Original Article

Acute effects of dynamic whole body vibration in well trained track & field sprinters

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Abstract:

Whole-body vibration is a neuromuscular training method and has been suggested as an acute ergogenic aid mode before practice, training and competition activities of athletes. The aim of this study was to investigate the acute effects of a whole-body vibration session on sprint running kinematics and neuromuscular performance in well trained track & field sprinters. 30 sprint athletes participated in this study (age 21.6 ± 4.1 years, height 1.76 ± 5.0 m, body mass 71.2 ± 6.4 kg). Both experimental (with vibration) and control (without vibration) groups performed a single session of whole-body vibration consisted of two dynamic exercises (half squat / lunge) using a body vibration platform (90 s, 50 Hz, 2 mm). Performance tests (60m sprint, counter movement jump, muscle power and sit & reach test) were performed before and after 6 min the whole-body vibration session. Counter movement jump was reduced after whole-body vibration by 3.9%, whereas all the other analyzed parameters remained unchanged. The results of this study do not support the use of whole-body vibration as an acute ergogenic aid during standardized warm-up in well trained track and field sprinters.

Key words: step length, step rate, flexibility, muscle power, single session, post-activation potentiation.

Introduction

Whole-body vibration (WBV) is a neuromuscular training method that has been developed and promoted as an alternative strength training method (Delecluse, Roelants and Verschueren, 2003) and as an ergogenic aid during warm-up before practice, training and competition activities of athletes (Bazett-Jones, Finch and Dugan, 2008). In WBV training, the participant stands on a platform that generates vertical sinusoidal vibration at frequencies between 25 and 50 Hz. Therefore, the body can acquire mechanical energy as it is a spring-mass system where tendons and muscles act like springs to store and release mechanical energy (Rittweger, 2010). Additionally, these mechanical stimuli stimulate sensory receptors, most likely muscle spindles, and might cause the activation of the alpha-motoneurons and initiates muscle contractions comparable to the “tonic vibration reflex” (Burke and Schiller, 1976; Hagbarth, and Eklund, 1966). Vibration stimulus is widely used among athletes as a part of their training regimen as there are studies reporting clearly the beneficial effects of short term (≤ 2 months) WBV training on muscle force and power (Issurin, 2005; Fagnani et al, 2006; Ronnestad, 2004; Mahieu, et al., 2006) and flexibility (Fagnani et al., 2006; Issurin, Liebermann and Tenenbaum, 1994; Tillaar, 2006) whereas the effects on sprint speed is controversy as some studies reported no beneficial effects (Colson et al., 2010; Cochrane, Legg and Hooker, 2004; Delecluse et al., 2005), where another showed significant improvements (Paradisis and Zacharogiannis, 2007).

WBV has been promoted as an ergogenic aid mode and, given its time efficiency for eliciting mild cardiovascular and metabolic changes (Cochrane et al., 2008; Rittweger, Schiessl and Felsenberg, 2001), it may be a suitable warm-up option to elicit temperature-related processes (Cochrane, 2011). Many researchers have reported temporary improvements in jumping ability after a single session of WBV (Bazett-Jones, Finch and Dugan, 2008; Cochrane and Stannard, 2005; Torvinen et al., 2002; Cormie et al., 2006; Jacobs and Burns, 2009; Sands et al., 2008), muscle force and power (Bosco et al., 2000; Stewart, Cochrane and Morton, 2009) which might be due to neural adaptations (Cochrane and Stannard, 2005). Since, as the increased motoneuron excitability is regarded as an integral part to enhance sprint performance (Ross, Leveritt and Riek, 2001) it could hypothesized that WBV may be a favorable method to enhance sprint performance (Cochrane, 2011). Recently, Rønnestad and Ellefsen, 2011 examined the acute effect of 30 s half squat with WBV (50 Hz) on 40 m sprint running on amateur soccer players and found that WBV resulted in an improved performance by 0.7%. Contrary, two studies examined the acute effects of WBV on elite skeleton athletes and reported no acute effects

