



Universidade do Estado do Rio de Janeiro

Centro Biomédico

Faculdade de Ciências Médica

Eloá Moreira Marconi

**Exercício de vibração de corpo inteiro como intervenção não farmacológica
para melhorar a resposta funcional e reduzir a pressão arterial em
indivíduos hipertensos com osteoartrite do joelho e promover respostas
relacionadas com biomarcadores inflamatórios em diferentes condições
clínicas**

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Tese apresentada, como requisito parcial para obtenção do título de Doutor, ao Programa de Pós-Graduação em Fisiopatologia Clínica e Experimental, da Universidade do Estado do Rio de Janeiro.

Orientador: Prof. Dr. Mario Bernardo Filho

Coorientadora: Prof.^a Dra. Danúbia da Cunha de Sá Caputo

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DEDICATÓRIA

Dedico essa tese às pessoas que estiveram ao meu lado me ajudando em cada obstáculo e festejando em cada conquista.

Minha Avó Cylne (*in memorian*), minha guia, meu exemplo de vida, que mesmo não estando presente fisicamente, com certeza está vibrando nesse momento. Sem ela meu caminho teria sido muito mais difícil. Meus pais Edson e Celéria, que sempre acreditaram no meu potencial. Meus sogros Maria Evangelina e Clézio por todo auxílio e carinho. Meu marido Leandro por estar do meu lado durante todo o tempo, me segurando nas quedas e me erguendo muitas vezes para que eu não desistisse. Minhas filhas amadas Aline e Larissa pela paciência de assistir todas as minhas apresentações e seminários, pelo período sem passeios e brincadeiras e por aturarem meu mau humor de vez em quando.

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Se uma pessoa é perseverante, por mais que seja dura de entendimento, se fará inteligente e por mais que seja fraca se transformará em forte.

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RESUMO

MARCONI, Eloá Moreira. *Exercício de vibração de corpo inteiro como intervenção não farmacológica para melhorar a resposta funcional e reduzir a pressão arterial em indivíduos hipertensos com osteoartrite do joelho e promover respostas relacionadas com biomarcadores inflamatórios em diferentes condições clínicas*. 2021. 104 f. Tese (Doutorado em Fisiopatologia Clínica e Experimental) – Faculdade de Ciências Médicas, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, 2021.

A osteoartrite do joelho (OAJ) é uma doença articular degenerativa que apresenta uma inflamação crônica de baixo grau relacionada com o envelhecimento (*Inflamm-Aging*). Pode estar associada com outras condições clínicas como a hipertensão arterial. A incapacidade funcional é uma característica importante da OAJ e pode atingir cerca de 20% das pessoas com OAJ sintomática, principalmente devido à fraqueza do quadríceps. O tratamento farmacológico é indicado para a redução dos sinais e sintomas da OAJ e para o controle da pressão arterial (PA), no entanto, formas não farmacológicas de tratamento tem sido sugeridas. O exercício de vibração de corpo inteiro (EVCI) tem sido proposto como uma intervenção não farmacológica para essas condições clínicas. Os objetivos desse trabalho foram investigar se o EVCI poderia ser utilizado como uma ferramenta mais sustentável para melhorar a resposta funcional em indivíduos com OAJ, apresentar um efeito anti-hipertensivo em indivíduos hipertensos com OAJ e sintetizar os efeitos dos EVCI nas respostas de biomarcadores inflamatórios (RBI) em diferentes condições clínicas. Foi realizado um estudo experimental *crossover* de dois períodos (*washout* 8 semanas). Dezenove indivíduos com OAJ e hipertensão controlada foram alocados em 2 grupos: (i) grupo submetido ao EVCI, com deslocamento pico a pico de 2,5 a 7,5 mm, frequência de 5 a 14 Hz e pico de aceleração de 0,12 a 2,95 g; (ii) grupo controle (0 Hz). Os participantes foram posicionados sentados em uma cadeira em frente a plataforma vibratória com os pés apoiados em sua base (2 x/semana, durante 5 semanas). A aferição da PA, o teste de sentar e levantar da cadeira 5 vezes (5CST) e a eletromiografia de superfície dos músculos Vasto Lateral foram avaliados antes e após o protocolo. Uma revisão sistemática foi realizada seguindo as recomendações do *Preferred Reporting Items for Systematic Reviews and Meta-Analysis* (PRISMA) e foi registrada no *International Prospective Register of Systematic Reviews* (PROSPERO). As pesquisas foram realizadas utilizando 7 bancos de dados. Os resultados do estudo *crossover* mostraram que não foram encontradas diferenças entre os grupos no *baseline* (antropometria, capacidade funcional, parâmetros da PA e medicações). O EVCI reduziu a PA sistólica ($p=0,02$), a PA média ($p=0,02$) e o tempo de execução do 5CST ($p=0,018$), enquanto não foram encontradas diferenças na PA diastólica ($p=0,11$) e no perfil eletromiográfico. A revisão sistemática incluiu 4 ensaios clínicos randomizados que envolviam RBI e EVCI com diferentes populações, protocolos e desfechos. Com base nos achados sobre os efeitos do EVCI nos indivíduos com OAJ, foi possível concluir que apenas 5 semanas de intervenção em uma postura confortável apresentou um efeito anti-hipertensivo e melhorou a resposta funcional nessa população sem alteração da excitação muscular. Além disso, a revisão sistemática mostrou que o EVCI pode apresentar benefícios em condições inflamatórias através de alterações nas RBI. Portanto, o EVCI poderia ser considerado uma ferramenta efetiva, contribuindo para reduzir a necessidade farmacológica em diversas condições clínicas, melhorando a resposta funcional, reduzindo a PA em indivíduos hipertensos com OAJ e promovendo respostas relacionadas com biomarcadores inflamatórios.

Palavras-chave: Exercício de vibração de corpo inteiro. Osteoartrite de joelho. Eletromiografia. Hipertensão. Inflamação. Tratamento não farmacológico.

ABSTRACT

MARCONI, Eloá Moreira. *Whole-body vibration exercise as a non-pharmacological intervention to improve functional response and reduce blood pressure in hypertensive patients with knee osteoarthritis and promote responses related to inflammatory biomarkers in different clinical conditions*. 2021. 104 f. Tese (Doutorado em Fisiopatologia Clínica e Experimental) – Faculdade de Ciências Médicas, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, 2021.

Knee Osteoarthritis (KOA) is a degenerative joint disease that presents a low-grade chronic inflammation linked to aging (inflamm-aging) and may be associated with other clinical conditions such as arterial hypertension. The functional disability is an important characteristic of the KOA and can affect about 20% of people who have symptomatic KOA, mainly due to the weakness of the quadriceps. Pharmacological treatment is usually used both to reduce the signs and symptoms of KOA and to control blood pressure (BP), however, a more sustainable form of treatment has been suggested. The whole-body vibration exercise (WBVE) has been proposed as a non-pharmacological intervention for these clinical conditions. The objective of this study was to investigate whether WBVE could be used as a non-pharmacological tool to improve the functional response in KOA individuals, to present an antihypertensive effect in hypertensive KOA individuals and to synthesize the effects of WBVE on the inflammatory biomarkers response (IBR) in different clinical status. An experimental crossover study of two periods (8 weeks washout) was carried out. Nineteen KOA individuals and with hypertension were allocated into 2 groups: (i) group submitted to WBVE, with peak to peak displacement from 2.5 to 7.5 mm, frequency from 5 to 14 Hz and acceleration peak from 0.12 to 2.95g; (ii) group control (0 Hz). Participants were positioned seated in a chair in front of the vibrating platform with their feet resting on its base (2 x/week, for 5 weeks). The measurement of BP, 5-repetition chair stand test (5CST) and surface electromyography of the vastus lateralis muscles were taken before and after the protocol. A systematic review was carried out following the recommendations of the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) and was recorded in the International Prospective Registry of systematic reviews (PROSPERO). The searches were realized using 7 databases. The results of the crossover study showed that no differences were found between groups in the baseline (anthropometry, functional capacity, BP parameters and medications). The WBVE reduced systolic BP ($p=0.02$), mean BP ($p=0.02$) and 5CST execution time ($p=0.018$), while no differences were found in diastolic BP ($p=0.11$) and the electromyographic profile. A systematic review included 4 randomized controlled trials involving IBR after WBVE with different groups, protocols and outcomes. Based on the findings on the effects of WBVE on individuals with KOA, it is possible to conclude that only 5 weeks of intervention with a comfortable posture showed an antihypertensive effect and improved the functional response in this population without alteration of muscle excitation. In addition, the investigation through systematic review showed that WBVE can be benefit in management of inflammatory conditions through changes in IBR. Therefore, WBVE could be considered a sustainable tool, contributing to reduce the pharmacological need in several clinical conditions, improving functional response, reducing BP in hypertensive individuals with KOA and promoting responses related to inflammatory biomarkers.

Keywords: Whole-body vibration exercise. Knee osteoarthritis. Electromyography. Hypertension. Inflammation. Non-pharmacological treatment.

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LISTA DE ABREVIATURAS E SIGLAS

5CST	<i>Five-Repetition Chair Stand Test</i> (teste de sentar e levantar da cadeira 5 vezes)
ACR	<i>American College of Rheumatology</i>
ACE	<i>Angiotensin-converting enzyme</i>
AP	Ântero-posterior
AT1	<i>Angiotensin II receptor type 1</i>
BMI	<i>Body mass index</i>
BP	<i>Blood pressure</i>
CAAE	Certificado de Apresentação para Apreciação Ética
CAPES	Coordenação de Aperfeiçoamento de Pessoal de Nível Superior
CG	<i>Control group</i>
CINAHL	<i>Cumulative Index to Nursing and Allied Health Literature</i>
COFFITO	Conselho Federal de Fisioterapia e Terapia Ocupacional
CON	<i>Control group</i>
COPD	<i>Chronic obstructive pulmonary disease</i>
CNPq	Conselho Nacional de Desenvolvimento Científico e Tecnológico
CRP	<i>C-reactive protein</i>
CVD	<i>Cardiovascular disease</i>
DBP	<i>Diastolic blood pressure</i>
EM	<i>Extracellular matrix</i>
EVCI	Exercício de vibração de corpo inteiro
F	Feminino
FAPERJ	Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro
GC	Grupo controle
GV	Grupo submetido ao EVCI
HUPE	Hospital Universitário Pedro Ernesto
IBR	<i>Inflammatory biomarkers response</i>
IKDC	<i>International Knee Documentation Committee</i>
IL	<i>Interleukin</i>
KOA	<i>Knee osteoarthritis</i>
LAVIMPI	Laboratório de Vibrações Mecânicas e Práticas Integrativas

LE	<i>Level of evidence</i>
MBP	<i>mean of blood pressure</i>
MSyn	<i>Metabolic syndrome</i>
NHMRC	<i>National Health and Medical Research Council</i>
OAJ	<i>Osteoartrite de joelho</i>
OARSI	<i>Osteoarthritis Research Society International</i>
OMS	<i>Organização Mundial de Saúde</i>
PA	<i>Pressão arterial</i>
PAD	<i>Pressão arterial diastólica</i>
PAM	<i>Pressão arterial média</i>
PAS	<i>Pressão arterial sistólica</i>
PEDro	<i>Physiotherapy Evidence Database</i>
PRISMA	<i>Preferred Reporting Items for Systematic Reviews and Meta-Analyses</i>
PROSPERO	<i>International Prospective Register of Systematic Reviews</i>
PV	<i>Plataforma vibratória</i>
RBI	<i>Respostas de biomarcadores inflamatórios</i>
RCT	<i>Randomized clinical trials</i>
ReBEC	<i>Registro brasileiro de ensaios clínicos</i>
RMS	<i>Root mean square (Raiz quadrada média)</i>
SAIDs	<i>Steroidal anti-inflammatory drugs</i>
SBP	<i>Systolic blood pressure</i>
sEMG	<i>Surface electromyography (Eletromiografia de superfície)</i>
SENIAM	<i>Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles</i>
sTNFR	<i>Soluble tumor necrosis factor receptor</i>
TCLE	<i>Termo de consentimento livre e esclarecido</i>
TKR	<i>Total knee replacement</i>
TNF	<i>Tumor necrosis factor</i>
UERJ	<i>Universidade do Estado do Rio de Janeiro</i>
VL	<i>Vastus Lateralis</i>
VLL	<i>Vastus Lateralis left</i>
VLR	<i>Vastus Lateralis right</i>

VP	<i>Vibrating Platform</i>
WBV	<i>Whole-body vibration</i>
WBVG	<i>Whole-body vibration group</i>
WOMAC	<i>Western Ontario and McMaster Universities OA Index</i>

LISTA DE SÍMBOLOS

%	Porcentagem
f	Frequência
Hz	Hertz
mm	Milímetro
D	Deslocamento pico a pico
A	Amplitude
a_{pico}	Aceleração de pico
s	Segundo
g	Aceleração da gravidade
\geq	Maior igual
$<$	Menor
n	Tamanho da amostra
=	Igual
\pm	Mais ou menos
kg	Quilograma
m	Metro
kg/m^2	Quilograma por metro quadrado
h	Hora/ <i>hour</i>
min	Minuto/ <i>minute</i>
p	p -valor
\leq	Menor igual
cm	Centímetro
$^{\circ}\text{C}$	Grau Celsius
μV	Microvolt

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INTRODUÇÃO

A osteoartrite do joelho (OAJ) é uma doença que leva à incapacidade funcional principalmente devido à dor, sendo o tipo de artrite mais prevalente em idosos (1–3). A degradação da cartilagem com remodelação óssea, formação de osteófitos, edema, baixa força muscular, estreitamento do espaço articular, inflamação, rigidez e perda da função articular podem estar presentes em indivíduos com OAJ (3,4). Além disso, é considerada uma doença sistêmica, pois os fatores biomecânicos estão acompanhados por um importante componente inflamatório, afetando todas as estruturas articulares e periarticulares (5,6). A OAJ também pode ser associada à síndrome metabólica (8), um importante fator de risco de mortalidade precoce, caracterizada pelo agrupamento de fatores de risco cardiovascular (7), como a obesidade (9), prevalência elevada de diabetes e aumento da pressão arterial (PA) (7,10). Alguns mecanismos podem ter influência sobre o elevado risco de doença cardiovascular entre os indivíduos com OAJ como: (i) presença de inflamação crônica de baixo grau relacionada com o envelhecimento (*inflamm-Aging*) (11–13); (ii) presença de adiponectinas e outras citocinas pró-inflamatórias produzidas pelo tecido adiposo, no caso de indivíduos com obesidade (5); (iii) alterações relevantes na matriz extracelular (14,15); (iv) dor e incapacidade funcional que podem resultar em inatividade física (estilo de vida sedentário) (16) e; (v) a associação com a presença de PA elevada (17–19).

O tratamento farmacológico é recomendado para a redução dos sintomas relacionados com a OAJ, assim como para outras comorbidades incluindo a hipertensão (3,20,21), o que leva esses indivíduos a um maior consumo de medicamentos, aumentando, assim, o custo de vida. Além disso, a administração de medicamentos pode gerar mais efeitos adversos/colaterais para o indivíduo e para o meio ambiente e isto vem sendo trabalhado pela “Química Verde” e a “Engenharia Verde” através do desenvolvimento de materiais e produtos químicos mais seguros através da avaliação do risco toxicológico tanto para o meio ambiente quanto para os consumidores (*Green Toxicology*) (22). No entanto, para se atingir uma produção sustentável e segura de novos produtos químicos, requer medidas importantes que, no caso de compostos farmacêuticos, podem haver limitações na obtenção de medicamentos ecológicos que sejam seguros e eficazes, além de aumentar o custo final do produto para o consumidor (22). Nesse contexto, uma boa estratégia seria investigar intervenções não farmacológicas e de baixo custo para essa população, como o exercício físico.

O exercício físico tem sido prescrito como intervenção não farmacológica tanto para reduzir os sintomas relacionados com a OAJ quanto para controlar a PA (3,23). A maioria das intervenções incluídas em programas de reabilitação neuromuscular é baseada em exercícios resistidos, promovendo a melhora da capacidade funcional em indivíduos com OAJ (24), mostrando que a função neuromuscular é relevante no desenvolvimento e na progressão da doença (25,26). No entanto, muitas intervenções podem levar à exacerbação dos sintomas e crises de dor nessa população (27). Dentre as diversas modalidades de exercícios propostas para indivíduos com OAJ, o exercício de vibração de corpo inteiro (EVCI) tem sido sugerido por apresentar respostas relevantes relacionadas com a redução dos principais sintomas da doença como: diminuição do nível de dor (28,29), melhora da função do joelho (função neuromuscular, flexibilidade, potência e força muscular) (25,29–31) e redução de biomarcadores inflamatórios (32).

O EVCI é realizado através de uma plataforma vibratória (PV) que transmite vibrações mecânicas a todo o corpo de um indivíduo que está em contato sobre a sua base (33–37). Esse estímulo vibratório produz respostas físicas e/ou fisiológicas (38) como: (i) a excitação vibratória dos fusos musculares e o aumento da sincronização da unidade motora (35,39) e/ou; (ii) produção ou inibição de biomarcadores inflamatórios e hormonais (32,40–42). Por isso, o EVCI pode ter uma importante aplicabilidade clínica no tratamento de diferentes doenças como por exemplo: (i) OAJ (28,43), (ii) síndrome metabólica (44), (iii) doença pulmonar obstrutiva crônica (45), (iv) fibromialgia (42,46,47) e (v) obesidade (48).

Uma das limitações mais comuns relatadas pelos indivíduos com OAJ é o levantar de uma cadeira devido a um comprometimento importante do quadríceps (49), por isso, o teste de sentar e levantar da cadeira 5 vezes (5-CST) tem sido usado para avaliar a capacidade funcional e a mobilidade desses indivíduos (50–52). Uma outra avaliação importante é a detecção do potencial elétrico resultante da corrente transmembrana das fibras musculares (excitação muscular) através da eletromiografia de superfície (sEMG), pois mede a atividade muscular e pode fornecer informações sobre as respostas neuromusculares aos exercícios e ao envelhecimento (53,54). Além disso, como as pessoas com OAJ têm maior probabilidade de desenvolver hipertensão, podendo apresentar 13% mais chance de desenvolver a doença do que indivíduos sem OAJ, a monitorização da PA e o tratamento da hipertensão nesses indivíduos (55) é muito importante.

A hipótese desse estudo é que o EVCI pode ser utilizado como uma intervenção não farmacológica, ou seja, uma ferramenta mais sustentável para melhorar as respostas funcional

e neuromuscular e apresentar um efeito anti-hipertensivo em indivíduos hipertensos com OAJ e, além disso, ter um efeito anti-inflamatório em diversas condições clínicas.

Para uma melhor compreensão e possíveis esclarecimentos quanto ao conteúdo do estudo esta tese foi estruturada em duas partes. A primeira parte apresenta uma breve revisão da literatura com os elementos que fazem parte do contexto da tese. A segunda parte apresenta a metodologia aplicada para a realização do ensaio clínico e da revisão sistemática, bem como os resultados encontrados referentes à capacidade funcional de membros inferiores, o comportamento neuromuscular do músculo vasto lateral (VL) durante o 5-CST e ao efeito anti-hipertensivo do EVCI em indivíduos com OAJ, além de uma síntese sobre a ação anti-inflamatória do EVCI em diversas condições clínicas.

1 OBJETIVOS

1.1 Objetivo geral

Avaliar efeitos do EVCI na capacidade funcional de membros inferiores, no comportamento neuromuscular do músculo VL durante o 5-CST e na PA de indivíduos hipertensos com OAJ, além de investigar a ação anti-inflamatória do EVCI em diferentes condições clínicas.

1.2 Objetivos específicos

- a) Medir a capacidade funcional dos membros inferiores pelo 5CST em indivíduos com OAJ submetidas ao EVCI;
- b) Quantificar a eficiência do músculo VL (bilateral) por meio da sEMG durante o 5CST em indivíduos com OAJ antes e após o EVCI;
- c) Verificar a resposta da PA de indivíduos hipertensos com OAJ submetidos ao EVCI;
- d) Elaborar uma revisão sistemática sobre os efeitos do EVCI nas respostas de biomarcadores inflamatórios (RBI) em diferentes condições clínicas.

2 REVISÃO DA LITERATURA

2.1 Osteoartrite do joelho

2.1.1 Fisiopatologia da osteoartrite do joelho

A OAJ é uma doença que envolve uma série de fatores complexos que comprometem a articulação do joelho. Embora a degradação da cartilagem articular seja a característica mais notável da doença, todas as estruturas peri e intra articulares (sinóvia, ligamentos, músculos e osso subcondral) também são afetadas (7,56). Além de fatores estruturais, componentes inflamatórios e metabólicos, incluindo sinovite ativa e inflamação sistêmica, também desempenham um papel fundamental na patogênese da doença (7,56).

Até o presente momento não existe uma cura para a OAJ (56), pois existem fatores não modificáveis que podem facilitar a instalação ou progressão da doença como: idade avançada, gênero (mais comum em mulheres) e influência genética (OAJ primária) (7,56). Entretanto, quando a OAJ se instala após algum trauma ou devido à comorbidades (OAJ secundária), pode apresentar alguns fatores modificáveis que, quando melhorados podem estabilizar ou impedir a progressão da doença como: lesão articular, fraqueza muscular, inatividade física, desalinhamento articular, movimentos viciosos (7,56). Além disso, dentre os fatores de risco sistêmico existem algumas comorbidades como a obesidade e a síndrome metabólica (7,56).

Um dos mecanismos de ação que contribuem para a instalação e progressão da OAJ é o estresse biomecânico, pois gera um desequilíbrio entre a destruição e o reparo dos tecidos das estruturas articulares (7,57). A cartilagem articular é um tecido conjuntivo flexível e mecanicamente complacente, encontrado na extremidade dos ossos longos (articulação do joelho), cuja principal função é proporcionar uma superfície lisa e lubrificada para facilitar a transmissão de cargas com baixo coeficiente de atrito (57). Entretanto, quando ocorre um estresse físico intensivo e repetitivo, a cartilagem articular pode não tolerar esse excesso de carga, sofrendo erosões superficiais que mais tarde tornam-se fissuras mais profundas seguidas por expansão da zona de cartilagem calcificada (osteófitos) (7,57). Nesse caso, a cartilagem articular acaba sendo incapaz de curar-se, pois apresenta um processo de

remodelamento extremamente lento em adultos, podendo levar até 2 décadas (os condrócitos substituem as macromoléculas da matriz degradada por componentes recém-sintetizados) (57). Outro mecanismo de ação possível seria que a cartilagem degradada induziria a uma reação de corpo estranho dentro das células sinoviais, podendo levar à produção de metaloproteases, angiogênese sinovial e produção de citocinas inflamatórias (56). Isso poderia causar mais destruição da cartilagem criando um ciclo degenerativo. Outra possibilidade seria que, na tentativa de reparar as pequenas lesões causadas pelo estresse articular, os condrócitos hipertróficos aumentariam sua atividade sintética e com isso acabariam gerando produtos de degradação da matriz extracelular e mediadores pró-inflamatórios, agindo na sinóvia adjacente hipertrofiando o tecido e aumento vascularização local (7).

