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Research article

The Effect of Acute Vibration Exercise on Short-Distance Sprinting and Reactive Agility

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Abstract
Vibration exercise (VbX) has been a popular modality to enhancing physical performance, where various training methods and techniques have been employed to improve immediate and long-term sprint performance. However, the use of acute side-alternating VbX on sprint and agility performance remains unclear. Eight female athletes preformed side-alternating vibration exercise (VbX) and control (no VbX) in a cross over randomised design that was conducted one week apart. After performing a warm-up, the athletes undertook maximal 5m sprints and maximal reactive agility sprints (RAT), this was followed by side-alternating VbX (26 Hz, 6mm) or control (no VbX). Immediately following the intervention, post-sprint tests and RAT were performed. There was a significant treatment effect but there was no time effect (pre vs. post) or interaction effect for sprint and RAT; however, side-alternating VbX did not compromise sprint and agility performance.

Key words: Explosive power, speed, postactivation potentiation, warm-up.

Introduction

Vibration exercise (VbX) has received a lot of attention as a modality to enhancing physical performance. It has been documented that following acute VbX, power and strength qualities are enhanced (Adams et al., 2009; Cochrane and Stannard, 2005; Cochrane et al., 2008; Stewart et al., 2009; Torvinen et al., 2002,). For example, explosive lower limb performance are increased through countermovement jump and squat jump height (Adams et al., 2009; Cochrane and Stannard, 2005; Cochrane et al., 2008; Rønnestad, 2009), where it is has been attributed to neural aspects such as; increased motor unit recruitment and synchronisation, enhanced stretch reflex, and reduced co-contraction (Cochrane, 2011a). Sprint and agility performance produces high force generation over a short period that requires elements of relative power and strength, which can cause similar neural changes to that of VbX (Bosco et al., 1999; Cochrane, 2011a). Therefore, if acute VbX can facilitate a positive influence on lower limb power, it could potentially enhance sprint and agility performance.

Sprinting performance, especially linear speed remains a critical component in most sporting activities. Various training methods and techniques have been employed by coaches and trainers to improve immediate and long-term sprint performance. However, the use of acute VbX on sprint performance remains unclear. Previous research has reported no significant benefit in 30 m sprint time for international skeleton athletes who were exposed to acute intermittent synchronous VbX (30 Hz, 4 mm peak-to-peak displacement [p-p]) (Bullock et al., 2008). In a follow up study conducted by the same researchers, national female skeleton athletes were exposed to a higher vibration frequency (45 Hz) with a reduced rest period between vibration exposures (180 s to 60 s) but no significant improvement in 30 m sprint time was reported (Bullock et al., 2009). Similarly, other synchronous vibration frequencies (30 Hz, 40 Hz, 50 Hz, 1.5 mm p-p) combined with high knee running for 5 s (4 bouts; 30 s rest) had no effect on 40 m sprint performance in track and field athletes (Guggenheimer et al., 2009). Contrary, Ronnestad and Ellefsen (2011) reported that in male competitive soccer players, 40 m sprint performance significantly improved following 30 s of synchronous VbX (50 Hz, 3 mm p-p) while performing 15 repetitions of bodyweight squats. However, the aforementioned studies have only used synchronous vibration (SV) (50 Hz maximum) machines to assess sprint performance, where both legs are vibrated as the platform moves predominately in the vertical direction at a fixed peak-to-peak displacement (1-4 mm) (e.g. Nemes ®, Pneu-vibe ®). Another commercially manufactured vibration platform, which has a teeterboard produces side-alternating vertical sinusoidal vibration (SAV) (30 Hz maximum) to the body (e.g. Galileo®). It rotates around an anteroposterior horizontal axis, so when the feet are further from the axis it results in a larger vibration peak-to-peak displacement (2-12 mm). The unique mechanical aspects of SV and SAV machines can influence different neuromuscular responses. It has reported that; (1) electromyography (EMG) of vastus lateralis and gastrocnemius was higher during SAV than SV; (2) tibialis anterior EMG was significantly greater during SV than SAV, and (3) during dynamic and static squatting, SAV produced greater lower limb EMG compared to SV (Abercromby et al., 2007). Additionally, SAV has been shown to produce greater changes in body balance compared to SV (Garcia-Lopez et al., 2012). However, to our knowledge no other study has investigated the effect of acute side-alternating VbX on sprint performance.

