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Artigo original

Effects of whole body vibration exercises on functional parameters: A study protocol involving chronic obstructive pulmonary disease

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Abstract

Introduction: Chronic obstructive pulmonary disease (COPD) is a chronic disease related to various systemic manifestations including dyspnea, exercise intolerance and peripheral muscular dysfunction, with a direct impact on functional capacity. Objectives: To describe a whole body vibration exercises (WBVE) protocol to verify the clinical benefits, and the potential of exacerbation of the disease. Methods: Individuals diagnosed with COPD, aged ≥ 40 years, will be randomly distributed into 4 groups: control group (CG) who will not undergo WBVE, with their normal daily routine, group who will be exposed to WBVE in the sitting position in an auxiliary chair once a week (GS1) and twice a week (GS2) and WBVE group twice a week in the standing position with knee flexion (GP2). The protocol will last 6 weeks, each session will have 5 sets of 1 min vibration with 1 min rest, frequency 25 Hz and peak-to-peak displacement 2.5 mm. Muscle strength and function will be assessed through manual dynamometry and surface electromyography and dyspnea using the Modified Borg Scale (MBS) and the Medical Research Council (MRC) Scale. Discussion: WBVE, due to the various effects already described, seem to be a promising exercise modality for individuals with COPD, potentially being used as an instrument for pulmonary rehabilitation. Conclusions: The results of this study may provide evidence to justify a WBVE program to the improvement on the physical performance and on neuromuscular function of individuals with COPD.

Keywords: COPD; Whole-body vibration exercise; Muscular function; Pulmonary rehabilitation.

Resumo

Efeitos dos exercícios de vibração de corpo inteiro em parâmetros funcionais: Protocolo envolvendo indivíduos com doença pulmonar obstrutiva crônica

Introdução: A doença pulmonar obstrutiva crônica (DPOC) é uma doença crônica relacionada a várias manifestações sistêmicas incluindo dispneia, intolerância ao exercício e disfunção muscular periférica, com impacto direto na capacidade funcional. Objetivos: Descrever o protocolo de um estudo que utilizará os exercícios de vibração de corpo inteiro (EVCI) como modalidade de exercício físico (EF) em indivíduos com DPOC com o objetivo de verificar os benefícios clínicos e o potencial de exacerbação da doença. Metodologia: Indivíduos com diagnóstico de DPOC, com idade ≥ 40 anos, serão distribuídos randomicamente em 4 grupos: grupo controle (GC) que não será submetido aos EVCI, grupo submetido aos EVCI na posição sentada 1 vez por semana (GS1) e 2 vezes por semana (GS2) e grupo submetido aos EVCI na posição agachada 2 vezes por semana (GP2). O protocolo terá duração de 6 semanas, cada sessão terá 5 séries de 1 min de vibração com 1 min de repouso, frequência de 25 Hz e deslocamento pico a pico 2,5 mm. Serão avaliadas força e função muscular usando o dinamômetro manual e a eletromiografia de superfície e a dispneia pela Escala Modificada de Borg (EMB) e Escala *Medical Research Council* (MRC). Discussão: Os EVCI, em decorrência de vários efeitos já descritos, parecem ser uma modalidade de exercício promissora para uso em indivíduos com DPOC,

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podendo potencialmente ser utilizado como instrumento da reabilitação pulmonar. Conclusões: Os resultados deste estudo poderão fornecer evidências para justificar um programa de reabilitação com EVCI para melhora do desempenho físico e função neuromuscular de indivíduos com DPOC.

Descritores: DPOC; Exercício de vibração de corpo inteiro; Função muscular; Reabilitação pulmonar.