O estresse, ou aumento da carga articular pode ser agravado pela fraqueza muscular naturalmente presente nos idosos devido à diminuição dos hormônios sexuais, disfunções mitocondriais e apoptoses que acarretam uma perda de massa muscular relacionada com a idade (sarcopenia) (58,59). Outro fator que pode aumentar o estresse ou aumentar a carga articular é a obesidade e o sobrepeso, que nesse caso, também apresenta uma inflamação sistêmica, aumentando o risco para o desenvolvimento da OAJ (56). Kanthawang *et al.*, 2020 (60) observaram uma alta correlação entre a degeneração estrutural do joelho, degeneração da composição da cartilagem e aumento do nível de dor com o aumento de biomarcadores de inflamação sinovial em indivíduos com obesidade e sobrepeso. Yusuf *et al.*, 2010 observaram uma associação entre o aumento da massa corporal e o desenvolvimento de osteoartrite nas mãos, sugerindo que outras consequências da obesidade poderiam estar relacionadas com a doença além da sobrecarga articular, possivelmente por meio da leptina e outras adipocinas (61). Rajandran *et al.*, 2020 observaram associações entre biomarcadores pró-inflamatórios e várias características da OAJ pela ressonância nuclear magnética no estágio inicial da doença (62). Alguns estudos mostraram um envolvimento direto de tecidos adiposos locais e sistêmicos no início e na progressão da OAJ (63,64), o que justificaria a associação da OAJ com risco de desenvolvimento de doença cardiovascular (aterosclerose, obesidade, síndrome metabólica, diabetes e hipertensão arterial) (7–10,55).

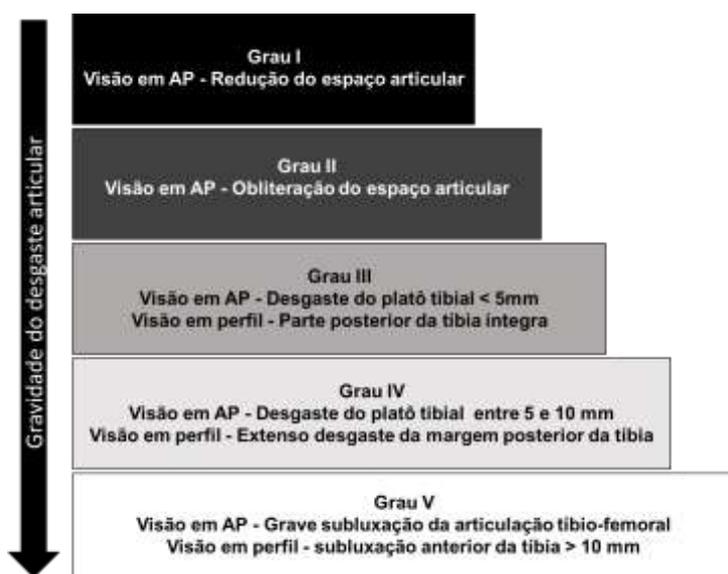
As disfunções do sistema imunológico relacionadas com a idade (imunossenescência) e sua íntima relação com a inflamação de baixo grau relacionada com o envelhecimento (*Inflamm-Aging*) também podem justificar a alta incidência de OAJ em indivíduos mais velhos (11). O fato de ambas (imunossenescência e *Inflamm-Aging*) apresentarem uma resposta a uma situação de estresse fisiológico demonstra a forte relação existente entre o sistema imune e a presença de respostas pró-inflamatórias relacionadas com o envelhecimento

(11). Normalmente, estímulos gerados por estressores antígenos crônicos provocam uma resposta imune no organismo de indivíduos jovens, porém essa resposta se apresenta mais fraca em indivíduos idosos com sinais de imunossenescência e *Inflamm-Aging*, contribuindo para uma maior incidência de doenças infecciosas ou mesmo crônico-degenerativas (11).

2.1.2 Diagnóstico

O diagnóstico da OAJ é clínico, baseado nos sintomas (dor, breve rigidez matinal e limitações funcionais) e em um exame físico específico (crepitação, movimento limitado ou doloroso, sensibilidade articular e edema) (7,56). Exames de imagem e laboratoriais não são necessários, porém podem ser considerados no caso de haver suspeita de outros diagnósticos (7,56). No caso da OAJ, o critério de *Ahlbäck* pode ser realizado para determinar o grau de degradação articular através de uma radiografia simples (65), e foi utilizado no presente estudo para identificar e classificar o desgaste estrutural da articulação do joelho (Figura 1).

Figura 1 – Classificação adaptada do grau de osteoartrite do joelho pelo Critério de *Ahlbäck*.



Legenda: AP – ântero-posterior.

Fonte: Extraído e adaptado de *Ahlbäck*, 1968 (65).

2.1.3 Tratamento

O tratamento da OAJ pode ser farmacológico, não-farmacológico ou cirúrgico quando necessário, porém, como até o presente momento não existe cura, é baseado na atenuação dos sinais e sintomas da doença, bem como na redução dos fatores de risco modificáveis como redução da obesidade e sobrepeso e fortalecimento muscular e o tratamento não-farmacológico é altamente incentivado (3,7,56,66–71).

O tratamento da OAJ não é proposto isoladamente por um único profissional,. envolve uma equipe multiprofissional composta por uma variedade de prestadores de serviços de saúde como: clínico geral, reumatologista, ortopedista, terapeuta ocupacional e fisioterapeuta (71). Existe uma variedade de diretrizes para o manejo de indivíduos com OAJ (3,66–71). O *American College of Rheumatology & Arthritis Foundation* sugere que a maioria dos pacientes com OAJ pode se beneficiar do encaminhamento para fisioterapia em vários momentos durante o curso de sua doença devido a incorporação de diversos recursos terapêuticos para a diminuição do nível de dor e o aumento da capacidade funcional desses indivíduos, incluindo o exercício físico (3,7,56). Embora nem todas as recomendações das diretrizes atuais de OAJ estejam dentro do escopo da prática de fisioterapia, o exercício físico tem se destacado como tratamento não farmacológico para indivíduos com OAJ, estando associado a melhores resultados quando supervisionado (3,56). Dessa forma, essas diretrizes destacam o importante papel dos fisioterapeutas, sendo muitas vezes essencial para o início e para a manutenção adequada do exercício físico no manejo dessa doença (3,66–71).

Existe uma gama de modalidade de exercícios físicos que demonstram reduzir efetivamente a dor e melhorar a função na OAJ, por esse motivo, todos os pacientes devem ser incentivados a considerar alguma forma de exercício físico como parte central do seu plano de tratamento (3,7,56). Porém, os benefícios clínicos tendem a declinar ao longo do tempo devido à baixa adesão (20,71). Embora não exista um nível de dor estabelecido para avaliar se um paciente deva ou não fazer exercício físico, a dor e a incapacidade funcional podem ser importantes barreiras na participação do indivíduo com OAJ em um programa de exercícios físicos (3). Dessa forma, é recomendável uma abordagem compartilhada entre o profissional e o paciente em relação à quando iniciar um programa de exercícios físicos concentrando a indicação nas preferências e no acesso do paciente ao tratamento (3). Fransen *et al.*, 2015 (72) mostraram em uma revisão sistemática que o exercício físico é capaz de melhorar a dor e melhorar a capacidade funcional de indivíduos com OAJ, apoiando essas

recomendações por meio de uma evidência de alta qualidade metodológica. Além disso, os exercícios físicos promovem muitos outros benefícios à saúde, estando diretamente relacionados com o tratamento e/ou prevenção de comorbidades associadas com a OAJ como: (i) obesidade (73), (ii) hipertensão arterial (74) e (iii) fragilidade e sarcopenia em idosos (75).

A PV é um dos recursos que pode ser utilizado pelo fisioterapeuta, sendo estabelecido como estratégia terapêutica pelo Conselho Federal de Fisioterapia e Terapia Ocupacional (COFFITO) através da Resolução nº 482 (abril de 2017). Nesse contexto, o EVCI pode ser introduzido no tratamento de indivíduos com OAJ como uma modalidade de exercício físico (35,37,38). Estudos mostram que o EVCI pode trazer benefícios, não só para indivíduos com OAJ como para as comorbidades associadas como: (i) estimular respostas imunológicas, metabólicas e miocinéticas favoráveis em indivíduos obesos e com peso normal (76), (ii) redução do nível de dor e melhora da capacidade funcional em indivíduos com OAJ (29), (iii) melhora na velocidade de marcha, mobilidade funcional e redução do risco que quedas em idosos (77).

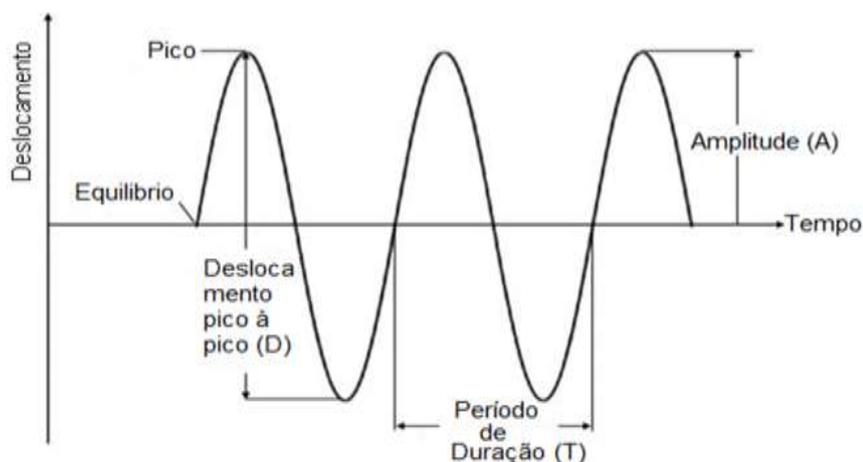
2.2 Exercícios de vibração de corpo inteiro

O EVCI, no sentido físico, é caracterizado por uma oscilação forçada do corpo, onde a energia é transferida de um atuador (PV) para um ressonador (corpo humano). Portanto, o EVCI é obtido devido à transmissão de vibrações mecânicas ao corpo todo de um indivíduo que posiciona uma região do corporal sobre a base de uma PV em funcionamento (33–37).

Para se obter uma linguagem comum e uso consistente de terminologias, Rauch *et al.*, 2010 e, mais recentemente Wuestefeld *et al.*, 2020 publicaram diretrizes para estudos sobre o EVCI (33,78).

As vibrações mecânicas produzidas por uma PV são definidas como um movimento oscilatório sinusoidal determinista (33,34,37). Para descrever uma vibração sinusoidal, é necessário fornecer informações sobre a frequência (f) e a extensão da vibração. A f é expressa em hertz (Hz). Ela representa o número de ciclos (período de duração de uma onda) por unidade de tempo, que neste caso é o segundo (s). A extensão da vibração pode ser dada como o deslocamento pico a pico (D) que é a medida entre os valores correspondentes aos pontos máximo e mínimo do ciclo e é expresso em milímetros (mm). A amplitude (A), também expressa em mm, e corresponde à metade do D (33,34,37) (Figura 2).

Figura 2 – Representação da vibração mecânica com movimento sinusoidal (deslocamento x tempo).



Fonte: Extraída e adaptada de Rauch et al. 2010 (33).

Para identificar a magnitude da vibração mecânica que é transmitida para o corpo e facilitar as comparações entre os estudos, também é recomendado fornecer a aceleração de pico (a_{Pico}) em múltiplos da aceleração da gravidade da Terra (símbolo: g ; $1\text{ g} = 9,81\text{ ms}^{-2}$). Dessa forma, pode-se considerar um exercício de baixa intensidade se a a_{pico} for $<1g$ e de alta intensidade se a a_{pico} for $\geq 1g$ (79). A a_{pico} pode ser matematicamente derivado da f e do D utilizando a seguinte equação:

$$a_{\text{Pico}} = 2 \times \pi^2 \times f^2 \times D \quad (33,35)$$

Além desses parâmetros biomecânicos, o tempo de trabalho intercalado com o tempo de repouso, o posicionamento do indivíduo e o tipo de PV utilizada (movimento alternado ou vertical), são fundamentais para a elaboração de um protocolo de EVCI (33,34). No caso da PV com movimentos alternados, o posicionamento dos pés precisam ser bem definidos, pois o D dependerá da distância entre eles, visto que quanto mais distante do eixo central, maior é o D (33–35,37). A quantidade de sessões, a periodicidade (Ex. quantas vezes por semana), bem como o número de repetições do tempo de vibração em uma sessão também são essenciais para a elaboração do protocolo. Considerando as inúmeras combinações entre os parâmetros descritos acima, é viável que exista uma grande variedade de protocolos de EVCI. Dessa

forma, os estudos devem fornecer detalhes precisos da intervenção para se ter maior confiabilidade e capacidade de reprodutibilidade.

3 MATERIAL E MÉTODOS

3.1 Questões éticas

Para a investigação dos efeitos dos EVCI nos indivíduos com OAJ, foi realizado um estudo clínico submetido e aprovado pelo Comitê de Ética em Pesquisa em seres humanos do Hospital Universitário Pedro Ernesto (HUPE), Universidade do Estado do Rio de Janeiro (UERJ) (CAAE 19826413.8.0000.5259) (Anexo-A) e no Registro Brasileiro de Ensaios Clínicos (REBEC) (RBR-7dfwct) (Anexo-B).

Os procedimentos realizados foram considerados não invasivos, isentos de riscos evidentes e todos os participantes do estudo foram orientados e tomaram conhecimento da pesquisa e através da leitura e assinatura do Termo de Consentimento Livre e Esclarecido (TCLE) antes de iniciar qualquer procedimento (Anexo-C).

A realização deste trabalho contou com auxílios de projetos aprovados pela Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ), pelo Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) e pela Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - código 001.

3.2 Critérios de inclusão

Foram incluídos no presente estudo, indivíduos de ambos os sexos em acompanhamento no Serviço de Ortopedia do HUPE, com diagnóstico de OAJ (Grau 2 e 3 pelo critério de *Ahlbäck*) (65), idade ≥ 60 anos.

3.3 Critérios de exclusão

Pacientes foram excluídos quando apresentaram no momento da avaliação: hipertensão arterial sem tratamento, doença neurológica que gerasse “medo” aos movimentos

na PV, doença clínica grave ou incapacitante, ou que não concordaram em assinar o TCLE ou a critério do investigador.

3.4 Desenho do estudo

Foi desenvolvido um estudo transversal, pseudorandomizado, intervencionista e *cross-over* (dois períodos) (80). Após uma triagem inicial, os participantes elegíveis foram aleatoriamente designados por ordem de chegada para o primeiro período do protocolo em dois grupos: (i) grupo submetido ao EVCI (GV) ou (ii) grupo controle (GC). Posteriormente, os grupos foram trocados para o segundo período de intervenção. Cada período teve uma duração de 5 semanas (2 dias por semana com pelo menos 48 h de descanso entre cada sessão) e foi separado por um *washout* de 8 semanas para permitir a eliminação sistêmica total da vibração mecânica com base em uma investigação anterior (81). Os dados foram coletados no início e no final do protocolo (após 5 semanas) sempre no mesmo horário (± 1 hora), pela manhã. Os participantes foram solicitados a manter os anti-hipertensivos e a não modificar seus hábitos de vida durante o estudo.

Para cada condição investigada foi realizado um cálculo amostral, descrito nos respectivos artigos e apresentados nos resultados dessa tese.

3.5 Participantes do estudo

Os participantes deste estudo foram diagnosticados com OAJ de acordo com o Critério de *Ahlbäck* (65) por médicos especializados, no ambulatório de ortopedia do HUPE. Após a confirmação do diagnóstico, os pacientes foram convidados a participar do estudo. Aqueles que concordaram foram encaminhados para o Laboratório de Vibrações Mecânicas e Práticas integrativas (LAVIMPI), localizado no Departamento de Biofísica e Biometria do Instituto de Biologia Alberto Alcântara Gomes, onde foram avaliados de acordo com os critérios de inclusão e exclusão, receberam orientações e assinaram o TCLE.

3.6 Intervenção

O protocolo teve uma duração de 5 semanas, onde os participantes eram submetidos ao EVCI 2 vezes por semana, com no mínimo 48h de intervalo entre as sessões, totalizando 10 sessões. Caso o participante não comparecesse, a sessão era remarcada para a mesma semana ou semana subsequente de forma que esse intervalo não ultrapassasse quatro dias, dessa forma as dez sessões puderam ser finalizadas.

Os participantes foram submetidos à vibração mecânica por meio de uma PV do tipo alternada (*Novaplate fitness evolution*, DAF Produtos Hospitalares Ltda, de procedência da Estek As, São Paulo) (Figura 3).

Figura 3 - Plataforma vibratória do tipo alternada utilizada no estudo.



Fonte: A Autora, 2020

Durante o EVCI, os pacientes ficavam sentados em uma cadeira posicionada na frente da PV com os pés descalços sobre a base da mesma e com as mãos apoiadas nos joelhos. Esse posicionamento das mãos foi essencial para que houvesse melhor transmissão da vibração mecânica para o corpo inteiro (Figura 4).

Figura 4 - Posicionamento do participante para a realização do EVCI.



Legenda: As setas pontilhadas demonstram a decomposição da vibração mecânica para todo o corpo.

Fonte: A Autora, 2020.

Para uma padronização do posicionamento, a base da PV foi demarcada previamente onde os participantes deveriam manter os pés durante as sessões onde foi estabelecido um D de 2,5, 5,0 e 7,5 mm (Figura 5). Em cada sessão, o participante realizou 3 min de vibração em cada D com 1 min de repouso entre elas.

Figura 5 – Demarcação do deslocamento pico a pico na base da plataforma vibratória.



Legenda: O deslocamento pico a pico (D) modifica de acordo com o posicionamento dos pés. a) $D= 2,5$ mm. b) $D= 5,0$ mm. c) $D= 7,5$ mm.

Fonte: A Autora, 2020.

A f variou de 5 a 14 Hz (a_{pico} variou de 0,12g a 2,95g) conforme mostrado na Tabela 1. O GC realizou o mesmo protocolo, porém com a PV desligada (0 Hz e $D=0$).

Tabela 1 – Variação da frequência e da aceleração de pico de acordo com o deslocamento pico a pico em cada sessão.

Sessão	f (Hz)	a_{pico} (g)		
		$D=2,5$ mm	$D=5,0$ mm	$D=7,5$ mm
1	5	0,12	0,25	0,35
2	6	0,18	0,36	0,54
3	7	0,24	0,49	0,73
4	8	0,32	0,64	0,96
5	9	0,40	0,81	1,22
6	10	0,50	1,00	1,50
7	11	0,60	1,21	1,82
8	12	0,72	1,44	2,17
9	13	0,84	1,69	2,54
10	14	0,98	1,97	2,95

Legenda: f – frequência. Hz – hertz. a_{pico} – aceleração de pico. g – múltiplo da gravidade. D – deslocamento pico a pico. mm – milímetro.

Fonte: A Autora, 2020.

3.7 Avaliações

3.7.1 Pressão arterial

A PA e os dados antropométricos foram medidos em uma sala com temperatura controlada (22 a 25 °C) e silenciosa. Utilizou-se uma balança digital (WelmyTM, São Paulo, SP Brasil) para medir a massa corporal (kg) e um estadiômetro de parede (American Medical do Brasil, São Paulo, SP, Brasil) para medir a altura (cm). Antes do início do protocolo (primeira sessão), a PA sistólica (PAS) e a PA diastólica (PAD) foram medidas no braço esquerdo, na posição sentada, usando um dispositivo automático (dispositivo Omron 705IT; OmronTM Healthcare Co., Kyoto, Japão) após 10 minutos de descanso. A PAS e PAD também foram medidas imediatamente após a última sessão. Três medidas em intervalos de 1 minuto foram coletadas e a média dos três valores foi considerada. A PA média (PAM) foi calculada usando a equação $PAM = (PAD.2) PAS/3$ (82).

3.7.2 Capacidade funcional

O 5CST foi utilizado para avaliar a mobilidade funcional e a força muscular dos membros inferiores. Os participantes foram instruídos a sentar em uma cadeira, com as costas retas totalmente apoiadas em seu encosto, os braços cruzados sobre o peito e os pés totalmente apoiados no chão e afastados aproximadamente na largura dos ombros. Iniciando na posição sentada, os indivíduos foram orientados a se levantarem completamente da cadeira e depois retornarem à posição inicial o mais rápido possível por cinco vezes seguidas. Com o auxílio de um cronômetro (Cronobio SW2018, Brasil), o avaliador mediu o tempo (segundos) que os indivíduos precisaram para realizar cinco subidas o mais rápido possível, sem o uso dos braços (83). Este teste foi realizado antes e após a realização das 5 semanas de intervenção.

3.7.3 Eletromiografia de superfície

A eletromiografia de superfície (sEMG) é uma ferramenta não invasiva para detecção do potencial elétrico resultante da corrente transmembrana das fibras musculares (excitação muscular). Pode ser usada para medir a atividade muscular e pode fornecer informações sobre as respostas neuromusculares a exercícios, envelhecimento e doenças como KOA (53,54). Para registrar a atividade sEMG do músculo VL durante o 5CST, a pele foi raspada e limpa com álcool a 70% e a pele morta foi removida antes da colocação do eletrodo, de acordo com as recomendações do *Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles* (SENIAM) (84). Os eletrodos foram colocados sobre o ventre muscular paralelamente às fibras dos músculos VL direito e esquerdo. O eletrodo de referência foi anexado ao processo espinhoso C7. Os sinais de sEMG foram coletados em microvolts (EMG832WF, EMGSystem, São Paulo, Brasil) usando eletrodos bipolares de Ag/AgCl de superfície passiva e auto-adesivos (Miotec Equipamentos biomédicos, Porto Alegre, Brasil). Um filtro passa-alto de 20 Hz e um filtro passa-baixo de 500 Hz foram usados para minimizar a interferência com ruídos de baixa frequência originados por movimentos indesejados de cabos e eletrodos. Para determinar a estimulação do VL foi utilizado um eletromiógrafo com frequência de amostragem ajustada em 2000 Hz. O perfil eletromiográfico do VL foi avaliado durante o

5CST (do movimento inicial de levantar até o último movimento de levantar) antes e após o protocolo (5 semanas), e a raiz quadrada média (RMS) (μV) foi calculada pelo *software* (Tool Box BR V1.0, EMG System do Brasil LTDA). A análise foi realizada com base na medida RMS (μV) fornecida pelo *software* do equipamento.

