SHORT-TERM VIBRATION TRAINING AND FEMALE JUMP PERFORMANCE: A FEASIBILITY STUDY INVESTIGATING A RELATIVELY LOW-COST, SIDE-ALTERNATING PLATFORM

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Abstract

This study investigated the effects of a short-term vibration training intervention, using a relatively low-cost side-alternating platform, on the jump performance of a young recreationally-active female population. Following institutional ethics approval, 22 recreationally-active females (mean: age = 21.1 ± 0.6 years; height = 1.66 ± 0.08 m; mass = 68.1 ± 9.8 kg), recruited via a convenience sampling method, were randomly assigned to a whole-body vibration training (WBVT) or control group. The WBVT group performed static squats and lunges, once-per-week over a six-week period, on a side-alternating vibration platform. The control group followed an identical training protocol without vibration exposure. Lower-body muscular power was assessed before and after the intervention using three maximal vertical countermovement jumps (VCMJ), performed on a contact mat. Results of a repeated measures t-test revealed the WBVT group significantly improved their VCMJ performance (P = 0.012) over the six-week intervention. The control groups' performance remained relatively stable with no significant increase in jump performance (P = 0.68). The current study supports the inclusion of vibration training as part of an exercise regime to increase jumping performance in a recreationally-active female population. As findings show comparable improvements to those from other studies following similar training protocols, using more expensive vibration platforms, further investigation is now warranted to ascertain responses to vibratory signals received from the variety of low-cost, vibration platform types currently available.

Keywords: Vibration, training, exercise, recreational, power, jumping

Introduction

Traditional training methods, such as plyometric and resistance training, have been consistently implemented to improve vertical jump performance and other characteristics associated with increased power output (Markovic, 2007). Recently, enhancements in performance, comparable to those seen during resistance training, have been reported following relatively short-term (~4-12weeks) exposure to vibration (Marin and Rhea, 2010). Generally described as a mechanical oscillation characterised by periodic alteration of force, displacement and acceleration, vibration exposure is widely regarded as detrimental to health (Rittweger, 2010); which is why in the workplace it is tightly regulated by the International Organization for Standardization (ISO) (ISO, 1997) and, where possible, minimised or avoided altogether. In contrast whole body vibration training (WBVT), a forced oscillation where energy is transferred from an actuator (i.e. a vibration platform) to a resonator (i.e. the human body), has become increasingly popular in sport and exercise science and rehabilitative medicine due to a range of positive health and performance outcomes (Hawkey, Rittweger and Rubin, 2016). Reported benefits include higher bone density (Gusi et al., 2006), increased power output (Bosco et al., 1999), improved jumping and sprinting performance (Paradisis and Zacharogiannis, 2007), enhanced flexibility (Cochrane and Stannard, 2005), and superior balance (Ritzmann et al., 2014). While the mechanisms by which vibration exposure can affect the musculoskeletal and other bodily systems are not universally accepted (Petit et al., 2010), the most acknowledged theories currently include stimulation of neuromuscular pathways and muscle spindles, increased muscle temperature and elevated hormone secretion (Hawkey, Rittweger and Rubin, 2016).

Vibration platforms, the specialised aparatus used for such training, usually operate in either a vertical (synchronous) motion (figure 1a) or side-alternating (see-saw) action (figure 1b), with the vibratory load dependent on frequency, amplitude, and acceleration (Hawkey, Rittweger and Rubin, 2016). As can be seen in figures 1a and 1b, the variation in design and operation of these platforms means that vibration is transferred to the user in very different ways. Vertical platforms (examples of which include Power Plate^{TM}, NEMES-Bosco^{TM} and Kuntotäry) raise both feet simultaneously. Conversely, side-alternating platforms (such as Galileo^{TM}) raise one foot at a time. While this results in much greater hip movement on a side-alternating platform than is experienced in the vertical variants, there is reportedly no difference in the subjective measure of intensity between the two platform types (Corrie et al. 2006).

