ORIGINAL ARTICLE

Comparison of the effects of resistance exercise versus kinesiotherapy in knee osteoarthritis

Natália Cristina de Oliveira[1], Sandoval Vatri[2], Fabio Marcon Alfieri[3]

ABSTRACT

Increased life expectancy in several populations makes osteoarthritis (OA) an important public health issue, as it is a very prevalent chronic disease and leading cause of pain and disability among adults and elderly. **Objective:** The aim of this study was to compare pain, mobility, functional capacity, and strength of patients with knee osteoarthritis submitted to two different interventions: resistance exercise (REG) and kinesiotherapy (KIG). **Methods:** This was a prospective randomized single blind clinical trial, which involved the participation of 30 adults of both sexes diagnosed with knee OA. Volunteers were evaluated for pain, stiffness, function, functional mobility, and strength by a blinded evaluator before and after the interventions. Through a simple drawing, participants were randomly assigned to one of the two intervention groups, and underwent 15 twice-weekly treatment sessions, lasting 30 minutes each. **Results:** Both interventions promoted significant improvements in all variables, and there were no reports of any adverse effects throughout the research. **Conclusion:** Both resistance exercise and kinesiotherapy are effective in improving pain, stiffness, function, functional mobility, and strength in patients with knee OA.

Keywords: Osteoarthritis Knee, Exercise, Rehabilitation

[1] Professor, Course of Physical Education and Masters in Health Promotion - UNASP.
[2] Student of the Master's Course in Health Promotion - UNASP.
[3] Coordinator of the Master's Course in Health Promotion - UNASP.

Mailing address:
Centro Universitário Adventista de São Paulo - UNASP
Fabio Marcon Alfieri
Estrada de Itapecerica, 5859
CEP 05858-001
São Paulo - SP
E-mail: fabio.alfieri@unasp.edu.br

Received on December 15, 2015.
Accepted on February 20, 2016.

DOI: 10.5935/0104-7795.20160002

INTRODUCTION

Osteoarthritis (OA) of the knee brings various disabilities to its sufferers, who are mostly elderly individuals.[1] This pathology is characterized by pain and progressive joint dysfunction, a result of the destruction of the subchondral bone and cartilage with consequent reduction of the articular space, inflammation, synovitis, and the formation of osteophytes.[2] The knee is one of the most common joints affected by OA, generating functional deficits in 10% of individuals over the age of 55.[3] With increasing life expectancy among several populations, including Brazil, OA should be considered a subject of public health interest, because it is a chronic disease and is a leading cause of pain and disability among adults and the elderly.[4]

In addition to pain, those with OA can experience muscle weakness, joint stiffness, crepitations, deformities, and functional damages (such as difficulty in carrying out daily tasks) that negatively interfere in their quality of life.[5,6]

Among the types of treatment for OA: drug therapy, surgery, and rehabilitation through exercises, and varying resources such as thermotherapy, cryotherapy, hydrotherapy, electrotherapy, ultrasound, laser, and even natural resources[7,8,9] stand out; various therapeutic interventions are being tested with the objective of promoting symptomatic relief or improving the functionality of patients with OA.[10]

One of the rehabilitation resources used in OA is physical and/or therapeutic exercise. Due to the possibility of promoting increased muscle strength, flexibility, proprioception, and the consequent reduction of pain, exercises relieve the symptoms of the disease.[11,12] Thus, therapeutic exercise is recommended in numerous guidelines as the non-pharmacological intervention for the treatment of knee OA.[13,14] However, it is worth emphasizing that there is still no consensus as to the parameters for the intensity and duration of each type of exercise.[11]

In relation to exercises, two types stand out: resistance exercises (either using external load, one's own body weight, elastic bands, or machines) that overload target muscles,[14,15] and kinesiotherapy that encompasses different types of therapeutic and aerobic exercises (such as isotonic, isometric, and isokinetic stretching and strengthening).[16]

OBJECTIVE

In view of evidence that both resistance exercise and kinesiotherapy can be beneficial in the treatment of knee OA, the objective of this study was to compare the pain, mobility, functional capacity, and strength in individuals with knee OA submitted to these two types of treatment.

