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Original article

Immediate effects of whole-body vibration on neuromuscular performance of quadriceps and oscillation of the center of pressure: A randomized controlled trial

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ABSTRACT

Background: Whole body vibration has become a popular practice in training and rehabilitation centers. Although proposed as a useful adjunct to improve various aspects of musculoskeletal function, its real benefits and immediate physiological responses are still uncertain.
Objectives: This study analyzed the immediate effects of whole-body vibration with two distinct frequencies on neuromuscular performance of the quadriceps femoris and in the postural control of healthy subjects.
Design: Randomized controlled trial.
Methods: Sixty physically active women were submitted to an evaluation of the oscillation of the center of pressure through baropodometry and isokinetic performance of quadriceps femoris muscle of the non-dominant limb, associated with the electromyographic amplitude assessment of vastus lateralis muscle. Subjects were randomly divided into three groups: control group – performed an exercise protocol with the vibrating platform off; 30 and 50 Hz groups – conducted the exercise protocol with the platform on, with a frequency of 30 and 50 Hz, respectively.
Results: There was a significant reduction in the time of peak torque in three evaluated groups ($p < 0.001$), with no differences between the groups ($p = 0.586$). There were no significant differences in pressure center oscillation, peak torque normalized for body weight, total work, and average power nor in the value of the root mean square in any of the groups.
Conclusion: This study suggests that the exercise protocol on the vibrating platform does not change neuromuscular performance or the pressure center oscillation of healthy women.
ClinicalTrials.gov Identifier: NCT02416362.

1. Introduction

The use of Whole-Body Vibration (WBV) has become a popular practice in training and rehabilitation centers because is a safe and practical resource in training athletes and in the rehabilitation of patients. The WBV works by a mechanism that produces vibrations in a combination of frequencies and amplitudes that are transmitted to the body in the form of mechanical energy in order to cause an increase in muscle recruitment by reflex triggered contractions (Albasini et al., 2010).

Two methods of applying vibration to the human body have been explored in the literature. Direct or segmental vibration, which corresponds to the application of the vibration stimulus directly on the muscle belly or tendon. Another method is the indirect vibration, when the vibration originates from a distant source and is transmitted through other bodily structures until reaching the target muscle, which as is the case of WBV (Luo et al., 2005).

It has been shown that WBV is able to increase electromyographic activity, strength and muscle power. It is suggested that these effects are due to a possible increase in excitatory response of muscle spindles, through the stretch reflex mechanisms that are triggered (Bosco et al., 1999a,b; Torvinen et al., 2002; Cardinale and Lim, 2003).

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The vast majority of research conducted with vibrating platforms typically involves participants performing an exercise protocol consisting of bilateral squats. However, Roelants et al. (2006) demonstrated that the quadriceps neural drive is considerably higher during a unilateral isometric squat position, when compared with the bilateral. Therefore, this type of intervention would provide a more evident answer before the vibration stimulus.

Furthermore, it is believed that such neurophysiological factors as those involved in the response to vibratory stimuli have an intimate relationship of dependence with the frequency and amplitude settings chosen for training (Bazett-Jones et al., 2008), however, it is unclear what the optimal parameters to provide an improvement in muscle function and postural control. Improvements in neuromuscular performance variables such as peak torque, power and muscle activation were demonstrated both in studies using lower frequencies, between 25 and 30 Hz (Cochrane and Stannard, 2005; Stewart et al., 2009; Cochrane et al., 2010) as those using higher frequencies, between 40 and 50 Hz (Hazell et al., 2007; Fernandes et al., 2013).

Bazett-Jones et al. (2008) have examined the effects of various combinations of frequencies and amplitudes in acceleration and jump height of men and women. For the group of men, none of the combinations provided has provoked significant improvements, unlike women, who showed improvement in jump height after vibration at frequencies of 40 and 50 Hz.

Some studies have shown improvements in neuromuscular performance immediately after a WBV protocol when compared to a stationary bicycle exercise, demonstrating its effectiveness as a warming method before explosive activities requiring strength, speed and power (Cochrane and Stannard, 2005; Cormie et al., 2006). Corroborating these results, a study showed that the intramuscular temperature of the vastus lateralis increased more after a WBV exercise at a frequency of 26 Hz when compared to other traditional forms of warming-up (Cochrane et al., 2008).