Resumen

Efectos de los ejercicios de vibración de cuerpo entero en parámetros funcionales: Protocolo envolviendo individuos con enfermedad pulmonar obstructiva crónica

Introducción: La enfermedad pulmonar obstructiva crónica (EPOC) es relacionada con varias manifestaciones sistémicas incluyendo disnea, intolerancia al ejercicio y disfunción muscular periférica, con impacto directo en la capacidad funcional. Objetivos: Proponer uno protocolo de los ejercicios de vibración de cuerpo entero (EVCE) para ser utilizado como modalidad de ejercicio físico en individuos con EPOC y verificar los beneficios clínicos y las potenciales exacerbaciónes de la enfermedad. Metodología: En el caso, pacientes con diagnóstico de EPOC, con edad ≥ 40 años, se distribuirán aleatoriamente en 4 grupos: grupo control (GC) que no será sometido a los EVCE, grupo sometidos a los EVCE en la posición sentada 1 vez a la semana (GS1) y 2 veces por semana (GS2) y grupo sometido a los EVCE en la posición agachada 2 veces por semana (GP2). El protocolo tendrá una duración de 6 semanas, cada sesión tendrá 5 series de 1 min de vibración con 1 min de reposo, frecuencia de 25 Hz y desplazamiento pico a pico 2,5 mm. Se evaluará fuerza y función muscular a través de la dinamometría manual y de la electromiografía de superfície, y la disnea a través de la Escala Modificada de Borg (EMB) y Escala del Medical Research Council (MRC). Discusión: Los EVCE, a causa de varios efectos ya descritos, parecen ser una modalidad de ejercicio prometedora para uso en individuos con EPOC, pudiendo potencialmente ser utilizado como instrumento de la rehabilitación pulmonar. Conclusiones: Los resultados de este estudio pueden proporcionar evidencia para justificar un programa de rehabilitación con EVCE para mejorar el desempeño físico y la función neuromuscular de individuos con EPOC.

Palabras clave: EPOC; Ejercicio de vibración de cuerpo entero; Función muscular; Rehabilitación pulmonar.

Introdução

The number of people with chronic diseases is increasing, but the knowledge about the impact on the multimorbidity and on the life expectancy is still limited.[1] Chronic diseases present gradual onset, with long or uncertain duration, which, in general, present multiple causes. Among the chronic diseases, cardiovascular diseases, chronic respiratory diseases (bronchitis, asthma, chronic obstructive pulmonary disease – COPD –, rhinitis), hypertension, cancer, diabetes and metabolic diseases (obesity, diabetes, dyslipidemia) can be mentioned. COPD is a chronic inflammatory condition of the airways[1] and one of the major causes of morbidity and mortality in the world.[2-4] The reduction of the pulmonary function is an important predictor for this cause,[2,5] and, it is associated with acute attacks such as increased cough, dyspnea and purulent sputum.[6,7]

According to the 2010 Global Burden of Disease (GBD) study, COPD was responsible for about 5% of global disability and 5% of total deaths (2.9 million).[7,8] COPD is rated as the fourth most common specific cause of death globally and predicted to be the third by 2030, in the absence of proper interventions that address the limitation of risks.[9]

Due to its chronic nature and its prevalence, it also results in several other related systemic manifestations, such as exercise intolerance,[10] peripheral muscle dysfunction,[11,12] dyspnea, recurrent acute and severe exacerbations, and the need for chronic pulmonary therapy, leading to hospitalization and resulting in impairment on the quality of life.[12,13] Moreover, muscle weakness contributes to exercise intolerance[8] which may contribute to the severity of the disease,[4,9] generating high costs for the health system worldwide[3,4]

The treatment program conventionally used for individuals with COPD is pulmonary rehabilitation (PR).[14] The goal of this intervention program is to improve physical performance and reduce dyspnea to prolong the life of individuals with COPD. Together with a PR element, physical exercise (PE) is recommended for all individuals with COPD.[15] The skeletal muscle training being an important component of PR[9] that improves exercise tolerance and performance in daily activities.[10] Resistance work during peripheral muscle training is effective in the treatment of these individuals.[16,17] PE also reduces COPD exacerbations and mortality. It would be a common general intervention to the management of COPD, being related to (i) the prevention and treatment of diseases, (ii) the well-being physical and psychological, and (iii) reduction of all causes of mortality.[3,8] However, endurance and aerobic exercises[18] are associated with a higher level of perceived dyspnea and the “fear of lacking air” lead individuals to have less adherence to physical activities.[10,19] The use of training for the peripheral musculature in the individual with COPD involves careful consideration of the possibility of exacerbations, risk of acute dyspnea or hypoxemia during resistance exercises[18,20] and/or aerobics.[21]

