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Whole body vibration training and its application to age-related performance decrements: an exploratory analysis

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ABSTRACT

Middle age is associated with a pronounced decline in power and flexibility. Whilst whole body vibration training (WBVT) improves performance in a range of populations, whether WBVT can improve muscle power and flexibility in a middle-aged population is not known. The present study aimed to determine the influence of 5 weeks progressive WBVT in middle-aged (45-55 yrs.) and younger (20-30 yrs.) recreationally active females. Participants in each age group were randomly allocated to an intervention (WBVT) or control group. The WBVT groups trained for five weeks on a vibration platform, while the control groups performed identical exercises, with no vibration. Prior to, and after, the five-week study vertical countermovement jump (VCMJ) and range of motion (ROM) performance were measured. WBVT significantly (*P* = 0.001) improved VCMJ performance when compared to the control groups. This improvement was significantly (*P* = 0.001) greater in the middle-aged compared with the younger WBVT group. WBVT significantly (*P* = 0.001) improved ROM irrespective of age. Taken together, these results suggest that WBVT can off-set age related performance decrements, which has therapeutic implications for musculoskeletal aging. Therefore, WBVT could be undertaken to minimise age-related performance deterioration in middle-aged female populations.

Key words: Aging, exercise, sarcopenia, muscle power, flexibility, vibration

INTRODUCTION

Middle age (35-59 yrs.) is associated with physiological decline, as evidenced by reduced aerobic capacity, insulin sensitivity, muscle strength, flexibility, muscle power, and mass [13,17,34]. In particular, muscle power declines earlier (~40 yrs.) and more precipitously (~10% per decade) than many of the aforementioned parameters [29,32]. The mechanisms underpinning this loss are complex and not completely understood but might be related to denervation with attendant fibre atrophy and lower physical activity levels in middle-aged compared with younger populations [8-10].

Exercise training is a powerful strategy for improving muscle power and performance [6]. Despite the well-documented benefits of exercise, adherence to exercise training regimes is low [12]. Lack of time to exercise, owing to work or family commitments, is commonly cited as a reason given for lack of adherence in both the general population [21] and middle-aged females [22]. Time-efficient exercise interventions are, therefore, required to increase exercise adherence in middle-aged populations.

Whole-body vibration training (WBVT) is a novel time-efficient exercise stimulus, with beneficial effects being reported with less than 30 minutes exposure per week [19]. It is believed that by stimulating neuromuscular pathways and muscle spindles, WBVT creates a tonic contraction of the muscle; often referred to as the tonic vibration reflex [30]. WBVT has enhanced proxy markers of muscle power (e.g. vertical jump performance) in sedentary [14] and recreationally active young populations [19]. In addition, WBVT has improved sprint performance [31] and flexibility [18] in young trained populations. Further, there is also evidence that older populations (≥ 60 yrs.) can benefit from WBVT, with increases in muscle strength [6] bone density [38], and improvements in balance [4,7] and quality of life [33] being reported. However, there is a paucity of research examining the effect of WBVT in middle-aged populations. Given the decrements in power and flexibility during middle age, the present study aimed to determine the effects of WBVT on two functional endpoints: namely jump performance (power marker) and range of motion (ROM: flexibility marker) in younger (20-30 yrs.) and middle-aged (45-55 yrs.) recreationally active females. It was hypothesised that WBVT would lead to similar performance enhancements in younger and middle-aged females.

METHODS

Experimental Approach to the Problem

The current study was designed to investigate the changes in vertical jump performance and ROM following 5 weeks of progressive WBVT in younger compared to middle-aged recreationally active females. Limited research has been carried out to compare the effects of WBVT on the performance of different age groups. To achieve this, a test-retest experimental design was chosen with intervention (WBVT) and control groups in two separate age groups.

Subjects

Following institutional ethical approval, 25 females (Table 1) were separated into young (20–30 yrs.) and middle-aged (45–55 yrs.) groups and were randomly assigned (within each age group) to WBVT or control groups. By completing both an informed consent form and physical activity readiness questionnaire (PAR-Q), all participants self-reported that they were recreationally active (<5 hrs of moderate intensity exercise per week), were not taking any medication, and reported no lower or upper extremity injuries in the previous 12 months that could have affected their ability to participate in the study. All middle-aged participants were post-menopausal.