Many court and field-based sports involve rapid changes of direction, which frequently has been termed as agility however, it has been suggested that agility performance should encompass cognitive and reactive components with a change of direction (Sheppard and Young, 2006). The majority of the agility research has assessed pre-planned change of direction protocols but recently, reactive agility test protocols have been developed to

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include a change of direction in response to an unanticipated stimulus (Gabbett et al., 2008; Green et al., 2011; Farrow et al., 2005; Sheppard et al., 2006). To date, there is scant research on the acute effect of VbX on reactive agility; previous research has reported that short-term (9 sessions) VbX exposure did not enhance agility performance (Cochrane et al. 2004) but the agility protocol failed to assess participant's response to an unpredictable stimulus to cause a directional change. Leg muscle qualities (strength, power, and asymmetry) are one of the components that contribute to the effectiveness of reactive agility (Young et al., 2002), where it has been reported that power and strength attributes have a strong relationship with short-distance change of direction (Negrete and Brophy, 2000). Acute VbX has shown to increase leg strength (Torvinen et al. 2002, Stewart et al. 2009) and leg power (Cochrane and Stannard, 2005, Cochrane et al., 2008), therefore if this enhancement can be realised then change of direction performance is likely to improve.

Previous acute VbX studies have focused on sprint distances over 10 to 40 m, however no research has assessed the effect of acute side-alternating VbX on short-sprint performance (less than 10 m). Further, it is unclear the efficacy of acute side-alternating VbX has on agility performance when a change of direction occurs in response to a generic external stimulus. Given the critical role that sprinting and agility have in most sports and activities, improving sprint and agility performance is of major importance to coaches, trainers and athletes where intuitively, acute side-alternating VbX maybe another viable method for enhancing physical performance. Therefore, the purpose of this study was to evaluate the efficacy of acute side-alternating VbX on short-distance sprint and reactive agility performance.

Methods

Participants

Eight female premier club netball players (20.0 ± 1.2 yr; height 1.77 ± 0.07 m; body mass 72 ±1.6 kg) who had at least eight years of netball involvement, with experience in general sport training history (≥ 3 years) and did not have any existing medical conditions volunteered to participate in this study. Informed written consent was obtained from the participants and ethical approval was granted by the University Human Ethics Committee. At the time of the study the players were in the competition phase, which include a game, two netball trainings and at least one self-directed physical training per week.

Study design

All participants performed side-alternating VbX and control (no vibration exercise) in a cross over randomised design that was conducted one week apart. A dynamic warm-up was completed prior to each trial, which included without rest; a 2 minute jog, 4 lunges per leg, 4 leg swing per leg, 4 squats, 4 heel raises per leg, followed with 3 x 5 m straight line sprints and 3 x 5m reactive agility test (RAT) performed at 80% of maximal effort. A 20 s rest separating each sprint was enforced, which involved walking back to the start line. Following the warm-up (within 2 min) participants completed three maximal 5m sprints and four maximal RAT on a vinyl surface of an indoor facility. Immediately following (within 10 s) side-alternating VbX or control, post-sprint tests and RAT were performed. One week prior to testing all participants were familiarised with the protocol and equipment and to account for daily biorhythms all trials were conducted at the same time of day. All participants were instructed to wear netball shoes to replicate in-match sprinting and to standardise any vibration damping.

Sprint test

Three 5 m maximal straight line sprints were performed at split times of 1.5 m, 3 m and 5 m that were recorded to the nearest 0.01 s by a dual-beam, modulated photocells (Swift Performance, Sydney, Australia) and were located 1.0 m above the ground. The start of each sprint trial was initiated by the participant and commenced from a stationary position 30 cm before the first photocell. The participants were instructed to maximally sprint to the final photocell gate and upon completion of each sprint a 30 s break was enforced, which involved walking back to the starting line and passively resting before starting the next sprint. The mean of the three sprint trials for 1.5 m, 3 m and 5 m was used for subsequent analysis.

