WHOLE BODY VIBRATION IN THE TREATMENT OF THE KNEE OSTEOARTHRITIS

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Abstract: Osteoarthritis (OA) is one of the most common musculoskeletal diseases, which has a negative impact on patients, and is a major cause of disability and reduced quality of life. The purpose of this article is to review published scientific studies concerning the use of Whole-body vibration (WBV) and therapeutic benefits in the rehabilitation of patients with knee joint osteoarthritis (KOA).
Materials and methods: For this article, a review of available scientific articles examining the use of WBV therapy in patients with osteoarthritis of the knee joint was made with the aim to investigate the therapeutic impact of vibration therapy on muscle strength, balance, proprioception, pain, and functional activity in gonarthritis.
Results: The review of the available literature revealed evidence of a positive effect of WBV therapy on one or more observed indicators, including muscle strength, postural balance, proprioception, pain, and functional activity in KOA. Depending on the applied therapeutic program (with or without performing therapeutic exercises) and the type of vibration platform used and the frequency of vibrations, there is ambiguity in the achieved therapeutic results. Data from studies that report increased muscle strength, improved balance, improved proprioception, and reduced pain have been reported, although there are data from other studies that show no significant changes after WBV training.
Conclusion: Whole-Body Vibration is a therapeutic modality that is ussed to stimulate mechanically the musculoskeletal system. The inclusion of WBV in the rehabilitation program in patients with KOA can effectively: increase muscle strength, improve balance and proprioception, reduce pain, and increase functional activity. Although there are data from studies that do not reveal significant changes after WBV application, vibrotherapy is used as a potentially efficiently and safe neuromuscular training in KOA, but the results are not unambiguous, and the studies need to be continued.
Keywords: Knee osteoarthritis, Whole-body vibration, Muscle weakness, Proprioception, Knee rehabilitation

1. INTRODUCTION

Osteoarthritis (OA) is one of the most common musculoskeletal diseases. It most commonly affects the knee joint, the hands, hip and the spine, although it can affect any joint. OA has a negative impact on both the individual patient and society, which is associated with increased health care costs and high economic burden. (Kloppenburg & Berenbaum (2020). OA is a major cause of disability and leads to reduced quality of life. (Neogi & Zhang (2013). Lai et al. (2021)) It is estimated that about 80% of OA is due to OA of the knee joint, with about 19% of the U.S. population aged 45 and over being affected. (Vos et al. (2012); Wallaceet al. (2017)) Osteoarthritis is more common in adults over the age of 65, especially in older women (Loeser (2010); Hsu & Siwiec (2021); Ferreira et al. (2019)). The main symptoms are arthralgia, stiffness, joint swelling, decreased muscle strength, impaired proprioception and physical limitations. (Bijlsma et al. (2011); Knoop et al. (2011). Lai et al. (2021))
OA is characterized by structural damage to the joints and loss of cartilage, which is manifested by a functional deficiency (Huang et al. (2017)). Radiologically, the changes are described by narrowing of the joint space, bone osteophytosis and subchondral sclerosis. Often these changes are weakly related to the sensation of pain (Roos et al. (2011); Roos & Arden (2016)) It is believed that symptomatic OA is preceded by a prolonged preclinical stage, characterized by the appearance and development of structural changes in the joint without the presence of subjective complaints. Changes in the surrounding muscles that progress together or precede changes in the subchondral bone and articular cartilage are also thought to be important. Muscle weakness is one of the earliest and most common symptoms of KOA and is considered a better predictor of joint narrowing and pain. (Roos et al. (2011). Roos & Arden (2016)) Probably muscle weakness can be a unifying link in the action of risk factors. (Ilieva & Minchev (2016)) The muscles around the joint give dynamic resistance to normal and pathologically altered joints (Leumann et al. (2019); Roos et al.(2011); Alnahdi et al. (2012)) involving the afferent sensor system.
In KOA, significant muscle damage is found that directly affects physical function and therapeutic interventions should be aimed at overcoming these damages. (McAlindon, et al. (2014)) Applying appropriate, therapeutic interventions could reduce pain and improve its function.
According to the recommendations for the management of KOA, therapeutic exercises are recommended as a highly effective treatment. Kinesitherapy may include aerobic and/or ground-based resistance exercises,

hydrokinesitherapy, weight loss, and Tai Chi. (Kolasinski et al. (2020); Bannuru et al. (2019)) Exercises that increase muscle strength are recommended. They are considered basic non-pharmacological therapy (Lai et al. (2021)).