on 30 m sprint performance (Bullock et al., 2008; 2009), where similar results were reported by Kavanaugh et al., (2011) on NCAA Division I collegiate sprinters and jumpers. However, in Kavanaugh et al., (2011) and Rønnestad and Ellefsen (2011) the rest between WBV and the tests was 1 min, whereas in Bullock studies (Bullock et al., 2008; 2009) the rest was 13 min. As a number of studies reported that the positive acute improvements after a relative short WBV intervention (< 60 s), lasted 5 min, whereas after that returned to a level at or below baseline (Bazett-Jones, Finch and Dugan, 2008; Jacobs and Burns, 2009; Bedient et al., 2009) more clarification is needed. Additionally, if the WBV intervention would be used as an aiding stimulus in the warm up before the start of the race in a competitive track and field setting, a realistic rest interval should be adapted. After observations on national championships track and field competition races, the authors identified that a realistic rest between WBV interventions and tests or races should be 6 min. So, the theoretical beneficial acute effects of WBV training on sprint performance and especially on well trained track and field sprint athletes needs more investigation and should be tested in realistic situations. The purpose of this study was to investigate the acute effects of a single session of WBV intervention after 6 min on sprint running kinematics, power and flexibility on well-trained track and field sprint athletes. It was hypothesized that the single session of WBV intervention would to produce significant improvements in the selected parameters on well-trained track and field sprint athletes.

Method

Participants and study design

Thirty male sprint athletes participated in this study (age 21.6 ± 4.1 years, height 1.76 ± 5.0 m, body mass 71.2 ± 6.4 kg, % of body fat 9.36 ± 1.82 % and personal best 100m time 11.04 ± 0.4 s). All participants were active well trained sprint athletes with at least 3-4 years of experience in sprinting training and there was no health issue or other reason for exclusion from the study. They were asked to avoid any additional training throughout the period of the study and to maintain a normal food intake. Informed consent was obtained from each participant before data collection. In addition, a detailed explanation of the experimental procedures and the test protocol, as well as the possible risks and benefits of the study was provided. Lastly, approval was granted by the university ethics board.

A two group, pre-post design was used in this study to determine whether a single session of WBV would result in a considerable increase on sprint running kinematics, power, counter movement jump (CMJ) and flexibility in well trained sprint athletes. The study took place at the beginning of the competitive period. The participants were randomly assigned to two groups, which included a vibration group (VG, $n = 15$) and a control group (CG, $n = 15$). The WBV was performed on a Power Plate® platform (Pro 5™). There was no significant difference between the two groups before intervention.

Protocol

The intervention involved a single WBV session on a vibration platform which consisted of two dynamic exercises, after completion of a standardized 20-min warm-up (the competition -specific sprint warm-up 10 min aerobic activity to elevate muscle temperature followed by dynamic stretching, bounding, jumping, and 60-85% accelerations). The vibration frequency was set at 50 Hz and the amplitude at 2 mm for the VG, whereas CG was not exposed to vibration (in the CG the vibration platform was switched off). As there are no scientific-based WBV programs the training program of this study was based on similar protocols that resulted in significant changes in muscle performance (Delecluse, Roelants and Verschueren, 2003; Torvinen et al., 2002). Participants were asked to perform both protocols wearing thin-soled gymnastic-type shoes to prevent bruising and to standardize the damping of the vibration due to the footwear (Cochrane and Stannard, 2005).

The protocol consisted of two dynamic exercises (semi-squat and lunge of each leg). The exercises were executed dynamically (rate: 2 s eccentric 2 s concentric) with the use of a metronome (Witter metronome taktell Picollo – In, Germany) and a goniometer (Lafayette, model 01129-Guymon Goniometer - In, USA). Semi squat exercise lasted 30 s and lunge of each leg lasted 30 s without rest in between, with total duration 90 s. The dynamic exercises were executed as follows: Semi-squat. - Subjects stood on the vibration platform with their legs mostly straight (170°) and slightly apart, while they kept their back straight. They bent their knees till the angle of 90° and returned back to the starting position (170°) according to the metronome's rate. Lunge. - Subjects placed one foot on the vibration platform, while the other foot remained on the floor. They bent both knees at an angle of 90° while they kept their back straight and their abs and pelvis engaged. They were moving upward the back leg being almost straight (170°) and returned back to the starting position, according to the rate of the metronome. They were instructed not to allow the front leg's knee to move forwards during their upwards and downwards movement. This exercise was performed one leg at a time.