RAT

RAT was performed using wireless, single beam timing gates (SmartSpeed, Fusion Sport, Queensland, Australia) that were located 1.0 m above the ground and recorded to the nearest 0.01 s. The timing gates were set out in a 1-1-2 formation (Figure 1), which is a typical movement pattern for a netball cut, where 45° is recommended as the optimal angle to attack and receive a pass. Additionally, Farrow et al., (2005) have also suggested this movement pattern to be the optimum for reactive-agility test. Participants started from a stationary position 30 cm behind the first timing gate and were instructed to sprint maximally towards the first set of gates and visually scan for the right or left gate to emit a flash to indicate the next gate to sprint through. Four maximal RAT (2 right and 2 left) were randomly performed with 30 s break being enforced between each sprint, which involved walking back to the starting line and passively resting before starting the next sprint. The mean time of the four RAT was used for subsequent analysis.

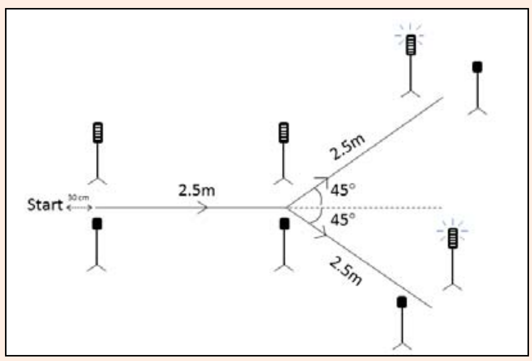

Figure 1. Reactive Agility Test.

VbX treatment

The side-alternating VbX treatment was performed on a commercial machine (Galileo 900, Novotec, Pforzheim, Germany), which had a motorised teeterboard that produced side- alternating vertical sinusoidal vibrations to the body. The vibrating plate had foot markings at an equal distance from the central oscillating axis, which enabled the participants to ensure their feet remained in the same position as any movement of the feet laterally or medially would affect the displacement of the plate. In an attempt to standardize any damping of vibration that may be attributable to footwear all participants were advised to wear the same netball shoes during VbX.

VbX involved participant standing in a static squat (135° of knee flexion) position, for five 1 minute exposures with 1 minute rest (standing to the side of the machine). The static squat was measured at the beginning of each squat with a manual goniometer. Every participant was instructed to placed their hands on their hips, maintain an upright torso and evenly distribute their weight through the soles of their feet. The vibration machine was set to 26 Hz and the foot position equated to 6 mm to a peak-to-peak displacement. This was verified by a single axis accelerometer (Imems®, ADXL250, Analog Devices, Norwood, MA, USA), which was fixed to the edge of the vibrating platform. A vibration frequency of 26 Hz was selected based on previous side-alternating VbX research that reported an increase in blood flow, (Kerschan-Schindl et al., 2001) and muscle temperature (Cochrane et al., 2008). The intermittent vibration protocol (5 x 1 min; with 1 minute rest) is similar to that used in previous studies (Garcia-Lopez et al., 2012, Turbanski et al., 2005). For the control condition the vibration machine was switched off and participants performed the exact stance (static squat, hands on hips, upright torso) and duration (five 1 minute intervals with 1 minute rest).

Statistical analyses

A three factor [treatment (VbX, control), time (Pre, Post) and repetitions (1, 2, 3)] repeated measures ANOVA was performed to examine the magnitude of the treatment effect over time for straight line sprint and sprint reactive-agility. Where there was significance, post-hoc pairwise comparisons were performed using Bonferroni adjustment to investigate changes in sprint times over time within treatment and control. The reliability of sprint and agility measures between testing sessions was assessed by intraclass correlation coefficients (ICCs). An ICC value of 0.75 or greater was considered acceptable for reliability (Portney and Watkins 2000). ICC and correlation coefficient between testing sessions revealed 0.836 and 9.6%; 0.881 and 5.6%; 0.926 and 4.1% for 1.5 m, 3 m and 5 m sprint split times respectively and 0.863 and 7.1% for RAT. Using repeated measures, within-between interaction a post-hoc power analysis (G*Power 3, version 3.1.5, Heinrich-Heine-University, Düsseldorf, Germany) revealed that a sample size of 8 participants with $\alpha = 0.05$ and effect size (f) of 0.24 achieved a power (β) of 0.75.

