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Artigo de revisão

Whole-body vibration exercises benefit individuals with knee osteoarthritis: a narrative review

Eloá Moreira-Marconi,[1,2] Marcia C. Moura-Fernandes,[1,2] Ygor Teixeira-Silva,[2,3] Danúbia C. Sá-Caputo,[2-5] Gefferson Silva-Costa,[3] Sérgio O. de Carvalho,[3] Tânia R. Lemos-Santos,[3] Alexandre G. Meirelles,[3] Mario Bernardo-Filho[3]

Abstract

Introduction: Osteoarthritis is a rheumatic disease and may be related to aging. The main joints affected are those that normally receive more stress over the years, such as the knees. Among the recommended non-pharmacological treatments for individuals with knee osteoarthritis (KOA) is the practice of exercises. Studies have suggested whole body vibration exercise (WBVE) as a non-pharmacological intervention for KOA individuals. Materials and methods: This review gathered studies involving WBVE and KOA individuals to verify the importance of this intervention to the management of KOA. Nine works were selected. Results: The protocols of all studies were analysed and the findings about the benefits of WBVE in KOA individuals have been fairly consistent. It was observed that, in general, these analysed papers reported a reduction of pain levels and an increase in functionality on the KOA individuals. Conclusion: WBVE can be used as a safe, feasible, effective, and inexpensive tool in the rehabilitation of KOA individuals.

Keywords: Knee osteoarthritis; Mechanical vibration; Rehabilitation; Exercise.

Resumo

Exercícios de vibração de corpo inteiro beneficiam indivíduos com osteoartrite do joelho: uma revisão narrativa

Introdução: A osteoartrite é uma doença reumática e pode estar relacionada ao envelhecimento. As principais articulações afetadas são aquelas que normalmente recebem mais estresse ao longo dos anos, como os joelhos. Entre os tratamentos não farmacológicos para indivíduos com osteoartrite do joelho (OAJ), recomenda-se a prática de exercícios. Estudos sugerem o exercício de vibração de corpo inteiro (EVCI) como uma intervenção não farmacológica para indivíduos com OAJ. Materiais e métodos: Esta revisão reuniu estudos envolvendo indivíduos EVCI e OAJ com o objetivo de verificar a importância desta intervenção no manejo da OAJ. Nove trabalhos foram selecionados. Resultados: Os protocolos foram organizados, e os achados sobre os benefícios do EVCI em indivíduos OAJ, descritos. Observou-se que, em geral, os artigos analisados relataram redução do nível de dor e aumento da funcionalidade nos indivíduos com OAJ. Conclusão: O EVCI pode ser usado como uma ferramenta segura, viável, eficaz e barata na reabilitação de indivíduos com OAJ.

1. Programa de Pós-Graduação em Fisiopatologia Clínica e Experimental, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brasil.
2. Programa de Pós-Graduação em Ciências Médicas, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil.
3. Laboratório de Vibrações Mecânicas e Práticas Integrativas – LAVIMPI, Instituto Biologia Roberto Alcântara Gomes, Departamento de Biofísica e Biometria, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brasil.
4. Faculdade Bezerra de Araújo, Rio de Janeiro, Brasil.
5. Centro Universitário Serra dos Órgãos, Teresópolis, Rio de Janeiro, Brasil.

***Endereço para correspondência:**
Rua Rocha Pita, 146/405
Rio de Janeiro, RJ. CEP: 20780-240.
E-mail: eloamarconi@gmail.com

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Resumen

Los ejercicios de vibración de cuerpo entero benefician a individuos con osteoartritis de la rodilla: una revisión narrativa

Introducción: La osteoartritis es una enfermedad reumática y puede estar relacionada con el envejecimiento. Las principales articulaciones afectadas son aquellas que normalmente reciben más estrés a lo largo de los años, como las rodillas. Entre los tratamientos no farmacológicos para individuos con osteoartritis de la rodilla (OAR), se recomienda la práctica de ejercicios. Los estudios sugieren el ejercicio de vibración de cuerpo entero (EVCE) como una intervención no farmacológica para individuos con OAR. Materiales y métodos: Esta revisión reunió estudios con EVCE y OAR con el objetivo de verificar la importancia de esta intervención en el manejo de la OAR. Resultados: Nueve trabajos fueron seleccionados. Los protocolos fueron organizados y los hallazgos sobre los beneficios del EVCE en individuos OAR se describen. En general, se observa que los artículos analizados relataron reducción del nivel de dolor y aumento de la funcionalidad en los individuos de la OAR. Conclusión: El EVCE puede ser utilizado como una herramienta segura, viable, eficaz y económica en la rehabilitación de individuos OAR.

Palabras clave: Osteoartritis de la rodilla; Vibración mecánica; Rehabilitación; Ejercicio.