WBV is increasingly used in KOA, especially to relieve pain, improve physical function (Wang et al. (2016); Yañez-Álvarez et al. (2020); Anwer et al. (2016)) and affect impaired proprioception. WBV is a method aimed at mechanical stimulation of the musculoskeletal system. The inclusion of WBV in the rehabilitation program most often pursues the following therapeutic goals: increasing muscle strength, improving balance and proprioception, reducing pain. Although there are studies that do not reveal significant changes after WBV, it is applied as a neuromuscular modality in muscle strength training (Alam et al. (2018); Amita Aggarwal et al. (2020)) and is used as a safe and potentially effective treatment. (Lai et al. (2021)) except for those with acute symptomatic OA, in which this type of therapy may be inapplicable.

2. MATERIALS AND METHODS

For this article, a review of available scientific articles examining the use of WBV therapy in patients with osteoarthritis of the knee joint was made with the aim to investigate the therapeutic impact of vibration therapy on muscle strength, balance, proprioception, pain, and functional activity in gonarthritis.

3. RESULTS

The review of the available literature revealed evidence of a positive effect of WBV therapy on one or more observed indicators, including muscle strength, balance, proprioception, pain, and functional activity in KOA. Depending on the applied therapeutic program (with or without performing therapeutic exercises) and the type of vibration platform used and the frequency of vibrations, there is ambiguity in the achieved therapeutic results. Data from studies that report increased muscle strength, improved balance, improved proprioception, and reduced pain have been reported, although there are data from other studies that show no significant changes after WBV training.

4. DISCUSSION

Vibration therapy is a method that leads to mechanical stimulation of the musculoskeletal system. In recent years, it is increasingly used in medical practice, including Physical and Rehabilitation Medicine, outside the gym, where it is actively used in healthy in order to improve the training process and increase muscle strength. WBV is applied as a therapeutic modality in diseases of the musculoskeletal system, OA of the lower limbs, chronic tendinopathy, osteoporosis, low back pain and diseases of the nervous system. (Alam et al. (2018); Maghbouli et al. (2021); Tsai et al. (2021); Yañez-Álvarez et al. (2020); Wysocki et al. (2011); Ruan et al. (2008); Lai et al. (2021); Wang et al. (2016); Dong et al. (2019). Horstmann et al. (2013); Alashram et al. (2019); Dincher et al. (2019)).