Pre – Post Testing

Performance tests were performed at maximal intensity by both groups, before (pre) and 6 min (post) after the WBV session. Pre-tests were performed during the first two testing days, while the WBV session and the post tests were performed during the last four days, after the completion of the standardized warm up. Prior

to performing the tests, the body mass, body height and the % of body fat were obtained (Durnin and Womersley, 1974). During the familiarization week, subjects were familiarized with the dynamic exercises and the tests and were randomly assigned into the VG and CG groups; additionally the 1RM was measured for leg extension and flexion (Stewart, Cochrane and Morton, 2009). Performance tests as described below, consisted of 60 m sprint, CMJ, maximal voluntary isotonic power of knee extensors (EXT) and flexors (FLE) bilaterally, and S&R. The 1st testing day occurred three to five days after the familiarization week and included the pre 60 m sprint tests, whereas the pre CMJ, muscle power and sit & reach tests were performed in the 2nd testing day. In the 3rd, 4th, 5th and 6th testing days, subjects performed the WBV intervention and after 6 min rest they performed randomly one of the performance tests (fig 1). Between testing days one day rest was intervened to avoid fatigue.

Fig 1. Study Protocol

60 m test

In the 60 m sprint test, subjects performed a maximal sprint using standing start, after the completion of the standardized warm up. The sprint tests were performed in an indoor track at a constant temperature of 25° C. The time and average velocity were obtained every 10 m (at 10, 20, 30, 40, 50 & 60 m) using the Brower timing system (Brower, USA). Additionally, the step length (SL) of each athlete was recorded by a video camera (Sony HDR SR10E). The filming of the sagittal plane of a full stride (two consecutive steps) performed with sampling frequency of 50 Hz. The cameras were placed at the points of 15 and 45 m and 10 m apart from the performance plane, such that their optical axis were horizontal, forming an angle of 90° with the horizontal plane of running. A metal calibration frame (2 x 2 m) was filmed such that the x-axis was parallel to the horizontal and the y-axis was perpendicular to the horizontal. SL (for distance intervals 10-20 m and 40-50 m) were calculated according to the methods of Paradisis and Cooke (2006), where step rates (for distance intervals 10-20 m and 40-50 m) were calculated according to the formula:

$$SR = AV \div SL$$

where SR = step rate, AV = average velocity of 10 m distance interval and SL = step length of 10 m distance interval (Paradisis and Cooke, 2006). As two consecutive steps were recorded two SL and SR were calculated.

Jumping tests

A CMJ test was performed, in order to assess the explosive strength/jumping performance (Lehance, Croisier and Bury, 2005). For the CMJ test the participants were asked to perform three maximal vertical jumps with hands positioned at the waist to assess the lower-limb explosive performance capacity. This test was performed on a contact mat, recording the flight time (Optojump, Microgate, It; Lehance, Croisier and Bury, 2005). The obtained flight time (t) was further used to determine the lift of the center of gravity (h), i.e., $h = gt^2/8$, where $g = 9.81 \text{ m}\cdot\text{s}^{-2}$. The best of three trials was recorded to determine the tests' score.

Muscle power tests

Maximal voluntary power was measured under isotonic ballistic condition (Bosco et al., 1995). A device ergopower (Ergotest Technology A.S. Langesund Norway) was used, based on a precise measure of the load displacements. Vertical displacements of the load were measured with a sensor which was interfaced to a computer which calculated the power corresponding to the load displacement (Bosco et al., 1995). The tests were executed in a leg extension – flexion machine (Technogym® Cesena, Italy). In EXT tests subjects were seated in an individually adjusted position to minimize displacement between the lower back and the backrest during muscular force exertion and were asked to extend the lower leg as fast as possible from a knee joint angle of 90° to 180°. In FLE tests, subjects stood facing the machine, while they placed their hands on the stationary bar of it. They kept stable both legs and flexed the knee of the tested leg as fast as possible through the complete range of motion. The resistance load was set at 60% of 1RM²⁵. The tests were repeated three times on each leg and the best score of the strongest leg power was recorded normalized by body mass (watt kg^{-1}).