3.8 Análise estatística

As análises estatísticas utilizadas para cada variável do estudo *crossover* sobre o efeito do EVCI em indivíduos com OAJ estão descritas nos artigos publicados. Ambos serão apresentados nos resultados dessa tese.

3.9 Revisão sistemática sobre os efeitos do EVCI nas respostas de biomarcadores inflamatórios.

A revisão sistemática foi elaborada seguindo as recomendações do *Preferred Reporting Items for Systematic Reviews and Meta-Analysis* (PRISMA) (85) e registrada no *International Prospective Register of Systematic Reviews* (PROSPERO) (CRD42020187943). A pesquisa foi feita em 20 de maio de 2020 e repetida em 30 de dezembro de 2020, em sete banco de dados (*Physiotherapy Evidence Database - PEDro*, *Medline/PubMed*, *Web of Science*, *SPORTDiscus*, *The Cochrane Library*, *Cumulative Index to Nursing and Allied Health Literature - CINAHL* e *Scopus*). As estratégias de busca utilizadas foram: (i) *Medline/Pubmed* - (((("inflammation"[All Fields]) OR ("inflammatory disease*" [All Fields])) OR ("inflammatory marker*" [All Fields])) OR ("inflammation"[MeSH Terms])) AND (((("whole body vibration"[All Fields]) OR ("wbv"[All Fields])) OR ("vibration"[MeSH Terms])); (ii) *Scopus* - ((TITLE-ABS-KEY ("whole body vibration") OR TITLE-ABS-KEY (wbv))) AND ((TITLE-ABS-KEY (inflammation) OR TITLE-ABS-KEY ("inflammatory disease*") OR TITLE-ABS-KEY ("inflammatory marker*"))); (iii) *Web of Science* - (TS=("inflammation") OR TS=("inflammatory disease*") OR TS=("inflammatory marker*")) AND (TS=("whole body vibration") OR TS=(wbv)); (iv) *The Cochrane Library* - ((inflammation):ti,ab,kw OR ("inflammatory disease"):ti,ab,kw OR ("Inflammatory

marker"):ti,ab,kw") AND (("whole body vibration"):ti,ab,kw OR ("wbv"):ti,ab,kw"); (v) SPORTDiscus and CINAHL - (whole body vibration or whole-body vibration or wbv) AND (inflammation or inflammatory or inflammatory marker) e (vi) PEDro – (a) whole body vibration or WBV and inflammation; (b) whole body vibration or WBV and inflammatory.

Todos os estudos incluídos foram ensaios clínicos randomizados, ou seja, com nível de evidência LII pelo *National Health and Medical Research Council* (NHMRC) (86). A qualidade metodológica foi classificada usando a escala PEDro (87,88) e o risco de viés foi avaliado através da ferramenta *Cochrane Collaboration's* (89,90).

Todas as etapas desta revisão sistemática os seus achados estão detalhados na seção de resultados desta tese.

4 RESULTADOS

4.1 Efeito do EVCI na capacidade funcional de indivíduos com OAJ pelo perfil eletromiográfico do músculo VL durante o 5CST.

Nesta tese será apresentado um artigo publicado em 23 de junho de 2020, na revista *Applied Sciences*, Fator de Impacto de 2,474 pelo *Journal Citation Reports*TM (JCR), que apresenta os resultados relacionados com a aquisição de informações sobre o efeito do EVCI nas respostas funcionais avaliadas pela EMGs durante o 5-CST em um protocolo especial no qual os indivíduos com OAJ estão sentados em uma posição confortável em uma cadeira auxiliar.

Dezenove participantes realizaram a sEMG durante o 5CST, em ambos os músculos VL, antes e após o protocolo de 10 sessões de EVCI em uma postura confortável. Houve uma melhora da capacidade funcional com uma diminuição no tempo de execução do 5CST no grupo submetido ao protocolo de EVCI, embora não tenham sido encontradas diferenças significativas entre os grupos. No entanto, esses indivíduos não apresentaram alteração na excitação muscular.

Maiores informações são encontradas à seguir, no artigo intitulado: “*Effect of whole-body vibration on the functional responses of the patients with knee osteoarthritis by the electromyographic profile of the Vastus Lateralis muscles during the Five-Repetition Chair Stand Test: A Randomized Crossover Trial.*”

Moreira-Marconi, E.; Teixeira-Silva, Y.; Meirelles, A.G.; et al. Effect of Whole-Body Vibration on the Functional Responses of the Patients with Knee Osteoarthritis by the Electromyographic Profile of the Vastus Lateralis Muscles during the Five-Repetition Chair Stand Test: A Randomized Crossover Trial. *Appl. Sci.* 2020, 10:4302.

Article

Effect of Whole-Body Vibration on the Functional Responses of the Patients with Knee Osteoarthritis by the Electromyographic Profile of the *Vastus Lateralis* Muscles during the Five-Repetition Chair Stand Test: A Randomized Crossover Trial

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Abstract: Knee osteoarthritis (KOA) can cause functional disability. Neuromuscular function is relevant in the development and progression of KOA. It can be evaluated by the analysis of the surface electromyography (sEMG), which has an important role in the understanding of KOA. Whole-body vibration (WBV) is an intervention suggested to treat KOA. The objective of this work was to verify the effectiveness of WBV on the functionality of lower limbs by the electromyographic profile of the vastus lateralis (VL) muscles during the five-repetition chair stand test (5CST) in patients with KOA. This was a two-period crossover trial study (8-week washout). Nineteen patients with KOA were allocated to the group submitted to WBV (WBVG), with peak-to-peak displacement of 2.5 to 7.5 mm, frequency from 5 to 14 Hz, and acceleration peak from 0.12 to 2.95 g, or to the control group (0 Hz) (2 days per week for 5 weeks). The 5CST and the sEMG of the VL during 5CST were evaluated before and after the interventions. Results: Significant differences in 5CST were evident only in WBVG ($p = 0.018$), showing a decrease of the execution time. The sEMG profile showed no significant difference. Therefore, only 10 sessions of WBV with comfortable posture can bring about improvement in functionality of KOA patients without alteration of the muscle excitation.

Keywords: knee osteoarthritis; conservative treatment; whole-body vibration; electromyography; physical and rehabilitation medicine

1. Introduction

Knee osteoarthritis (KOA) is the most prevalent type of arthritis that leads to disability in the elderly, mainly due to pain [1–3]. Cartilage degradation with bone remodeling, joint space narrowing, formation of osteophytes, swelling, low muscle strength, joint inflammation, stiffness, and loss of joint function may be present in KOA patients [3,4]. Neuromuscular function is relevant in the development and progression of KOA [5,6] and, as Mills et al. [7] reported, neuromuscular differences in muscle activity and amplitude. Surface electromyography (sEMG) is a noninvasive tool for detection of the electric potential resulting from the transmembrane current of muscle fibers (muscle excitation). It can be used to measure the muscle activity and might provide insight into neuromuscular responses to exercises, aging, and diseases such as KOA [8,9]. Bigham et al. [8] showed an alteration in neuromuscular activation in individuals with KOA (male and female) compared to healthy individuals, suggesting compensation due to knee extensor muscle strength reduction. Most of the interventions included in neuromuscular rehabilitation programs are based on resistance exercises, promoting the improvement of the pain level and function response in patients with KOA [10]. However, many interventions can lead to symptom exacerbation and pain flares in this population [11]. Therefore, feasible interventions that can induce clinical benefits in patients with KOA have been evaluated in recent years, including whole-body vibration (WBV) [12–15]. An umbrella review reported that moderate evidence supports the role of WBV as a viable clinical intervention for managing KOA, although more studies are still warranted [15]. In a crossover investigation, Liphardt et al. [16] verified that WBV can prevent the loss of tibial articular cartilage thickness (determined by magnetic resonance image) after prolonged immobilization in healthy male individuals. Moreover, authors reported that mechanical vibration can lead to adaptations in muscle and bone [16,17]. In rats, according to Musumeci et al. [18], it is possible that the mechanical stimulation in the articular cartilage could release lubricin antibodies that are capable of inhibiting caspase-3 activity, preventing chondrocyte death. In consequence, mechanical stimulation could be a possible therapeutic treatment, as in osteoporosis, and mild physical activity could also be used as a therapeutic treatment for cartilage disease such as osteoarthritis [18]. Although WBV has shown importance in improving various parameters related to the joint [16,18], it is relevant to consider some undesirable findings, such as the deleterious effect of prolonged vibration from off-road motorcycling on the elbow joint [19].

The clinical benefits of WBV are attributed to the vibratory excitation of muscle spindles and increased motor unit synchronization [17,20]. The importance of this intervention lies in the positive effects reported on muscle strength and flexibility and improvements in symptom severity (i.e., pain) in various populations [21–27]. Until now, only one study showed a decrease in pain level (assessed by the visual analogue scale) using sitting posture in an auxiliary chair with both feet placed on the vibrating platform (VP) [13]. Several authors [13,28,29] have suggested that this posture can reduce the load on the knee joint when compared to squat posture.

The aim of this investigation is to analyze the short-term effectiveness of WBV on lower-limb functionality through examining the electromyographic activity of the vastus lateralis (VL) [30] muscle during the five-repetition chair stand test (5CST). Therefore, the hypothesis was that the WBV can improve the functional mobility and the neuromuscular response of patients with KOA.

2. Materials and Methods

2.1. Participants

Between March 2013 and July 2017, participants with KOA diagnosed according to the Ahlback criteria [31] were referred by their physicians from the orthopedics department of the local hospital. Inclusion criteria required participants to have a clinical diagnosis of KOA with Ahlback degree 2 or 3, to be age 50 years or above, and to sign an informed consent form [31]. Exclusion criteria comprised other musculoskeletal disorders, joint prosthesis or total knee replacement (TKR), neurological diseases, and uncontrolled hypertension. Participants were instructed to discontinue pain medications during the study period, which was checked before each session. The study was approved by the ethics committee in accordance with the Declaration of Helsinki and the Brazilian clinical trial registry platform (Certificado de Apresentação para Apreciação Ética-CAAE-19826413.8.0000.5259 and RBR-7dfwct).

2.2. Sample Size

The sample size was determined using the formula by Miot [32] for an infinite population. The time to perform the 5CST in individuals with KOA was used as an outcome, considering the standard deviation of 2.4 and mean of 24.3 s [33]; and 16 individuals were established for each group.

2.3. Interventions and Groups

In this two-period crossover trial [34], 19 participants (age 65.42 ± 8.41 years, 3 males and 16 females) were assigned in order of referral by the researcher into two groups in the first period of the intervention: the control group (CON) ($n = 10$) and the group that received mechanical vibration (WBVG) ($n = 9$). After that, the groups were switched to the second intervention period. Each intervention period was separated by an 8-week washout to allow for the effective systemic elimination of the mechanical vibrating before initiation of the subsequent treatment based on a previous protocol [35] so that all individuals participated in both groups. Each intervention period lasted 5 weeks (2 days per week with at least 48 h of rest between each session).

Participants were seated in a chair with bare feet placed on a side-alternating VP (Novaplate Fitness Evolution, DAF Produtos Hospitalares Ltda, São Paulo, Brazil) with knees flexed (100 to 120° —measured by a goniometer). The hands of participants were positioned on their knees to smooth the transmission of the vibration to the whole body [28,29], as shown in Figure 1a. The vibration protocol of Neto et al. [13] was implemented for this study. Briefly, this involved 10 sessions (two sessions per week for 5 weeks), and participants had to place their feet on demarcated lines on the VP that corresponded to peak-to-peak displacement of 2.5, 5.0, and 7.5 mm (amplitude of 1.25, 2.5, and 3.75 mm) (Figure 1a). The initial vibration frequency was set at 5 Hz and progressively increased by 1 Hz in subsequent sessions, with 14 Hz being the highest frequency attained in session 10. Peak acceleration (a_{Peak}), measured from a three-axial accelerometer attached to the VP using adhesive tape (Vibration Data logger DT-178A, Ruby Electronics, Saratoga, NY, USA), ranged from 0.12 to 2.95 g over

the 10 sessions. For each session, participants performed 3 min of vibration at the three peak-to-peak displacements, with 1 min of rest between each bout (Figure 1b). During the entire intervention, the participants were accompanied by the investigator to ensure that the feet were kept in contact with the base of the VP, the hands remained facing the knees, and the effect of the mechanical vibration was distributed throughout the body. The participants in the control group performed the same protocol as the WBVG, but the VP was switched off (0 Hz), according to previous studies [13,28,29].

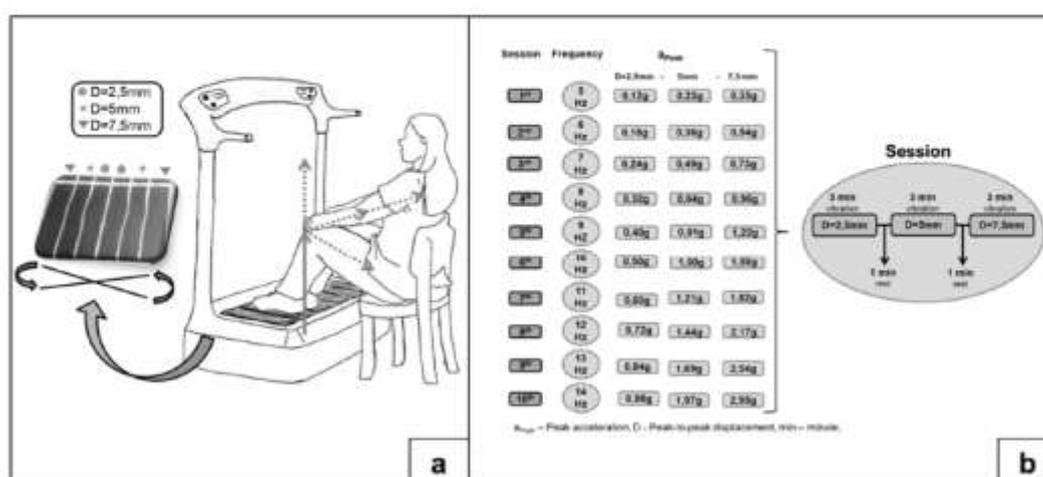


Figure 1. (a) The position of participants on the vibrating platform. (b) The protocol of the whole-body vibration group (WBVG) intervention.

2.4. Physical Performance Measures

2.4.1. Five-Repetition Chair Stand Test

The 5CST was used to evaluate the functional mobility and muscle strength of the lower limbs. Participants were instructed to sit in the middle of the chair with arms crossed over the chest, feet approximately shoulder-width apart and placed on the floor, and back straight. From the sitting position, individuals ascended without the use of the arms to an upright position before sitting down five consecutive times as quickly as possible [36]. Using a digital chronometer (Cronobio SW2018, Brazil), the time to perform the test was recorded. The test was applied at baseline (before the intervention) and immediately after the last intervention in both groups.

2.4.2. Measurement and Surface Electromyography Instrumentation

To record sEMG activity of the VL muscle during the 5CST, skin was shaved and cleaned with 70% alcohol and dead skin was removed before the electrode placement according to the Surface Electromyography for the Noninvasive Assessment of Muscles recommendations [37]. The electrodes were put over the mid-belly of the muscle parallel to the fibers on the right and left VL muscles. The reference electrode was attached to the C7 spinous process. sEMG signals were collected in microvolts (EMG832WE, EMGSystem, São Paulo, Brazil) using passive surface self-adhesive bipolar Ag/AgCl electrodes (Miotec Equipamentos biomédicos, Porto Alegre, Brazil). A high-pass filter of 20 Hz and a low-pass filter of 500 Hz were used to minimize interference from movement artifacts of cables and electrodes. To determine the excitation of the VL, an electromyograph with sampling frequency set at 2000 Hz was used. The electromyographic profile of the VL was evaluated during the 5CST (from the initial movement upward to the last upward movement) before and after the protocol (5 weeks), and the root mean square (RMS) (μV) was calculated by the software (Tool Box BR V1.0 by EMG System do Brasil LTDA). The analysis was conducted based on the RMS (μV) measure provided by the equipment software. The test was applied at baseline (before the intervention) and immediately after the last intervention.

2.5. Statistical Analysis

R software, version 3.5.0 [38] with the R coin package [39], was utilized to perform the statistical analyses. Results were considered significant when $p < 0.05$. The Wilcoxon signed-rank test for paired samples was used to compare the time (s) of the 5CST and the RMS values (μV) recorded before and after the interventions (CON and WBVG). The Mann–Whitney test was used to compare the time (s) of the 5CST and the RMS values (μV) between groups at baseline and after intervention.

3. Results

In this crossover study, 19 participants were assigned to two groups: CON ($n = 10$) and WBVG ($n = 9$). Three CON participants did not return to WBVG after the washout period (8 weeks). The flowchart of the individuals throughout the work is reported in Figure 2. Table 1 shows some anthropometric characteristics of the participants of both groups before the first intervention (baseline). No participant used pain medication during the study period. After performing this protocol, none of the individuals reported adverse effects.

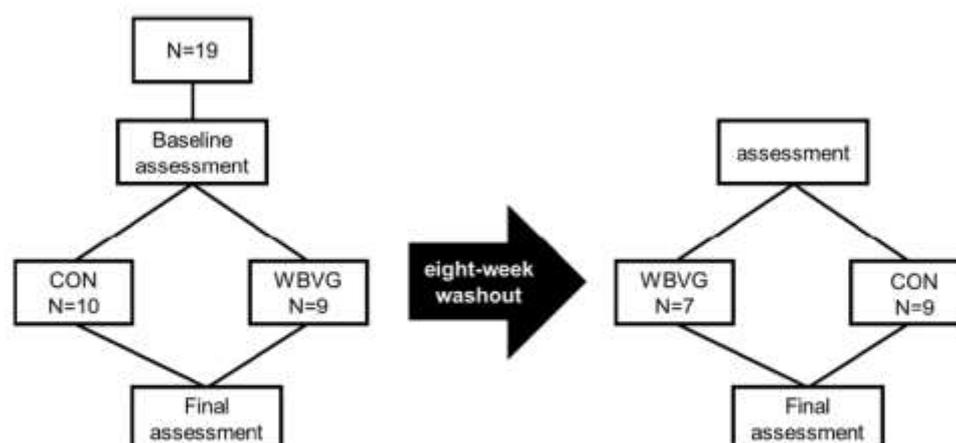


Figure 2. Flowchart with some information about the individuals that participated in the study and the crossover intervention. CON—control group; WBVG—vibration group.

Table 1. Mean (SD) of demographic characteristics of participants at baseline ($n = 19$).

Variables	CON ($n = 10$)	WBVG ($n = 9$)	p -Value
Age (years)	66.89 (8.55)	64.1 (8.50)	0.4862
Stature (m)	1.592 (0.08)	1.568 (0.07)	0.4878
Body mass (kg)	84.91 (14.7)	85.21 (16.28)	0.9671
Body mass index ($\text{kg}\cdot\text{m}^{-2}$)	33.73 (6.92)	34.98 (8.69)	0.9438

CON—control group; WBVG—vibration group. $p < 0.05$.

Considering that the intervention periods were separated by an 8-week washout period to allow for the effective systemic elimination of the mechanical vibration, the analysis was performed per group independent of the intervention period.

No significant differences were found between groups at the beginning regarding time to complete the 5CST ($p = 0.665$) and RMS values (μV) in the right VL muscle ($p = 0.481$) and left VL muscle ($p = 0.800$).

The effects of the interventions are reported in Table 2 and Figure 3. Significant differences in completing 5CST were evident in WBVG, but no significant differences were found in CON. During the 5CST, there was no significant difference in VL excitation (RMS) (μV) between CON and WBVG of right and left VL muscles.

Table 2. Descriptive statistics for the five-repetition chair stand test and right and left vastus lateralis electromyography during the five-repetition chair stand test for CON and WBVG.

		Mean	Range	Standard Deviation	Coefficient of Variation	Standard Error	Minimum	1st Quartile	Median	3rd Quartile	Maximum	p-Value
5CST (s)	CON (n = 19)	Before	36.37	12.41	0.45	3.44	13.97	16.35	22.41	33.94	50.34	0.060
		After	25.12	7.63	0.35	2.11	13.57	16.50	19.78	23.34	38.69	
	WBVG (n = 16)	Before	63.69	17.21	0.63	4.77	14.00	16.47	22.28	32.63	77.69	0.018 [§]
		After	32.57	9.49	0.43	2.73	12.53	15.25	17.82	26.38	45.10	
VLR RMS (μ V)	CON (n = 19)	Before	34.96	14.38	0.61	3.99	7.57	11.30	19.22	40.84	42.53	0.352
		After	77.33	22.05	0.62	6.11	3.76	17.63	42.54	45.6	81.09	
	WBVG (n = 16)	Before	75.73	22.07	0.67	6.12	4.34	14.56	33.67	42.73	80.07	0.599
		After	65.88	21.65	0.65	6.25	8.43	15.00	33.01	43.91	74.31	
VLL RMS (μ V)	CON (n = 19)	Before	24.83	6.16	0.24	1.71	9.96	22.68	26.21	26.93	34.79	0.095
		After	75.20	18.24	0.56	5.06	3.39	25.97	27.29	31.93	78.59	
	WBVG (n = 16)	Before	65.82	16.73	0.67	4.64	5.47	12.45	25.82	27.72	71.29	0.454
		After	27.05	8.60	0.33	2.48	10.59	21.42	27.64	31.81	37.64	

5CST—five-repetition chair stand test; VLR—vastus lateralis right; VLL—vastus lateralis left; CON—control group; WBVG—vibration group; RMS—root mean square. [§] $p < 0.05$.