Procedures

Participants completed a five min warm-up on a Monark Ergomedic Bike, maintaining their heart rate between 120- 140 b-min^{-1} in accordance with American College of Sports Medicine (ACSM) guidelines [3]. All participants were required to perform 3 vertical countermovement jumps (VCMJ) on a Probotics Just Jump Mat (Probotics Inc. USA), which has been reported to be a reliable measure of assessing muscular performance [26]. Participants were instructed to keep their hands on their hips throughout the VCMJ, as arm movement can influence jump performance [23]. Participants also performed 3 range of motion (ROM) tests using the traditional sit-and-reach box [3,24,27]. For both tests, the mean of all 3 trials was used for subsequent statistical analysis. Participants were tested twice; pre and post the 5-week intervention period.

Interventions

Following a familiarisation session and a demonstration of correct positioning, participants performed a static squat (90^o) and a lunge on each leg on a Power Plate Pro5 vibration platform (Figure 1). While the WBVT group followed the overload training principal (Figure 2), the control group performed the identical isometric exercises, following the same itinerary as the WBVT group but with no vibration. Both groups trained once per week performing each exercise for 60s, with a 60s recovery after each exercise; totalling ~3 min exposure time per training session. During the first and second week, the frequency was pre-set to 30 Hz and the amplitude controlled at 4 mm. For the third week, the frequency was set to 35 Hz. During the fourth week the frequency was increased to 40 Hz, and on the fifth week to 45 Hz. Protocol, including frequency and amplitude settings, exercises and durations, was selected based on previous research showing improvements in jump performance and ROM [11,14,18-19]. During all trials the participant was required to wear the same rubber soled shoes [25]. To align with recommendations regarding recovery periods following resistance training, VCMJ performance and ROM were re-assessed 72 hrs following the last training session [28,39]. Both VCMJ and ROM were re-assessed at a similar time of day (± 1 hrs) as the first assessment to avoid the confounding influence of circadian variation [16].

Insert Figure 1 near here

Insert Figure 2 near here

Statistical Analyses

A one-way ANOVA was utilised to assess baseline values of age, height, mass and baseline VCMJ and ROM performance between groups. A 2-way mixed model ANOVA was employed to assess within (pre vs post) and between (treatment groups) subject main effects. If any significant F values were observed, Bonferroni post-hoc tests were performed to determine where any significant differences occurred. An alpha value of $P \leq 0.05$ was used for all tests. All statistical analysis was performed with the statistical package for social sciences version 20.0 (SPSS, England). All data in text, tables and figures are presented as mean and standard deviation (M ± SD).

RESULTS

Baseline participant anthropometrical characteristics

As expected, age significantly differed by group ($P \leq 0.001$). Specifically, the two middle-aged groups were significantly older than the two younger groups ($P \leq 0.05$, see table 1). However, there were no significant differences ($P \geq 0.05$) between age-matched control and vibration groups. Height, mass and BMI were not significantly different ($P \geq 0.05$) between groups at baseline (see table 1). All participants were classified as having a healthy BMI in accordance with the World Health Organization [40].

Insert Table 1 near here

Jump performance

Baseline

VCMJ differed significantly between groups at baseline ($P \leq 0.001$), being significantly lower in the two middle-aged groups compared to the two younger groups ($P \leq 0.05$; see table 1). VCMJ did not significantly differ between the two younger groups ($P \geq 0.05$) or between the two middle-aged groups ($P \geq 0.05$).

Training

There was a significant effect of time ($P \leq 0.001$) and a significant time*group interaction ($P = 0.001$). Post-hoc analysis revealed that there was a significant effect of WBVT, with a significant improvement in VCMJ performance being observed in the WBVT groups compared to the control groups ($P \leq 0.05$; see figure 3 and table 2), irrespective of age. VCMJ performance improved to a greater extent in the middle-aged compared with the younger WBVT group ($P = 0.001$).

Insert Figure 3 near here

Insert Table 2 near here

ROM

Baseline

ROM differed significantly between groups at baseline ($P = 0.014$; see table 1). Post-hoc analysis revealed that only the middle-aged WBVT group and the young control group differed significantly ($P = 0.028$).