Introduction

Whole body vibration exercise (WBVE) induces specific responses in the body that may potentially be used for therapeutic purposes[1]. It is produced by mechanical vibrations generated in a oscillating/vibratory platform (OVP). These mechanical vibrations are defined as a deterministic sinusoidal oscillatory motion[2] that is transferred to the body of the individual that is in contact with the base of the functioning OVP. There are two main types of OVP: side-to-side alternating and vertical (synchronic and triplanar).[1]

Biomechanical parameters, such as working time interspersed with rest time, frequency (f), peak-to-peak displacement (D), amplitude, and peak acceleration (aPeak), as well as the positioning of the individual and the type of OVP, are fundamental for the elaboration of a safe and useful protocol[3] and should be considered in the ellaboration of WBVE protocols.[3]

WBVE was found beneficial for muscle power and balance and beneficial for the elderly, as demonstrated by studies that involving WBVE and degenerative diseases.[1,4–6]

According to the United Nations,[7] the proportion of people aged 60 and over should double between 2007 and 2050, and the current number should more than triple, reaching to two billion people by 2050. The increase of life expectancy has an impact on the economies and healthcare of countries.[7] In consequence, the use of drugs for managment of symptoms and diseases common to aging is also increasing, along with costs for the patient and for the healthcare system. Furthemore, these drugs may induce comorbidities[8] that can lead to even greater drug intake and potential toxicity.[9]

One of the main clinical problems related to aging is the degeneration of the musculoskeletal system, compromising the capacity to generate muscle strength and power, as well as leading to joint diseases.[10] As a consequence, a decrease in the functionality and and increase in dependency on care and aid to perform daily activities can occur[10] and, as it stands, there's need for more programs of prevention and/or primary treatment of aging-related diseases.

Every movement is a mechanical phenomenon and the human body is influenced by the age and constantly subject to loads of all kinds. The study of the forces that act in the human body is fundamental for the understanding of static and dynamic situations of human movement, be it normal or pathological. There is a functional load bearing unit constituted by subchondral bone and articular cartilage. The disharmony between these loads relates to the movement impairment of people with injuries or diseases, especially that related to the knee.[11]

The knee joint is considered one of the most complex ones of the human body due to, besides the flexion and extension, its movement having a rotational component.[12] Its bony structures are patella, femoral condyles, and tibial plateaus. There are also extra-articular structures that support and influence the knee joint (synovium, capsule, ligaments and musculotendinous units). These components move harmoniously, allowing the joint movements (flexion, extension, internal rotation, and external rotation).[13] The compromising of the knee joint can lead to osteoarthritis (OA).

Osteoarthritis is a rheumatic disease and may be related to aging. It is uncommon before 40 and more frequent after 60 years of age.[14] According to the World Health Organization (WHO),[15] OA is the most prevalent joint disease in the world. OA is one of the ten most disabling diseases in developed countries and about 25% of individuals with OA cannot perform their main daily activities unaided (ADL) due to functional disability. According to WHO, it is estimated that 9.6% of men and 18.0% of women over 60 years of age have symptomatic OA and that 80% of that population have movement limitations, but the onset can occur as early as at 40 years of age.[15] The main joints affected are those that normally receive more stress over the years, such as the knees.[16]

The combination of cellular alteration with biomechanical tension causes a molecular derangement of the joint tissues, followed by anatomical and/or physiological disorders. In consequence, remodeling of subchondral bone and bone neoformation in the form of osteophytes, development of medullary lesions, changes in the synovial membrane, joint capsule, ligaments, and periarticular muscles are expected.[17] Meniscal lesions, extrusion, muscle and ligament imbalance may also be present.[18] In this way, symptoms evolve with pain, stiffness, and joint instability, leading to loss of joint function to various degrees.[18] Joint pain is the main cause of the limitations of daily activities and is often the biggest complaint reported in clinical care.[19,20]

Osteoarthritis of the knee

Knee oateoarthritis (KOA) can affect one or both sides of the body. Its main feature is joint degeneration with progressive changes in hyaline cartilage. There is no single cause for its onset, and although the causes of KOA are still unclear, a multifactorial condition seems to be present, which can be primary (idiopathic), occurring by genetic influence, metabolic disorders, hormonal disorders, age, and by the participation of inflammatory cytokines. It may also be secondary, caused by joint wear due to external factors.[14]

According to the Sociedade Brasileira de Reumatologia (SBR),[14] the joint can be damaged by biomechanical stresses. This occurs in repetitive activities that exceeds the protection capacity of the joint. Thus, the cartilage receives excessive forces that it is not ready to receive. There are occupational and sports activities that can lead to joint damage due to repetitive use of the joints. In these cases, KOA may appear early.[14]