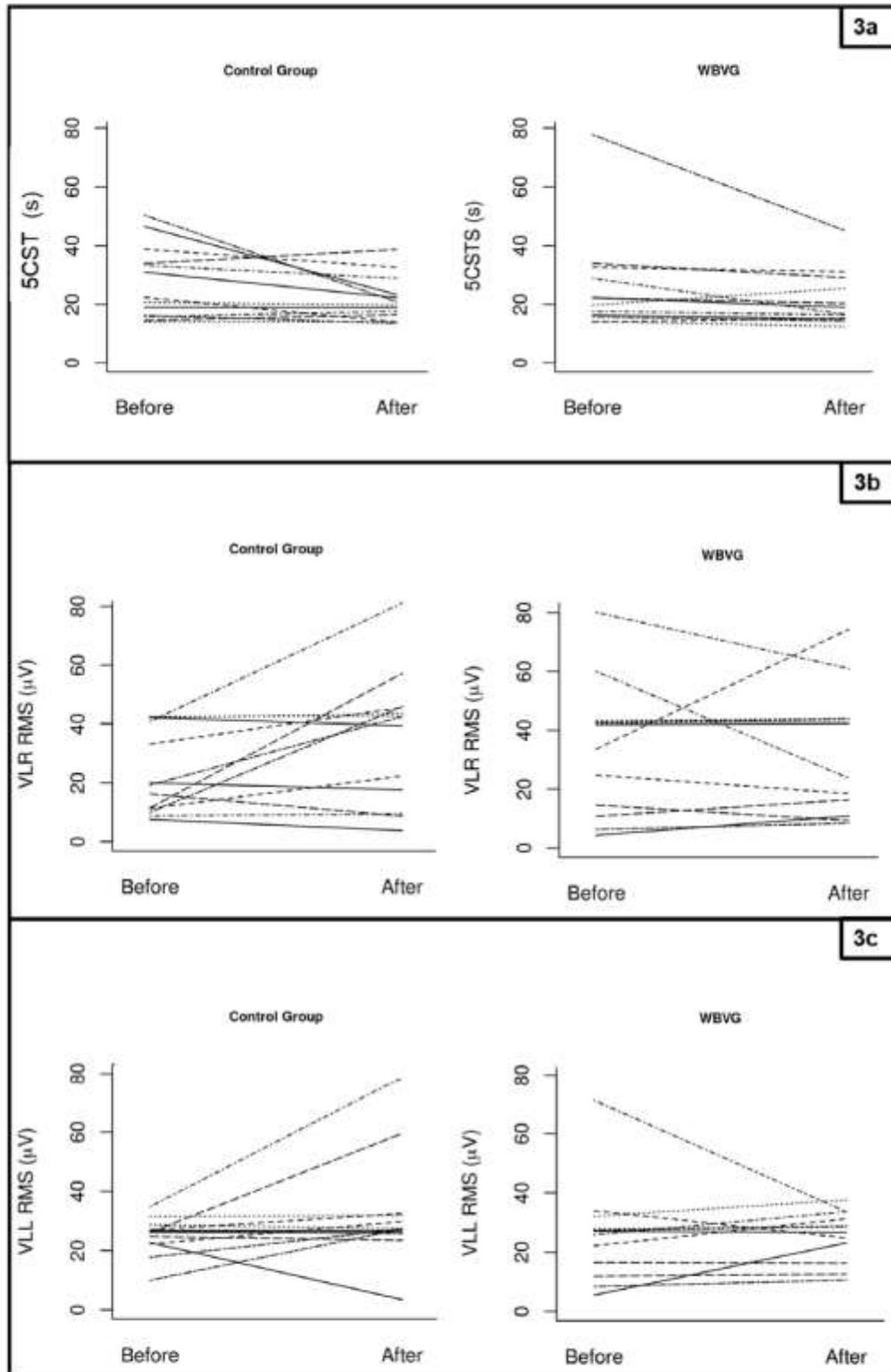


Figure 3. Outcome measures before and after intervention: (a) execution time of five-repetition chair stand test, (b) electromyographic activity of the vastus lateralis right, and (c) electromyographic activity of the vastus lateralis left. Legend: 5CST—five-repetition chair stand test; VLR—vastus lateralis right; VLL—vastus lateralis left; control group (n = 19); WBVG—vibration group (n = 16); RMS—root mean square. $p < 0.05$.

The time required to perform the 5CST was reduced after intervention in both groups, but the differences were only significant in the WBVG. Although there were no significant differences between performance times of the test in both groups, it is interesting to note that there was a clear opposite tendency regarding RMS values (μV) in both VL muscles, with RMS values (μV) lowering in the WBVG and increasing in the CON group.

After intervention, no significant differences were found between groups ($n = 16$) considering the 5CST ($p = 0.716$) and RMS values (μV) in the right VL muscle ($p = 0.607$) and left VL muscle ($p = 0.128$).

4. Discussion

This investigation analyzed the effectiveness of a 5-week, nonpharmacological intervention (WBV) on lower-limb functionality and electromyographic activity during the 5CST. Although the electromyographic profiles of the VL of both lower limbs did not change ($p > 0.05$), 5CST completion time improved after 5 weeks of WBVG.

In the current study, subjects sat on an auxiliary chair with knees flexed and bare feet on the base of the VP, aiming to decrease the knee load impact. Previous research observed a decrease of pain level using the same position in patients with KOA [13], and this could justify the improvement in functionality of the lower limbs evaluated by the 5CST, as shown in the current study. Fransen et al. [40] suggested that any type of short-term physical activity program carried out repeatedly and monitored can improve physical function and quality of life and reduce the pain related to KOA. Thus, the WBV can be considered a type of regular exercise capable of promoting the improvement of physical capacity in patients with KOA. Other studies present similar results concerning pain level and functional performance using the squat position on the VP. Prior research reported that a single bout of intermittent WBV ($10 \times$ one minute of mechanical vibration with one minute rest) of 35 Hz and 4–6 mm significantly improved the time taken to complete the step test after 5 min of performed [41]. In longer-term investigations of WBVG, Avelar et al. [42] observed that KOA patients improved their functional test scores and Western Ontario and McMaster Universities OA Index (WOMAC) values. However, the improvements were not significantly different from the CG that performed squat training without WBVG. Another study involving 8 weeks of WBV training showed a significant increase in muscle strength and knee extension in women with KOA [43]. In a meta-analysis review [44], the authors concluded that 8 to 12 weeks of WBV training could be beneficial in rehabilitation programs, especially for KOA, leading to a decrease of the pain level and the enhancement of physical functions such as walking and balance, suggesting that the WBV is an effective and safe approach for this population.

Despite the reduction in time taken to perform the 5CST, which suggests an improvement of functionality, no significant differences were observed in sEMG RMS (μV) of the VL between pre- and postintervention for CON and WBVG. Similarly, other research found no significant difference in sEMG of KOA subjects that performed squats with or without WBV [45,46]. In contrast, Benedetti et al. [47] reported increased muscle activity in patients with KOA that were treated with localized muscle vibration, which is consistent with previous studies reporting that the vibratory stimulus increases neuromuscular activity [48–50].

Although no consensus is established, as the vibratory stimulus affects the neuromuscular system, it is suggested that the increase in sEMG activity is related to an excitatory response of the muscle spindles in consequence of the stretch reflex mechanism during WBV [48–50]. However, the current findings indicate that the excitatory responses of muscle fibers do not remain after the end of the protocol, since we observed a tendency of the amplitude of the sEMG to decrease in the group submitted to mechanical vibration.

The strength of this study is related to the acquisition of information about the effect of WBV on functional responses evaluated by sEMG in a special protocol in which the individuals with KOA are seated in a comfortable position in an ancillary chair.

This work has limitations that must be considered in the interpretation of the results. There are a myriad of different possibilities in selecting the biomechanical parameters, and to date there is still no

optimal WBVG protocol. Moreover, the Ahlback grading, the osteoarthritis laterality, and the body mass index were not indicated as inclusion criteria. Although there are studies considering the analysis of various muscles [7,46], in the design of the current work, considering the clinical conditions of the individuals with KOA, only the response of the VL muscle was investigated. Furthermore, following this idea, no rigorous evaluation of the transmissibility was performed, and the results are presented only as RMS values (μV). It is relevant to point out, not as a specific limitation but as a relevant approach, that this study used a protocol with low vibration frequencies and with the participants with KOA seated in an ancillary chair in front of the VP with their feet on the base of the VP. These conditions could have had an influence on the findings described.

5. Conclusions

In the protocol of the 10 sessions of WBV with comfortable posture, patients with KOA presented functional responses with a decrease in the time taken to perform the 5CST (WBV group $p < 0.05$), although no significant differences were found between the groups. This suggests that further investigation is needed to better understand the effect of WBV on functionality using the 5CST in individuals with KOA. However, these individuals did not present any alteration in muscle excitation. As a result, it is relevant to highlight the clinical evidence of the findings of the current study.

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4.2 Efeito do EVCI na pressão arterial de indivíduos hipertensos com OAJ.

Os resultados relacionados com o efeito do EVCI na pressão arterial de indivíduos hipertensos com OAJ apresentado através de um artigo publicado em 28 de outubro de 2020, na revista *Sustainability*, Fator de Impacto de 2,576 pelo JCR.

Dezenove participantes realizaram o protocolo de 10 sessões de EVCI em uma postura confortável (sentados em uma cadeira auxiliar). A pressão arterial dos indivíduos foi aferida antes e após o protocolo. Este estudo apresentou uma redução da pressão arterial sistólica e da pressão arterial média, enquanto nenhuma alteração significativa foi encontrada na PA diastólica. Esse trabalho concluiu que o EVCI exerce um efeito anti-hipertensivo, podendo ser considerado uma ferramenta importante no tratamento não-farmacológico de indivíduos hipertensos com OAJ.

Maiores informações são encontradas à seguir, no artigo intitulado: “*Whole-body vibration as antihypertensive non-pharmacological treatment in hypertensive individuals with knee osteoarthritis: randomized cross-over trial*”.

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Article

Whole-Body Vibration as Antihypertensive Non-Pharmacological Treatment in Hypertensive Individuals with Knee Osteoarthritis: Randomized Cross-Over Trial

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Abstract: (1) **Background:** Hypertension is a serious medical condition characterized by a persistent increase in blood pressure (BP), which is prevalent in individuals with knee osteoarthritis (KOA). Pharmacological interventions are normally used to treat both hypertension and KOA; however, a more sustainable form of treatment is desirable for these clinical conditions. Whole-body vibration (WBV) exercise has been proposed as a non-pharmacological therapy for reducing both BP and KOA symptomatology. This study aimed to evaluate the antihypertensive effect of WBV in hypertensive individuals with KOA. (2) **Methods:** Nineteen hypertensive individuals with KOA were randomly

allocated to either a control (CG) ($n = 9$) or a WBV group (WBVG) ($n = 10$). Subjects in the WBVG were positioned sitting in a chair in front of a vibrating platform (VP) with the feet on the base (peak-to-peak displacement 2.5, 5.0 and 7.5 mm; frequencies 5 to 14 Hz). In the CG, subjects assumed the same position with the VP turned off. The protocols in the CG and WBVG were performed 2 days/week for a total of 5 weeks. (3) Results: No baseline differences (age, anthropometrics, BP parameters and medications) between the groups were found ($p > 0.05$). WBV exercise reduced systolic BP (SBP: 126.1 ± 2.7 versus 119.1 ± 3.2 mmHg; $p = 0.001$; post hoc: $p = 0.02$; $F = 23.97$) and mean BP (MBP: 82.6 ± 1.8 versus 78.7 ± 1.8 , $p = 0.001$, post hoc: $p = 0.02$; $F = 23.97$), while no significant changes were found in diastolic BP (DBP: 68.5 ± 2.2 versus 64.4 ± 2.3 ; $p = 0.11$; $F = 2.68$). (4) Conclusions: WBV might be considered a sustainable therapy for exerting an antihypertensive effect in medicated hypertensive individuals with KOA. This decline in BP might translate to a reduction in pharmacological need, although further studies are necessary to understand the mechanisms underlying the described effect.

Keywords: hypertension; whole-body vibration; knee osteoarthritis; physical and Rehabilitation medicine; non-pharmacological treatment; sustainability

1. Introduction

Currently, 1.13 billion people worldwide have hypertension [1]. This medical condition is characterized by a persistent increase in blood pressure (BP) [1] that can be associated with several chronic diseases (e.g., knee osteoarthritis - KOA [2], metabolic syndrome - MSyn [3,4], obesity [5] and diabetes [3]).

KOA, considered a systemic disease, is connected with biomechanical factors and an important inflammatory component affecting articular and periarticular structures [6,7]. In addition, KOA is also linked with some cardiovascular risk factors, as MSyn [8], obesity [9], elevated prevalence of diabetes and a rise in BP [10]. Liu et al. showed the association of mortality risk in individuals with symptomatic KOA, including hypertension, as one of these factors [11]. The new classification for phenotyping KOA involves components of MSyn, such as increased BP associated with cardiovascular risk factors (i.e., "pre-hypertension or hypertension") [12]. Although many studies reported the association between KOA and hypertension [13–15]; to our knowledge, only a longitudinal investigation reported the incidence of hypertension in individuals with KOA. The authors of this investigation concluded that individuals with KOA are 13% more likely to develop hypertension than those without KOA [2].

Different mechanisms seem to influence the elevated risk of cardiovascular disease (CVD) among KOA individuals, including: (i) the presence of low-chronic grade inflammation (inflamm-aging) [16,17]; (ii) relevant changes in extracellular matrix (ECM) [18,19] and (iii) pain and disability that may result in physical inactivity (sedentary lifestyle) [20].

Since individuals with KOA are more likely to develop hypertension, monitoring and treating BP in these individuals is desirable. Therefore, in order to obtain long-term health benefits and prevent CVD, the close surveillance and better management of BP in this population is recommended [2].

The use of medications is indicated for the treatment of hypertension and for the reduction of symptoms related to KOA [21,22]. The presence of these two diseases leads to an increase in the consumption of medicines, increasing the cost for the individual. In addition, the administration of a greater number of medications can have greater adverse/side effects for the individual and for the environment. Green Chemistry and Green Engineering have worked on the development of safer materials and chemicals, assessing the toxicological risk for both the environment and consumers (Green Toxicology) [23]. However, in order to achieve a sustainable and safe production of new chemical products, this process requires important measures. In the case of pharmaceutical compounds, there may be limitations on obtaining ecological medicines that are safe and effective

without increasing the final cost for the consumer [23]. In this context, a good strategy would be to investigate non-pharmacological and low-cost treatments in the health area. Ikeda et al. [24] reported that in some low- and middle-income countries, the use of medications for hypertension is reduced. This suggests that a comprehensive approach to the prevention and control of high BP has been investigated since medication is an expensive alternative and most people are hypertensive. Following these considerations, physical exercise has been prescribed to reduce both BP and symptoms related to KOA [22,25].

Among the various modalities of exercise proposed for KOA individuals, whole-body vibration (WBV) exercise has been suggested due to relevant responses related to the reduction of BP [26]. Moreover, WBV exercise promotes improvements in the quality of life, knee joint function (neuromuscular function, flexibility, muscle power and strength), bone mineral density, and decreases pain levels and number of falls [27–30]. WBV exercise has also been shown to have an important clinical application for subjects with cardiovascular risk [26,31–33], particularly for individuals unable to perform regular physical exercise, such as KOA individuals. Moreover, the WBV intervention is a non-pharmacological treatment option that is economic and safe for individuals who cannot use or refuse medication. Thus, the current study aimed to evaluate the antihypertensive effects of WBV exercise in hypertensive individuals with KOA. The hypothesis is that a WBV exercise program (5 weeks) would improve BP in hypertensive individuals with KOA.

2. Materials and Methods

2.1. Subjects

Nineteen outpatients from the Orthopedics Department of the *Hospital Universitário Pedro Ernesto, Universidade do Estado do Rio de Janeiro (HUPE-UERJ)* with KOA diagnostic according to the criteria of the Ahlbäck [34] participated in the current study. Subjects were recruited between March 2014 and July 2017. This investigation with hypertensive KOA individuals is included in a general project about the clinical intervention of WBV exercise in a KOA population, which was approved by the Ethics Committee in Research of the *HUPE-UERJ*. All the interventions are in accordance with the Declaration of Helsinki and have a clinical trial registration (CAAE- 19826413.8.0000.5259 and RBR-7dfwct, respectively).

2.1.1. Inclusion Criteria

Participants had a clinical diagnosis of KOA with Ahlbäck degree 2 and 3, were over 50 years of age, and had low functional capacity (International Knee Documentation Committee (IKDC) score between 20 and 50) [35]. All participants self-declared the continuous use of antihypertensive drugs prescribed by their doctors and were unaware of their hypertension level.

2.1.2. Exclusion Criteria

Participants with joint prosthesis or total knee replacement, other musculoskeletal disorders, neurological diseases or hypertension without treatment, and those that refused to sign the informed consent were excluded.

2.2. Study Design

The study was a two step crossover trial [36] with a washout period for the total elimination of the mechanical vibration effect, which is in accordance with a previous investigation [37] (Figure 1). Following an initial screening that included medical history, anthropometric (age, stature, body mass and body mass index (BMI)) and BP measurements, eligible participants were randomly assigned by arrival order to either a WBV group (WBVG) or a control group (CG). In WBVG, the individuals were exposed to mechanical vibration and in the CG, the individuals participated in the same protocol as

the WBVG, but with the vibrating platform (VP) turned off. Following the initial intervention and an 8-week washout period, the groups were switched to the second intervention step.

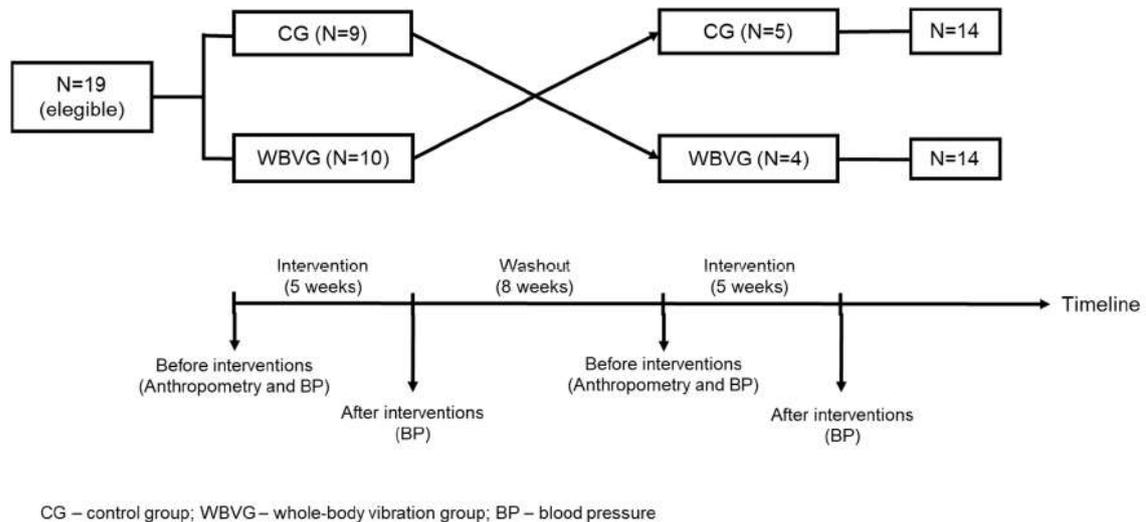


Figure 1. Randomized crossover clinical trial design.

Data were collected at baseline (before starting the protocol) and at the end of the protocol (after 5 weeks) always at the same time (± 1 h), in the morning.

Participants were instructed to maintain the antihypertensive drugs prescribed by their doctors and not to modify their lifestyle habits (diet, exercise) during the study.

2.3. Anthropometry and BP

BP and anthropometric parameters were measured in a silent temperature-controlled room (22–25 °C). A digital scale (Welmy™, São Paulo, SP, Brazil) was used to measure the body mass (kg) and a wall mounted stadiometer (American Medical do Brazil, São Paulo, SP, Brazil) was utilized to measure height (cm).

Before the start of the protocol (first session) the systolic BP (SBP) and the diastolic BP (DBP) were measured in a left arm, in the seated position, using an automatic device (Omron 705IT device; Omron™ Healthcare Co., Kyoto, Japan) after 10 min of rest. The SBP and DBP were also measured immediately after the last session. Three measurements at 1-min intervals were collected and the mean of the three values was used for comparison. The mean of BP (MBP) was calculated using the equation $MBP = (DBP \cdot 2 + SBP) / 3$ [38]. A difference after and before the intervention ($\Delta = \text{post} - \text{pre}$) was calculated in each BP parameter (SBP, DBP and MBP).

2.4. Whole-Body Vibration Intervention

The WBV protocol was performed for 5 weeks, two days per week (10 sessions) with an interval of at least 2 days between sessions. The position of the subjects during the WBV session was in accordance with previous studies [39–42]: (i) participant sitting in an ancillary chair in front of the VP, (ii) feet on VP base (barefoot), (iii) knee with a comfortable flexion between 100–120° (measured by manual goniometer), (iv) the hands on the knees to facilitate the transmission of the mechanical vibration for the whole body of the individual. The VP used was a side alternated movement of the base (Novaplate Fitness Evolution, DAF Produtos Hospitalares LTDA, São Paulo, Brazil). The participants were instructed to maintain this position with feet in each peak-to-peak displacement (2.5, 5.0 and 7.5 mm) indicated on the base of the VP for 3 min, resting 1 min after each bout. The frequency was increased in each session from 5 Hz (first session) up to 14 Hz (last session), corresponding to peak acceleration (a_{Peak}) from

0.12 to 2.95 g [39–42]. The CG followed the same protocol as the WBVG, but with the VP turned off (no vibration).

2.5. Statistical Analysis

The Kolmogorov-Smirnov test was used to test data normality. Mauchly's and Levene's tests were used to verify the sphericity and homogeneity of data and when necessary, the Greenhouse-Geisser correction was applied.

Student-t test was performed for calculation of possible baseline differences between the two groups. A 2-way ANOVA (group (G and WBVG) X time (pre and post treatments)) was performed to establish the intervention effects over time. In case of significant F ratio, the Bonferroni post-hoc test was applied. Data are expressed as mean \pm standard error (SEM). The software SPSS 20.0 (SPSS IncTM, Chicago, IL, USA) was used for the statistical calculations and $p \leq 0.05$ was considered as probability level for statistical significance.

Based on previous study [31], the software G*Power 3.1.5 (Universitat Dusseldorf, Dusseldorf, Germany) performed a sample size taking into consideration a α error probability = 0.05; β error probability = 0.80; effect size $f = 0.25$; correlation among repeated measures = 0.5; nonsphericity correction $\epsilon = 1$. A statistical power of 0.82 was estimated and after calculations, it was determined to be a total of $n = 24$ (12 participants per group).

3. Results

Nineteen individuals with KOA were randomly allocated in CG ($n = 9$) and WBVG ($n = 10$). Five individuals from the WBVG returned to perform the second step of the treatment (CG) and four individuals from the CG returned to the WBVG totaling fourteen people in each group (2 males and 12 females) (Figure 1). Therefore, 14 individuals in CG and 14 individuals in WBVG concluded all the protocols proposed which were similar to previous studies [31,43,44].