METHODS

The present study was approved by the Ethics Committee in Research of the Centro Universitário Adventista de São Paulo (Report Nº. 243.745). All volunteers who participated in the research signed an informed consent form. This was a prospective, randomized, single blind clinical trial with 30 adult and elderly individuals of both sexes. The study was carried out on the premises of the Policlínica Universitária and at the Sports Center (CENAPE) of the Centro Universitário Adventista de São Paulo (Unasp, São Paulo campus).

The recruitment of the participants was done by screening patients referred for treatment by the *Unidades Básicas de Saúde* (UBS)/ Basic Health Units (BHU) from the Capão Redondo region. Telephone contact was made with the patients who had been diagnosed with OA and the interested parties were invited to attend the *Policlínica* to receive more information about the study. Patients who met the following inclusion criteria were included in the study: diagnosis of OA, medical prescription to participate in a program of exercises or physical therapy, without any other chronic disease and without any chronic use of any medication (except for that prescribed for the OA). Individuals who had a total or partial prosthesis in one or both knees or hips, decompensated heart diseases, hypertension, rheumatoid arthritis, fibromyalgia, or neurological diseases that might affect their locomotion did not participate in the study.

Individuals who agreed to participate in the research were submitted to the evaluations described below, individually, before and after the interventions, by an evaluator who did not know to which intervention group each participant belonged. To evaluate pain, joint stiffness, and functionality we used the Womac[17] questionnaire (Western Ontario and McMaster Universities Osteoarthritis Index), specific for OA, in its version validated for Portuguese.[18] This instrument checks the perception of pain, stiffness, and functionality based on the 48 hours prior to its application. The score ranges from 0 to 4 in each of the 24 items, and the higher the score, the worse the pain.

To measure their functional mobility, the Timed Up and Go (TUG) test was used. The test consists in measuring in seconds the time spent by the individual to rise from his seat, walk three meters, return, and sit down again. The test was repeated three times, with the fastest time obtained being selected for the analysis.[19] This method of evaluation of functional mobility has already been used by Brazilian researchers in a similar sample.[7]

The strength of knee extensors was measured by a dynamometer (TKK 5002 - Takei, Japan). During the test for knee extensors, the participants were oriented to step onto the device, bend their knees to 120° and hold the handlebar attached to the equipment. At a signal from the evaluator, the subject should pull up on the bar with the maximum strength possible from the knee extensors for 4 seconds. Three attempts were made at intervals of 60 seconds and the highest value found was recorded.

To evaluation of pain intensity, the Visual Analog Scale (VAS) was used, which consists of a straight-line 10cm long, on which each participant made a mark, indicating the place that best defined their pain. Closer to the left end of the line was for less pain, and closer to the right was for more intense pain.[21] This method of pain assessment has already been used by Brazilian researchers in a similar sample.[7]

The treatment was carried out twice a week, totaling 15 sessions. By a simple drawing, the participants were randomly directed to one of the 2 intervention groups: kinesiotherapy (KIG) and resistance exercise (REG).

The KIG held supervised stretching exercises for the flexor and extensor muscles of the hips and knees, and for the plantar flexor and dorsiflexors. The participants in this group also conducted a strengthening of these same muscle groups, using their own body weight as resistance. This step had duration of 20 minutes. The volunteers then performed a 10-minute walk in circuit, detouring around sleeping mats, hula hoops, stairs, and cones in order to work their coordination and proprioception.

The participants of the REG went through 30-minute supervised sessions, composed of a

warm-up (5 minutes walking on the treadmill), and a program of isotonic resistance exercises. The program consisted of 2 series of 8 to 12 repetitions of each of the following exercises: leg press, leg curl, calf raise, and leg extension, all running on Vitally machines (São José do Rio Preto - São Paulo, Brazil).