Training

There was a significant effect of time ($P \leq 0.005$) and a significant time*group interaction ($P = 0.001$). Post-hoc analysis revealed that there was a significant effect of WBVT, with a significant improvement in ROM being observed in the WBVT groups compared with the control groups ($P \leq 0.05$; see figure 4 and table 2).

Insert Figure 4 near here

DISCUSSION

To address whether WBVT can attenuate age-related performance decrements during middle age the present study determined the influence of 5 weeks progressive WBVT on performance-related markers of power and flexibility in middle-aged compared with young recreationally active females. In this regard, we show for the first time that WBVT significantly improves VCMJ performance and flexibility in a middle-aged population. Indeed, jump performance improved to a greater extent in the middle-aged compared to the younger WBVT group, probably owing to lower baseline performance. The improvements in power and ROM support the notion that WBVT can be utilised to offset the age-related decline in skeletal muscle function.

In line with previous work [29,32], we observed lower VCMJ, a proxy marker of muscle power, in middle-aged compared with younger females. Indeed, muscle power begins to decline at ~40 years of age and declines precipitously thereafter [29,32]. The magnitude of several age-related declines can, however, be attenuated by regular exercise training in elderly [1,6,8-10] and middle-aged populations [2,20,36]. In support of this notion, we provide novel data demonstrating that WBVT significantly improved VCMJ in middle-aged females. Indeed, middle-aged individuals improved to a greater extent than younger individuals. This likely reflects a greater scope for improvement in the middle-aged group given their lower baseline level. Nonetheless, WBVT appears to be an effective countermeasure for attenuating age-related declines in a marker of muscle power.

It is acknowledged that WBVT did not reverse VCMJ to the level of a younger female; the middle-aged group recorded a mean post-intervention jump height of 24.9 cm compared to the younger group improving to 36.6 cm (mean difference = 11.7 cm). This could reflect a residual age-related deficit that training cannot fully override or simply the short-term nature of our exercise intervention. The improvements (~13%) in the current study's middle-aged group are however, similar in magnitude (~10%) to those observed in other short-term [19] and longer duration (~15%) WBVT studies [14,37]. We do, however, readily acknowledge that a limitation of our study is that we did not compare WBVT to any other training modality (e.g. progressive resistance exercise). Hence, whether WBVT is a more effective training stimulus than other modalities in this cohort, is an open question.

The age-related decline in joint flexibility underpins a decreased ROM in older populations [35]. We report significantly lower ROM in the middle-aged WBVT compared to the young control group at baseline. That this effect is confined to these two groups, not evident generally between young and middle-aged and thus not attributable to biological age *per se*, renders this observation difficult to reconcile at first glance. We speculate that this difference is attributable to differences in innate flexibility between these two groups or perhaps differences in the type of habitual physical activity undertaken. It could equally reflect our relatively low sample size (n = 6 and n = 7). In any event, 5 weeks of progressive WBVT significantly improved ROM, irrespective of age. This observation is concordant with previous work, documenting an enhancement of ROM with WBVT [18]. Whether WBVT attenuates the age-related decline in flexibility is not resolved herein, since we did not observe any age-related deficits in this parameter at baseline. Proof of concept, might be provided by the favourable response of middle-aged individuals to WBVT and the increase in flexibility following exercise training in the elderly [17].

PRACTICAL APPLICATIONS

From a practical perspective, we have delineated a novel time-efficient WBVT exercise paradigm that can be utilised to attenuate the age-related performance declines in middle-aged females. Although, further work is required to elucidate other benefits of WBVT in middle-aged populations, such as increased maximal oxygen uptake, WBVT might be a time-efficient countermeasure for certain age-related performance losses in middle-aged females. Practitioners, therefore, might consider utilising WBVT to enhance muscle power and flexibility in middle-aged females**.**

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Table 1: Baseline participant characteristics. Data is presented as M and SD (±). Group P values are derived from the one-way ANOVA analysis.

[*]denotes significant difference from young WBVT; [#]denotes significant difference from young control. [1]: classifications taken from the World Health Organization (WHO) Expert Committee [40].

Table 2: Pre- and post- performance (VCMJ and ROM) for younger and middle-aged groups (WBVT and control). Data is presented as M and SD (±).