Muscular strength is essential for the health and physiological function of the organism. Muscles have a strong relationship with joint stability, locomotion, and performing everyday tasks such as going up and down stairs or sitting and getting up from a chair. In addition to muscle strength, muscle power plays an important role, since the restoration of balance normally depends on the rapid action of lower limb musculature, precisely the most affected by KOA and by the aging process in general.[22]

Loss of muscle strength can reduce the individual's resistance for performing their daily tasks. This functional decline can be aggravated by aging and/or sedentary lifestyle, resulting in greater muscle weakness and fatigue. Both the aging process and the sedentary lifestyle can be causes of KOA. It can be emphasized that with age there is a decrease in the elasticity of the tissue due to the reduction of the number of sarcomeres in parallel with hypotrophy of the type II muscle fibers (rapid conduction), increase of the fatty tissue and presence of random collagen bonds, thus impairing the functional motor units. With this, there is a musculoskeletal imbalance placing the joint in situations of mechanical overload. Thus, it is possible to correlate the joint instability of KOA with the physiological process of aging.[22,23]

Individuals who have muscle weakness that can lead to compromised joints (KOA - valgus or varus) and who engage in inadequate or poorly planned exercises can overload the lower limbs and accelerate KOA development. Therefore, a through evaluation is necessary to define an intervention without joint overload in order to reduce pain and strengthen of the periarticular muscles, decreasing the need of medication.[14] When there is joint instability, exercise is essential for strengthening the muscles, and it is an integral part of the treatment of KOA.[14] Squats may be effective for lower limb muscle development by increasing muscle activity progressively as the knees flex. However, excessive patellofemoral forces may contribute to knee injuries such as chondromalacia and KOA itself.[24]

There is still no cure for KOA, but there is consensus to suggest the best treatment options.[8,25,26] According to the American College of Rheumatology (ACR) and the Osteoarthritis Research Society International (OARSI), the recommendation is the combination of pharmacological and non-pharmacological treatment, such as exercise, with the aim of reducing pain and increasing functional capacity of the knee. When this goal is not achieved, surgical procedure is suggested.[17,19] Symptoms associated with KOA lead to disabilities that may hamper ADL, including those related to occupational tasks.[27]

For health professionals, clinical interventions aimed at maintaining or improving the independence and autonomy of the individual with some type of limitation are important to the achievement of the best quality of life. Age-related or disease-related to muscle weakness may affect the lower extremities, compromising the performance for walking, maintaining balance, climbing stairs, lifting and moving objects, getting up from a chair, bed or floor, cleaning the house, bathing or dressing, which are activities affected by the senile KOA.[28] These limitations, together with joint pain, leads the different levels of disability in KOA patients,[29] which are often responsible for the low adherence to the treatment, further damaging their physical performance.

KOA individuals also present reduced muscle strength, especially the quadriceps, which may or may not be associated with muscle atrophy, pain, and edema. This factor contributes to a decrease in functional independence in ADL, affecting the individual's quality of life.[27]

Among the non-pharmacological treatments recommended is the practice of aerobic and/or resistant activities associated with weight loss.[26] One of the aims of the exercise is to increase muscle strength and kinesthesia of the lower limbs to stabilize or delay the process of articular cartilage degradation.[20] However, excessive joint load may lead to aggravation of the disease with a greater inflammatory response, joint pain and edema.[30] Adherence to exercise needs to be stimulated in the KOA population because, if exercises are not carefully prescribed, pain and discomfort may arise or exacerbate during ADL, which can lead to frustration, causing the individual to give up the treatment.[30,31] The limitations in functionalilty in KOA individuals often prevent them from performing or maintaining a therapeutic intervention. For all these reasons, the WBVE has been suggested as an option of physical exercise for KOA individuals.[4,32–34]

Studies have reported the benefits of WBVE in subjects with KOA, such as pain reduction, quadriceps muscle strengthening, and balance improvement,[4,35,36] suggesting WBVE as a non-pharmacological intervention for this population.

Whole body vibration exercise on the management of KOA individuals

There are studies that describe the benefits of WBVE in KOA individuals, as shown in Table 1. However, since there are no standard WBVE protocols, further investigation is necessary to establish optimal protocols.

Discussion

Trans et al.[37] evaluated the maximal voluntary muscle strength of hamstrings and the quadriceps muscles by isokinetic dynamometry; proprioception with threshold for detection of passive movement; functionality, pain, and stiffness with Western Ontario e McMaster Universities Osteoarthritis Index (WOMAC) and level of pain whith visual analogic scale (VAS). This study had three groups (WBVE on a stable platform, WBVE on a balance board, and control group) and an increase of muscle performance was observed due to WBVE.

Avelar et al.[4] suggested that the addition of WBVE to squat training may represent a feasible and effective way of improving self perception of stiffness and physical function, mobility, and muscle condition in older adults with KOA. For this work, they used Berg Balance Scale (BBS), Timed Up and Go Test (TUG), Chair Stand Test (CST), 6-Minute Walk Test (6MWT), and WOMAC.