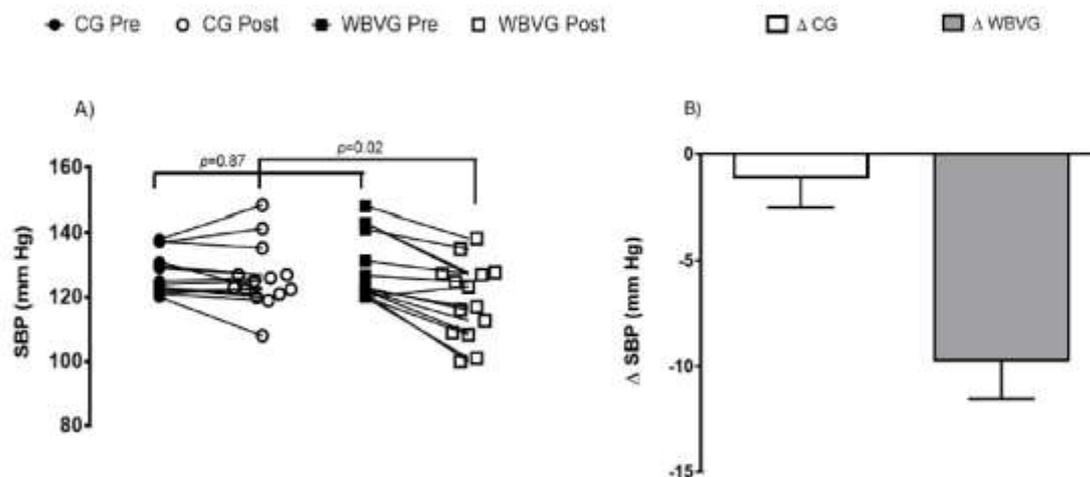
Table 1 shows that anthropometric and BP parameters collected before the interventions and the medications used by participants were not significantly different in the two groups ($p > 0.05$). Although all individuals were taking antihypertensive drugs, the SBP levels of both groups were compatible with prehypertension ($n = 11$) and hypertension ($n = 3$) [45].

Figures 2–4 show changes in BP data following the interventions of the two groups (WBVG and CG). A significant Group versus Time interaction showed differences between WBVG and CG decreasing the SBP ($F = 23.97$, $p = 0.001$) and MBP ($F = 23.97$, $p = 0.007$), as reported in the Figure 2A A, respectively. No significant changes were found in DBP ($F = 2.68$, $p = 0.11$) (Figure 4A). In addition, significant differences were found between post-conditions (WBVG versus CG) for SBP (119.1 ± 3.2 versus 126.1 ± 2.7 mmHg; $\Delta -9.6$ mmHg; post hoc: $p = 0.02$), as shown in Figure 2B, and MBP (78.7 ± 1.8 versus 82.6 ± 1.8 ; $\Delta -5.0$ mmHg; $p = 0.04$), as reported in Figure 3B, but not for DBP (64.4 ± 2.3 versus 68.5 ± 2.2 ; $\Delta -4.1$ mmHg, $p = 0.2$) (Figure 4B).

Table 1. Anthropometric and blood pressure (BP) parameters and medications used by participants in both study groups: control group (CG) and whole-body vibration group (WBG).

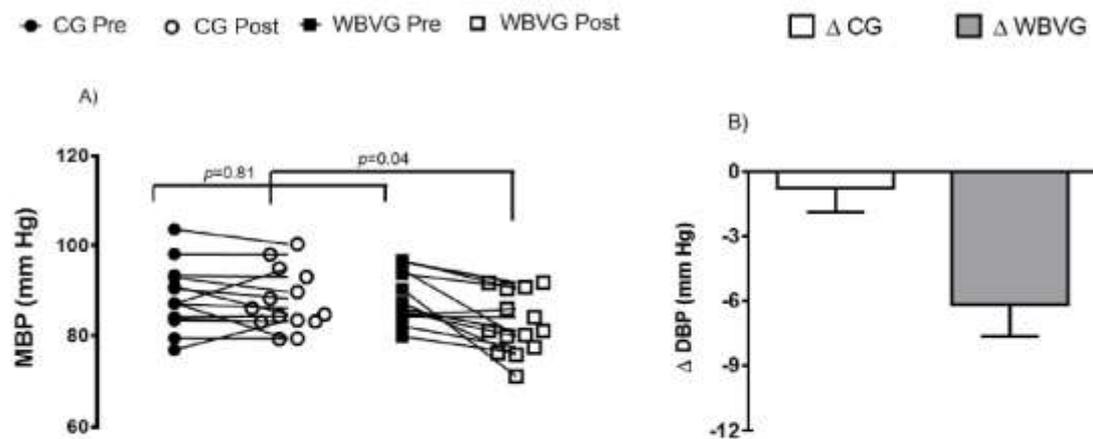
Variable	Control Group (CG) n = 14 (2 M and 12 F)	Vibration Group (WBG) n = 14 (2 M and 12 F)	Independent T-Test
Age (year)	64.1 ± 3.3	67.1 ± 2.8	0.518
Body mass (kg)	82.8 ± 2.8	86.8 ± 3.8	0.642
Stature (cm)	160.8 ± 0.1	160.8 ± 0.2	0.431
BMI (kg/m ²)	33.2 ± 1.6	35.2 ± 2.0	0.428
IKDC score	26.14 ± 2.36	29.45 ± 2.51	0.349
SBP (mmHg)	127.2 ± 1.7	128.3 ± 2.7	0.871
DBP (mmHg)	69.0 ± 2.7	68.7 ± 2.3	0.881
MBP (mmHg)	88.4 ± 1.9	88.7 ± 1.5	0.943
Medications			Chi-Square Test
Diuretic + AT1 blocker or ACE inhibitor	3	5	0.50
AT1 blocker	6	6	0.64
ACE inhibitor	2	1	0.54
Beta-1 blocker	2	1	0.54
Calcium blocker	2	2	0.70
Metformin	2	1	0.54
Statins	3	4	0.66
SAIDs	2	3	0.62
Chondroitin sulphate	1	1	0.75

M—males; F—females; BMI—body mass index; IKDC—International Knee Documentation Committee; SBP—systolic blood pressure; DBP—diastolic blood pressure; MBP—mean blood pressure. Data expressed in mean ± standard error. ACE = angiotensin-converting enzyme; AT1 = angiotensin II receptor type 1; SAIDs: steroidal anti-inflammatory drugs.



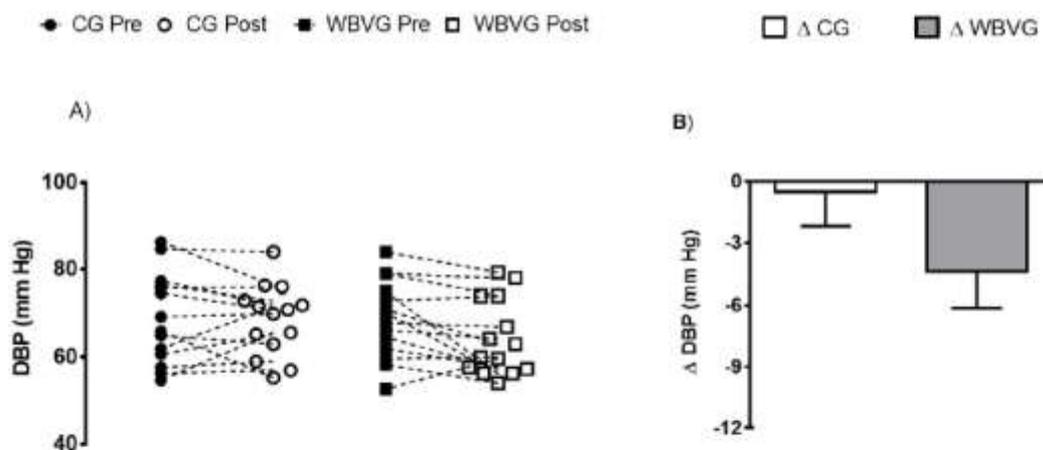
SBP - systolic blood pressure; WBG - whole-body vibration group; CG - control group; Δ=post-pre (difference). Significant Group versus Time effect (F=23.97; p=0.001). Significant difference between WBG versus CG (p=0.02).

Figure 2. Systolic blood pressure in knee osteoarthritis individuals of control group compared with whole-body vibration group. (A) Group (CG and WBG) X Time (pre and post treatments) and (B) Difference of means (Δ = post-pre).



MBP - mean blood pressure; WBVG – whole-body vibration group; CG - control group; Δ =post-pre (difference). Significant Group versus Time effect ($F=8.56$; $p=0.007$). Significant difference between WBVG versus CG ($p=0.04$).

Figure 3. Mean blood pressure in knee osteoarthritis individuals of control group compared with whole-body vibration group. (A) Group (CG and WBVG) X Time (pre and post treatments) and (B) Difference of means (Δ = post-pre).



DBP - diastolic blood pressure; WBVG – whole-body vibration group; CG - control group; Δ =post-pre (difference). No significant Group versus Time effect ($F=2.68$; $p=0.114$). No significant difference between WBVG versus CG ($p=0.2$).

Figure 4. Diastolic blood pressure in knee osteoarthritis individuals of control group compared with whole-body vibration group. (A) Group (CG and WBVG) X Time (pre and post treatments) and (B) Difference of means (Δ = post-pre).

4. Discussion

The association of KOA with cardiovascular risk factors has been discussed in several studies [10–12]. As far as we know, the current work is the first which aimed to evaluate the WBV exercise effects on the BP levels in individuals who suffer with KOA. It is important to report that the washout period of 8 weeks [37] was sufficient for a total elimination of the mechanical vibration effect, because the comparison of the baseline in both groups was similar (SBP – $p = 0.87$; DBP – $p = 0.881$ and MBP – $p = 0.943$). Although previous studies have used longer protocols (between 6 and 12 weeks) in non-KOA populations [31,43–47], we showed that an even shorter duration protocol (5 weeks) provides promising outcomes for hypertensive KOA individuals. This encourages further short studies in this population.

4.1. Blood Pressure and Whole-Body Vibration

The most relevant results of the present investigation are that SBP and MBP had a significant reduction after 5 weeks of WBV intervention in individuals with KOA compared with CG. These findings are in line with several authors that have previously demonstrated that resting BP decreases after WBV in different populations. Alvarez-Alvarado et al. [32] and Figueroa et al. [26] reported reductions at resting SBP (−5 mmHg) without changes in DBP in young women (overweight/obese) and normotensive (Baseline: SBP/DBP < 120/80 mmHg) after 6 weeks of a WBV program. Furthermore, authors observed SBP and MBP reduction after a WBV program versus a control group (6–12 weeks) in obese postmenopausal women with both elevated BP and hypertension [31,43–47]. Other investigations indicated a greater decrease in blood pressure between WBV intervention versus control group, when the baseline BP is high (>120/80 mmHg). Figueroa et al. [31] reported a decrease in SBP (−9 mmHg) in obese postmenopausal women with high BP. Figueroa et al. [44] showed a reduction of the SBP (−10 mmHg), DBP (−5 mmHg) and MBP (−6 mmHg) in postmenopausal women with hypertension. Wang et al. [47] found a decrease in SBP (−8 mmHg) and DBP (−3 mmHg) in obese hypertensive postmenopausal women. In the current study, we found significant reductions in SBP and MBP between intervention and control groups (−9.0 and 5.0 mmHg respectively). However, we note that three subjects that began the study with SBP levels above 140 mmHg (143, 144 and 148 mmHg) had a major reduction in SBP (−15 mmHg) after the WBV protocol. This find is similar to other studies [31,44,47], in which greater reductions in BP can be achieved in individuals who begin the WBV exercise with higher BP. Further studies are needed to confirm this suggestion.

Considering that the local vascular resistance was modulated by the high production of metabolites after several muscle contractions during physical exercise [48], chronic reductions in BP after WBV have been attributed to arterial vasodilation in the exercised limbs [31,44]. In the present study, reductions in SBP and MBP would be elicited by means of WBV without voluntary contraction of the musculature, due to the position of the individuals on the VP (sitting in an ancillary chair in front of the VP with the feet supported on its base). This decrease is compatible with another study that showed a decrease in SBP (−12 mmHg) and MBP (−9 mmHg) after WBV in obese postmenopausal women [44]. Despite this study not showing any significant changes in DBP, Manimmanakorn et al. reported that 12 weeks of WBV improved resting DBP pressure in type II diabetic patients [49]. Beijer et al. compared a resistance exercise with and without vibration performed by healthy males during 6 weeks of intervention. They found a positive effect of vibratory stimulus in decreasing DBP [50]. No modification in the antihypertensive treatment was detected in both groups during the study.

4.2. Association between Hypertension and Knee Osteoarthritis

Some symptoms of KOA may be related to hypertension; these include pain [51,52], physical inactivity [53] and inflammatory factor [54,55]. Furthermore, the use of some analgesics can affect BP and can interfere in the effects of antihypertensive therapy [56]. Authors have shown that WBV exercise might produce several benefits on the management of individuals with KOA such as a decrease in pain levels [29,57,58], improvement of functional capacity [29,57–59] and the concentration of inflammatory biomarkers [58]. Wang et al. found a decrease in the level of pain, joint stiffness (knee) and an improvement of functional capacity in individuals with KOA after 12 weeks of WBV [29]. Zafar et al. showed in a systematic review and meta-analysis that WBV reduces the level of pain and improves the functional capacity in individuals with KOA [57]. Similarly, Wang et al. showed that WBV programs of 8 and 12 weeks were beneficial for improving functional capacity in the same population; it is suggested that WBV could be included in rehabilitation programs [59]. Simão et al. suggested that 12 weeks of WBV would improve the self-perception of pain level, functional capacity (balance and gait quality) and inflammatory markers (reductions in the concentrations of soluble tumor necrosis factor receptor - sTNFR1 and sTNFR2) in elderly subjects with KOA [58]. These studies could justify our findings about the BP reduction in this population after a WBV program.

In addition, symptoms related to KOA can impair the maintenance of squat positioning which is usually performed in studies with hypertensive patients without KOA [26,31,32,43,44,46,47]. The current work uses a protocol in which the KOA individuals are exposed to WBV exercise in a comfortable and safe position [39–42]. The seated position in an ancillary chair allows patients to perform the WBV protocol without increasing the load on their knee joints. Naturally, it is relevant to highlight that this positioning could benefit other hypertensive individuals who have other clinical limitations, such as obesity, wheelchair use or diseases that prevent the squat posture. Further studies using the same protocol with hypertensive individuals without KOA but with other physical disabilities are suggested.

4.3. Possible Mechanisms of the Whole-Body Vibration to Reduce Blood Pressure

Considering the WBV intervention, BP reductions could be associated with vasodilation of the muscular arteries [60]. Some authors have shown WBV to acutely improve arterial function such as leg's skin blood flow in healthy persons [60–62]. Additionally, these studies indicated that vibratory stimulus could produce local vasodilation of peripheral arteries, decreasing the BP and reducing cardiovascular strain. Indeed, it has been shown that WBV intervention increases blood flow [63] and decreases arterial stiffness [60] as well as wave reflection [62] in the exposed limbs.

The same mechanisms that cause vascular improvements through vasodilation might justify declines in resting BP after our WBV intervention. Another possibility for the significant BP reduction after WBV intervention would be the increase in concentration of nitric oxide (NO) and endothelial NO synthase activity [46,63]. Furthermore to NO, the reduction of endothelin-1 (a vasoconstrictor) could be another endothelial factor involved with vasodilatory response to vibratory stimulus [64]. Another potential mechanism may be an improvement in autonomic nervous system activity. Joyner et al. [65] reported that the autonomic nervous system and its sympathetic pathway performs a great function in BP regulation. Furthermore, decreased parasympathetic and increased sympathetic activities modify sympathovagal balance and it would be the main mechanism to establish hypertension and pre-hypertension [66]. Previous research reported concomitant decreases in both resting BP and sympathovagal balance after WBV intervention in overweight/obese women [26,47].

4.4. Limitations of Study

Some limitations of this work include that there was no separate osteoarthritis classification by Ahlbäck criteria. Moreover, vasoactive substances and sympathetic activity were not measured, which would have helped in the explanation of the current findings. We also did not control for some covariates, like Na⁺ intake, K⁺ intake, serum Na⁺, K⁺ levels, diuresis, sleep, and daily physical activity and this may interfere in some responses to the investigation.

4.5. Strength of Study

The strength of this work is that it shows the effectiveness of a non-pharmacological and low-cost intervention for the treatment of hypertensive individuals with KOA. It offers a more sustainable treatment option, as this population could reduce the consumption of medications, reducing adverse/side effects, improving not only health but helping to preserve the environment (Green Toxicology) [23].

5. Conclusions

The current study showed that WBV exercise was able to produce antihypertensive effect on SBP and MBP in medicated hypertensive KOA individuals. Thus, WBV exercise might be considered a sustainable tool to decrease BP. Of importance, no participant increased the use of medications or left the research due to BP related issues during the interventions. This suggests that further research should be carried out to investigate the association between the use of WBV intervention and the reduction of the consumption of antihypertensive medications.

Author Contributions: Conceptualization, E.M.-M. and M.B.-F.; data curation, E.M.-M., A.R.-S., P.L.-S., R.G.C., and L.L.P.-D.; formal analysis, R.G.C.; funding acquisition, E.M.-M., M.C.M.-F. and M.B.-F.; investigation, V.d.S.C., M.C.M.-F., A.G.d.M., R.G.C. and Y.T.-S.; methodology, E.M.-M., A.R.-S., P.L.-S., L.L.P.-D., Y.T.-S., and A.G.d.M.; supervision, D.C.S.-C. and M.B.-F.; writing—original draft, E.M.-M., M.B.-F.; writing—review & editing, E.M.-M., V.d.S.C., A.C.R.L., R.T., V.A.M., A.S., A.W., B.S. and M.B.-F. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

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4.3 Efeito anti-inflamatório do EVCI em diferentes estados clínicos.

A inflamação é considerada um mecanismo de defesa vital para a saúde, atuando também como uma resposta protetora do sistema imunológico (91,92). Ela restaura e defende funções fisiológicas quando os mecanismos homeostáticos não são suficientes, substituindo ou suprimindo controles homeostáticos incompatíveis (91,92). Assim, Os mediadores inflamatórios atuam coordenando a RBI (91,92). Essas respostas podem ser agudas ou crônicas, sendo protagonista na defesa contra insultos, infecções e lesões que ameaçam a vida (endógenos, exógenos, infecciosos ou não infecciosos) (91–93). RBI ocorrem em estados patológicos agudos. Esses podem se tornar crônicos quando não há controle, sendo responsável por uma variedade de doenças inflamatórias crônicas (91–94).

Os exercícios físicos podem desencadear adaptações importantes no sistema imunológico, podendo ter um impacto favorável na patogênese imune (95–97). Tendo em vista que o EVCI um tipo de exercício físico (35,37,38) e que fatores inflamatórios são relevantes na fisiopatogenia da OAJ (7,56), ao longo desta tese, foi desenvolvida uma revisão sistemática visando apresentar os estudos mais atuais relacionados com os efeitos do EVCI nas RBI. Foram encontrados e analisados 4 ensaios clínicos randomizados. Os estudos incluídos mostraram benefícios relacionados com as RBI (citocinas, adipocinas e proteína C-reativa) em diferentes condições clínicas (idosos saudáveis, obesos, homens saudáveis e idosos com osteoartrite de joelho) usando vários protocolos de EVCI.

Nesta revisão Moreira-Marconi *et al.*, 2020, sugerem que o EVCI pode ser útil no tratamento das condições inflamatórias. No entanto, não há evidências suficientes para apoiar ou refutar essa hipótese. Portanto, mais investigações com ensaios clínicos randomizados devem ser realizadas.

Maiores informações são encontradas à seguir, na revisão sistemática intitulada: “*Inflammatory biomarkers responses of whole-body vibration in several clinical status. A systematic review.*”, submetido para a revista *Complementary therapies in medicine* (ANEXO D).

Inflammatory biomarkers responses of whole-body vibration in different clinical status. A systematic review.

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Abstract

Objective: To summarize effects of whole-body vibration (WBV) on inflammatory biomarkers response (IBR) in different clinical status by systematic review.

Design: Systematic Review according Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and registered in International Prospective Register of Systematic Reviews (PROSPERO) number CRD42020187943.

Method: Searches were conducted using Physiotherapy Evidence Database (PEDro), Medline/PubMed, Web of Science, SPORTDiscus, The Cochrane Library, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Scopus databases to identify studies about the effect of WBV on IBR in different clinical status. The methodological quality (PEDro scale), risk of bias (Cochrane Collaboration's tool) and level of evidence (National Health and Medical Research Council hierarchy of evidence-NHMRC) were rated.

Results: Four randomized clinical trials (RCT) met the selection criteria. The studies described different protocols and clinical status of the patients. Two works were classified as 'high', one 'fair' and one 'poor' by PEDro score. One paper was classified as low risk of bias, two as unclear risk and one as high in performance bias domain. The studies included showed benefits related with IBR (cytokines, adipokines and c-reactive protein) in various clinical conditions (healthy elderly, obese, healthy male and

knee osteoarthritis elderly) using several WBV protocols. All studies described modification on IBR.

Conclusion: WBV might be useful on the management of the inflammatory conditions. However, there is no sufficient evidence that WBV could have relevant effects on IBR due the diversity of protocols and clinical conditions. Therefore, investigations with more RCT might be conducted.

Keywords: Inflammation, whole-body vibration exercise, cytokines, adipokines, c-reactive protein, physical and rehabilitation medicine.

1. Introduction

Inflammation is considered a vital defense mechanism for health, acting as a protective response of the immune system ^{1,2}. It restores and defends physiological functions when homeostatic mechanisms are not sufficient, by replacing or suppressing incompatible homeostatic controls ^{1,2}. Thus, inflammatory mediators act by temporarily deactivating normal homeostasis with a higher physiological priority to achieve a satisfactory inflammatory biomarkers response (IBR) ^{1,2}. IBR (acute or chronic) is the protagonist in defending against life-threatening insults, infection and injury ¹⁻³, and can be triggered by several factors (endogenous, exogenous, infectious or non-infectious) ^{2,3}. IBR, more than beneficial to the organism, is also a potential mechanism for the onset of acute pathological states, which can become chronic when the acute form is not controlled, being responsible for a variety of chronic inflammatory diseases ¹⁻⁴, such as osteoarthritis ⁵, obesity ⁶, type 2 diabetes ⁷, fibromyalgia ⁸, cardiovascular disease ⁹ and chronic obstructive pulmonary disease (COPD) ¹⁰. IBR also can also be found in elderly populations, leading to the Inflamm-Aging (chronic low-grade inflammation relation to aging) ¹¹ as well in healthy individuals after physical exercises ¹². Therefore, it is important to identify physiological responses produced by inflammation in different clinical status, as the persistence or non-resolution of inflammation, that can cause changes in the defense mechanisms leading to an excessive or abnormal IBR ⁴. Thus, these mechanisms can be used for the development of anti-inflammatory therapies in chronic inflammatory diseases, such as physical exercises.

