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Systematic review

Effect of whole body vibration training on quadriceps muscle strength in individuals with knee osteoarthritis: a systematic review and meta-analysis

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Abstract

Background Several studies have reported the effects of whole body vibration (WBV) training on muscle strength. This systematic review investigates the current evidence regarding the effects of WBV training on quadriceps muscle strength in individuals with knee osteoarthritis (OA).

Data sources We searched PubMed, CINAHL, Embase, Scopus, PEDro, and Science citation index for research articles published prior to March 2015 using the keywords whole body vibration, vibration training, strength and vibratory exercise in combination with the Medical Subject Heading 'Osteoarthritis knee'.

Study selection This meta-analysis was limited to randomized controlled trials published in the English language.

Data extraction The quality of the selected studies was assessed by two independent evaluators using the PEDro scale and criteria given by the International Society of Musculoskeletal and Neuronal Interactions (ISMNI) for reporting WBV intervention studies. The risk of bias was assessed using the Cochrane collaboration's tool for domain-based evaluation. Isokinetic quadriceps muscle strength was calculated for each intervention.

Results Eighteen studies were identified in the search. Of these, four studies met the inclusion criteria. Three of these four studies reached high methodological quality on the PEDro scale. Out of the four studies, only one study found significantly greater quadriceps muscle strength gains following WBV compared to the control group.

Conclusions In three of the four studies that compared a control group performing the same exercise as the WBV groups, no additional effect of WBV on quadriceps muscle strength in individuals with knee OA was indicated.

Keywords: Osteoarthritis; Whole body vibration; Knee; Pain; Strength

Introduction

Knee osteoarthritis (OA) is the most common form of degenerative joint disease affecting both males and females [1,2]. The symptoms of knee OA include pain, joint stiffness and reduced quadriceps strength, causing physical disability [3]. Strength of the quadriceps muscles is a vital intrinsic factor for controlling knee joint function. The role of lower extremity strength in knee joint shock attenuation during weight bearing activities has been established. Increased or uncontrolled loading on the joint can increase the risk of development or progression of the disease; therefore, the

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strength of the quadriceps muscle needs to be considered in the study of knee OA [4]. Recently, Øiestad *et al.* [5] published a systematic review and meta-analysis to investigate the association between knee extensor muscle weakness and the risk of developing knee OA. They reported that knee extensor muscle weakness was associated with a higher risk of developing knee OA in both males and females. Another study reported an increased risk of developing knee OA in individuals with weak knee extensor muscles, especially in women [6].

Recently, the use of whole body vibration (WBV) for improving muscle strength in individuals with knee OA has been recommended as an efficient and alternative method to resistance training [7–12]. Trans *et al.* has reported increased quadriceps muscle strength following WBV exercise on a stable platform compared to a control group [8]. Another study reported significant improvement in quadriceps muscle strength following WBV exercise in women with knee pain [9]. In addition, Roelants *et al.* [12] reported improvement in quadriceps muscle strength following WBV exercise in older women. However, Park *et al.* reported that gains in quadriceps muscle strength following WBV exercises were similar compared to those of a control group [10]. WBV reduces rehabilitation time compared with other traditional resistance training programs [13].

WBV training is an exercise program performed with the body on a vibration platform [14]. These vibrations can stimulate the primary endings of the muscle spindles, and thereby activate α-motor neurons which cause muscle contractions, similar to the tonic vibration reflex [8]. WBV training can be given via two types of machine: rotational vibration (RV) and the vertical vibration (VV) machines [15]. RV machines can vibrate in two dimensions (right and left), whereas VV machines can vibrate in all three spatial dimensions. The study suggests that it is easier to maintain the correct training posture on a VV machine compared to on a RV machine [15].

Recently, Wang *et al.* published a systematic review and meta-analysis to investigate the effects of WBV on pain, stiffness and physical function in individuals with knee OA [16]. They reported that the WBV training program significantly improves physical function, but that there is no evidence that WBV can reduce pain and stiffness in individuals with knee OA. In another systematic review, Osawa *et al.* [17] investigated the effects of WBV on muscle strength and power in young and older individuals. They concluded that the addition of WBV to an exercise program enhances quadriceps muscle strength and counter movement jump performance compared to the same exercises without WBV. In addition, Zafar *et al.* [18] reported reductions in pain and improvements in function following WBV training in individuals with knee OA. More recently, Wang *et al.* [19] reported improvements in symptoms, physical function, and gait parameters following WBV training in individuals with medial compartment knee OA. However, Li *et al.* [20] reported only limited evidence to support the effectiveness of WBV in the treatment of knee OA.

To date, no systematic reviews or meta-analyses have been published regarding the effect of whole body vibration therapy on quadriceps muscle strength in individuals with knee OA. Therefore, the objective of this review was to investigate evidence regarding the effect of WBV training on quadriceps muscle strength in individuals with knee OA.

Methods

Data sources

The search was conducted in PubMed, Embase, Scopus, PEDro and the Science Citation Index, using the keywords whole body vibration, vibration therapy, strength, and vibratory exercise with 'Osteoarthritis knee', and the Medical Subject Heading 'osteoarthritis, knee' in combination with 'whole body vibration' or 'vibration'. The bibliographical survey was limited to randomized controlled trials (RCTs) published prior to March 2015. Manual searching of the references given in the identified papers was used to identify other potential papers. The studies were selected independently by two evaluators (SA and HZ), based on titles and abstracts.

Inclusion and exclusion criteria

Trials were required to compare exercise with and without WBV, or exercise with WBV and control. Studies that did not include WBV in their interventions were excluded. The outcome measure of interest was isokinetic quadriceps muscle strength in individuals with knee OA. The patients in the included studies should have had radiographic or symptomatic knee OA diagnosed by a physician.

Assessment of methodological quality

The quality of the included studies was evaluated by two independent evaluators (SA and HZ) using the PEDro scale [21]. Studies with a score equal to or more than 5 were considered high quality in the criteria given by Moseley *et al.* [22] In the present review, all studies with scores greater than or equal to 5 (5/10) were considered to be of high methodological quality. The domain-based evaluation of risk of bias was assessed using the Cochrane collaboration's tool for assessing risk of bias. Risk of bias was classified as low, unclear or high in each domain [23].

In addition, we also reviewed the quality of each study based on the recommendations of the International Society of Musculoskeletal and Neuronal Interactions (ISMNI) for reporting WBV intervention studies, consisting of 13 factors [24]. We reviewed whether each article adequately described the 13 questions inquiring about WBV parameters (e.g. frequency, amplitude, and acceleration) and the participants' position (e.g. holding on to a railing, exercise position, and foot wear condition). Based on the description of each of the