The exercises were performed unilaterally with an initial workload of 60% of the maximum load achieved in the 1-MR test on the weaker limb. The volunteers were instructed to perform the exercises with the technique indicated and to avoid the Valsalva maneuver. They were also instructed to rest for 30 to 60 seconds between the series. To promote a workload capable of promoting improvements throughout the treatment period, the intensity of the exercises was increased from 5 to 10% whenever the participants demonstrated adaptation to the load. This adaptation was considered to have occurred when 2 series of 12 repetitions of one of the proposed exercises were carried out perfectly with both legs without great apparent effort.

The data analysis was performed using the Graph Pad Instat statistical package. The data were presented as means ± standard deviations. The Kolmogorov-Smirnov test was used to verify the normality of the data from the variables studied. The basal characteristics of the two intervention groups at the beginning of the study were compared using the *T*-test (continuous variables) and Fisher's exact test (categorical variables). The comparisons between the groups before and after interventions were made by means of two-way analysis of variance (ANOVA). In all cases, the α descriptive level was established at 5% ($\alpha < 0.05$).

RESULTS

The study participants were recruited in the period from March 2014 to May 2015, totaling 232 patients with OA. Of this total, 178 were unable or unwilling to participate due to problems coming to the location of the study. Of the 54 chosen as likely participants of the research, 18 started other treatments concomitantly to the present study, and for this reason were excluded from the analysis. Thus, 36 individuals were randomized into the two intervention groups of this study. Three subjects left from each group, leaving 15 of each that went on to complete the treatment.

Throughout the research, there was no report of any adverse effect in any of the participants of the two groups (REG and KIG). The general characteristics of each group are described in Table 1, which shows that the groups had similar characteristics.

There was effect of time in relation to the evaluations of pain, joint stiffness, and functionality (WOMAC), functional mobility (TUG), strength (dynamometry), and pain (visual analog scale) in both groups, and no differences were found between the interventions (Table 2).

DISCUSSION

The objective of this study was to compare the pain, mobility, and functional capacity of individuals with knee OA submitted to either resistance exercise or kinesiotherapy. The results showed that patients with OA can be benefited by either intervention, corroborating various other results that show improvements in symptoms of the disease with the practice of different types of exercise.[11,12]

In relation to the baseline data of the groups in this study, the homogeneity of the sample is noteworthy. In addition, two other factors are important. The first is the age of the participants (KIG = 61.67 ± 12.12 and REG = 59.20 ± 10.04) being within the parameters mentioned in the literature, which reveals greater prevalence of OA in individuals aged 55 years or more.[3,22,23] The second factor is the excess weight, observed in both groups (BMI = 29.91 ± 4.09 in the KIG and 29.93 ± 3.16 in the REG). The relationship between overweight and obesity and OA is known, because the increased articular overload represents an important mechanical stress and leads to the worsening of the clinical presentation.[24] For this reason, the participation in the exercise programs that, in addition to bringing functional benefits, will contribute to the reduction of body weight has been recommended to prevent and treat knee OA.[25]

An important variable analyzed in this study was the intensity of pain, evaluated by the VAS. In both groups, there was a decrease of pain, with neither group better than the other, showing that both types of exercises were able to reduce this important complaint of patients with OA.

Reducing pain is a crucial factor in motivating individuals with knee OA to exercise and to have autonomy for day-to-day activities, such as walking and climbing up and down stairs. In this sense, countless studies and reviews involving therapeutic exercise and resistance exercise have demonstrated success in the reduction of pain in these patients,[11,12,14,26-29] which can cause a natural increase in the level of physical activity, helping control weight and increasing physical capacity.