Physical exercises have been suggested as a non-pharmacological intervention to management of different clinical status. The biological responses to them depend on the type, duration and intensity ¹³⁻¹⁵. They can trigger important adaptations in the immune system ¹³⁻¹⁵. Pereira *et al.* 2012 ¹⁶ have shown that a session of moderate-intensity exercise promoted positive immediate IBR in individuals with heart failure. Deckx *et al.* 2016 ¹⁷ found a reduction in the production of inflammatory mediators upon Toll-like receptor stimulation and an increase in the immune-regulatory function of circulating plasmacytoid dendritic cells after a program of 12-week of combined endurance and resistance exercise program. This would be suggestive of a favorable impact of exercise on the underlying immune pathogenesis of individuals with multiple sclerosis. Whole-body vibration (WBV) exercise is a type of physical exercise that might act on inflammation responses^{18,19} due the capacity of stimulating the sensory components that promote systemic responses ²⁰. Another possible mechanism of the WBV act on IBR could be justified by the possibility of physical exercise to regulate the immune system ^{21,22}. This would be related to the ability in reducing the number of senescent and exhausted T-cells, and increase the proliferative capacity of T cells, decreasing the circulatory levels of inflammatory cytokines, improving the phagocytic activity of neutrophils, raising the cytotoxic activity of Natural-Killer cells and increasing the length of leukocyte telomeres in aging humans ^{21,22}. Moreover, WBV is considered a physical exercise that promotes physiological alterations, such as increased muscle

performance and IBR, that are similar to those observed with traditional modalities of physical exercise^{22,23}.

WBV exercise is produced in individuals who are in contact with the base of a vibrating platform (VP), that transmits mechanical vibration for them^{24,25}. WBV exercise has been suggested as a non-pharmacological intervention to treat different inflammatory diseases^{24,26}, such as osteoarthritis^{27,28}, metabolic syndrome²⁹, COPD³⁰, fibromyalgia³¹⁻³³ and obesity³⁴. Different WBV protocols have been described, however, the mechanisms that underline the IBR in these clinical statuses related to the WBV exercise are not fully clear yet. Therefore, the objective of this systematic review was to summarize effects of WBV exercise on IBR in individuals with different clinical status.

2. Material and Methods

2.1. Protocol and Registration

The methods of the analysis, inclusion and exclusion criteria were specified in advance and documented in a protocol. This work was registered in International Prospective Register of Systematic Reviews (PROSPERO) number CRD42020187943.

2.2. Research question

This systematic review aimed to answer a question. Can WBV have anti-inflammatory action in individuals with different clinical status? PICOS (P = Patients, I = Intervention, C = Comparison, O = Outcomes, S = studies design) method was used to define the five major components of the research question³⁵: P = individuals that presented inflammatory conditions; I = WBV; C = comparison of the interventions with and without WBV exercise; O = inflammatory biomarkers response (blood markers of inflammation), S = randomized controlled trial (RCT).

2.3. Search strategy used to find the publications

Three independently reviewers (EMM, ACGS and AGM) accessed Physiotherapy Evidence Database (PEDro), Medline/PubMed, Web of Science, SPORTDiscus, The Cochrane Library, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Scopus databases. The search was carried out on May 20th, 2020. The search was repeated on December 30th, 2020. The search expression used in this review was: (i) Medline/Pubmed - (((("inflammation"[All Fields]) OR ("inflammatory disease"[All Fields])) OR ("inflammatory marker"[All Fields])) OR ("inflammation"[MeSH Terms])) AND (((("whole body vibration"[All Fields]) OR ("wbv"[All Fields])) OR ("vibration"[MeSH Terms])); (ii) Scopus - ((TITLE-ABS-KEY ("whole body vibration") OR TITLE-ABS-KEY (wbv))) AND ((TITLE-ABS-KEY (inflammation) OR TITLE-ABS-KEY ("inflammatory disease*") OR TITLE-ABS-KEY ("inflammatory marker*"))); (iii) Web of Science - (TS=("inflammation") OR TS=("inflammatory disease*") OR TS=("inflammatory marker*")) AND (TS=("whole body vibration") OR TS=(wbv)); (iv) The Cochrane Library - ((inflammation):ti,ab,kw OR ("inflammatory disease"):ti,ab,kw OR ("Inflammatory marker"):ti,ab,kw) AND (("whole body vibration"):ti,ab,kw OR ("wbv"):ti,ab,kw); (v) SPORTDiscus and CINAHL - (whole body vibration or whole-body vibration or wbv) AND (inflammation or inflammatory or inflammatory marker). To PEDro database was used the sentences: (i) whole body vibration or WBV and inflammation, (ii) whole body vibration or WBV and inflammatory.

All the pooled publications were screened following the inclusion and exclusion criteria.

2.4. Inclusion criteria

All the publications found in the databases were preliminarily considered to be included in this systematic review. To fulfil the inclusion criteria, the studies should include: (i) investigation about the effects of WBV exercise on IBR (blood markers of inflammation); (ii) RCT; and (iii) publication with patients that performed static or dynamic exercises on a VP.

2.5. Exclusion criteria

As exclusion criteria were eliminated: (i) review articles; (ii) case reports; (iii) study protocol and (iv) WBV associated with other therapeutic intervention.

2.6. Study selection and data extraction

All publications found on the databases were exported to a data management software (Excel), and the duplicates were removed. The review was conducted following four steps. Records were identified through database search and reference screening (Identification) and two reviewers (ACGS and AGM) independently examined titles and abstracts and relevant studies were included based in eligibility criteria (Screening). Relevant full texts were analyzed for eligibility (Eligibility), and all relevant studies were included in the systematic review. The disagreements were resolved by a third reviewer (YTS).

The data were extracted from each article and were imported to an Excel spreadsheet containing: (i) data regarding study information (author and year), (ii) clinical status of the participants, (iii) aim, (iv) Characteristics of the participants (sample size, age, sex) and groups (WBV or without WBV), (v) inflammation evaluation (blood markers of inflammation), (vi) WBV exercise protocols, (vii) biomechanical parameters (frequency, peak-to-peak displacement and peak acceleration) and (viii) IBR. Two reviewers (EMM and YTS) independently made this extracting to the spreadsheet. The disagreements were resolved by a third reviewer (AGM).

2.7. Methodological quality, risk of bias and levels of evidence (LE) of the selected papers

Studies were independently appraised by two reviewers (MESMO and AS) and when there was a disagreement, a third researcher was consulted (EMM). The methodological quality was evaluated according the PEDro scale which tests the methodological quality of clinical trials of physical therapy interventions. On this scale, there are 10 items established based on an "expert consensus"³⁶. The publications were classified as 'high' (score of seven or greater); 'fair' (score of five to six) and 'poor' (score of four or below)³⁷.

The level of evidence of each work was classified according to the National Health and Medical Research Council (NHMRC) hierarchy of evidence³⁸.

The risk of bias of the included studies was evaluated using the Cochrane Collaboration's tool. It assesses the internal validity of the trial and assessment of the risk of possible bias in different phases of the studies, as: (i) random sequence generation, (ii) allocation concealment, (iii) blinding of participants, (iv) personnel and outcome assessment, (v) incomplete outcome measures, (vi) selective outcome reporting and (vii) other types of bias. Each item was qualified as low risk (green), unclear risk (yellow) or high risk (red)³⁹.

3. Results

Three hundred and four papers (Web of Science = 67, SPORTDiscus = 11, The Cochrane Library = 10, CINAHL = 14, Medline/Pubmed = 137, PEDro = 5, Scopus = 60) were initially screened. A total of 119 records were identified as duplicates and they were removed. Of these, 4 articles met the inclusion criteria. The selection process is schematized in the PRISMA flowchart ³⁵ (Figure 1).

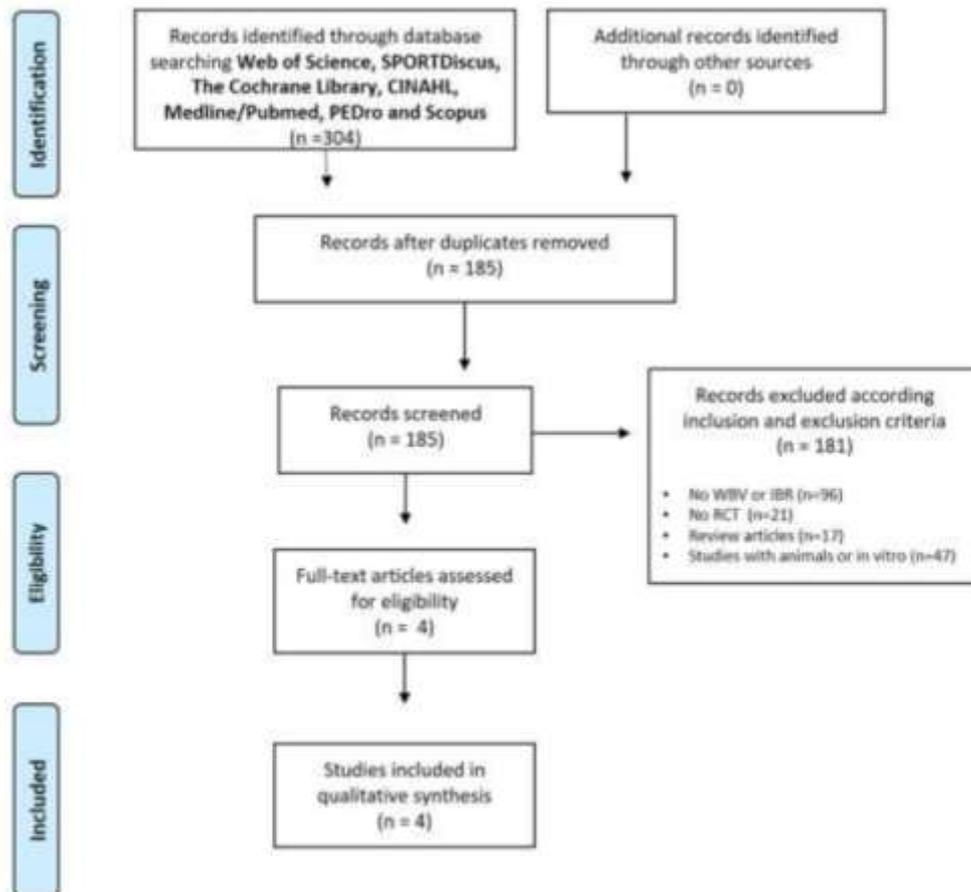


Figure 1. PRISMA flow diagram of the literature selection process.

Table 1 summarizes the publications selected in this systematic review, presenting the characteristics of the WBV protocols, level of evidence, methodological quality and the IBR. The included studies showed improvements on the IBR (cytokines, adipokines and c-reactive protein) in individuals with different clinical conditions (healthy elderly, obese, healthy male and knee osteoarthritis elderly) using several WBV protocols.

Table 1 – Characteristics of the publications included in the current systematic review.

Author/Year	Clinical status	Participants /groups	Inflammation evaluation	WBV protocol	Frequency/ peak-to-peak displacement/ f_{peak} $D = 2 \text{ mm}$ a_{peak} – no information	NIMRC/ PEDro scale	Inflammation biomarkers responses
Bellia et al. 2013. ⁴⁰	Middle-Aged Obese	N=34 age 43 ± 6 years (mean ± SD) Male and female Groups (WBV plus hypocaloric diet group or diet alone)	high-sensitivity CRP, plasma leptin, adiponectin and TNF- α	3 times per week for 8 weeks VP – vertical platform Position - static squatting (110° of knee flexion) Session - 10 times of 60 s of vibration and 60 s of rest	$f = 30 \text{ Hz}$ / $D = 2 \text{ mm}$ a_{peak} – no information	L-II 8/10 (fair)	Adiponectin increased in WBV group compared with control group.
Rodriguez-Miguel et al. 2016. ⁴¹	Healthy older adults	N=38 age 71.04 ± 1.5 years (mean ± SD) Male and female Groups (WBV and control)	TLRs (TLR2 and TLR4), TNF- α , IL-10, and CRP	Twice a week for 8 weeks VP – vertical platform Position - static or dynamic exercises (a) half-squat between 120 and 130-knee, (b) deep squat with 90-knee angle, (c) wide-stance squat and calves with a knee angle between 120 and 130- (two sets per exercise mode). Session - 30 to 60 seconds with an interval of 2.5 to 3 min between exercises and 5 min between sets.	$f = 20$ to 35 Hz / $D = 4 \text{ mm}$ a_{peak} – no information	L-II 4/10 (poor)	Plasma levels of CRP and TNF- α decreased in WBV group from pre to post.
Di Giminiani et al. 2020. ⁴¹	Male students	N=28 Age – WBV: 22.7 ± 0.6 years / Control: 22.2 ± 0.8 years (mean ± SD) Male Groups (WBV and Control)	IL-6	Single session VP – no information Position – isometric half-squat Session – 10 series of 1 min and 1 min of rest (4 min of rest after the first 5 series).	$f = 30$ or 45Hz, $D =$ no information a_{peak} – individualized determined by EMG	L-II 9/10 (high)	IL-6 increased significantly over time in the WBV group
Simão et al. 2012. ⁴²	KOA elderly	N=32 age 75 ± 7.4 years (mean ± SD) Male and female Groups - (1) squat exercises with WBV, (2) squat exercises without WBV, (3) control	sTNFR1 sTNFR2	3 times per week 12 weeks VP – vertical platform Position - squat exercise (approximately 10 to 60° of knee flexion) Session – 20 to 40 s of the squat with 20 to 25 s of rest (8 to 8 repetitions)	$f = 35$ to 40Hz / $D = 4 \text{ mm}$ / $a_{peak} = 2.78$ to 3.26g.	L-II 7/10 (high)	In the WBV group, there was reduction on the plasma concentrations of the inflammatory markers sTNFR1 and sTNFR2.

Abbreviations: WBV - whole-body vibration; VP - vibrating platform, f - frequencies, D - peak-to-peak displacement, a_{peak} - peak acceleration; NIMRC - levels of evidence according National Health and Medical Research Council; HIIT - high intensity interval training, SD - standard deviation; CRP - c-reactive protein; IL - interleukin; TNF - tumor necrosis factor; sTNFR - soluble tumor necrosis factor receptor; KOA - knee osteoarthritis; PEDro score – (a) high methodological quality 27, (b) fair methodological quality = 5 or 6, (c) poor⁵⁴.

3.1. Study population

The selected studies included several populations with different clinical status. One publication analyzed the effects of WBV exercises on knee osteoarthritis⁴², one in healthy elderly individuals¹⁹, one on young male students⁴¹, and one in obese individuals⁴⁰. All studies aimed to investigate IBR after the intervention of WBV.

3.2. Whole-body vibration exercise protocol

Almost all the selected studies used vertical VP, exception one⁴¹, that did not inform the VP movement. The frequency and peak-to-peak displacement (*D*) of the mechanical vibrations ranged from 12 to 50 Hz and 2 to 4 mm, respectively, and one publication⁴¹ did not inform the *D* in mm. One study⁴¹ investigated the acute effect of WBV exercise while three studies^{19,40,42} examined the effects of long-term WBV protocols.

3.3. Methodological quality

All studies were classified as Level II according to the NHMRC classification³⁸. Regarding to the methodological quality (PEDro score), two works^{41,42} were considered 'high' methodological quality (≥ 7), one⁴⁰ were 'fair' methodological quality (5 or 6), and one was considered 'poor' (≤ 4)¹⁹.

3.4. Risk of bias

The risk of bias was evaluated according with the Cochrane Collaboration's tool³⁹. The detailed assessment of risk of bias was presented in Figure 2⁴³. It is verified that one paper¹⁹ presented high risk of bias in only one domain (performance bias). One study⁴¹ was classified as low risk of bias and two as unclear due to insufficient information^{40,42}.

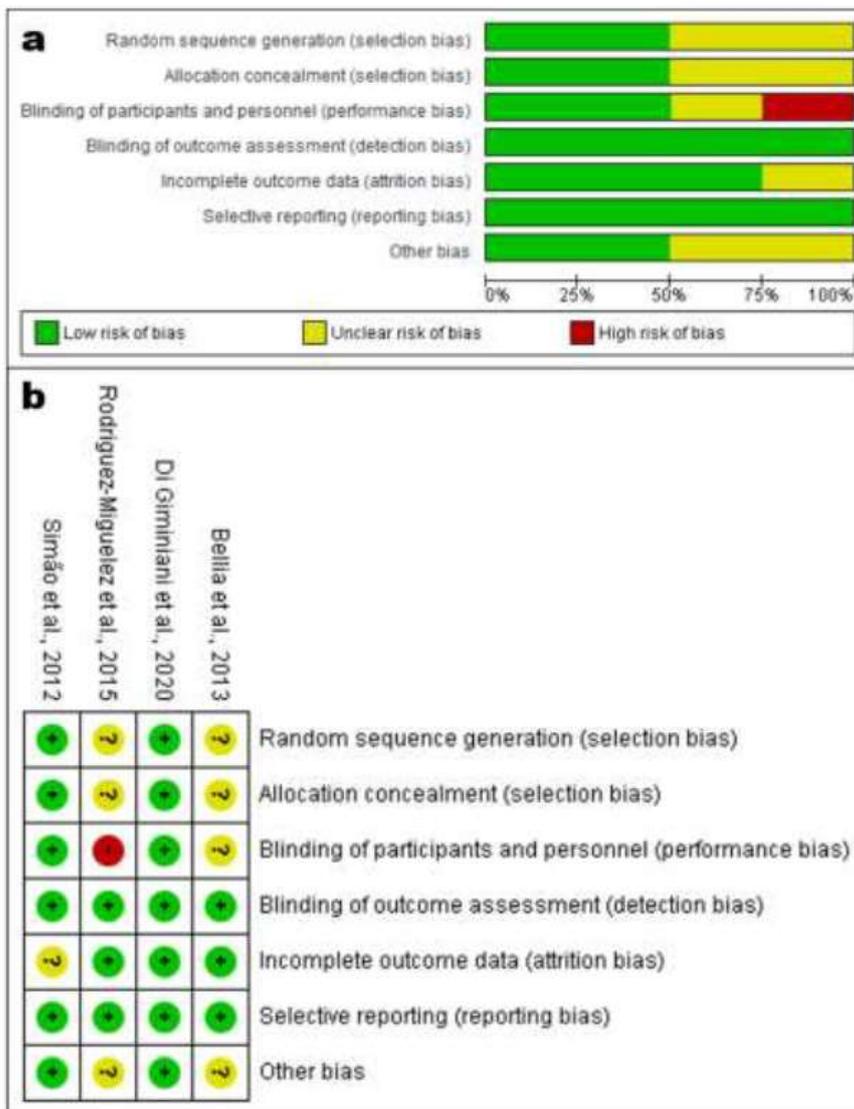


Figure 2. (a) Risk of bias graph and (b) Summary indicating the risk of bias of each domain in each study. Green for low risk of bias, yellow for unclear risk of bias and red for high risk of bias⁴³.

3.5. Inflammation biomarkers

Two studies analyzed the effects of WBV exercises on the concentrations of c-reactive protein (CRP)^{19,40}, one on IL-6⁴¹, one on IL-10¹⁹, two on tumor necrosis factor (TNF- α)^{19,40}, one on soluble tumor necrosis factor receptor (sTNFR1, sTNFR2)⁴²; one toll-like receptor (TLR2 and TLR4)¹⁹, one on adiponectin⁴⁰ and one on leptin⁴⁰. IBR were analyzed in various populations that are showed in the Table 1 and they are indicated in Figure 3.

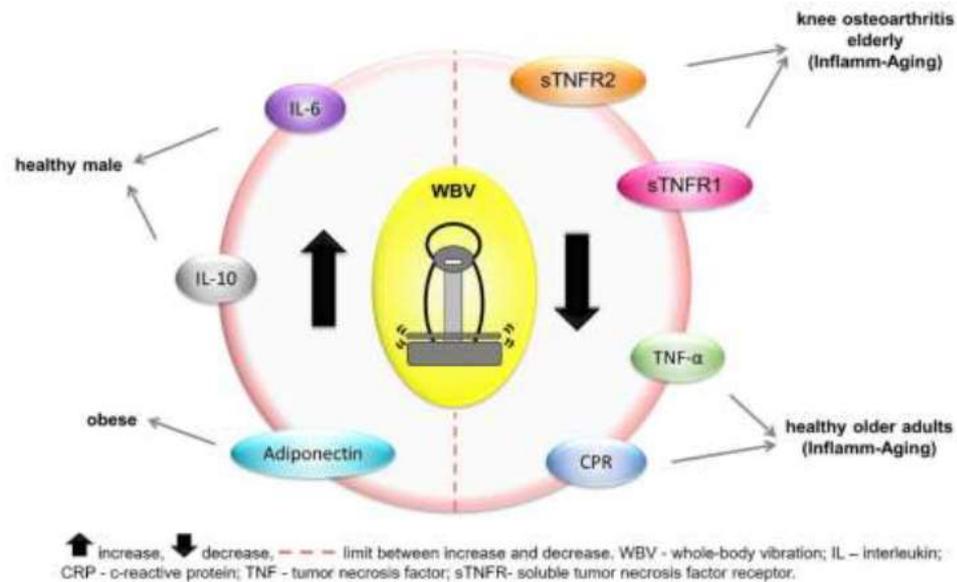


Figure 3. Inflammatory biomarkers responses by whole-body vibration intervention in each clinical status.

4. Discussion

The current study investigated the effects of WBV exercise on IBR in individuals with different clinical status and, to the best of our knowledge, this is the first systematic review aiming to examine these responses. In this investigation were included four studies with various protocols and clinical status. However, it is important to consider that all studies were classified as Level II (NHMRC) ³⁸ (Table 1), the analysis of methodological quality (PEDro score) (Table 1) evidenced that two works were considered 'high' (≥ 7) ^{41,42}, one 'fair' (5 or 6) ⁴⁰, and one 'poor' (≤ 4) ¹⁹. Furthermore, one paper ¹⁹ presented high risk of bias in only one domain (performance bias). One study ⁴¹ was classified as low risk of bias and two as unclear ^{40,42}. (Figure 2).