Knowing the importance of PE to improve life conditions of individuals with COPD, and since these modalities can promote exacerbation of the disease, research in this field is necessary, developing safe means to offer PE as a treatment. The whole body vibration exercises (WBVE) arise in this context. Studies have demonstrated the efficacy of WBVE, as a form of PE, without provoking exacerbation of the disease, with several benefits for these individuals.[22,23] It is suggested that WBVE, when used as a modality of PE, under appropriated conditions, in individuals with COPD, does not lead to exacerbation of the disease, bringing several clinical benefits. Therefore, WBVE may be a great intervention in the management of these individuals, but more studies are needed.[22,24]

WBVE are produced when the subject is in contact with the base of the oscillating/vibratory platform (OVP) turned on[2]. OVP can be used to perform PA by transmitting mechanical vibration (MV)[25] to the person's body and can improve physical fitness.[26] MV is a physical agent with periodic, deterministic oscillation, acceleration change, force and displacement over time.

WBVE induces muscle contractions through involuntary reflex and may be useful to aid in the treatment of COPD individuals.[27] In addition, WBVE could also be responsible for neuro-endocrine responses[28]. In this way, WBVE can be an option in the management of individuals with COPD, used as a PA in the PR protocol,[29] in an effective, safe and viable intervention.[29-31]

Accordingly, the current work aims to describe a whole body vibration exercises (WBVE) protocol to verify the clinical benefits, and the potential of exacerbation of the disease. In addition, it will investigate the effects of WBVE intervention on the electromyographic pattern of muscles of the lower limbs, in the handgrip strength (HS), on the exercise tolerance and on functional performance of COPD individuals. We will conduct a prospective and randomized controlled trial, crossover, to investigate the efficacy of a 6-week WBV exposition on comprehensive outcomes in COPD individuals. The results of this study will determine the effectiveness and provide scientific evidence for the use of the WBVE to the COPD individuals.

Methods

Ethics Committe

Project approved by the *Comitê de Ética em pesquisa de seres humanos do Hospital Universitário Pedro Ernesto (HUPE), Universidade do Estado do Rio de Janeiro (UERJ)* (CAAE: 49219115.3.0000.5259).

Study design

Prospective and randomized controlled, crossover, double-blinded trial. Individuals with diagnosis of COPD, aged 40 years and older, will be screened at the *Serviço de Pneumologia* by a physician, *Policlínica Piquet Carneiro (PPC), UERJ*. The individuals will be randomized and allocated into 4 groups: control group (CG) who will not undergo WBVE, with their normal daily routine, group who will be exposed to WBVE in the sitting position in an auxiliary chair once a week (GS1) and twice a week (GS2) and WBVE group twice a week in the standing position with knee flexion (GP2).

Participants

Recruitment of participants is ongoing.

Inclusion criteria

Individuals of (i) both sexes and (ii) outpatient at the *HUPE*, diagnosed with COPD based on criteria established by the Global Initiative for Chronic Lung Disease (GOLD) with stable disease with Expiratory Volume Forced in the 1st Second (FEV1) < 50% and independents.

Exclusion criteria

Individuals with exacerbation of the disease for less than 3 months; (i) labyrinthitis; (ii) osteoporosis reported; (iii) other respiratory diseases; (iv) pacemaker; (v) previous history of fractures and/or other orthopedic diseases submitted to surgeries with implantation of metallic material; (vi) peripheral vascular disease and/or thromboembolism; (vii) heavy smoker and/or alcoholic beverage; (viii) decompensated cardiovascular disease; (ix) aneurysm; (x) previous vitreous hemorrhage; (xi) malnutrition; (xii) postoperative; (xiii) neurological disease that causes "fear" to the movements in the OVP; (xiv) serious or incapacitating clinical illness, at the decision of the investigator.