An association between physical function, pain, and joint stiffness has already been reported in patients with knee OA.[6] In addition, pain and functional disability exert a negative impact on the quality of life of patients.[30] Both interventions evaluated in this study produced a significant reduction in WOMAC scores (indicating reduced pain, joint stiffness, and functional improvement), a reduction of time in the TUG (indicating better functional mobility),

Table 1. General characteristics of the sample

	KIG	REG	*p*
N	15	15	
Males/females	6/9	4/11	0.69*
Age (Years)	61.67 ± 12.12	59.20 ± 10.04	0.616
Weight (kg)	77.47 ± 8.93	75.57 ± 8.06	0.480
Height (cm)	161.37 ± 9.36	158.91 ± 4.19	0.123
BMI (kg/cm^2)	29.91 ± 4.09	29.93 ± 3.16	0.373

** Fisher's exact test, BMI: body mass index, kg: kilograms, cm: centimeters; KIG: Kinesiotherapy Group; REG: Resistance Exercise Group. Data are expressed as mean ± standard deviation.*

Table 2. Evaluation of both groups before and after treatment

	KIG		REG		Effect of Time	Effect of group
	Before	After	Before	After		
WOMAC	54.07 ± 19.41	47.73 ± 22.61	58.29 ± 16.06	42.21 ± 17.19	0.001	NS
TUG (s)	11.62 ± 2.35	9.89 ± 1.99	12.13 ± 3.15	10.87 ± 3.40	< 0.001	NS
DINAM (kg)	64.60 ± 32.07	69.14 ± 31.96	56.64 ± 24.26	69.00 ± 22.62	0.006	NS
VAS (cm)	6.78 ± 2.48	4.59 ± 3.27	7.49 ± 2.47	5.98 ± 3.86	0.016	NS

Kg: kilograms, cm: centimeters; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; TUG: Timed Up and Go; DINAM: Dynamometry; VAS: Visual Analog Scale; KIG: Kinesiotherapy Group; REG : Resistance Exercise Group. Data are expressed as mean ± standard deviation. NS: without/Not statistically significant.

and decreased pain as evaluated by the VAS. It is believed that the functional improvements arising from participating in exercise programs have influenced the patients' quality of life, however, a limitation of this study is that quality of life has not been evaluated.

Reduced strength, especially in the quadriceps, is common in patients with OA.[31,32] Muscle deficits affect functionality and must be one of the targets in rehabilitation.[32] A significant increase in the strength of knee extensors was verified in the participants of both groups. The increase of strength in the participants of the REG was expected, and had already been observed by other authors who submitted patients with knee OA to resistance training exercises.[15,33] In relation to the KIG, the main focus of the intervention was not to increase strength, but surprisingly patients exhibited very similar results to those of the REG in relation to this variable. The kinesiotherapy applied in this study, involving coordination and proprioception training, is intimately related to functional performance.[34] This type of training can influence strength, as already reported by the authors who compared patients with OA submitted to resistance exercises and proprioception training.[35] It is speculated that the increase in the mobility, proprioception, and balance, in addition to the reduction of pain, have contributed to the better implementation of the exercises and the tasks of daily living, resulting in strength gain.

Muscle strength, especially in knee extensors, contributes to the improvement of the joint stability and function, and is the main determinant of performance and physical function of patients with OA.[36, 37] Thus, there is evidence suggesting that muscle strengthening, in addition to mollifying the symptomatology, can reduce the progression of joint damage in individuals with OA.[38,39]

This is one of the few studies that compare resistance exercises with kinesiotherapy. However, it is worth emphasizing that the reduced sample size as well as the fact that we did not control the classification of disease severity have limited the generalization of the results of the present study. Despite this, the homogeneity of the groups in this study should be noted, as well as the fact that evaluation instruments standardized in the literature have been used.

CONCLUSION

The results of this study indicate that both the resistance exercises as kinesiotherapy interventions are capable of producing improvement in pain, joint stiffness, functionality, functional mobility, and strength of patients with knee OA. Thus, both represent effective methods for improving pain as well as functional and strength deficits that are characteristic of patients with knee OA. Future studies analyzing the severity of the disease, with larger samples and with even more precise methods of evaluating strength may contribute to the continuity of the study of the effects of the different rehabilitation techniques for such a debilitating disease.