The hypothesis of most authors is that vibrations stimulate muscle spindles and α-motoneurons and initiate muscle contractions. (Xu (2016)) The inclusion of WBV in the rehabilitation program aims to: increase muscle strength, improve balance, improve proprioception, reduce pain, and increase functional activity. Vibration therapy is conducted in the form of general vibration of the whole body (Alam et al. (2018) or by means of local vibrations directed to muscle groups, where high-frequency oscillations are applied. (Iodice et al. (2011)). WBV uses vibrating devices - vibrating platforms, specially designed devices, or comercial devices. The type of the mechanical device generating the vibration is essential. The therapeutic effect is modified depending on the technical characteristics of the platform and the specifics of the vibrating parameters. Main characteristics of the vibrating devices are frequency (in Hz; the number of Hz indicates the number of the full cycle of movement up and down in one second), amplitude (in mm), direction of movement of vibrations. (Rauch (2009); Maghbouli et al. (2021)) The frequency of vibrations of WBV varies in the low frequency range (5–60 Hz), with the muscles responding with automatic contractions and relaxations. Due to the low-frequency mechanical oscillations, the tension in them increases and becomes more efficient. In traditional training, about 40% of motor units are activated, while in WBV treatment, this percentage can increase significantly. (Delecluse et al. (2005); Lamont et al. (2010); Cormie et al. (2006); Rittweger, J., et al.(2002); Abercromby et al. (2007); Amonette et al. (2005); Abercromb, et al. (2007); Simsek D. (2017)). Functional changes affect not only the muscles, but also the exposed to vibrations: ligaments, bones, nervous and endocrine systems. In a normal vibro-training, the trainee stands vertically on the device in a static position or performs dynamic exercises. As a result of the non-exhausting vibro-training the muscular force increases. A larger number of motor units are activated compared to consciously induced muscle contractions. Although, more intense muscle stimulation also leads to faster muscle fatigue. (Maghbouli et al. (2021); Bosco et al. (1999); Lephart & Henry (1995); Jackson & Turner (2003); Harnie et al. (2020); Krol et al. (2011); Saxena et al. (2020)] Training with WBV can be as effective as training against resistance to increase muscle strength (Delecluse et al. (2003)). In another study, Roelants al. (2004) reported an increase in dynamic extensor muscle strength in KJ in

postmenopausal women by 15% after a 24-week WBV course, 3 times per week. Studies show that even a low frequency of 20 Hz and an amplitude of 2 mm can give positive results in WBV (Rittweger (2002); Cardinale & Lim (2003); Gerodimos et al. (2010)) Iodice et. al. (2011) and these are believed to appeare as a result of vibration to a mechanism allowing better processing of afferent signals. Vibrations appear as a powerful stimulator for proprioceptors, skin receptors and neuromuscular spindles and play an important role in the observed long-term effects, although lower levels of muscle activation are found after prolonged vibrostimulation. Jackson & Turner (2003) found that prolonged vibration stimulation (30 min at 30 Hz) significantly reduced muscle strength per m. rectus femoris at extension in KJ and decreased iEMG muscle activity. Together with the described effects of WBV, there is an improvement in peripheral blood circulation, lymphatic drainage, faster elimination of waste products due to rapid muscle contractions 20-50/min, where the muscles increase their pumping function in relation to blood vessels and lymph vessels., faster recovery after exercise and pain control. (Kerschan-Schind et al. (2001))

WBV is increasingly applied as a therapeutic option to address some of the main symptoms of KOA. Its effectiveness in terms of pain, functional activity, quadriceps strength, KJ mobility, proprioception and postural balance is studied. It is believed that WBV may be effective in reducing pain and improving functional activity as assessed by the WOMAC Index. (Tsuji et al. (2014); Wang et al. (2016); Philip & George (2019); Yañez-Álvarez et al. (2020)), although some studies have not found a significant difference. (Bokaeian et al. (2016); Wang et al. (2015)) In KOA, muscle weakness is one of the earliest and most common symptoms and is considered a better predictor of joint narrowing and pain (Roos et al. (2011)) It can be a unifying relation in the action of risk factors. Periarticular muscles play an important role in the dynamic stability of normal and pathologically altered joints (Leumann et al. (2019); Roos & Arden (2016); Alnahdi et al. (2012)) involving the afferent sensory system.

Impaired proprioception is associated with the appearance and development of KOA. Significant differences in proprioception have been reported in patients with KOA compared to healthy representatives at the same age. Three functions of knee proprioception have been described: protection against excessive movement, stabilization during static body position, and coordination of movements. (Knoop et al. (2011)) In addition, proprioceptive impairment could cause pain in the KJ or limited functional activity. (Bennell et al. (2003) Patients with cartilage destruction have a higher proprioceptive deficit than the controls. It is so severe that it can cover the contralateral healthy knee. However, it remains debatable whether proprioceptive deficiency is cause of or consequence of OA (Al-Dadah et al. (2020)). It is still being investigated whether WBV has a positive effect on proprioception, and data from studies conducted are not unambiguous. Trans et al. (2009) report that WBV training on a stable platform (VibM) leads to an increase in knee muscle strength (extension/flexion), while WBV on a balance platform improves proprioception (threshold for detection of passive movement). Segal et al. (2013) reported that the addition of vibration therapy to a 12-week exercise program did not significantly improve the strength or power of the lower limb, compared to exercise programe without vibration therapy. Lai, Z. et al. (2021) after 8 weeks of WBV training also did not report about significantly improved proprioception of the knee. They indicate that the type of vibration equipment or methods used to test proprioception may be relevant.