All values are reported as mean ± SD and level of statistical significance was set at $p < 0.05$, and the other statistical analyses were computed using SPSS for Windows (version 20.0, IBM, New York, USA).

Results

There was a significant treatment effect ($p = 0.04$) for 1.5 m sprint such that VbX produced a faster 1.5 m sprint time compared to control. However, there was no time effect (pre vs. post) or interaction effect between treatment and pre-post values.

A significant time effect (pre vs. post) was evident for 3 m sprint ($p = 0.011$) and 5m sprint ($p = 0.025$), indicating pre times were faster than post sprint times but there was no treatment effect or interaction effect (treatment x time)(Table 1). There were no significant changes for the RAT test and there was no significant order effect of the outcome measures.

Discussion

To our knowledge, no other studies have investigated the effect of acute side-alternating VbX on short-distance sprint and reactive agility performance. There was an expectation that side-alternating VbX may potentiate shorter sprint distances, as previous studies have found acute VbX to increase other types of explosive movements, such as vertical jump (Adams et al. 2009; Cochrane and Stannard 2005; Cochrane et al., 2008; Rønnestad, 2009). Therefore, it was reasonable to postulate that if acute VbX can improve explosive movements, it could improve short-distance sprint performance. Accordingly, a treatment effect was reported at 1.5 m, where VbX enhanced sprint time compared to control but there was no detectable change between pre-post times (interaction effect). However, VbX failed to enhance 3 m and 5 m split time, which could be due to the complex and dynamic nature of sprinting where the purported increase in muscle power from VbX is probably lost on cyclic movement patterns of high force and power generation. This current finding of 3 m and 5 m is in agreement with

Table 1. Sprint and reactive agility times from VbX and control. Data are means (±SD).

Sprint Tests	Time	VbX	Control	Statistical Analysis
1.5 m (s)	**Pre**	.40 (.04)	.43 (.03)	Treatment effect p = 0.04
	Post	.41 (.04)	.45 (.03)	
3 m (s)	**Pre**	.74 (.05)	.75 (.03)	Time effect p = 0.011
	Post	.77 (.05)	.77 (.04)	
5 m (s)	**Pre**	1.15 (.05)	1.18 (.05)	Time effect p = 0.025
	Post	1.17 (.04)	1.20 (.06)	
RAT (s)	**Pre**	1.89 (.15)	1.90 (.46)	NS
	Post	1.91 (.11)	1.92 (.14)	

RAT – Reactive agility sprint

previous studies, which have reported that acute synchronous VbX had no effect on long duration (10-30 m) sprint performance (Bullock et al., 2008; Guggenheimer et al., 2009). Contrary, it has been shown that acute synchronous VbX (50 Hz, 3 mm) with concurrent body-weight squatting improved 40 m sprint time (Rønnestad and Ellefsen, 2011); however, the discrepancy may be explained by the different methodologies employed by the various studies where several factors can influence the effectiveness of muscular performance; such as, duration, volume, intensity, the rest period between activity and performance, and participant characteristics (Tillin and Bishop, 2009). Further, it has been reported that an inadequate VbX duration (Guggenheimer et al., 2009) and lengthy time delay between VbX and sprint trials (Bullock et al., 2009) may exacerbate the inability to enhance sprint performance.