Sit & reach test

The sit & reach (S&R) test was used to access subject's low back and hip-joint flexibility. Subjects removed their shoes and sat with their legs fully extended directly in front of them. The soles of the feet were placed against the edge of the box. With the hands overlapped and parallel to the box, subjects were directed to slowly reach forward as far as possible and hold for 2 s without bouncing. The farthest distance (cm) reached with the fingertips was recorded. The best of the three trials was recorded.

Statistics Analysis

ANOVA with repeated measures ($2 \times 2 \times 6$) were used to establish if there were any significant interactions between time (pre and post tests), group (VG and CG) and time performance (six distance intervals). Additionally, ANOVAs with repeated measures ($2 \times 2 \times 2$) were used to establish if there were any significant interactions between time, group and performance in distance intervals (10-20 and 50-60) for SL and SR. Finally, ANOVA with repeated measures (2×2) were used to establish if there were any significant interactions between time and group were used for all the other variables. For all the ANOVAs, the assumption of sphericity was examined with the Mauchly's test. In the event of significant interaction effects, post-hoc Tukey tests were used to identify the differences. In additions, effect sizes, using the Cohen's (Cohen, 1988) criterion (d, defined effect sizes as "small, $d = 0.2$," "medium, $d = 0.5$," and "large, $d = 0.8$ ") was used for data interpretation. Intraday variation of variables was estimated with the interclass correlation coefficient (ICC). The differences between the two groups concerning the anthropometric characteristics and the pre-test performance were analyzed by t-test analysis for independent sample. The significance level for the tests was set at $P < 0.05$.

Results

Anthropometric data and intraday variation

Statistical analysis showed no significant differences between the two groups in anthropometric characteristics (table 1) and pre performance tests. The ICC was used to estimate the intraday variation of the dependent variables (20 m, CMJ and SR). The ICCs between pre and post testing for time on 10 m, 20 m, 30 m, 40 m, 50 m and 60 m were 0.770, 0.890, 0.915, 0.939, 0.953 and 0.961 respectively, for SL and SR on 10-20 and 40-50 distance intervals were 0.795, 0.695, 0.722 and 0.681 respectively, for CMJ, EXE, FLE and SR were 0.960, 0.921, 0.873 and 0.961 respectively.

Table 1. Anthropometric data of all participants

	Body Mass (kgr)	Body Height (cm)	% Body Fat (%)	100m time (s)
VG	70.9 $\pm$ 8.59	177 $\pm$ 4.9	9.3 $\pm$ 1.71	11.0 $\pm$ 0.35
CG	71.2 $\pm$ 6.41	176 $\pm$ 5.0	9.4 $\pm$ 1.82	11.0 $\pm$ 0.40

Abbreviations: VG = vibration group, CG = control group

The statistical analysis for the 60 m time and the distance intervals 10 m, 20, 30 m, 40 m and 50 m of the 60 m sprint revealed no significant interaction effect between time and group ($F = 0.335$, $p = 0.912$, $\eta_p^2 = 0.080$, power = 0.122) and main effects (table 2). Similarly, the statistical analysis for the final running velocity of the 60 m sprint revealed no significant interaction effect between time and group ($F = 0.543$, $p = 0.457$, $\eta_p^2 = 0.019$, power = 0.110) and main effects.

Table 2. Mean $\pm$ s, % differences (post-pre tests) and size effect (d) of the distance intervals of the 60 m sprint test (N = 30).