Figure 1: Exercises performed on the WBV platform

Figure 2: 5-week training programme on the WBVT platform

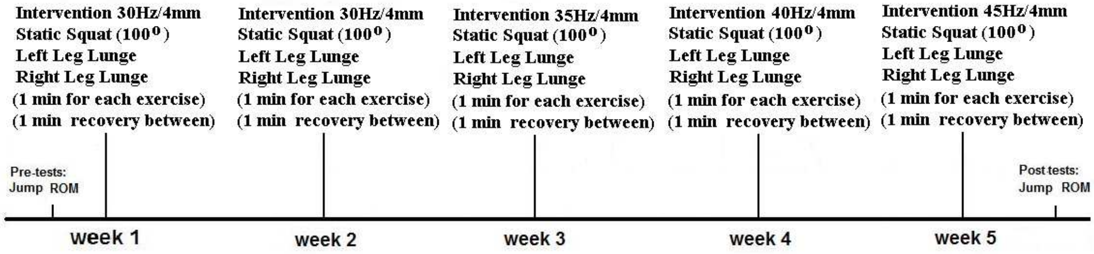
Figure 3: Changes in jump performance. Data is presented as percentage changes from baseline

Figure 4: Changes in range of motion. Data is presented as percentage changes from baseline

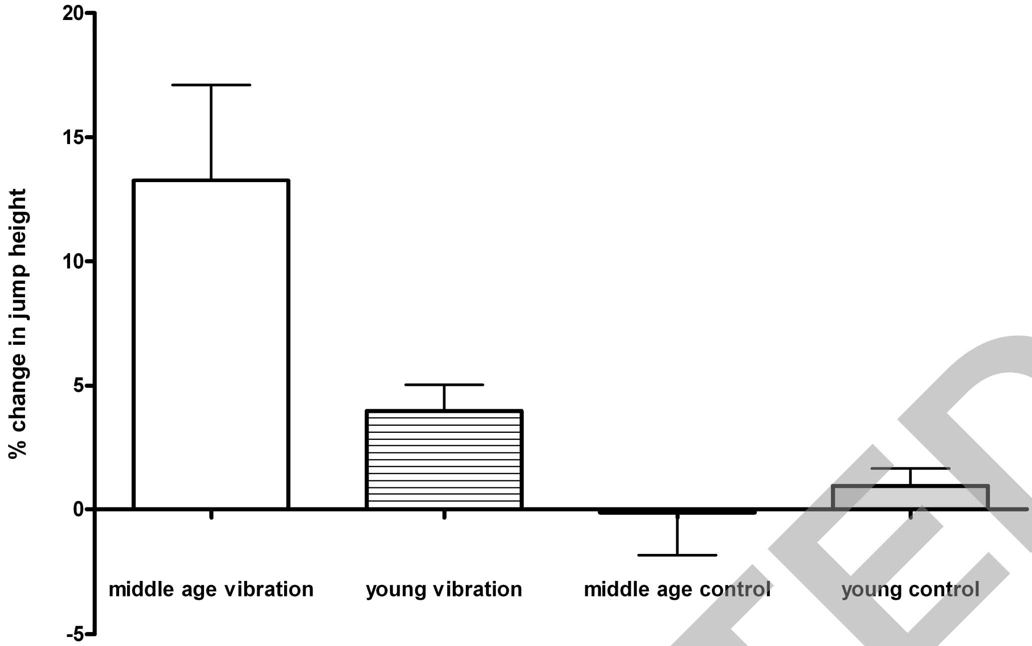
Parameter	Young WBVT (n=6)	Young Control (n=7)	Middle-aged WBVT (n=6)	Middle-aged Control (n=6)	Group P value
Age (yrs.)	24.7 ± 2.6	21.0 ± 0.8	52.0 ± 4.4 *#	49.5 ± 2.9 *#	≤0.001
Mass (kg)	61.7 ± 5.2	56.9 ± 6.6	67.4 ± 12.2	67.8 ± 10.7	0.122
Height (cm)	164.6 ± 1.5	164.5 ± 5.7	164.2 ± 4.7	164.8 ± 5.3	0.761
BMI (kg/m^2)	22.7 ± 1.8	21 ± 2.2	24.9 ± 2.1	24.9 ± 1.4	0.45
BMI classification[1]	Normal	Normal	Normal	Normal	n/a
Jump performance (cm)	35.1 ± 3.0	36.2 ± 5.4	22.3 ± 4.3 *#	24.2 ± 4.8 *#	≤0.001
ROM (cm)	30.2 ± 9.4	31.0 ± 6.5	19.4 ± 3.0 #	23.5 ± 5.4	0.014