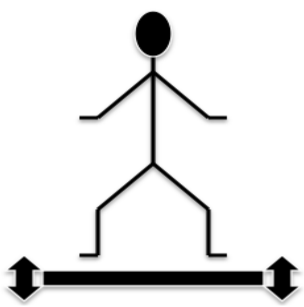

Figure 1(a): Vertical vibration platform

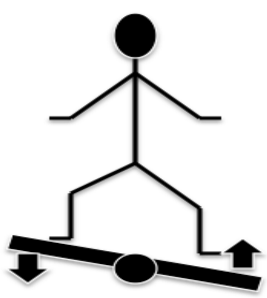

Figure 1(b): Side-alternating vibration platform

Several studies have demonstrated that WBVT can enhance muscle strength and power. One 12-week study, using a Power Plate™ platform, reported an 8% improvement in jump performance for a young sedentary female population (Delecluse et al., 2003). This is comparable with results from much longer duration studies (4-8 months), using a Kuntotäry platform, which reported similar improvements of 8.5% (Torvinen *et al*., 2002) and 7.8% (Torvinen et al., 2003) respectively. Other studies have reported even more dramatic improvements (~15%) in vertical countermovement jump (VCMJ) performance following shorter duration (six-week) interventions in young recreationally-active males on a NEMES-Bosco™ system (Hawkey, 2012a). Using a similar protocol, but on a Power Plate™ device, another study reported a ~13% improvement in the VCMJ performance of a post-menopausal female group (Hawkey *et al*., 2016); although it should be noted that the same study highlighted a significant, but slightly more modest, ~4% improvement in VCMJ in their corresponding young (~25yrs.), recreationally-active female population during their six-week WBVT programme. This level of improvement is consistent with findings by Paradisis and Zacharogiannis (2007) and Sewell et al (2017) who both reported an ~3% increase in jump performance following a six-week programme on a Power Plate™ platform and 12-week intervention on a side-alternating Vibraflex-Galileo™ platform, respectively.

Importantly though, much of this WBVT research has utilised higher-end, comparatively expensive vibration platforms. Reported to be the most prevalent devices used in a gym environment worldwide, Power Plate™ have a range of platforms for personal use costing between $2,595 - $7,995 USD, and a professional range offered from $9,495 - $14,995 USD (Power Plate™: www.powerplate.com). For comparison, machines that are commercially available, and regularly purchased to use at home, cost from as little as ~$79.99 USD (Vibration Plate Reviews and Guide: www.vibrationplateguide.co.uk). With evidence that these domestic machines are becoming increasingly popular (Whiteman, 2007), and potentially being used more by the general population (Fischbach, 2007), data from machines most easily accessible, and at relatively affordable prices, becomes even more crucial. This becomes particularly relevant when considering that disparities in relation to the effects of WBVT on performance have been attributed to differing protocols and varying testing and training equipment (Hawkey, 2012a). Therefore, the aim of the current study was to ascertain the effects of a six-week WBVT programme, using a relatively low-cost, side-alternating platform, on the VCMJ performance of a young recreationally active female population.

Method

Participants

Following institutional ethics approval, and in accordance with the latest rendition of the Helsinki Declaration (World Medical Association, 2013), 22 females, recruited through a convenience sampling method, were randomly assigned to either a WBVT or control group (Table 1). Through the completion of informed consent forms and physical activity readiness questionnaires (PAR-Q), and through verbal validation throughout the study, all participants confirmed that they were healthy, and not suffering from any illnesses, injuries or conditions that would prevent or restrict their involvement. In particular, specific exclusion criteria for WBVT included cardiovascular complaints, metal/synthetic implants, migraines, thrombosis, epilepsy, lumbar disc problems and pregnancy (Hawkey, 2012b). All participants were identified as being recreationally-active, defined by Bolgar et al. (2010) as undertaking ≤80mins of moderate-intensity activity per week. Throughout the duration of the intervention period all participants (WBVT and control) were asked to maintain their current activity levels and to not alter their dietary intake as specified in previous WBVT research (Babraj and Hawkey, 2017).