		10 m (s)	20 m (s)	30 m (s)	40 m (s)	50 m (s)	60 m (s)
VG	Pre	1.83 $\pm$ 0.13	3.06 $\pm$ 0.15	4.19 $\pm$ 0.19	5.28 $\pm$ 0.23	6.36 $\pm$ 0.28	7.45 $\pm$ 0.31
	Post	1.86 $\pm$ 0.12	3.10 $\pm$ 0.15	4.23 $\pm$ 0.23	5.32 $\pm$ 0.23	6.41 $\pm$ 0.27	7.50 $\pm$ 0.31
	d	0.211	0.253	0.237	0.183	0.182	0.140
CG	Pre	1.89 $\pm$ 0.11	3.14 $\pm$ 0.15	4.28 $\pm$ 0.20	5.39 $\pm$ 0.25	6.51 $\pm$ 0.30	7.63 $\pm$ 0.36
	Post	1.89 $\pm$ 0.09	3.14 $\pm$ 0.11	4.29 $\pm$ 0.15	5.40 $\pm$ 0.19	6.51 $\pm$ 0.24	7.64 $\pm$ 0.29
	d	0.054	0.020	0.034	0.036	0.027	0.029

Abbreviations: VC = vibration group, CG = control group, d = effect size using the Cohen's criterion.

The statistical analysis for the SL in the 10-20 and 40-50 distance intervals of the 60 m sprint revealed no significant interaction effect between time and group ($F = 0.195$, $p = 0.824$, $\eta_p^2 = 0.014$, power = 0.077) and main effects (table 3). Similarly, the statistical analysis for the SR in the 10-20 and 40-50 distance intervals of the 60 m sprint revealed no significant interaction effect between time and group ($F = 0.440$, $p = 0.648$, $\eta_p^2 = 0.032$, power = 0.114) and main effects (table 3).

Table 3. Mean $\pm$ s, % differences (post-pre tests) and size effect (d) of the step length and rate of the 60 m sprint test.

		SL (m)		SR (Hz)	
		10-20	40-50	10-20	40-50
VG	Pre	2.01 $\pm$ 0.20	2.33 $\pm$ 0.24	4.10 $\pm$ 0.38	4.02 $\pm$ 0.35
	Post	2.04 $\pm$ 0.19	2.32 $\pm$ 0.19	4.00 $\pm$ 0.31	3.99 $\pm$ 0.32
	d	0.146	0.043	0.293	0.098
CG	Pre	2.09 $\pm$ 0.17	2.34 $\pm$ 0.23	3.87 $\pm$ 0.24	3.88 $\pm$ 0.40
	Post	2.15 $\pm$ 0.15	2.29 $\pm$ 0.19	3.74 $\pm$ 0.23	3.97 $\pm$ 0.40
	d	0.370	0.212	0.585	0.225

Abbreviations: SL = step length, SR = step rate, 10-20 = distance interval 10 – 20 m, 40-50 = distance interval 40 – 50 m, VG = vibration group, CG = control group, d = effect size using the Cohen's criterion.

The statistical analysis for the CMJ revealed significant interaction effect between time and group ($F = 5.948$, $p = 0.023$, $\eta_p^2 = 0.213$, power = 0.645). With respect to the time by group effect, the post-hoc tests used to estimate differences between pre and post testing for VG and CG revealed significant decrease (-3.9%) only for VG paired results comparison (CG: $p = 0.650$, $d = 0.048$; VG: $p < 0.010$, $d = 0.304$, Table 4).

The statistical analysis for the S&R revealed no significant interaction effect between time and group ($F = 4.111$, $p = 0.054$, $\eta_p^2 = 0.146$, power = 0.495) and main effects (Table 4). Similarly, statistical analysis for EXT ($F = 0.001$, $p = 0.978$, $\eta_p^2 = 0.001$, power = 0.050) and FLE ($F = 0.026$, $p = 0.874$, $\eta_p^2 = 0.001$, power = 0.053) revealed no significant interaction effects between time and group and mains effects (table 4).

Table 4. Mean $\pm$ s, % differences (post-pre tests) and size effect (d) of the countermovement jump, sit & reach and dynamometry tests.