The results of this work showed that WBV exercise may be useful on management of inflammatory conditions altering the concentrations of some blood markers of inflammation, but this effect is not fully clear yet. However, the IBR promoted by WBV might be justified due to WBV is a kind of physical exercise. It is relevant to highlight that the protocols with WBV can be personalized to subjects in different clinical status. This is pointed out by Rittweger *et al.*, 2010 ²⁴ and Wuestefeld *et al.*, 2020 ²⁵. Sallam and Laher 2016 ⁴⁴, in a review about the modulation of the oxidative stress and inflammation by physical exercises, suggested that the biological responses related to WBV would depend on various factors, such as, intensity, type, periodicity, and duration of the exercises, including, individual's characteristics. Then, the development of personalized physical exercise programs is essential. In addition, Oroszi *et al.*, 2020 ²⁰ showed that the WBV can promote physiological responses as an indirect effect of the stimulus vibratory and Moreira-Marconi *et al.*, 2020 ⁴⁵ summarized the hormonal responses in several studies about vibratory stimulus (local and WBV).

4.1. C-reactive protein (CRP)

The CRP has both pro-inflammatory and anti-inflammatory properties, it is synthesized in the liver hepatocytes and, in minor quantitative, by endothelial cells, smooth muscle cells, lymphocytes, macrophages, and adipocytes ⁴⁶. It is a blood markers of inflammation normally found in chronic systemic inflammation and used in cardiovascular disease risk assessment ⁴⁷. Physical exercise seems to reduce the CRP

level in individuals with different clinical status. Han *et al.* 2019⁴⁸ showed in a meta-analysis that the physical exercise can be used as a therapy to reverse the low-grade inflammatory state reducing the CRP levels in children and adolescents with overweight or obesity. Fedewa *et al.* 2017⁴⁷ suggested that the physical exercise and the body mass index decrease are associated with the CRP levels reduction regardless of age or sex. Kohut *et al.* 2006⁴⁹ compared aerobic exercises with flexibility/strength exercises and found greater reductions in CRP level in the aerobic exercises group. This is consistent with Zheng *et al.* 2019⁵⁰ that reported that aerobic exercises can have a benefic effect on the reduction of the blood markers of inflammation including CRP levels in individuals with more than 40 years old. Moreover, El-Kader and Al-Jiffri 2019⁵¹ also reported a significant decrease of CRP in obese post-menopausal women that performed aerobic exercise or resisted exercise training. According the results of this review, the WBV exercise, as well as other modalities of the physical exercises, also reduce the CRP level. Rodriguez-Miguel *et al.* 2015¹⁹ shown a decrease on the CRP level in healthy older adults after 8 weeks of the WBV exercise (twice a week) using frequencies of the 20-35 Hz. On the other hand a pilot study by Seefried *et al.* 2017⁵² observed no significant decline of CRP levels in individuals in end stage renal disease (hemodialysis patients) using frequencies of 14 -28 Hz associated with other exercises, twice weekly for 12 weeks before or after hemodialysis sessions. Oh *et al.* 2019¹⁸ observed that CRP level and hepatic stiffness decreased in individuals with nonalcoholic fatty liver disease submitted to WBV exercise (30-50 Hz) for twice a week during 6 months, suggesting that a low-intensity WBV program may be considered the best program for patients who have difficulty engaging in exercise.

4.2. Cytokines

Cytokines are soluble proteins or glycoproteins that regulate the functions of the immune system, and they can increase (pro-inflammatory) or attenuate (anti-inflammatory) the IBR, being necessary for the homeostasis of the organism⁵³. Changes on the concentration of the cytokines can be balanced with interventions as physical exercises including WBV exercise and this can have beneficial effects on IBR in individuals with various clinical status. Di Giminiani *et al.* 2020⁴¹ founded an increase of the IL-6 in only one session of WBV (30 or 45 Hz) in young males. Neves *et al.* 2014⁵⁴ demonstrated acute increase of the IL-6 after high intensity physical exercises when compared with low intensity while IL-10 had a greater reduction to low intensity. Cerqueira *et al.* 2020¹², in a systematic review, investigated the IBR after different intensity of physical exercises and observed an increase on TNF- α and IL-10 only after intense exercise and an increase on IL-6, IL-10 and IL-1 β with more with intense than with moderate exercise, TNF- α is a potent pro-inflammatory cytokine that can perform a variety of biological activities including inflammation⁵⁵. Hazell *et al.* 2014⁵⁶ added WBV exercise (45 Hz) to only one session of the physical exercise (using body mass as the resistance) and found a significant increases in IL-1 β and IL-6 but with no differences between groups (with and without WBV). In addition, the IL-10 increased more in healthy male submitted to WBV than to exercise without vibration. Lage *et al.* 2018⁵⁷ showed higher levels of IL-10 in individuals with COPD after only one session of the WBV exercise (35 Hz) compared with at rest. Whereas that the IL-10 is an anti-inflammatory cytokine⁵⁸, WBV exercise can be significant effects on this anti-inflammatory responses. However, one study compared aerobic exercises with flexibility/strength exercises measuring IL-6, TNF- α and IL-18 finding greater reductions in IL-6, and IL-18 in the aerobic exercises group whereas that TNF- α declined in both groups⁴⁹. Similarly, Zheng *et al.* 2019⁵⁰ also found a reduction of the TNF- α e IL-6 after aerobic exercises. Oh *et al.* 2019¹⁸ also observed that TNF- α decreased in individuals with nonalcoholic fatty liver disease after 6 months WBV exercise (twice a week) with frequencies from 30 to 50 Hz.

sTNFR1 and sTNFR2 are distinct receptors of the TNF- α ⁵⁵. The expression of these receptors may vary between cell types and tissue. The sTNFR1 is expressed on every cell type in the body while the expression of TNFR2 is limited to endothelial cells, nerve cells and cells of the immune system ⁵⁵. Simão *et al.* 2012 ⁴² found significant reductions on the concentrations of the sTNFR1 and sTNFR2 after the 12 weeks of the WBV (3 times per week) using frequencies from 35 up to 40 Hz, suggesting that the WBV intervention reduces the IBR in knee osteoarthritis elderly. In contrast, Ribeiro *et al.* 2018 ³¹ found a decrease on plasma level of sTNFR1 and increased levels of sTNFR2 in individuals with fibromyalgia and an increase of the sTNFR1 plasma levels in the healthy women after the only one session of the WBV exercise (40 Hz). This could be explained by the fact that plasma levels of sTNFR1 are already higher in individuals with fibromyalgia at rest, showing a probable attempt to control chronic systemic inflammation ³¹. Moreover, Marín *et al.* 2011 ⁵⁹ suggested that physical exercise load can be increasing using a WBV program or by an improvement of resistance. In addition, it is important to consider the findings described by Rodriguez-Miguel *et al.* 2015 ¹⁹ that showed a decrease of the TNF- α in healthy older adults after 8 weeks of the WBV (twice a week) using from 20 to 35 Hz supporting the efficacy of WBV to counteract, at least in part, the Inflamm-Aging.

4.3. Adiponectin and Leptin

Adiponectin and Leptin are adipokines (or adipocytokines) produced by the adipose tissue. Adipokines present pro and anti-inflammatory actions besides act in satiety mechanisms and body weight maintenance and to present pro and anti-nociceptive properties which modulate pain perception ^{60,61}. Their reduction is correlated with increase of the pro-inflammatory cytokines such as IL-6, IL-12, IL-18, and TNF- α ⁶¹. Bellia *et al.* 2013 ⁴⁰ observed a significant increase of the adiponectin in an intervention of the 8 weeks WBV exercise (3 times per week) with frequency of 30 Hz in obese individuals however, they found no difference on the leptin level. Oh *et al.* 2019 ¹⁸ observed that adiponectin increased in individuals with nonalcoholic fatty liver disease submitted to WBV exercise together with a decrease of the TNF- α and CRP levels that can be attributed to the remarkable improvement of hepatic stiffness caused by the WBV program. However, Ribeiro *et al.* 2018 ³¹ found a decreased plasma level of adiponectin in individuals with fibromyalgia after the one session of the WBV exercise (40 Hz). They also found an increase in leptin levels concluding that a single session of the WBV exercise can improve the IBR in patients with fibromyalgia, reaching values close to healthy women.

The strength of this work is to propose the application of WBV exercise, as a non-pharmacological intervention, in the management of inflammatory diseases. It is highly advantageous for individuals who cannot or choose not to take anti-inflammatory drugs due to its adverse effects. Although the mechanism of action of mechanical vibration on IBR to WBV is not clear yet, this work might stimulate additional investigations about this subject aiming an optimal and specific WBV protocol for each clinical status.

The findings of this investigation must be interpreted with caution due important limitations. The first limitation of this systematic review is the inclusion of only RCT (only four papers). This was done in the attempt of improving the methodological quality of this work compiling only high-quality evidence, since relevant information from non-RCT studies could be added. However, various of those papers were included in the Discussion section. The WBV protocols, outcome measures and population included in the selected studies were very distinct and this is a major limitation, this difficult the comparison between the papers and the interpretation of

WBV effects. Third, the overall methodological quality and the risk of bias vary among the included works.

5. Conclusion

In conclusion, considering the findings of the current systematic review, it is possible to conclude that WBV exercise may be useful on the management of inflammation in individuals with different clinical status. However, there is no sufficient evidence to support or refute the notion that WBV exercise could have significant effects on inflammation. Therefore, more investigations might be conducted to verify to increase the scientific evidence related to results presented in this work.

Competing interests

The authors declare that there are not financial competing interests (political, personal, religious, ideological, academic, intellectual, commercial or any other) in relation to this manuscript.

Author's Contributions

EMM, DCSC and MBF contributed conception and design of the study. EMM, YTS, AGM and ACGS organized the database and selected the studies. MESMO and AS classified the studies by Methodological quality, risk of bias and levels of evidence of the selected papers. EMM, YTS and AS wrote the first draft of the manuscript. EMM, LLPD, AGM and ACGS wrote sections of the manuscript. EMM, DCSC, LLPD and MBF reviewed the final version of the manuscript. All the authors contributed conceptually, reviewed, provided feedback, read, and approved the submitted version.

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5 DISCUSSÃO

Nessa tese foi investigada a eficácia de uma intervenção não farmacológica (EVCI) de 5 semanas na PA, nas respostas funcionais dos membros inferiores e na atividade eletromiográfica do músculo VL durante o 5CST de indivíduos com OAJ. Além disso, estudou as RBI em diferentes condições clínicas após diversos protocolos de EVCI. Até onde se sabe, esta é a primeira revisão sistemática com o objetivo de examinar essas respostas e também o primeiro estudo sobre os efeitos do EVCI em indivíduos hipertensos com OAJ.

O estudo sobre a excitabilidade dos músculos VL durante um teste funcional (5CST) após um protocolo diferenciado de EVCI (participantes sentados em uma cadeira com os pés apoiados na base da PV) sugere uma reflexão sobre os mecanismos da vibração mecânica, pois os achados relacionados com a flexibilidade (melhora no tempo de execução do 5CST) parece não ter sido compatível com as respostas da EMGs dos músculos VL (não houve alteração na excitabilidade muscular - $p > 0,05$). Isto sugere que a melhora da capacidade funcional pode ter sido através de uma resposta indireta ou sistêmica (38) através da redução de alguns sintomas relacionados com a OAJ e não pelo aumento da resposta muscular. Estudos anteriores mostram que o EVCI pode melhorar alguns sintomas que justificariam essa hipótese como: (i) nível de dor (28,29,98,99), (ii) redução da rigidez articular (98), (iii) melhora da mobilidade (29,98) e (iv) alteração em biomarcadores inflamatórios (32). Por outro lado, alguns estudos mostram um aumento da força dos quadríceps após o EVCI em indivíduos com OAJ, porém, utilizaram a postura agachada (estática ou dinâmica) durante o estímulo vibratório (98–102). Isso sugere que a resposta muscular poderia ser devido à adição da vibração mecânica à contração muscular do quadríceps durante o EVCI, o que não aconteceu no presente estudo, visto que a postura utilizada foi sentada em uma cadeira auxiliar com os pés apoiados na base da PV. Porém, a utilização das mãos apoiadas nos joelhos facilitaram a transmissão da vibração mecânica para todo o corpo (103), justificando assim, a possibilidade das respostas indiretas e/ou sistêmicas.

A redução significativa da PAS ($p=0,02$) e da PAM ($p=0,04$) após 5 semanas de EVCI em comparação com o GC encontrada nesta investigação, juntamente com a observação das RBI encontradas na revisão sistemática corrobora a ideia sobre resposta indireta e/ou sistêmica ao EVCI.

Nesse contexto, a força deste estudo está relacionada com a aquisição de informações sobre os efeitos do EVCI nas respostas funcionais e na PA em um protocolo especial no qual

os indivíduos com OAJ ficam sentados em uma posição confortável em uma cadeira auxiliar durante o estímulo vibratório. Os benefícios encontrados mostram que existe a possibilidade do uso desta intervenção para alcançar alguns objetivos similares ao tratamento farmacológico como por exemplo anti-inflamatórios e anti-hipertensivos, podendo causar uma redução no consumo de medicamentos e oferecer uma opção de tratamento mais sustentável colaborando com a proposta da “Química Verde” e a “Engenharia Verde”. Isso é altamente vantajoso para pessoas que não podem ou optam por não tomar medicamentos devido aos seus efeitos adversos, melhorando não só a saúde, mas ajudando a preservar o meio ambiente (*Green Toxicology*). Entretanto, mais pesquisas precisam ser realizadas para confirmar ou refutar essa hipótese. Além disso, como a PV já tem sido utilizada como ferramenta para o tratamento fisioterapêutico, o conhecimento acerca dos efeitos do EVCI e a relação multiprofissional se faz essencial para a observação desses benefícios na aplicabilidade clínica.

As limitações desse trabalho estão relatadas nos artigos publicados e incluídos nesta tese.

CONCLUSÃO

Com base nos achados do presente estudo, apenas 5 semanas de EVCI com uma postura confortável apresentou um efeito anti-hipertensivo e melhorou a resposta funcional dos indivíduos com OAJ sem alteração da excitação muscular. Além disso, a investigação através da revisão sistemática mostrou que o EVCI pode apresentar modificações na produção de biomarcadores, com potencial impacto nas diferentes condições clínicas. Portanto, o EVCI poderia ser considerado uma ferramenta sustentável, contribuindo o tratamento convencional em diversas condições clínicas.

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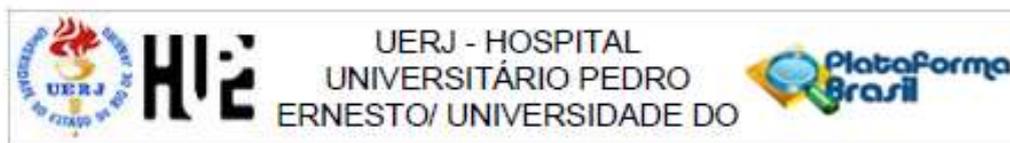
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ANEXO A – Aprovação do Comitê de Ética



PARECER CONSUBSTANCIADO DO CEP

DADOS DA EMENDA

Título da Pesquisa: Pesquisa sobre o efeito de um procedimento associado com uma das Práticas Integrativas e Complementares (auriculoterapia) no Sistema Único de Saúde e as vibrações mecânicas geradas em plataforma oscilante vibratória na evolução de indivíduos com doença crônica não transmissível (osteoartrite de joelho).

Pesquisador: Mario Bernardo Filho

Área Temática:

Versão: 3

CAAE: 19826413.8.0000.5259

Instituição Proponente: Hospital Universitário Pedro Ernesto/UERJ

Patrocinador Principal: FUN CARLOS CHAGAS F. DE AMPARO A PESQUISA DO ESTADO DO RIO DE JANEIRO - FAPERJ
CONS NAC DE DESENVOLVIMENTO CIENTIFICO E TECNOLÓGICO
Universidade do Estado do Rio de Janeiro - UERJ

DADOS DO PARECER

Número do Parecer: 2.819.894

Apresentação do Projeto:

Emenda para aprovação de documentação e alteração de informações relativas ao protocolo.

Objetivo da Pesquisa:

Emenda para aprovação de documentação e alteração de informações relativas ao protocolo.

Avaliação dos Riscos e Benefícios:

Emenda para aprovação de documentação e alteração de informações relativas ao protocolo.

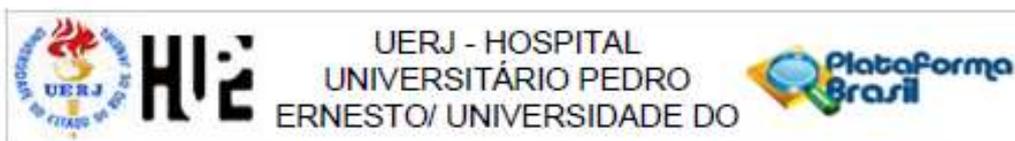
Comentários e Considerações sobre a Pesquisa:**Justificativa da Emenda:**

Foram acrescentadas algumas avaliações não invasivas no projeto. Houve uma modernização das referências e da nomenclatura gonalgia para osteoartrite de joelho.

Considerações sobre os Termos de apresentação obrigatória:

Os documentos enviados a este Comitê estão dentro das boas práticas em pesquisa e apresentando todos dados necessários para apreciação ética.

Endereço: Avenida 28 de Setembro 77 - Térreo
Bairro: Vila Isabel CEP: 20.551-030
UF: RJ Município: RIO DE JANEIRO
Telefone: (21)2968-8253 E-mail: cep.hupe.interno@gmail.com



Continuação do Parecer: 2.819.894

Conclusões ou Pendências e Lista de Inadequações:

A emenda apresenta todas as informações necessárias para avaliação ética. Diante do exposto e à luz da Resolução CNS nº466/2012, a Emenda pode ser enquadrada na categoria – APROVADO.

Considerações Finais a critério do CEP:

Tendo em vista a legislação vigente, o CEP recomenda ao Pesquisador: Comunicar toda e qualquer alteração do projeto e no termo de consentimento livre e esclarecido, para análise das mudanças; Informar imediatamente qualquer evento adverso ocorrido durante o desenvolvimento da pesquisa; O Comitê de Ética solicita a V. S^a., que encaminhe relatórios parciais de andamento a cada 06 (seis) Meses da pesquisa e ao término, encaminhe a esta comissão um sumário dos resultados do projeto; Os dados individuais de todas as etapas da pesquisa devem ser mantidos em local seguro por 5 anos para possível auditoria dos órgãos competentes.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_1089202_E2.pdf	20/07/2018 16:14:39		Aceito
Folha de Rosto	FolhaDeRostoAssinada.pdf	20/07/2018 16:11:37	Eloá Moreira Marconi	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.pdf	17/07/2018 11:29:48	Eloá Moreira Marconi	Aceito
Projeto Detalhado / Brochura Investigador	PROJETO_COMPETO.pdf	17/07/2018 11:27:47	Eloá Moreira Marconi	Aceito
Parecer Anterior	PB_PARECER_CONSUBSTANCIADO_CEP_2528890_E1.pdf	03/07/2018 19:17:48	Eloá Moreira Marconi	Aceito

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

Endereço: Avenida 28 de Setembro 77 - Térreo
 Bairro: Vila Isabel CEP: 20.551-030
 UF: RJ Município: RIO DE JANEIRO
 Telefone: (21)2868-8253 E-mail: cep.hupe.interno@gmail.com



Continuação do Parecer: 2.819.804

RIO DE JANEIRO, 14 de Agosto de 2018

Assinado por:
WILLE OIGMAN
(Coordenador)

Endereço: Avenida 28 de Setembro 77 - Térreo
Bairro: Vila Isabel CEP: 20.551-030
UF: RJ Município: RIO DE JANEIRO
Telefone: (21)2866-8253 E-mail: cep.hupe.interno@gmail.com

ANEXO B – Registro Brasileiro de Ensaios Clínicos

BRASIL

[Ir para o conteúdo](#) | [Ir para o menu](#) | [Habilitar alto contraste](#) | [3](#)

@ReBEC
Registro Brasileiro de Ensaios Clínicos

Registro Visualizar

Procurar nos estudos

Estudo publicado

RBR-7dfwct The effect of auriculotherapy and mechanical vibrations generated on oscillating vibratory platform in individuals Knee...

Data de registro: 02/08/2018
Última atualização: 02/08/2018

Tipo de estudo:

Intervenções

Título científico:

en

Research on the effect of a procedure involving the association one of the Integrative and Complementary Practices (auriculotherapy) in the "Sistema Único de Saúde" and the mechanical vibrations generated in oscillating/vibratory platform in the management of individuals with a chronic non-communicable disease (Gonarthrosis)

pt-br

Pesquisa sobre o efeito de um procedimento associado com uma das Práticas Integrativas e Complementares (auriculoterapia) no Sistema Único de Saúde e as vibrações mecânicas geradas em plataforma oscilante vibratória na evolução de indivíduos com doença crônica não transmissível (Gonartrose)

Identificação do ensaio

- Número do UTN: U1111-1216-3198
- Título público:

en

The effect of auriculotherapy and mechanical vibrations generated on oscillating vibratory platform in individuals knee arthrosis

pt-br

O efeito da auriculoterapia e das vibrações mecânicas geradas em plataforma oscilante vibratória em indivíduos Artrose do joelho

- Acrônimo científico:
- Acrônimo público:
- Identificadores secundários:
 - número do CAAE: 19826413.8.0000.5259
Orgão emissor: Plataforma Brasil
 - Número do Parecer do CEP: 2.528.890
Orgão emissor: Comitê de Ética em Pesquisa do Hospital Universitário Pedro Ernesto

Patrocinadores

Enviar mensagem

- Patrocinador primário: Universidade do Estado do Rio de Janeiro

- Patrocinador secundário:

- Instituição: Universidade do Estado do Rio de Janeiro

- Fontes de apoio financeiro ou material:

- Instituição: Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro - FAPERJ
 - Instituição: Conselho Nacional de Desenvolvimento Científico e Tecnológico

Condições de saúde

- Condições de Saúde:

en

Gonarthrosis, knee Joint Diseases.

pt-br

Gonartrose primária bilateral/auriculoterapia

- Descritores gerais para condições de saúde:

en

C05 Musculoskeletal diseases

pt-br

C05 Doenças musculoesqueléticas

es

C05 Enfermedades musculoesqueléticas

en

M00-M99 XIII - Diseases of the musculoskeletal system and connective tissue

pt-br

M00-M99 XIII - Doenças do sistema osteomuscular e do tecido conjuntivo

- Descritores específicos para condições de saúde:

Intervenções

- Intervenções:

en

Whole body vibration exercise (WBVE), Auriculotherapy, auriculotherapy association with WBVE, placebo control. Whole body vibration exercise protocol: There will be 10 sessions, 02 times per week, totaling 05 weeks of protocol. The oscillating/vibrating platform (OVP) used is of the alternating type. In order to obtain adequate chair height and knee flexion in the sitting posture, an initial study will be performed using a digital accelerometer. Individuals will be guided by the evaluators, to sit in a chair, with their feet propped at the base of the OVP, arms outstretched and hands on their knees. The base of the OVP will be previously marked in 3 positions for placing the feet of the participants. These positions correspond to 3 different peak-to-peak displacements (D) (Position 1 - D = 2,5 mm, position 2 - D = 5 mm and position 3 - D = 7,5 mm). The frequency will vary from 5 to 14 Hz. The total

pt-br

Exercício de Vibração de corpo inteiro (EVCI), Auriculoterapia, associação da auriculoterapia com EVCI, controle placebo. Protocolo de exercício de vibração de corpo inteiro: Serão realizadas 10 sessões, 02 vezes por semana, totalizando 05 semanas de protocolo. A plataforma oscilante/vibratória (POV) utilizada apresenta movimentos alternados de subida e descida de uma base de forma alternada, isto é, no momento em que o lado esquerdo sobe o lado direito desce, e vice-versa. Para a obtenção da altura da cadeira e do grau de flexão de joelho adequados na postura sentada, será realizado um estudo inicial utilizando um acelerômetro digital. Os indivíduos serão orientados pelos avaliadores, a sentar-se em uma cadeira, com os pés apoiados na base da POV, com os braços estendidos e com as mãos apoiadas sobre os joelhos. A base da POV estará previamente marcada em 3 posições para a colocação dos pés

intervention time will be 11 min divided into 3 sets of 3 minutes with 1 minute rest between them. An opaque board shall be attached to the OVP display so that the participant does not identify the time and frequency used. The Evaluator will follow all procedures and will guide the participant to report any discomfort that occurs during the WBVE. In the event of any discomfort or discomfort on the part of the participant, the procedure will be automatically terminated.