Salmon et al.[34] have shown that only one session can improve the functionality (step test) 5 minutes after WBVE and a moderate correlation was found between the VAS scores and the time to complete the step test.

Simão et al.[33] have shown, in the WBVE group compared to the control group, a significant reduction of the plasma concentrations of surface TNF-α receptors 1 and 2 (sTNFR1 and sTNFR2), a significant increase in the self-reported pain (WOMAC), balance (BBS), and gait performance (6MWT).

Park et al.[5] have shown a reduction of the pain level (Numeric Rating Scale - NRS) after WBVE comparing with control group and 2 months after the intervention. The study showed improvements of isometric torque of both knee extensors. However, as for the isokinetic torque of knee extensors, both groups showed improvements only in the right side.

Wang et al.[38] performed the comparison between quadriceps resistance exercise and WBVE + quadriceps resistance exercise. Clinical assessments of outcomes included evaluation of pain level (VAS), balance and mobility (TUG), physical function (WOMAC), functional performance (6MWT), active knee flexion and extension of the affected knee joint (goniometer), knee flexors and extensors strength (hand-held dynamometer), biomarkers indicating severity of joint and cartilage damage (serum cartilage oligomeric matrix protein - sCOMP and urinary Crosslinked C-telopeptides of Type II collagen -uCTX-II), daily activities (Lequesne index), and quality of life (Medical Outcomes Short Form 36 - SF-36) at baseline, 2, 4, 16 and 24 weeks. The results showed a significantly improvement in VAS at 4 weeks, in VAS, 6MWT, WOMAC pain, and WOMAC physical function at 16 weeks, and in all primary outcomes at 24 weeks.

Wang et al.[6] have evaluated the pain level (VAS), physical function (WOMAC and TUG) and gait (6MWT and 3D gait analysis) at baseline, 12 and 16 weeks. The results showed that WBVE associated with quadriceps exercise improved physical function at 12 weeks compared with baseline values.

Bokaeian et al.[39] have shown that the combination of WBV and strengthening exercise was significantly more effective in improving functional activity tests (2 min walk test - 2MWT, timed 50 foot walk test - 50FWT and TUG) than the strengthening exercise alone.

Neto et al.[40] described that KOA participants treated with WBVE or in a combined intervention (WBVE and auriculotherapy) decreased of the level of pain (VAS) in the acute and cumulative effects, but the range of the movement (knee´s flexion) was not altered in the participants of all groups.

Conclusion

Although the studies had different WBVE protocols and have evaluated several outcomes, it is observed, in general, a reduction of pain level and an increase of the functionality in KOA individuals. We can conclude that WBVE can be used as a safe, feasible, effective and inexpensive tool in the rehabilitation of KOA individuals.

Conflict of interest

The authors declare that there is not financial conflict of interest (political, personal, religious, ideological, academic, intellectual, commercial, or any other) in relation to this manuscript.

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Table 1. Parameters used in studies about the effect of whole body vibration exercise in individuals with knee osteoarthritis

Study	Size of the simple/ Age/Sex	Oscillating/vibratory platform	Frequency/D or A	Duration of the intervention (weeks)/number of session/week
Trans et al.[37]	n=52 mean age: 60.4±9.6 female	side-to-side alternating	F= 25 to 30 Hz D= not informed	8 weeks twice a week
Avelar et al.[4]	n=23 age >60 male and female	Vertical	F= 35 to 40 Hz D= 4mm	12 weeks three times a week
Salmon et al.[34]	n=17 age: not informed sex: not informed	Vertical	F= 35 Hz D= 4-6 mm	1 session
Simão et al.[33]	n=32 age >60 male and female	Vertical	F= 35 to 40 Hz D= 4mm	12 weeks three times a week
Park et al.[5]	n=22 age >50 female	Vertical	F= 12 to 14 Hz D= 2.5 to 5 mm	8 weeks three times a week
Wang et al.[38]	n=49 age: 40 to 65 male and female	Vertical	F= 35 Hz D= 4-6 mm	24 weeks five times a week
Wang et al.[6]	n=49 age: 40 to 80 male and female	Vertical	F= 35 Hz D= 4-6 mm	12 weeks five times a week
Bokaeian et al.[39]	n=28 age: 35 to 76 male and female	Vertical	F= 25 to 30 Hz D= 2 mm	8 weeks 24 sessions three times a week
Neto et al.[40]	n=78 age >40 male and female	side-to-side alternating	F= 5 to 14 Hz D= 2.5 to 7.5 mm	5 weeks 10 sessions twice a week

F - frequency, D - peak-to-peak displacement, A – amplitude

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