



THE EFFECT OF 8-WEEK WHOLE BODY VIBRATION ON UPPER EXTREMITIES' STRENGTH PARAMETERS

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Abstract:

The purpose of the study was to investigate the effect of an 8-week whole-body vibration intervention program on muscular strength of upper extremities. Twenty-four physical educators participated in this study. Participants were separated in two equal groups; the experimental group (EG), and the control group (CG). Before the inception of the intervention program all participants were evaluated with random order in the a) the circumference of each arm, b) the number of push-ups; c) grip strength; d) chest medicine ball throw and immediately after the end of intervention program and two days after. Participants applied a total of 24 sessions, three times per week at the same time of the day. The frequency and amplitude of the vibration platform were 35 Hz and 2 mm, respectively. The intervention program consisted of three different exercises which each had duration of 30 sec. A 30 sec rest was mediated between each trial and a 2 min time interval between exercises in order to avoid the fatigue effect. No significant interaction effect was found for the examined upper extremities variables ($p < .05$). Furthermore, no significant time and no group effect were found also ($p < .05$). Paired t-test comparisons revealed significant post differences in comparison to baseline values on medicine ball throw and left arm circumference. According to the results, EG showed a statistically significant improvement in medical ball throw and in left hand circumference, while improvement was also found in the other parameters considered.

Keywords: vibration, upper extremities, muscular strength, grip strength

1. Introduction

In recent years, vibration has been used to improve the physical fitness of both athletes and people of different ages who participated in fitness programs (Jordan, Norris, Smith, & Herzog, 2005; Luo, McNamara, & Moran, 2005). Whole Body Vibration (WBV) is

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implemented with spectacular results not only to improve muscle strength (Dallas et al, 2015; Tsopani et al, 2014) but also other parameters such as flexibility (Tsopani et al, 2014), balance (Dallas et al, 2016), but also for therapeutic purposes (Perraton, Machotka, Kumar, 2011). Previous studies claim that the effect of vibration on a muscle triggers the vibrational tonic vibration reflex which causes the muscular spindle Ia fibers of the muscle to cause muscle contraction and which is the most likely mechanism of neuromuscular activation of the vibrating muscle (Roelants, Verschueren, Delecluse, Lewvin, Stijnen, 2006). Bongiovanni, Hagbarth, and Stjernberg. (1990) support that because of the stimulation of muscle by the transfer of vibrations, the cooperation of the central and peripheral nervous system is improved. Vibration training is considered to be training for neuromuscular adjustments and propriety because of the acceleration factor called the body to face on the platform. Based on mechanical stimulation of the muscle, Tonic vibration reflexes (TVR) are manifested (De Gail, Lance, Neilson, 1966). With muscle irritation Ia stimulation, a tonic contraction is manifested in the muscle, which increases the muscular tone of the muscle (Bosco, Cardinale, Tsarpela, 1999). A great number of studies are referred to the effect of vibration on lower limbs muscular strength (Bazett-Jones, Finch, Dugan, 2008; Dallas, Mavidis, Kirialanis, Papouliakos, 2017; Jacobs, & Burns, 2009; Osawa, Oguma, Ishii, 2015; Rees, Murphy, Watsford, 2008; Yu, Seo, Kang, Kim, Kwon, 2015). However, a limited number of findings have dealt with the effect of vibration on the upper part of the body (Cochrane & Hawke, 2007; Cochrane, Stannard, Walmsely, Firth, 2008; Hazell, Jakobi, Kenno, 2007; Hong, Velez, Moland, Sullivan, 2010; Issurin & Tenenbaum, 1999; Marin, Herrero, Milton, Hazell, García-Loopez, 2013; Poston, Holcomb, Guadagnoli, Linn, 2007). An assessment of hand function was done by handgrip strength (Alkurdi and Dweiri, 2010). In the study by Morel et al. (2017) authors examined the effect of vibration on handgrip strength on young soldiers who performing push-ups on the vibratory platform. According to the results no significant improvement was found after vibrational intervention protocols. Further, as Thomas and colleagues stated an 8-w intervention resistance training program improved significantly handgrip strength in young adults (Thomas, Sahlberg, Svantesson, 2008). However, to the author's knowledge there are no other studies that investigate the effect of vibration intervention on upper extremities muscular strength. So, the purpose of the study was to examine the effect of 8-week whole-body vibration protocol on upper limbs parameters on physical education students. It was hypothesized that a significant difference will be found after the application of WBV protocol.