Withdrawal criteria and management

Withdrawal from the study will be allowed if the participant (i) made such a request, (ii) developed a serious disease, such as heart disease or stroke, and continuing their participation became inappropriate in the opinion of the investigator and (iii) had an adverse reaction related to the WBVE

Characterization of the parameters used in the intervention with WBVE

The type will be a side-to-side alternating OVP (Novaplate fitness evolution, *DAF Produtos Hospitalares Ltda*, from Estek As, *São Paulo*). In the sitting position, individuals will be positioned seated in a chair placed in front of the OVP with their hands resting on the knees and the feet will be on the base of the OVP. In the standing position, individuals will be standing with 130 degrees knee flexion. The individuals will be without footwear. In all groups the peak-to-peak displacement will be 2.5 mm. The time of the interventions will be 6 weeks, each session will have 5 sets, with working time (WT) of 1 min interpased with a rest time (TR) of 1 min. The frequency used will be 25 Hz. A supervisor followed every procedure and instructed the patient to report any discomfort. Depending on the situation, the procedure may be finished.

Surface electromyography

Electromyography (EMG) is the technique that permits to evaluate the muscular function by means of the interpretation of the electric signals emitted by the skeletal musculature.[32] Surface electrodes will be positioned in the vastus lateralis, vastus medial and rectus femoris muscles of the individuals (surface electrodes will be positioned according to SENIAM orientation).[32] This electromyographyc pattern will be collected through a software coupled to the instrument (EMG832WF, EMG System, São José dos Campos) on the first and last day of the intervention (before and after the session) in all groups.

Handgrip strength

The handgrip strength (HS) will be evaluated with an isometric, hydraulic hand dynamometer (model EMG832WF, EMG System, *São José dos Campos, SP*). Dynamometry is a reliable, reproducible and easy-to-use tool.[33]

Three measures of HS with the dominant hand, for 3 seconds each, with verbal encouragement, and a 15-second interval between evaluations will be performed before and after the intervention in each group. It will be considered the best of the three measures.[34,35].

Modified Borg Scale and Medical Research Council Scale

The Medical Research Council (MRC)[36] breathlessness scale comprises five statements that describe almost the entire range of respiratory disability from none (Grade 1) to almost complete incapacity (Grade 5).[37] It will be used to assess dyspnea on the first and last day of the interventions.

The modified Borg Scale (MBS) is a numerical rule from "0" to "10", where the individual indicates a score for their level of dyspnea, at the beginning and at the end of each session, "0" being no dyspnea and "10", dyspnea maximum. It has the potential to provide quick, easy, and rapid information about a patient's dyspnea state.[38]

Sit-to-stand test five times

The sit-to-stand test evaluates an individual's activity of daily living, and uses the repetitive motion of standing-up and siting down on a chair.[16]

The test begins with the individual sitting in a chair, with the spine erect, feet resting on the floor, and arms crossed against the chest. After the signal of the supervisor, the individual will stand up fully and then returns to the fully seated position, being encouraged to sit and stand for five consecutive times. The supervisor records the total time that the individual takes to finish the test. This test will be performed on the first and last day of the intervention.

Statistical analysis

For the statistical analysis, the normality test of Shapiro-Wilk will be used and appropriate tests will be applied later. The software will be BioEstat 5.3. An intent-to-treat analysis will be performed including all participants in the analysis according to the original allocation of the group. The repeated measurement variance analysis will be used to evaluate the difference between and within the group. The Bonferroni post hoc test will be used to compare the results. Data will be presented as mean and standard deviation, and the significance will be set to 0.05.