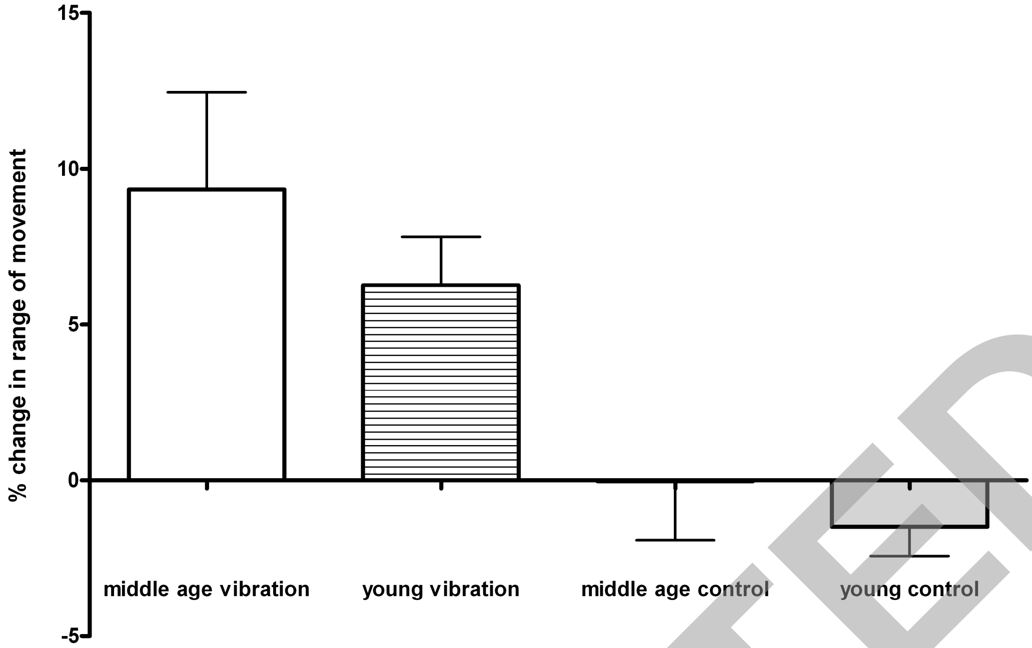
Group:	Pre- VCMJ (cm)	Post- VCMJ (cm)	Pre- ROM (cm)	Post- ROM (cm)
Young WBVT (n=6)	35.1 ± 3.0	36.6 ± 3.5	30.2 ± 9.4	31.9 ± 9.1
Young Control (n=7)	36.2 ± 5.4	36.5 ± 5.0	31.0 ± 6.5	30.4 ± 5.6
Middle-aged WBVT (n=6)	22.3 ± 4.3	24.9 ± 3.3	19.4 ± 3.0	21.3 ± 3.9
Middle-aged Control (n=6)	24.2 ± 4.8	24.1 ± 4.0	23.5 ± 5.4	23.4 ± 4.5


POWER PLATE
next



Intervention 30Hz/4mm
Static Squat (100°)
Left Leg Lunge
Right Leg Lunge
(1 min for each exercise)
(1 min recovery between)
Intervention 30Hz/4mm
Static Squat (100°)
Left Leg Lunge
Right Leg Lunge
(1 min for each exercise)
(1 min recovery between)
Intervention 35Hz/4mm
Static Squat (100°)
Left Leg Lunge
Right Leg Lunge
(1 min for each exercise)
(1 min recovery between)
Intervention 40Hz/4mm
Static Squat (100°)
Left Leg Lunge
Right Leg Lunge
(1 min for each exercise)
(1 min recovery between)
Intervention 45Hz/4mm
Static Squat (100°)
Left Leg Lunge
Right Leg Lunge
(1 min for each exercise)
(1 min recovery between)
Pre-tests:
Jump ROM
Post tests:
Jump ROM
week 1
week 2
week 3
week 4
week 5


20
15
10
5
0
-5
% change in jump height
middle age vibration
young vibration
middle age control
young control



15
10
5
0
-5
% change in range of movement
middle age vibration
young vibration
middle age control
young control