Table: Physical characteristics (mean ± standard deviation) of participants

	Age (years)	Height (cm)	Body mass (kg)
WBVT Group (n = 11)	21 ± 0.8	165.2 ± 8.5	66.4 ± 9.8
Control Group (n = 11)	21.2 ± 0.4	167.6 ± 3.4	68.3 ± 8.2

Measures

In accordance with American College of Sports Medicine (ACSM) guidelines (ACSM, 2013), and previous WBVT studies (Hawkey et al. 2016), both experimental and control groups undertook a controlled warm-up consisting of five minutes cycling on a cycle ergometer (Monark Ergomedic) at 60 rpm and 50 W, maintaining heart rate between 120-140 b-min^{-1}, prior to each testing and training session. The WBVT group trained for a six-week period, on a side-alternating vibration platform (Crazy Fit Massage, WBV-X1150). This platform was chosen due to it being reasonably priced (~$150) and also because it has been described by independent reviewers as “dominating the budget end of the vibration platform market” (Vibration Plate Reviews and Guide: www.vibrationplateguide.co.uk). In accordance with previous WBVT studies conducted on recreationally-active populations (Hawkey, 2012a; Hawkey et al. 2016), and because the participants were accustomed to exercising on a weekly basis, the current study utilised a similar once-per-week training intervention. Following and adapted from previously established training protocols (Dabbs et al., 2015; Hawkey *et al*. 2016; Petit *et al*. 2010), participants performed 30s each of static squats (90° knee angle) and alternate right and left leg static lunges (90° front knee angle) (Figures 2a-2c). Knee angles were initially measured with the use of a goniometer, and then controlled visually. Rest periods between the sets were maintained at 60s in accordance with ACSM recommendations stating that 60-120s of recovery time should be implemented for novices undertaking resistance-type training (Ratamess *et al*., 2009). During both the squats and lunges, feet were required to remain flat on the platform surface and be placed on markers to ensure parity between training sessions and participants; this was particularly in respect of amplitude levels, which remained at 4mm throughout the study. The positioning of the markers was determined during a pilot study during which footage from a high-speed video camera was used to ensure the correct amplitude was implemented. In accordance with the overload training principle (Ingham, 2007), and in acknowledgement of a meta-analysis by Marin and Rhea (2010), which reported that ~24Hz is the most commonly implemented frequency to enhance performance when using a side-alternating platform, the frequency of the platform was gradually increased from 20Hz – 24Hz over the six-week study. The control group followed an identical isometric training protocol without vibration exposure.

Figure 2a (squat 900) Figure 2b (right leg lunge) Figure 2c (left leg lunge)

Figures 2a – 2c. Training positions in the WBVT and control group

Muscular power was assessed, before and after the training intervention, using the mean average of three maximal VCMJ performed on a contact mat (Just Jump, Probotics, USA), in accordance with previous research assessing VCMJ following WBVT (Hawkey, 2012a; Hawkey et al., 2016; Paradisis and Zacharogiannis, 2007). Hands were required to remain on hips during performance of the VCMJ to ensure consistency between trials and participants (Lees et al. 2004). A period of 15s was implemented between each VCMJ in accordance with Read and Cisar (2001) who found this to be the optimal recovery time when conducting maximal jump testing. To allow for sufficient recovery (McLester et al. 2003), and to avoid the confounding influence of circadian variation (Teo et al. 2011), VCMJ performance was assessed 72 hours following the last training session and at a similar time of day (± 1 hrs) as the pre-intervention testing.

Statistical Analysis

An independent samples t-test was used to assess any differences in the baseline VCMJ performance of the WBVT and control groups. A repeated measures t-test was employed to assess pre- vs. post- jump performance in the WBVT and control groups respectively. An alpha value of 0.05 was used for all tests. All statistical analysis was performed with the statistical package for social sciences (IBM SPSS Statistical Software, v20, England).

Results

The independent samples t-test reported no significant difference ($P = 0.2$) between the baseline jump performances of the WBVT (32.6 ± 2.4 cm) and control groups (31.5 ± 3.1 cm). Results of a repeated measures t-test revealed that the WBVT group significantly improved their VCMJ performance ($P = 0.012$) over the six-week intervention. In contrast, the control groups' performance remained relatively stable with no significant increase in jump performance ($P = 0.68$) during the six-week intervention (Table 2).

Table 2: Pre- and Post- test VCMJ performance for WBVT and control groups

	Control Group		WBVT Group	
	Pre- Test	Post- Test	Pre- Test	Post- Test
Jump Height (cm)	31.5 ± 3.1	32.6 ± 2.9	32.6 ± 2.4	36.1 ± 3.4*

*Indicates significant (p<0.05) difference in pre- to post- VCMJ performance of the WBVT group

Discussion

Vibration training has become a popular technique among trained and untrained individuals, either as the sole training method or as a supplementary training aid (Osawa et al., 2011). However, the majority of research has utilised higher-end, comparatively expensive, vibration platforms. The purpose of this current investigation therefore was to ascertain the effects of a six-week WBVT intervention on the VCMJ performance of a recreationally-active female population, using a relatively low cost, side-alternating system.