Discussion

Strategies for prevention or ameliorating COPD exacerbations may have an important impact on the health burden of this common disease and thus improve the morbidity and mortality.[39]

Gloeckl et al.[22] has suggested that WBVE seem to be a promising exercise modality for patients with COPD and may enhance the effects of a multidisciplinary rehabilitation program. Moreover, Gloeckl et al[40] have pointed out that the implementation of WBVE improve postural balance performance and muscle power output. The neuromuscular adaptation related to improved balance performance may be an important mechanism of the improvement in exercise capacity after WBVE especially in COPD patients with impaired balance performance and low exercise capacity. Pleguezuelos et al.[41] have verified that WBVE provide significant improvements in functional capacity in severe COPD patients without changes in muscular force. Braz Jr et al.[24] have pointed out the WBVE may potentially be a safe and feasible way to improve functional capacity in the 6-minute walk test (6MWT) of patients with COPD undergoing a training program on the vibrating platform as well as in all domains of the Saint George´s Respiratory Questionnaire quality of life. Neves et al[42] demonstrated that the WBVE induced clinically significant benefits regarding exercise capacity, muscle strength and quality of life in patients with COPD, that were not related to inflammatory-oxidative biomarkers changes.

Pleguezuelos et al, 2013[41] have reported that WBVE during hospitalized exacerbations did not cause procedure-related adverse events and induced clinically significant benefits regarding exercise capacity and health-related quality of life that were associated with increased serum levels of irisin, a marker of muscle activity. In this line, Furness et al[43] have verified in a community-based proof-of-concept trial that a session of WBVE can be completed with the absence of dyspnea for people with COPD. Furthermore, there were no meaningful differences among WBVE and no vibration group for heart rate and oxygen saturation. There is scope for long-term community-based intervention research using WBVE given the known effects of WBVE on peripheral muscle function and functional independence. Moreover, Furness et al,[10] showed that WBVE did not exacerbate symptoms of COPD that can be associated with physical inactivity. The WBVE intervention improved tests to simulate activities of daily living such as rising from a chair, turning, and walking gait with greater effect than a no vibration group. As a standalone community-based intervention, WBVE was an efficacious mode of exercise training for people with stable COPD that did not negatively affect exercise tolerance or exacerbate the disease, while concurrently improving functional performance of the lower limbs.[10]

Putting together all the considerations, it is possible to suggest that WBVE seem to be an important modality of exercise for the management of individuals with COPD. This stimulates the elaboration of the protocols presented in the current work.

The strengths of our protocol are that 1) this investigation responses on neuromuscular function through the evaluation of the electromyographic pattern after WBVE in individuals with COPD in muscles, which has not been described in this population; 2) the study with two different protocols involving WBVE, with an intervention period of 6-weeks; 3) the evaluation of dyspnea through the MBS and the MRC will permit to verify the impact of the WBVE. On the other hand, the use of a large sample size will also address the current study's limitation of relying on a relatively small study population and the fact that it is not a multicenter trial.

Conclusion

In conclusion, this study attempts to estimate the effect of WBVE on outcomes, including daily life function and neuromuscular control, in individuals with COPD. The study results may provide evidence to support the beneficial effects of a WBVE program on the physical performance and neuromuscular control of individuals with COPD. The findings of this study will fill the research gap in the efficacy of WBVE based on the results of the proposed project. Further comprehensive research on the exercise rehabilitation of COPD will be proposed. Furthermore, the possible mechanism of postural instability in COPD patients may be discussed.

References

1. Raluy-Callado M, Lambrelli D, MacLachlan S, et al. Epidemiology, severity, and treatment of chronic obstructive pulmonary disease in the United Kingdom by GOLD 2013. Int J Chron Obstruct Pulmon Dis. 2015;10:925-937.
2. Greulich T, Nell C, Koepke J, et al. Benefits of whole body vibration training in patients hospitalised for COPD exacerbations - a randomized clinical trial. BMC Pulmonary Medicine. 2014;14:60.
3. Guertin KA, Gu F, Wacholder S, et al. Time to First Morning Cigarette and Risk of Chronic Obstructive Pulmonary Disease: Smokers in the PLCO Cancer Screening Trial. You M, ed. PLoS ONE. 2015;10e0125973.
4. Global Initiative for Chronic Obstructive Lung Disease [homepage on the Internet] Global Strategy for the Diagnosis, Management and Prevention of COPD. Global Initiative for Chronic Obstructive Lung Disease (GOLD); 2014.
5. World Health Organization (WHO). Chronic obstructive pulmonary disease (COPD). Updated January 2015; Fact sheet N°315. Available from: http://www.who.int/mediacentre/factsheets/fs315/en/. Acessed: 15 Jul, 2018.