		CMJ (cm)	SR (cm)	EXT (watt kg ⁻¹)	FLE (watt kg ⁻¹)
VG	Pre	44.89 $\pm$ 5.30	28.46 $\pm$ 8.61	3.05 $\pm$ 0.70	2.08 $\pm$ 0.39
	Post	43.19 $\pm$ 5.86*	29.46 $\pm$ 7.17	3.06 $\pm$ 0.51	2.09 $\pm$ 0.43
	d	0.304	0.145	0.024	0.009
CG	Pre	43.45 $\pm$ 5.80	27.00 $\pm$ 7.86	3.25 $\pm$ 0.53	2.19 $\pm$ 0.43
	Post	43.73 $\pm$ 5.67	25.82 $\pm$ 7.04	3.27 $\pm$ 0.47	2.18 $\pm$ 0.26
	d	0.048	0.158	0.037	0.037

* Significantly different from pre test ($p < 0.05$) as determined by repeated-measures analysis of variance and post hoc Tukey tests.

Abbreviations: CMJ = countermovement jump, SR = sit and reach test, EXT = dynamometry of knee extensors, FLE = dynamometry of knee flexors, VG = vibration group, CG = control group, d = effect size using the Cohen's criterion.

Discussion

The purpose of the present investigation was to compare the acute effects of a WBV session on sprinting, jumping performance and flexibility in well trained track and field sprinters. The results indicated that WBV did not affect 60 m sprint performance and the related parameters running speed SL and SR. This is in agreement with the results reported by Kavanaugh et al. (2011) and supports previous findings (Bullock et al., 2008;2009; Guggenheimer et al., 2009). Contrary, Rønnestad and Ellefsen (2011) concluded that a 30 s WBV resulted in improved 40 m sprint performance by 0.7%, even though the effect size (0.20) of these changes was relatively small. However, it has to be mentioned that Rønnestad and Ellefsen (2011) examined the effect of WBV on amateur soccer players and the rest between the WBV session and the performance tests was 1 min. The results of this study indicate that EXT and FLE remained statistically unchanged after WBV session in well trained track and field sprinters supporting the results of previous studies (Wilson, Murphy and Pryor, 1994; Da Silva-Grigoletto et al., 2009) but disagreed with those of Stewart et al. (2009). Similarly, the results indicate that flexibility remained statistically unchanged after WBV session in well trained track and field sprinters, even though there was an 3.4% improvement ($P = 0.054$, effect size = 0.145, nine out of fifteen participants increased it). Contrary to these results, other studies showed improvements in flexibility after WBV interventions (Cochrane and Stannard, 2005; Cormie et al., 2006; Jacobs and Burns, 2009; Cardinal and Lim, 2003). The only variable that indicated an acute significant reduction after the WBV was CMJ (3.8%), even though the effect size was relatively small (0.30). Contrary to our results, other studies showed either no changes (Torvinen et al., 2002; Gerodimos et al., 2010; Dabbs et al., 2011) or improvements (Rønnestad, 2009). Interestingly, Rønnestad

(2009) found that WBV increased CMJ (4.4%) in untrained subjects, whereas did not produce any changes in recreational trained subjects.

