. If this is the case, an alternative solution would be the use of a direct vibration stimulus to the muscle belly that could reduce the potential dampening effect and improve whole-body vibration application. We propose that frequency and amplitude specificity is required due to the potentially different focus areas of the force-velocity relationship required in elite sporting events. For example, improvements in leg press and countermovement jump height have been found using a lower frequency but greater amplitude (26 Hz/10 mm and 26 Hz/6 mm) (Bosco *et al.*, 1999; Cochrane & Stannard, 2005). Studies reporting performance enhancements following whole-body vibration have utilized tasks heavily focused on rapid single-effort

applications of force, possibly placing a greater reliance on the force aspect of the force-velocity curve. In contrast, the performance task in the present study, sprinting, is a high force cyclical movement pattern that may relate more closely to the velocity component of the force-velocity relationship. Further research is needed to establish if gains can be found in velocity-specific tasks.

Novel to this study is the observation that female athletes were able to achieve 75, 80, and 85% of their upright running velocity at 10, 15, and 20 m while performing an on-ice skeleton push. These values are similar to those reported for US females national team members of 70, 75, and 85% using dry land push sleds (Sands *et al.*, 2005).

The present sample size was limited due to the individual nature of skeleton competition and the related small squad sizes. Therefore, it is plausible that our inability to determine a difference between the whole-body vibration and control groups is the result of a type II error. However, the coefficient of variation in skeleton push velocity was 3.5% and the power ($\beta = 0.896$) was adequate, indicating that the research design was of sufficient strength to

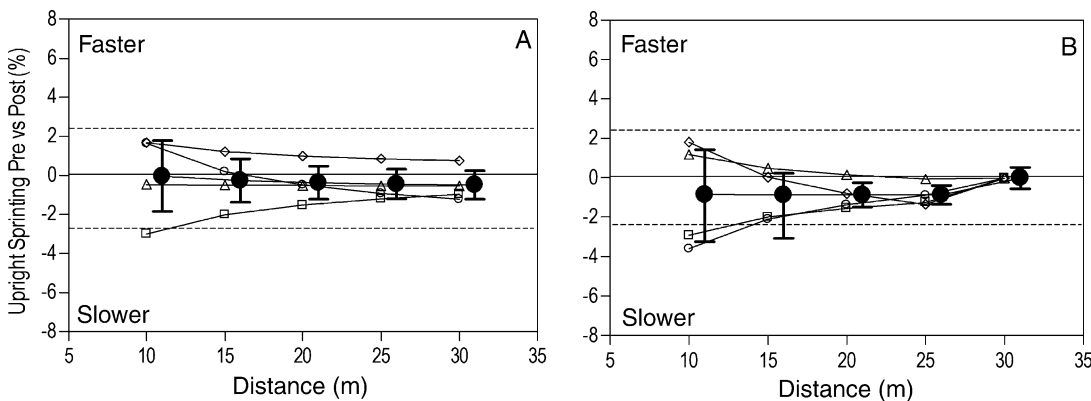


Figure 3. Individual changes for each of four athletes (open symbols) and the mean change (\pm 90% confidence limits; solid symbols) from pre- to post-test in the 30-m sprint for the control group (A) and whole-body vibration group (B).

demonstrate a difference even though this was a sample of convenience using highly trained skeleton athletes. An issue encountered in whole-body vibration research is quantification of the actual vibrations each muscle receives. In this instance, the vibration platform was set at 45 Hz and 4 mm amplitude, but it is possible that the body mass of the athlete, the position of the feet on the vibration platform, and the type of footwear worn could attenuate the frequency and amplitude. Furthermore, the vibration transmitted up the body will vary depending on muscle-tendon complex stiffness; thus the actual vibrations that reach the leg extensors may vary greatly among individuals. The ability to quantify the amount of vibration each muscle receives would allow for a greater understanding of the positive and negative outcomes from whole-body vibration research.

Conclusion

When a full competition warm-up was used by highly trained sprint athletes, the second series of maximal skeleton pushes or 30-m upright sprinting was not compromised and no performance benefits were found with the addition of an acute bout of whole-body vibration. Trained skeleton athletes are able to achieve a high percentage of their upright sprinting time in a bent-over running position, which supports the identification and selection of faster athletes for a fast skeleton push.

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