6. Liao L-Y, Chen K-M, Chung W-S, et al. Efficacy of a respiratory rehabilitation exercise training package in hospitalized elderly patients with acute exacerbation of COPD: a randomized control trial. Int J Chron Obstruct Pulmon Dis. 2015;10:1703-1709.
7. Carr SJ, Goldstein RS, Brooks D. Acute exacerbations of COPD in subjects completing pulmonary rehabilitation. Chest. 2007;132:127-134.
8. Franssen FM, Broekhuizen R, Janssen PP, et al. Limb muscle dysfunction in COPD: Effects of muscles wasting and exercise training. Med Sci Sports Exerc. 2005;37:2-9.
9. World Health Organization. The global impact of respiratory disease. Accessed: 2018 August 1. Available from: http:// www.who.int/gard/publications.
10. Furness T, Joseph C, Naughton G, et al. Benefits of whole-body vibration to people with COPD: a community-based efficacy trial. BMC Pulm Med. 2014;14:38.
11. Mathers CD, Loncar D. Projections of Global Mortality and Burden of Disease from 2002 to 2030. Samet J, editor. PLoS Med. 2006;3:e 442.
12. Spruit MA, Singh SJ, Garvey C, et al. An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. Am J Respir Crit Care Med. 2013;188:e13-64.
13. Bernard S, Whittom F, Leblanc P, et al. Aerobic and strength training in patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med. 1999;159:896–901.
14. Nici L, Donner C, Wouters E, et al. American Thoracic Society/European Respiratory Society statement on pulmonary rehabilitation. Am J Respir Crit Care Med. 2006;173:1390-413.
15. Vestbo J, Hurd SS, Agustí AG, et al. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. Am J Respir Crit Care Med. 2013;187:347-65.
16. Furness T, Bate N, Welsh L, et al. Efficacy of a whole-body vibration intervention to effect exercise tolerance and functional performance of the lower limbs of people with chronic obstructive pulmonary disease. BMC Pulmonary Medicine. 2012;12:71.
17. O'Shea S, Taylor N, Paratz F. peripheral muscle strength training in COPD a systematic review. Chest. 2004;126:903-914.
18. Panton LB, Golden J, Broeder CE, et al. The effects of resistance training on functional outcomes in patients with chronic obstructive pulmonary disease. Eur J Appl Physiol. 2004;91:443-9.
19. Normandin EA, McCusker C, Connors M, et al. An evaluation of two approaches to exercise conditioning in pulmonary rehabilitation. Chest. 2002;121:1085-91.
20. Kongsgaard M, Backer V, Jørgensen K, et al. Heavy resistance training increases muscle size, strength and physical function in elderly male COPD-patients--a pilot study. Respir Med. 2004;98:1000-7.
21. Oliveira CC, Carrascosa CR, Borghi-Silva A, et al. Influence of respiratory pressure support on hemodynamics and exercise tolerance in patients with COPD. Eur J Appl Physiol. 2010;109:681-9.
22. Gloeckl R, Heinzelmann I, Baeuerle S, et al. Effects of whole body vibration in patients with chronic obstructive pulmonary disease--a randomized controlled trial. Respir Med. 2012 Jan;106;1:75-83.
23. Sá-Caputo D, Gonçalves CR, Morel DS, et al. Benefits of Whole-Body Vibration, as a Component of the Pulmonary Rehabilitation, in Patients with Chronic Obstructive Pulmonary Disease: A Narrative Review with a Suitable Approach. Evidence-based Complementary and Alternative Medicine: eCAM. 2016;2016:2560710.
24. Braz Júnior DS, Dornelas de Andrade A, Teixeira AS, et al. Whole-body vibration improves functional capacity and quality of life in patients with severe chronic obstructive pulmonary disease (COPD): a pilot study. Int J Chron Obstruct Pulmon Dis. 2015;10:125-32.