Although a few studies have attempted to ascertain VbX optimisation in strength and power measures (Adams et al., 2009; Turner et al. 2011) the parameters of vibration frequency, displacement, body position, rest interval, and duration have yet to be fully elucidated. Therefore, it is plausible that the side-alternating VbX parameters of the current study did not facilitate the potential effects to enhance sprint and reactive agility performance. However, we did carefully consider the vibration parameters for instance, the selection of the current vibration frequency, and displacement, have been shown to increase muscle activation, muscle temperature and blood flow (Cochrane et al., 2010; Cochrane et al., 2008; Kerschan-Schindl et al., 2001), which are key elements for promoting muscular performance in side-alternating VbX (Cochrane and Stannard, 2005; Cochrane et al., 2010; Stewart et al., 2009). An earlier study has cautioned the use of short vibration duration exposure as an ergogenic effect for sprint running (Guggenheimer et al., 2009). Therefore, to ensure an adequate stimulus, we selected an intermittent protocol of 5 x 60 s vibration exposure, and to negate any possibility of fatigue we interspersed each exposure with 60 s rest.

Additionally, the type of VbX machine (side-alternating vs. synchronous) is also likely to influence the outcome of the current study. The side-alternating machines produce unilateral vibration to the left and right foot, which differs to synchronous VbX where both legs are vibrated as the platform moves predominately in the vertical direction (Cochrane, 2011b). To date, only synchronous VbX has been used to assess sprint performance with mixed results (Bullock et al., 2008, Guggenheimer et al., 2009, Rønnestad and Ellefsen, 2011) but no study has examined the acute effect of side-alternating VbX on sprint performance. The literature also indicates that a higher vibration frequency can have a positive influence on muscular performance (Adams et al., 2009; Gerodimos et al., 2010; Rønnestad and Ellefsen, 2011) but this is only possible in synchronous vibration machines that are capable of reaching 50 Hz compared to that of 30 Hz for side-alternating machines. But the peak-to-peak displacement in side-alternating machines is higher (2-12 mm) compared to 2-4 mm in synchronous machines. Therefore, the gravitational load (acceleration), which is a product of frequency and peak-to-peak displacement, should be considered when comparing machines. Further, there is a lack of research comparing side-alternating and synchronous VbX but recent research has reported that side-alternating VbX generates greater muscle activation of lower limb muscles compared to synchronous VbX (Abercromby et al., 2007, Ritzmann et al., 2013). Further, it has been suggested that the transmission of vertical acceleration differs between side-alternating and synchronous VbX (Pel et al., 2009) and side-alternating VbX significantly improved body balance parameters in active participants compared to synchronous VbX (Garcia-Lopez et al., 2012). Accordingly, where possible, findings need to be compared with similar VbX machines.

Earlier studies have reported that short-term (9 sessions) VbX failed to enhance 5-0-5 up and back test (Cochrane et al., 2004) and 4 min of VbX did not improve change-of-direction (Torvinen et al., 2002). However, the aforementioned studies only assessed pre-planned change of direction but the literature suggests that agility should include a change of direction in response to an unpredictable stimulus (Sheppard and Young, 2006). In the current study the reactive component was included but acute side-alternating VbX failed to enhance agility performance. Agility is a multi-faceted skill where anticipation, sensory processing, visual scanning, change of direction speed, technique, relative strength and power, and body characteristics are all components that contribute to agility performance (Sheppard and Young, 2006). Therefore, it is difficulty to isolate the various components that influence agility performance; however, we attempted to focus on the visual scanning acuity by instructing the athletes to visually scan for a flashing light (unanticipated stimulus) to produce a change of direction. Although, the current protocol was reactive, future research should focus on an anticipatory response from sport-specific stimuli (Farrow et al., 2005; Gabbett et al., 2008; Serpell et al., 2010; Sheppard et al., 2006). This would improve the ecological validity as it would allow anticipatory responses to be investigated from sport-specific stimuli.

Conclusion

In conclusion, acute side-alternating, intermittent VbX (26 Hz, 6 mm [p-p]) enhanced 1.5 m sprint time but it did not improve sprint (3 m and 5 m) and reactive agility. Because acute VbX does not compromise performance, it could be an effective warm-up modality for explosive power and strength activities.

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Key points

- Acute VbX could be beneficial for the acceleration phase (1.5m) of a short-distance sprint.
- Acute VbX does not have positive influence on short-distance (3m & 5m) sprint performance.
- Acute VbX does not enhance reactive agility performance.

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