Results from the current study indicate that short-term WBVT benefits jump performance in a young recreationally-active female population. These findings support previous studies highlighting significant increases in strength and power following exposure to vibration (Delecluse et al. 2003; Torvinen *et al*. 2002; Torvinen et al. 2003; Hawkey, 2012a; Hawkey et al. 2016). The most distinctive discovery with this current research though is that the ~11% improvement in VCMJ performance of the WBVT group is relatively consistent with improvements in studies by Hawkey (2012a) and Hawkey et al (2016), who utilised NEMES-Bosco and Power Plate Pro5 vibration platforms and reported improvements of 15% and 13% respectively. Notably, both these studies investigated recreationally-active participants over a similar once-per-week, six-week testing and training programme. This appears to suggest that the vibration platform used in the current study, a side-alternating Crazy Fit Massage, costing ~$150 USD, is as effective as higher-end machines often costing >60 times as much. This is particularly noteworthy as cheaper, domestic machines have been growing in popularity (Whiteman, 2007), and are being used by an increasing number of exercisers (Fischbach, 2007); making any data gathered from these easily accessible, and relatively affordable, devices essential in the effective formation of exercise training programmes. The current study potentially highlights that it is not necessary to spend relatively large amounts of money on higher-end vibration platforms when the same benefits in performance can be realised on considerably cheaper, commercially available, machines designed for domestic use. It is worth emphasising here that participants in the current study, both WBVT and control groups, only trained once-per-week. While this training frequency is consistent with that of Hawkey (2012a) and Hawkey et al (2016), other research has implemented much more intense training protocols. Delecluse et al. (2003), Torvinen et al. (2002) and Paradisis and Zacharogiannis (2007) all required their vibration participants to train three-five times each week, although the performance gains in these studies ranged from (3-8.5%). They also employed different training protocols for their control groups; for example, the control group in Delecluse et al. (2003) study undertook no training at all.

While the findings of this current study clearly support the use of a lower-cost WBVT platform to enhance lower body power in a recreationally-active female population, there are some limitations in study design that must be taken into consideration. Despite all participants being asked to continue with their usual exercise regimes and maintain nutritional intake throughout the duration of the intervention period, there was no strict control of these two variables outside the confines of the current study. While it cannot be assumed that this confounding influence equilibrated across groups, the lack of change in the control group supports the view that performance changes were largely attributable to WBVT. Also, notwithstanding the positioning of the feet on the platform being controlled with specific instructions to place them on markers to ensure consistent amplitude, individual participants could have potentially been exposed to variable training loads. The amplitude users are exposed to on side-alternating vibration platforms is significantly affected by foot placement; the further away the feet are from the central fulcrum the higher levels of amplitude the user is exposed to (Hawkey, 2012b).

Additionally, the absence of any direct comparison to other training techniques (e.g. progressive resistance exercise or plyometric training) is recognised and, therefore, whether WBVT is a more effective training stimulus than other modalities in this population remains an open question. Finally, with such differing results from the use of various vibration platforms it is difficult for the exercise trainer or health professional to ascertain which system is most appropriate for improving a desired outcome. Considering that disparities in findings between WBVT research have been attributed to differing protocols, inconsistencies in terminology (such as the use of amplitude and peak-to-peak displacement), variations in the performance level, age, sex, and/or experience of the participants, and varying testing and training equipment (Hawkey, 2012a; Lorenzen et al., 2009; Petit et al., 2010) future research assessing two or more different platform types against each other, rather than in isolation, would be beneficial.

Conclusions

In conclusion, numerous studies have demonstrated that WBVT is an effective exercise modality that can enhance muscular strength and power. Results from this current study also show increased VCMJ performance in a recreationally-active female population following short-term exposure to side-alternating WBVT. These results suggest that those wanting to improve lower body muscular power should consider incorporating WBVT into their training regimes. Specifically, this current study suggests that training on a relatively inexpensive, side-alternating vibration platform is as effective as exercising on more expensive platforms (both vertical and side-alternating variants). Future research should now further, and directly, investigate any differences in the responses elicited from different vibratory signals received from the variety of vibration platform types currently available on the commercial market.

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