ACKNOWLEDGEMENTS

Thanks to Leslie Andrews Portes, for allowing us to use the space of the Laboratório de Fisiologia do Exercício/Exercise Physiology Laboratory (LAFEX/UNASP-SP) for the evaluations in this study.

REFERENCES

1. Busija L, Bridgett L, Williams SR, Osborne RH, Buchbinder R, March L, et al. Osteoarthritis. Best Pract Res Clin Rheumatol. 2010;24(6):757-68. DOI: http://dx.doi.org/10.1016/j.berh.2010.11.001
2. Dieppe PA, Lohmander LS. Pathogenesis and management of pain in osteoarthritis. Lancet. 2005;365(9463):965-73. DOI: http://dx.doi.org/10.1016/S0140-6736(05)71086-2
3. Peat G, McCarney R, Croft P. Knee pain and osteoarthritis in older adults: a review of community burden and current use of primary health care. Ann Rheum Dis. 2001;60(2):91-7. DOI: http://dx.doi.org/10.1136/ard.60.2.91
4. Allen KD, Golightly YM. Curr Opin Rheumatol. 2015;27(3):276-83.
5. Alkan BM, Fidan F, Tosun A, Ardıçoğlu O. Quality of life and self-reported disability in patients with knee osteoarthritis. Mod Rheumatol. 2014;24(1):166-71. DOI: http://dx.doi.org/10.3109/14397595.2013.854046
6. Aghdam ARM, Kolahi S, Hasankhani H, Behshid M, Varmaziar A. The relationship between pain and physical function in adults with knee osteoarthritis. Intl Res J Appl Bas Sci. 2013;4(5):1102-6.
7. Arthur K, Nascimento LC, Figueiredo DAS, Souza LB, Alfieri FM. Efeitos da geoterapia e fitoterapia associadas à cinesioterapia na osteoartrite de joelho: estudo randomizado duplo cego. Acta Fisiatr. 2012;19(1):11-5 DOI: http://dx.doi.org/10.5935/0104-7795.20120003
8. Maly MR, Robbins SM. Osteoarthritis year in review 2014: rehabilitation and outcomes. Osteoarthritis Cartilage. 2014;22(12):1958-88. DOI: http://dx.doi.org/10.1016/j.joca.2014.08.011
9. Rezende MU, Campos GC, Pailo AF. Conceitos atuais em osteoartrite. Acta Ortop Bras. 2013;21(2):120-2. DOI: http://dx.doi.org/10.1590/S1413-78522013000200010
10. Sofat N, Kuttapitiya A. Future directions for the management of pain in osteoarthritis. Int J Clin Rheumtol. 2014;9(2):197-276. DOI: http://dx.doi.org/10.2217/ijr.14.10
11. Duarte VS, Santos MLS, Rodrigues KA, Ramires JB, Arêas GPT, Borges GF. Exercícios físicos e osteoartrose: uma revisão sistemática. Fisioter Mov. 2013;26(1):193-202. DOI: http://dx.doi.org/10.1590/S0103-51502013000100022
12. Fransen M, McConnell S, Harmer AR, Van der Esch M, Simic M, Bennell KL. Exercise for osteoarthritis of the knee: a Cochrane systematic review. Br J Sports Med. 2015;49(24):1554-7. DOI: http://dx.doi.org/10.1136/bjsports-2015-095424
13. McAlindon TE, Bannuru RR, Sullivan MC, Arden NK, Berenbaum F, Bierma-Zeinstra SM, et al. OARSI guidelines for the non-surgical management of knee osteoarthritis. Osteoarthritis Cartilage. 2014;22(3):363-88. DOI: http://dx.doi.org/10.1016/j.joca.2014.01.003
14. Li Y, Su Y, Chen S, Zhang Y, Zhang Z, Liu C, et al. The effects of resistance exercise in patients with knee osteoarthritis: A systematic review and meta-analysis. Clin Rehabil. 2015. pii: 0269215515610039. DOI: http://dx.doi.org/10.1177/0269215515610039
15. Jorge RT, Souza MC, Chiari A, Jones A, Fernandes Ada R, Lombardi Júnior I, et al. Progressive resistance exercise in women with osteoarthritis of the knee: a randomized controlled trial. Clin Rehabil. 2015;29(3):234-43. DOI: http://dx.doi.org/10.1177/0269215514540920
16. Bunning RD, Materson RS. A rational program of exercise for patients with osteoarthritis. Semin Arthritis Rheum. 1991;21(3 Suppl 2):33-43. DOI: http://dx.doi.org/10.1016/0049-0172(91)90038-2
17. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol. 1988;15(12):1833-40.
18. Fernandes MI. Tradução e validação do questionário de qualidade de vida específico para osteoartrose WOMAC (Western Ontario and McMaster Universities) para a língua portuguesa [Dissertação]. São Paulo: Universidade Federal de São Paulo, Escola Paulista de Medicina; 2001.
19. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39(2):142-8. DOI: http://dx.doi.org/10.1111/j.1532-5415.1991.tb01616.x
20. Heyward VH. Advanced fitness assessment and exercise prescription. 4 ed. Champaign: Human Kinectis; 2002.
21. Champman RS, Syrjala KL. Measurement of pain. In: Bonica JJ, ed. The management of pain. London: Lea & Febiger; 1990. p.580-94.
22. Zhang Y, Jordan JM. Epidemiology of osteoarthritis. Clin Geriatr Med. 2010;26(3):355-69. DOI: http://dx.doi.org/10.1016/j.cger.2010.03.001
23. Srikanth VK, Fryer JL, Zhai G, Winzenberg TM, Hosmer D, Jones G. A meta-analysis of sex differences prevalence, incidence and severity of osteoarthritis. Osteoarthritis Cartilage. 2005;13(9):769-81. DOI: http://dx.doi.org/10.1016/j.joca.2005.04.014
24. Visser AW, de Mutsert R, le Cessie S, den Heijer M, Rosendaal FR, Kloppenburg M, et al. The relative contribution of mechanical stress and systemic processes in different types of osteoarthritis: the NEO study. Ann Rheum Dis. 2015;74(10):1842-7. DOI: http://dx.doi.org/10.1136/annrheumdis-2013-205012