The differences of the observations between the results of the present study and those from the literature could be attributed to methodological issues that could affect the results. In particular, an important methodological issue that could affect the observed results is the subject selection; in the present study well trained track and field sprinters were participated, whereas other used recreational subjects (Torvinen, 2002; Jacobs and Burns, 2009; Gerodimos et al., 2010; Dabbs et al., 2011) or elite gymnast (Sands et al., 2008; Cardinal and Lim, 2003). Indeed, as the subjects on the present study were highly trained, the dose response of the vibration parameters of frequency, amplitude and duration may not have been at an appropriate level to elicit the desired responses of the neuromuscular system (Cochrane, 2011). It has been reported that sprint-trained athletes' motor unit pool requires greater stimulation from the Ia afferents for a reflex to be elicited (Ross, Leveritt and Riek, 2001). However, the optimal WBV exposure dose – response for the human body and specifically athletic performance and the mechanisms leading to enhanced performance, remains unclear. Additionally, it is possible that well trained track and field sprinters had well-developed musculotendinous component that can resist high impact loads (de Ruiter et al., 2003), which is positively related to sprinting speed (Ross, Leveritt and Riek, 2001). This stiffer musculotendinous component increases the ability to transmit force rapidly, resulting in a higher rate of force development (Erskine et al., 2007) and shortening of the electromechanical delay (de Ruiter et al., 2003) and improves muscle performance during rapid movements. However, as the increased stiffness in elite sprint athletes is possibly a function of the pre-contracted muscle rather than tendons (de Ruiter et al., 2003), the vibration stimulus transmitted to the musculature and muscle spindles in elite sprint athletes may be less than in the untrained subjects. Thus elite athletes may either need a greater frequency, amplitude or duration of vibration or the use of a direct vibration stimulus to the muscle belly that could reduce the potential dampening effect or improve WBV application (Bullock et al., 2009). It seems that there is a difference in muscle response between the well trained and untrained subjects (Kubo et al., 2002). The reason for this difference may be associated with the higher sensitivity of muscle receptors and central nervous system of elite athletes to additional stimulation (Issurin, Liebermann and Tenenbaum, 1994). It is possible that the WBV stimulus used in the present study is not the appropriate warm-up modality for well-trained track and field sprinters.

Another methodological issue that could affect the results is the rest interval between WBV intervention and the performance of the tests. The rest adopted in the present study was 6 min whereas others used 0–2 min (Cochrane and Stannard, 2005; Torvinen et al., 2002; Jacobs and Burns, 2009; Sands et al., 2008; Stewart, Cochrane and Morton, 2009; Cardinal and Lim, 2003; Gerodimos et al., 2010; Dabbs et al., 2011). It has been reported that the positive acute improvements in performance lasted 2⁴⁰ or 5 min (Bazett-Jones, Finch and Dugan, 2008; Jacobs and Burns, 2009; Bedient et al., 2009), whereas after that time period performance returned to values below those of pre WBV intervention (Cardinal and Lim, 2003). The rest interval adapted in this study (6 min) was the most realistic for the practical application in a competitive track and field setting if the WBV intervention could be performed as an aiding stimulus in the warm up before the start of the race. It looks like that the 6 min rest after the WBV may have been too long and dissipated all positive or negative effects of the intervention.

A third methodological issue that could affect the results is the duration of WBV exposure. In the present study the WBV exposure was 90 s whereas others used 2 min (Stewart, Cochrane and Morton, 2009) or 4–6 min (Cochrane and Stannard, 2005; Torvinen et al., 2002; Jacobs and Burns, 2009; Gerodimos et al., 2010; Dabbs et al., 2011). Final, a methodological issue that could affect the results is the warm-up before the protocol. In the present study a 20-min warm-up was adopted whereas others used no warm-up (Cochrane and Stannard, 2005; Jacobs and Burns, 2009; Stewart, Cochrane and Morton, 2009). The warm-up which was used prior to WBV might already “fully potentiate” the stretch reflex response, motoneuron excitability, and fast-twitch fiber recruitment and the following WBV session did not add any significant benefit in these athletes (Bullock et al., 2009). It seems that the WBV stimulus, based on the settings used in the present study, is not the appropriate warm-up modality for well-trained track and field sprinters in competition setting. Nevertheless, the mechanisms and optimal dose - response relation of vibration exposure remain unclear and further research is needed to be clarified. Further research is needed to see whether a different WBV protocol (frequency, amplitude, vibration exposure) would have an additive effect on neuromuscular and sprint performance.

Conclusions

The inclusion of a 90 s WBV session in a standardized warm up procedure before competitions did not add any benefit on sprint running kinematics, muscle power and flexibility in well trained track and field sprinters. Contrary to our hypothesis, WBV produced small but significant reductions in jumping ability. It seems subject's training level, the rest interval between WBV intervention and the performance of the tests and warm-up before WBV intervention affected significantly the expected outcome after an acute WBV session. The results of this study do not support the use of WBV as an acute ergogenic aid during standardized warm-up in well trained track and field sprinters.

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