Protocol of auriculotherapy: A tape with two seeds will be placed on the points to be stimulated in both ears (Knee, Kidney and Shenmen point). The tapes will be changed once a week. All participants will be asked to stimulate points at least 3 times a day.

a) Control Group placebo (GC)(n=50): Seedless tapes will be affixed on the same points as the treatment protocol. The participant will remain in the sitting position with the feet in the OVP for the same period of the treatment protocol, but the OVP will be turned off.

b) Auriculotherapy Group (GAT)(n=50): A tape with 2 mustard seeds on Knee, Shenmen and Kidney points will be affixed. The participant will remain in the sitting position with the feet in the OVP for the same period of the treatment protocol, but the OVP will be turned off.

c) WBVE Group (GV)(n=50): Seedless tapes will be affixed on the same points as the treatment protocol. The participant will remain in the sitting position with the feet in the OVP following the biomechanical parameters described above.

d) Auriculotherapy + WBVE Group (GAT + V)(n=50): A tape with 2 mustard seeds on Knee, Shenmen and Kidney points will be affixed. The participant will remain in the sitting position with the feet in the OVP following the biomechanical parameters described above.

dos participantes. Essas posições correspondem a três deslocamentos pico a pico (D) distintos (Posição 1 - D = 2,5 mm; posição 2 - D = 5 mm e posição 3 - D = 7,5 mm). A frequência terá uma variação de 5 a 14 Hz. O tempo total de intervenção será de 11 min divididos em 3 séries de 3 minutos com 1 minuto de descanso entre elas. Será fixada uma placa opaca no visor da POV para que o participante não identifique o tempo e a frequência utilizada. O Avaliador acompanhará todo procedimento e orientará que o participante relate qualquer desconforto que ocorra durante o EVCI. Caso ocorra algum desconforto, ou mal estar por parte do participante, o procedimento será automaticamente encerrado.

Protocolo de auriculoterapia: Um esparadrapo com duas sementes será colocado nos pontos a serem estimulados em ambas orelhas (ponto Joelho, Rim e Shenmen). Os esparadrapos serão trocados uma vez por semana. Todos os participantes serão orientados a estimular os pontos pelo menos 3 vezes por dia.

a) Grupo Controle placebo (GC) (n=50): Serão afixados esparadrapos sem sementes sobre os mesmos pontos do protocolo de tratamento. O participante permanecerá no posicionamento sentado com os pés na POV pelo mesmo período do protocolo de tratamento, porém a POV estará desligada.

b) Grupo Auriculoterapia (GAT) (n=50): Serão afixados esparadrapos com 2 sementes de mostarda sobre os pontos Joelho, Shenmen e Rim. O participante permanecerá no posicionamento sentado com os pés na POV pelo mesmo período do protocolo de tratamento, porém a POV estará desligada.

c) Grupo EVCI (GV) (n=50): Serão afixados esparadrapos sem sementes sobre os mesmos pontos do protocolo de tratamento. O participante permanecerá no posicionamento sentado com os pés na POV

segundo os parâmetros biomecânicos descritos acima. d) Grupo Auriculoterapia + EVCI (GAT + V)(n=50): Serão afixados esparadrapos com 2 sementes de mostarda sobre os pontos Joelho, Sherman e Rím. O participante permanecerá no posicionamento sentado com os pés na PCV seguindo os parâmetros biomecânicos descritos acima.

• **Descritores para as intervenções:**

en E02.190.204 Auriculotherapy	pt-br E02.190.204 Auriculoterapia	es E02.190.204 Auriculoterapia
en G01.374.930 Vibration	pt-br G01.374.930 Vibração	es G01.374.930 Vibración
en E02.760.169.063.500.387 Exercise Therapy	pt-br E02.760.169.063.500.387 Terapia por Exercício	es E02.760.169.063.500.387 Terapia por Ejercicio
en H02.403.680 Physical and Rehabilitation Medicine	pt-br H02.403.680 Medicina Física e Reabilitação	es H02.403.680 Medicina Física y Rehabilitación
en T75.2 Effects of vibration	pt-br T75.2 Efeitos da vibração	es T75.2 Efectos de la vibración

Recrutamento

• **Situação de recrutamento:** Recrutando

• **Países de recrutamento**

- Brasil

• **Data prevista do primeiro recrutamento:** 10/05/2013

• **Data prevista do último recrutamento:** 31/01/2022

• **Tamanho da amostra alvo:** Género para inclusão: Idade mínima para inclusão: Idade máxima para inclusão:

200 - 18- 90-

• **Critérios de inclusão:**

en
Individuals over 18 years of age with Knee osteoarthritis or healthy (no chronic diseases or lesions in lower limbs).

pt-br
Indivíduos com idade superior a 18 anos, com Gonartrose ou saudáveis (sem doenças crônicas ou lesões em membros inferiores).

• **Critérios de exclusão:**

en
Individuals who are taking viscosupplementation and / or corticoids less than 12 months old; Individuals currently in another rehabilitation program; Individuals with clinical manifestations that did not allow the accomplishment of exercises; Individuals with presence of cardiac pacemaker; Individuals with recent surgeries in the lower limbs (1 year).

pt-br
Indivíduos que estejam fazendo uso de viscosuplementação e ou corticóides com menos de 12 meses; Indivíduos que se encontram no momento, em outro programa de reabilitação; Indivíduos com manifestações clínicas que não permitam a realização de exercícios; Indivíduos com presença de marca-passo cardíaco; Indivíduos com cirurgias

individuals with hip or bilateral knee arthroplasty; individuals with rheumatoid arthritis and / or spinal arthrodesis; individuals who refused to sign the Informed Consent Term (TCLE).

recortes em membros inferiores (1 ano), indivíduos com artroplastia de quadril ou bilateral de joelho, indivíduos com artrite reumatóide e/ou artrose de coluna; indivíduos que recusaram assinar o Termo de Consentimento Livre e Esclarecido (TCLE).

Tipo de estudo

- Desenho de estudos:

en
Randomized clinical trial, parallel, triple blind, 4-arm

pt-br
Ensaio clínico de tratamento, randomizado-controlado, paralelo, triplo-cego, com 4 braços.

Programa de acesso expandido	Enfoque do estudo	Desenho da Intervenção	Número de braços	Tipo de mascaramento	Tipo de alocação	Fase do estudo
	Tratamento	Paralelo	4	Tripla-cego	Randomizado controlado	N/A

Desfechos

- Desfechos primários:

en
Decreased pain level; verified through visual analogue scale (VAS). At least a 20% reduction in pain level is expected.

pt-br
Diminuição do nível de dor; verificada por meio da escala visual analógica (EVA); espera-se pelo menos uma redução de 20% do nível de dor.

en
Improvement of postural control, mobility and balance; verified through the Time Up and Go Test (TUG); a reduction in test run time of at least 5% between pre- and post-intervention is expected, and maintenance of follow-up improvement (7 and 14 days after the last session) is expected.

pt-br
Melhora do controle postural, da mobilidade e do equilíbrio; verificados por meio do Time Up and Go Test (TUG); espera-se uma redução no tempo de execução do teste de pelo menos 5% entre o pré e pós intervenção e uma manutenção da melhora no follow up (7 e 14 dias após a última sessão).

- Desfechos secundários:

en
Improvement of the knee range of motion, measured bilaterally with a digital Goniometer; angulation of active knee flexion is expected to increase by at least 5% between pre and post intervention and maintenance of improvement at follow up (7 and 14 days after the last session).

pt-br
Melhora do arco de movimento dos joelhos, mensurada bilateralmente com um Goniômetro digital; espera-se aumentar a angulação da flexão ativa do joelho em pelo menos 5% entre o pré e pós intervenção e uma manutenção da melhora no follow up (7 e 14 dias após a última sessão).

en
Improved flexibility; through anterior trunk flexion; it is expected to decrease the distance between the middle finger and the floor by at least 5%

pt-br
Melhora da flexibilidade; através da flexão anterior de tronco; espera-se diminuir a distância entre o dedo médio e o chão em pelo menos 5% entre o pré

between pre and post intervention and maintenance of improvement at follow up (7 and 14 days after the last session).

en

Analysis of the response of the organism to the interventions; verified through changes in blood parameters; it is hoped to analyze the changes to understand the physiological effect of whole-body vibration exercises between pre and post intervention.

e pós intervenção e uma manutenção da melhora no follow up (7 e 14 dias após a última sessão).

pt-br

Análise da resposta do organismo às intervenções; verificado por meio de alterações nos parâmetros sanguíneos; espera-se analisar as alterações para compreender o efeito fisiológico dos exercícios de vibração de corpo inteiro no pré e pós intervenção.

en

Improvement of the recruitment of muscle fibers of the lower limbs; verified by electromyographic tracing of the medial, anterior tibial, and vastus lateralis (bilateral, medial gastrocnemius muscles; an improvement of at least 5% between pre- and post-intervention is expected and maintenance of improvement at follow up (7 and 14 days after the last session).

pt-br

Melhora do recrutamento das fibras musculares dos membros inferiores; verificado através do traçado eletroencefálico dos músculos gastrocnêmio medial, tibial anterior e vasto lateral (bilateral); espera-se uma melhora de pelo menos 5% entre o pré e pós intervenção e uma manutenção da melhora no follow up (7 e 14 dias após a última sessão).

en

Improvement of body composition; verified through bioimpedance; an improvement of at least 5% between pre- and post-intervention is expected, and maintenance of improvement at follow-up (7 and 14 days after the last session) is expected.

pt-br

Melhora da composição corporal; verificada através da bioimpedância; espera-se uma melhora de pelo menos 5% entre o pré e pós intervenção e uma manutenção da melhora no follow up (7 e 14 dias após a última sessão).

en

Improvement of the quality of life; verified by means of the Western Ontario and McMaster Universities Osteoarthritis Index of Osteoarthritis (WOMAC), Medical Outcomes Study 36 - Item Short-Form Health Survey (SF-36) and Knee Injury Osteoarthritis Outcome Score - KOOS; an improvement of at least 15% between pre- and post-intervention and maintenance of improvement at follow-up (7 and 14 days after the last session) is expected.

pt-br

Melhora da qualidade de vida; verificada por meio dos questionários Western Ontario e McMaster Universities Osteoarthritis Index of Osteoarthritis (WOMAC), Medical Outcomes Study 36 - Item Short-Form Health Survey (SF-36) e Knee Injury Osteoarthritis Outcome Score - KOOS; espera-se uma melhora de pelo menos 15% entre o pré e pós intervenção e uma manutenção da melhora no follow up (7 e 14 dias após a última sessão).

en

Decreased "fear of falling"; verified through the Falls Efficacy Scale (FES-I) questionnaire; an improvement of at least 5% between pre- and post-

pt-br

Diminuição do "medo de cair"; verificada através do questionário Falls Efficacy Scale (FES-I); espera-se uma melhora de pelo menos 5% entre o pré e pós

Intervention is expected, and maintenance of improvement at follow-up (7 and 14 days after the last session) is expected.

en

Change in the temperature of the skins of the lower limbs; measured by a thermographic camera; it is expected to analyze changes in skin temperature during whole body vibration exercises to understand the effect of mechanical vibrations on the body.

Intervenção e uma manutenção da melhora no follow up (7 e 14 dias após a última sessão).

pt-br

Mudança na temperatura da pele dos membros inferiores; mensurada por uma câmera termográfica; espera-se analisar as alterações da temperatura da pele durante os exercícios de vibração de corpo inteiro para compreender o efeito das vibrações mecânicas no organismo.

en

Increased handgrip strength (HS); verified through the Manual Strength Dynamometer; a HS increase of at least 10% between pre- and post-intervention and maintenance of improvement at follow-up (7 and 14 days after the last session) is expected.

pt-br

Aumento da força de preensão palmar (FPP); verificada através do Dinamômetro de Força Manual; espera-se um aumento da FPP de pelo menos 10% entre o pré e pós intervenção e uma manutenção da melhora no follow up (7 e 14 dias após a última sessão).

en

Improvement in sleep quality; verified by the Pittsburgh Sleep Quality Index and Epworth Sleepiness Scale; an improvement of at least 5% between pre- and post-intervention is expected, and maintenance of improvement at follow-up (7 and 14 days after the last session) is expected.

pt-br

Melhora na qualidade do sono; verificada pelo Índice da Qualidade de Sono de Pittsburgh e Escala de Sonolência de Epworth; espera-se uma melhora de pelo menos 5% entre o pré e pós intervenção e uma manutenção da melhora no follow up (7 e 14 dias após a última sessão).

en

Increased functional capacity of lower limbs; verified through the Lequesne Index, Lysholm knee Scoring Scale and Short Physical Performance Battery (SPPB); an improvement of at least 5% between pre- and post-intervention is expected, and maintenance of improvement at follow-up (7 and 14 days after the last session) is expected.

pt-br

Aumento da capacidade funcional dos membros inferiores; verificada por meio do Índice de Lequesne, Lysholm knee Scoring Scale e Short Physical Performance Battery - SPPB; espera-se uma melhora de pelo menos 5% entre o pré e pós intervenção e uma manutenção da melhora no follow up (7 e 14 dias após a última sessão).

Contatos

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Total de Ensaios Clínicos 9780.

Existem 9780 ensaios clínicos registrados.

Existem 2694 ensaios clínicos recrutando.

Existem 183 ensaios clínicos em análise.

Total 3793 em rascunho.

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ANEXO C – Termo de Consentimento Livre e Esclarecido



TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Pesquisa sobre o efeito de um procedimento associado com uma das Práticas Integrativas e Complementares (auriculoterapia) no Sistema Único de Saúde e as vibrações mecânicas geradas em plataforma oscilante vibratória na evolução de indivíduos com doença crônica não transmissível (osteoartrite de joelho).

O(A) Sr(a). está sendo convidado(a) a participar de uma pesquisa. Antes de decidir participar, é importante que entenda o porquê que a pesquisa está sendo realizada, quais são os passos do estudo e os possíveis benefícios, riscos e desconfortos que pode lhe causar. Leia com calma as informações abaixo e esclareça todas as dúvidas.

Procedimentos do estudo e objetivos: Os exercícios de vibração de corpo inteiro são gerados através de vibrações mecânicas produzidas em plataforma oscilante/vibratória. Existem parâmetros biomecânicos importantes a serem considerados para a elaboração de um protocolo de tratamento. A auriculoterapia é uma técnica que utiliza sementes de mostarda que são colocadas em pontos específicos da orelha. Essas duas técnicas serão utilizadas na tentativa de melhora de sintomas devido a disfunção da articulação do joelho. O número total das sessões será 10 (dez), 2 vezes por semana com duração total de aproximadamente 20 min para cada sessão. O objetivo do presente estudo é verificar alterações clínicas devido à associação da auriculoterapia e dos exercícios de vibração de corpo inteiro.

Custos, não remuneração e compensação: Sua participação neste estudo não terá nenhum custo adicional. Somente serão coletados dados a partir de seus registros médicos e avaliações realizadas durante a pesquisa. Sua participação neste estudo não será remunerada.

Riscos e benefícios: A coleta de sangue será realizada por profissional habilitado e capacitado. O material utilizado será identificado e descartável a fim de garantir total segurança ao participante. Todos os demais procedimentos realizados não serão invasivos e sem riscos relacionados à obtenção de informações para este estudo. Os seus cuidados médicos não serão alterados por sua participação.

Confidencialidade: As normas brasileiras garantem o sigilo dos seus dados. Todas as informações desse estudo são confidenciais. Seus dados pessoais permanecerão sob sigilo absoluto, no Laboratório de Vibrações Mecânicas e Práticas Integrativas – LAVIMPI, onde se realizará a pesquisa.

Participação voluntária: Sua participação é voluntária; ou seja, você não é obrigado (a) a participar. Seu tratamento e relacionamento com o médico não serão afetados pela decisão de participar ou não deste estudo. Caso decida participar, receberá este documento para assinar em duas vias. Uma ficará com você e outra com o responsável pela pesquisa. Você ainda tem liberdade para deixar o estudo a qualquer momento sem precisar se explicar por que decidiu sair. Caso você recuse participar deste estudo, você não será penalizado de nenhuma forma e sua decisão não prejudicará qualquer cuidado médico ao qual você tem direito.

Informações importantes: Se você tiver dúvidas em relação aos seus direitos como participante da pesquisa entre em contato com o Comitê de Ética em Pesquisa do Hospital Universitário Pedro Ernesto no Boulevard 28 de Setembro, 77 – Térreo, no telefone (21) 2264-0853 ou procure o responsável por esse estudo - Mário Bernardo Filho, Professor Titular da UERJ, Boulevard 28 de Setembro, 87, 4º andar, Departamento de Biofísica e Biometria, Laboratório de Vibrações Mecânicas e Práticas Integrativas - LAVIMPI pelo telefone (21) 2868-8332.

Projeto de Pesquisa dos Departamentos de Biofísica e Biometria e de Ortopedia.

Investigador Principal: Prof. Dr. Mário Bernardo-Filho

Instituição: Instituto de Biologia Roberto Alcântara Gomes, Hospital Universitário Pedro Ernesto (HUPE), Universidade da Terceira Idade (UNATI) e Policlínica Piquet Carneiro (PPC) da Universidade do Estado do Rio de Janeiro (UERJ).

1) Eu li, ou leram para mim o Termo de Consentimento Livre e Esclarecido para esse estudo. Recebi todas as explicações sobre a natureza, objetivo e duração deste estudo. As minhas perguntas foram respondidas satisfatoriamente.

2) Concordo em participar desse estudo.

3) Entendo que minha participação no estudo é voluntária e que posso me recusar a participar ou posso sair do estudo a qualquer momento. Caso eu recuse participar deste estudo, não serei penalizado de nenhuma forma e minha decisão não prejudicará qualquer cuidado médico ao qual tenho direito.

Rio de Janeiro, ____ de _____ de _____.

Nome do pesquisador que apresentou o TCLE: _____ Ass: _____

Nome do Participante: _____ Ass: _____

Nome da Testemunha: _____ Ass: _____

ANEXO D – Comprovante de submissão da revisão sistemática

Complementary Therapies in Medicine
Inflammatory biomarkers responses of whole-body vibration in different clinical status.
A systematic review.
 --Manuscript Draft--

Manuscript Number:	CTIM-D-20-00067R1
Article Type:	Review Article
Section/Category:	Health Services Research
Keywords:	inflammation; whole-body vibration exercise; cytokines; Adipokines; C-reactive protein; physical and rehabilitation medicine
Corresponding Author:	Aline Cristina Gomes Santos Universidade do Estado do Rio de Janeiro Rio de Janeiro, RJ BRAZIL
First Author:	Eloá Moreira-Marconi
Order of Authors:	Eloá Moreira-Marconi Ygor Teixeira-Silva Alexandre Gonçalves de Meirelles Maria Eduarda de Souza Melo-Oliveira Aline Cristina Gomes Santos Laisa Liane Paineiras-Domingos Adérito Selxas Danúbia da Cunha de Sá-Caputo Mario Bernardo-Filho
Abstract:	<p>Objective: To summarize effects of whole-body vibration (WBV) on inflammatory biomarkers response (IBR) in different clinical status by systematic review.</p> <p>Design: Systematic Review according Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and registered in International Prospective Register of Systematic Reviews (PROSPERO) number CRD42020187943.</p> <p>Method: Searches were conducted using Physiotherapy Evidence Database (PEDro), Medline/PubMed, Web of Science, SPORTDiscus, The Cochrane Library, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Scopus databases to identify studies about the effect of WBV on IBR in different clinical status. The methodological quality (PEDro scale), risk of bias (Cochrane Collaboration's tool) and level of evidence (National Health and Medical Research Council hierarchy of evidence-NHMRC) were rated.</p> <p>Results: Four randomized clinical trials (RCT) met the selection criteria. The studies described different protocols and clinical status of the patients. Two works were classified as 'high', one 'fair' and one 'poor' by PEDro score. One paper was classified as low risk of bias, two as unclear risk and one as high in performance bias domain. The studies included showed benefits related with IBR (cytokines, adipokines and c-reactive protein) in various clinical conditions (healthy elderly, obese, healthy male and knee osteoarthritis elderly) using several WBV protocols. All studies described modification on IBR.</p> <p>Conclusion: WBV might be useful on the management of the inflammatory conditions. However, there is no sufficient evidence that WBV could have relevant effects on IBR due the diversity of protocols and clinical conditions. Therefore, investigations with more RCT might be conducted.</p>
Suggested Reviewers:	Redha Talar redha.talar@univ-reims.fr Borja Sanudo bsancon@us.es

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12/01/2021

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Eloá Moreira Marconi <eloamarconi@gmail.com>

Fwd: Confirming submission to Complementary Therapies in Medicine

1 mensagem

Aline Santos <aline.santos@uerj.br>
Para: Eloá Moreira-Marconi <eloamarconi@gmail.com>

12 de janeiro de 2021 18:00

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Manuscript Number: CTIM-D-20-00067R1

Inflammatory biomarkers responses of whole-body vibration in different clinical status. A systematic review.

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