2. Material and Methods

2.1 Subjects

Twenty-four physical education students with a mean age 21.83 ± 1.76 years, body mass 60.34 ± 9.43 kg, body height 167.54 ± 5.89 kg and body fat 23.40 ± 7.52 % participated in this study. Participants were separated in two equal group; the experimental group (EG) (age 21.58 ± 1.38 years, body mass 59.72 ± 10.00 kg, body height 168.00 ± 6.64 kg, and body fat 21.79 ± 8.05), and the control group (CG) (age 22.08 ± 2.11 years, body mass $60.97 \pm$

9.22 kg, body height 167.08 ± 5.30 kg and body fat 25.00 ± 6.93). No statistically significant difference was found in the aforementioned parameters between groups ($p > .05$). The study protocol was approved from the University's ethical committee and all procedures were performed in accordance with the ethical standards of the Helsinki Declaration of 1975 as revised in 1983.

2.2 Experimental Design

The EG implemented an 8-week program in addition to his academic duties, whereas the CG followed only their academic duties. Participants applied a total of 24 sessions, three times per week at the same time of the day. All students were coming from the same classes by attending the same hours of the specific courses in the program in order not to affect the results of this research study. All the students were right-handed. The phase of the ammonia cycle was also recorded. The measurement of body weight (Kg) and body height was done with a precision scales (Bilance Salus Milano) and the measurement of body fat was done with scale type TANITA: inner Scan-Body Composition Monitor. The evaluation of grip strength test was done with the LaFayette Grip Strength Dynamometer (LaFayette Instrument Company Incorporated, 2004). The frequency and amplitude of the vibration platform were 35 Hz and 2 mm, respectively (Sands et al, 2006). Before the inception of the intervention program all participants were evaluated with random order in the a) the circumference of each arm (cm), b) the number of push-ups; c) grip strength (N); d) chest medicine ball 2Kg throw (cm) (baseline values) and immediately after the end of intervention program (post 1) and two days after (post 2). Three trials of each exercise were performed and the best one was used for further statistical analysis. The intervention program consisted of three different exercises which each had duration of 30 sec: a) isometric squats; b) from knee position, push-ups with hands on vibration platform; c) from rear sitting position flex and extend elbow joint with hands on vibration platform. A 30 sec rest was mediated between each trial and a 2 min time interval between exercises in order to avoid the fatigue effect.

2.3 Statistical Analysis

The statistical package SPSS v. 24 was used for the statistical analysis. A two-way (group x time) ANOVA with repeated measures on the second factor was used in order to examine the impact of time (pre, post1, post2) and group (EG, CG) on the dependent variables. Sphericity was checked using Mauchly's test, and the Greenhouse-Geisser's correction on degrees of freedom was applied when necessary. In cases where interaction between time and group was detected, the simple effects were investigated, and Bonferonni's correction was used. In the absence of interaction, the main effects of the two factors (time and group) on the dependent variables were investigated. All statistical significances were tested at $\alpha = 0.05$.

3. Results

Of the totality of the somatometric characteristics only for the body mass a significant time effect was found ($F_{(2)} = 17.87$, $p < .001$, $\eta^2 = .448$). The somatometric characteristics of the groups in various measurements are presented in table 1.

Table 1: Somatometric characteristics of groups in various measurements

	Pre		Post 1		Post 2	
	EG	CG	EG	CG	EG	CG
BM (kg)	59.71 ± 10.00	60.96 ± 9.22	58.75 ± 9.58	60.08 ± 9.50	58.89 ± 9.65	59.85 ± 9.50
BH (cm)	168.00 ± 6.64	167.08 ± 5.29	168.00 ± 6.64	167.50 ± 5.40	168.00 ± 6.64	167.50 ± 5.40
% BF	21.79 ± 8.04	25.01 ± 6.92	22.60 ± 8.11	24.82 ± 6.97	22.27 ± 7.42	24.4 ± 7.23

BM: Body mass; BH: body height; %BF: body fat

No significant interaction effect was found for the examined upper extremities variables ($p < .05$). Furthermore, no significant time and no group effect were found also ($p < .05$).