25. Rittweger J. Vibration as an exercise modality: how it may work, and what its potential might be. Eur J Appl Physio. 2010;108:877-904.
26. Bogaerts ACG, Delecluse C, Claessens AL, et al. Effects of whole body vibration training on cardiorespiratory fitness and muscle strength in older individuals (A I-year randomised controlled trial). Age Ageing; 2009;1-7.
27. Cidem M, Karacan I, Diraçoglu D, et al. A Randomized Trial on the Effect of Bone Tissue on Vibration-induced Muscle Strength Gain and Vibration-induced Reflex Muscle Activity. Balkan medical journal. 2014;31:11-22.
28. Prisby RD, Lafage-Proust M, Malaval L, et al. Effects of whole body vibration on the skeleton and other organ systems in man and animal models: What we know and what we need to know. Ageing Res Rev. 2008;7:319-329.
29. Cardinale M, Wakeling J. Whole body vibration exercise: are vibrations good for you? Br J Sports Med. 2005;39:585-589.
30. Furness T, Joseph C, Naughton G, et al. Benefits of whole-body vibration to people with COPD: a community-based efficacy trial. BMC Pulm Med. 2014;14:38.
31. Zaki ME. Effects of whole body vibration and resistance training on bone mineral density and anthropometry in obese postmenopausal women. J Osteoporos [Internet]. 2014. Acessed: 2018 Jul 10. Available from: http://www.hindawi.com/ journals/jos/2014/702589/
32. Balshaw TG, Fry A, Maden-Wilkinson TM, et al. Reliability of quadriceps surface electromyography measurements is improved by two vs. single site recordings. Eur J Appl Physiol. 2017;117:1085-1094.
33. Savva C, Giakas G, Efstathiou M, et al. Test-retest reliability of handgrip strength measurement using a hydraulic hand dynamometer in patients with cervical radiculopathy. J Manipulative Physiol Ther. 2014;37:206-210.
34. Kosar AC, Candow DG, Putland JT. Potential beneficial effects of whole-body vibration for muscle recovery after exercise. J Strength Cond Res. 2012;26:2907-11.
35. Gordon NM, Rudroff T, Enoka JA, et al. Handedness but not dominance influences variability in endurance time for sustained, submaximal contractions. J Neurophysiol 2012;108:1501-10.
36. Crisafulli E, Clini EM. Measures of dyspnea in pulmonary rehabilitation. Multidiscip Respir Med. 2010;5:202-10.
37. Stenton C. The MRC breathlessness scale. Occup Med (Lond). 2008;58:226-7.
38. Kendrick KR, Baxi SC, Smith RM. Usefulness of the modified 0-10 Borg scale in assessing the degree of dyspnea in patients with COPD and asthma. J Emerg Nurs. 2000. 26:216-22.
39. de Oliveira LC, de Oliveira RG, de Almeida Pires-Oliveira DA. Effects of Whole-Body Vibration Versus Pilates Exercise on Bone Mineral Density in Postmenopausal Women. J Geriatr Phys Ther. 2018 Feb 12. doi: 10.1519/JPT.0000000000000184.
40. Gloeckl R, Jarosch I, Bengsch U, et al. What's the secret behind the benefits of whole-body vibration training in patients with COPD? A randomized, controlled trial. Respir Med. 2017;126:17-24.

41. Pleguezuelos E, Pérez ME, Guirao L, et al. Effects of whole body vibration training in patients with severe chronic obstructive pulmonary disease. Respirology. 2013;18:1028-34.
42. Neves CDC, Lacerda ACR, Lage VKS, et al. Whole-body vibration training increases physical measures and quality of life without altering inflammatory-oxidative biomarkers in patients with moderate COPD. J Appl Physiol (1985). 2018 May 3. doi: 10.1152/japplphysiol.01037.2017.
43. Furness T, Joseph C, Welsh L, et al. Whole-body vibration as a mode of dyspnoea free physical activity: a community-based proof-of-concept trial. BMC Res Notes. 2013 Nov 11;6:452. doi: 10.1186/1756-0500-6-452.