According to some authors in KOA, pain in the knee joint is associated with weakness of the quadriceps and impaired balance, which requires the development of appropriate strategies for managing KOA. (Kimet al. (2018)) Symptomatic KOA adversely affects neuromuscular function. There are reports that the presence of swelling in the knee joint affects muscle strength and proprioception. (Cho et al. (2011)). Although there is still insufficient convincing evidence, impaired proprioception and weakness of the surrounding muscles are thought to be essential for the development or progression of KOA. It is likely that decreased muscle strength and poor proprioception may lead to increased pain in KJ Lai, Z. et al. (2021) and reduced functional activity. (Van der Esch et al. (2014); Ericsson et al. (2021)). According to Cudejko et al. (2018) impaired proprioception is probably also associated with the presence of systemic inflammation. Impaired proprioception is probably the way in which systemic inflammation affects muscle weakness in KOA.

Increasing muscle strength is a potential therapeutic goal in WBV therapy. Muscle weakness of the periarticular muscles probably leads to joint instability and joint alignment, which is associated with faster progression of KOA. (Van der Esch et al. (2014). According to studies, WBV can lead to a significant increase in muscle strength. According to Lai et al. (2021), there are several factors that explain the positive changes. WBV leads to mechanical stimulation of the body, and this stimulation is transmitted to the primary endings of the muscle spindles. The length of the muscle and its adjacent tendon is changed and the "tonic vibration reflex" is triggered, mediated by Ia afferentation and activation of muscle fibers. (Park et al. (2013)). At the same time, the vibro-platform probably changes the acceleration, which corrects the resistance during WBV training and leads to an improvement in muscle strength. (Lai et al. (2021)). Zhang et al. (2021) after a study reported that WBV training can increase the degree of activation of muscles, flexors, and extensors of KJ. They offer as the most effective vibration frequency of 20 Hz at 60° knee flexion. According to them, the choice of vibration parameters and the angle of the knee joint on the

vibroplatform should consider the individual differences of patients and the goals of rehabilitation in order to increase the effectiveness of neuromuscular activation. Although some authors found an improvement in functionality after WBV administration, they did not find a significant change in the EMG data for increased muscle activation. (Moreira-Marconi E. et al. (2020)). The strength of the provoked tonic vibration reflex is probably related to the WBV training protocol, which includes vibration frequency, displacement amplitude, starting position.

WBV therapy is currently thought to lead to increased muscle strength (Philip & George (2019); Yañez-Álvarez et al. (2020) Lai et al. (2019)), proprioception, balance, and joint mobility, (Dolny & Reyes (2008); Amita Aggarwal et al. (2020), gait (Fischer et al. (2019)) and postural stability when walking (Lai et al. (2017)). The mechanism of increasing muscle strength after WBV therapy is not fully understood. Presumably, vibration training can activate muscle spindles, mediate neural signals through Ia afferent pathways and activate muscle fibers through large α-motor neurons, and trigger a "tonic vibration reflex," leading to reflexive improvement in motor unit activation. (Lai et al. (2019))

5. CONCLUSION

Whole-Body Vibration is a therapeutic modality that is applied to stimulate mechanically the musculoskeletal system. The inclusion of WBV in the rehabilitation program in patients with KOA can effectively: increase muscle strength, improve balance and proprioception, reduce pain, and increase functional activity. Although there are data from studies that do not reveal significant changes after WBV application, vibrotherapy is used as a potentially efficiently and safe neuromuscular training in KOA, but the results are not unambiguous, and the studies need to be continued.

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