Table 2: Means and standard deviations of upper extremities on various measurements

	Pre		Post 1		Post 2	
	EG	CG	EG	CG	EG	CG
Grip R	29.67 ± 6.61	30.75 ± 6.85	28.91 ± 5.91	29.41 ± 5.81	29.67 ± 5.01	28.25 ± 5.59
Grip L	27.41 ± 5.11	28.67 ± 5.35	28.25 ± 5.43	28.50 ± 4.17	28.08 ± 3.63	27.50 ± 4.38
Med	423.41 ± 65.77	415.33 ± 90.27	445.83 ± 63.59	406.75 ± 57.00	456.58 ± 71.03	399.17 ± 56.35
Arm R	25.70 ± 2.01	25.91 ± 2.15	25.87 ± 2.14	26.33 ± 2.78	25.83 ± 1.95	26.29 ± 2.81
Arm L	25.41 ± 1.88	25.91 ± 2.15	26.08 ± 2.02	26.41 ± 2.54	25.87 ± 1.57	26.33 ± 2.64

Grip R: right hand grip; Grip L: left hand grip; Med: medicine ball throw; Arm R: right arm circumference; Arm L: left arm circumference

Paired t-test comparisons revealed significant post differences in comparison to baseline values on medicine ball throw ($t_{(11)} = -3.39$, $p = .006$) and left arm circumference ($t_{(11)} = -4.69$, $p = .001$).

4. Discussion

The purpose of this study was to examine the effect of an 8-week WBV program on upper extremities parameters. Results showed that the majority of the examined parameters were not significantly affected by the intervention program. However, a significant improvement was found for the medicine ball throw in the EG which improve the baseline values by 5.29% in contrast to CG which reported a slight reduction by 2.06%. It is mentioned that the improvement that showed the EG was maintained for two days, indicating a further increase in this measurement by 7.83% in comparison to the baseline values in contrast to CG that showed a further decrease by 3.89% two days after the end of the intervention program. Another important finding was the increment of the left arm circumference in both groups. Although no significant differences were found EG reported an increase by 2.63% and 1.81% immediately after and two days after the end of intervention program, respectively percentages that are slightly higher than those of the

control group (1.92% and 1.62%, respectively). Finally, slight improvement that found on handgrip of left hand in EG was obviously greater compared to CG immediately after (3.06% and -0.59%, respectively) and two days after the end of the intervention program (2.44% and -4.08%, respectively).

The improvement that showed EG on medicine ball throw is also supported by the study by Poston et al (2007) that found significantly higher upper limb strength when performing weight lifting on a bench than supine bed and those of Marin et al. (2012) who found that a significant increase in biceps brachii EMG in healthy older adults after a WBV intervention. Also, support findings of Issurin and Tenenbaum (1999) who report an improvement of muscular strength of the biceps after vibration training. The slight improvement of the EG on handgrip of left arm reinforces previous data of Cochrane και Hawke (2007) who revealed a slight improvement in grip strength in climbers practicing vibration and those of Poston et al (2007) who report that there was no statistically significant improvement but only a slight improvement of 1.78%. Furthermore, our findings are in congruence with results by Hand et al. (2009) that applied a 10-w WBV program, three times per week, on student athletes performing a modified push-up position and found no significant strength gains in the subjects' rotator cuff muscle output. However, these data are in contrast with findings of Cochrane and Hawke (2007) who did not find any positive effect on climbers when dropping a medical ball and those of Hazell et al. (2007), who applied a range of WBV frequencies and amplitude in healthy young men, and found no effect on upper extremities skeletal muscle electromyography. Concerning handgrip strength our results showed no significant improvement in left handgrip a finding that is in agreement with data of More et al. (2017) but opposed from data of Thomas et al. (2008) who found significant improvement in handgrip strength after an 8-w resistance training program. It is remarkable that EG showed a significant improvement on left arm circumference by 2.63% and 1.81% immediately after and two days after the end of the intervention program, respectively percentages which are slightly higher from those of CG (1.92% and 1.62%, respectively). The gains in muscular strength after WBV training may be explained by a number of mechanisms; the tonic vibration reflex (Cardinale and Bosco, 2003), increased hormone secretion (Bosco et al, 2000), stimulation of proprioceptive pathways (Delecluse et al., 2003), post activation potentiation (Cochrane et al., 2010), and muscle hypertrophy (Delecluse et al., 2003).

Overall, according to the results, EG showed a statistically significant improvement in medical ball throw and in left hand circumference, while improvement was also found in the other parameters considered, with the exception of right-hand gestation only, where only a slight decrease was observed in the final measurement immediately afterwards. It was speculated that the specific program intensity (vibration frequency and vibration amplitude) that remained stable throughout the intervention program was not enough to create the appropriate adjustments to make a significant improvement. Possibly a difference in intensity might have had different effects.

The results of the present study must be applied with considerable caution. The study refers on physical education students of 18- to 24-year-old who underwent an 8-week workout with constant and moderate intensity, with a frequency of three sessions

per week. Furthermore, it was unknown whether the academic duties could influence the final outcome of the intervention program.

4.1 Recommendations

Further research is needed to examine the effect of WBV training with greater volume or with other aged groups with athletes of other sports.

Conflict of Interest Statement

No potential conflict of interest relevant to this article was reported.

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