Other authors demonstrated a transient improvement in vertical jump height, peak torque and isometric postural balance of healthy subjects immediately after exercise on the platform; such effects dissipated 2 min after the intervention (Torvinen et al., 2002; Bazett-Jones et al., 2008).

Despite being a widely used resource in gyms and rehabilitation centers, there is a gap to be filled in the literature about the acute neurophysiological responses in skeletal muscle after WBV. Several frequency and intensity combinations used in the studies and inconsistent results reflect the lack of consensus, making interpretation of its effectiveness difficult. In addition, few studies have used, in association, evaluation methods considered gold standard for analyzing the possible effects of WBV on neuromuscular performance, such as electromyography, baropodometry and isokinetic dynamometry.

Given the above, this study was elaborated in order to examine the effects of a WBV protocol, with distinct frequencies, on the isokinetic performance of quadriceps femoris muscle, the electromyographic amplitude of vastus lateralis muscle and the oscillation of the center of pressure. We postulate that the exercise protocol associated with WBV improves neuromuscular performance and oscillation of the center of pressure in healthy subjects. This study was registered at www.clinicaltrials.gov with the registration number NCT02416362.

2. Materials & methods

2.1. Participants

The study sample consisted of sixty physically active women (average age: 22.7 ± 3.5 years; body mass index – BMI: 22.6 ± 2.4 kg/m^2) non-probabilistically recruited in a local university. The inclusion criteria were: being healthy, practicing recreational physical activity at least three times a week without training at a competitive level (Pincivero et al., 2003), aged between 18 and 28 years. Exclusion criteria were inability to understand the commands given in the protocols, incorrect execution of assessment procedures or presence of pain, discomfort, vertigo or dizziness during the tests and interventions. Following these criteria, there were no exclusions in this study.

Subjects were randomly divided, using the method of randomly permuted blocks in the website www.randomization.com. After randomization, the order of the participants was put in a numbered, sealed and opaque envelopes. Those envelopes were only opened at the moment of the intervention. The participants were allocated into three different groups of 20 individuals each: Control Group, 30 Hz group and 50 Hz group. This study was approved by the local university Research Ethics Committee (protocol number 752.291) and complied with ethical aspects based on Resolution 466/12 of the National Health Council and Declaration of Helsinki. All participants volunteered to take part in the study and gave their informed consent after being advised of the objectives, risks and benefits of the research.

2.2. Experimental design

A pilot study was conducted in order to adjust all the research procedures and to train the researchers involved. Two evaluators participated in the study: evaluator 1 was responsible for carrying out the evaluation of all the volunteers, while the second evaluator was exclusively responsible for implementing the intervention.

Initially the volunteers performed an evaluation of the oscillation of the center of pressure of the non-dominant limb through a computerized baropodometer (Eclipse 3000-Guy-Capron ® SA, France) with a 40 × 40 cm surface and an acquisition frequency of 20 Hz. The volunteers were positioned with support on the non-dominant limb and the knee kept at 40° flexion (considering 0° to full extension of the knee), verified by a universal goniometer. The non-assessed lower limb should be at 0° flexion to the hip and at 90° flexion to the knee (Fig. 1). The data acquisition time was 10 s. The evaluation was repeated three times with a 1-min rest period between tests. For the analysis of the variables, the average of the two best evaluations related to amplitude and speed displacement of the body pressure center was used.

For the evaluation of isokinetic performance, the volunteers were positioned sitting at a computerized isokinetic dynamometer (BiodexMulti-Joint System 4, Biodex Biomedical System Inc.®, New York, USA). The rotation axis of the dynamometer was aligned with the lateral epicondyle of the femur and the lever arm was adjusted and fixed to the distal region of the leg according to the recommendations of Dvir (Dvir, 2004). The gravity correction factor was performed on the dynamometer using the weight of the lower limb at 30° of knee flexion. Five maximum concentric contractions of the knee were performed at 60°/s, from 90° of flexion until complete extension. For all evaluations, the following variables were considered: peak torque normalized for body weight (PT/BW, expressed as a percentage) total work (Joules), average power (Watts) and time of peak torque (ms). Familiarization with the equipment was permitted before the evaluation by conducting three submaximal contractions at 60°/s. Throughout the isokinetic evaluation verbal encouragement was provided, as well as a visual feedback on the monitor of the equipment.

To record electromyographic activity, the skin was prepared by trichotomy and the area was cleaned with 70% alcohol prior to electrode placement. The electromyographic signal was captured by an 8 channels signal conditioner module (Telemyo direct