25. Vincent HK, Heywood K, Connelly J, Hurley RW. Obesity and weight loss in the treatment and prevention of osteoarthritis. PM R. 2012;4(5 Suppl):S59-67. DOI: http://dx.doi.org/10.1016/j.pmrj.2012.01.005
26. Iwamoto J, Sato Y, Takeda T, Matsumoto H. Effectiveness of exercise for osteoarthritis of the knee: A review of the literature. World J Orthop. 2011;2(5):37-42. DOI: http://dx.doi.org/10.5312/wjo.v2.i5.37
27. Imoto AM, Peccin MSP, Trevisani VFM. Exercícios de fortalecimento de quadríceps são efetivos na melhora da dor, função e qualidade de vida de pacientes com osteoartrite do joelho. Acta Ortop Bras. 2012;20(3):174-9. DOI: http://dx.doi.org/10.1590/S1413-78522012000300008
28. Imoto AM, Peccin MSP, Trevisani VFM. Impacto dos exercícios na capacidade funcional e dor em pacientes com osteoartrite de joelhos: ensaio clínico randomizado. Rev Bras Reumatol. 2012; 52(6):876-82. DOI: http://dx.doi.org/10.1590/S0482-50042012000600006
29. Barduzzi GO, Rocha Júnior PR, Souza Neto JC, Aveiro MC. Capacidade funcional de idosos com osteoartrite submetidos a fisioterapia aquática e terrestre. Fisioter Mov.2013;26(2):349-60. DOI: http://dx.doi.org/10.1590/S0103-51502013000200012
30. Boutron I, Rannou F, Jardinaud-Lopez M, Meric G, Revel M, Poiraudeau S. Disability and quality of life of patients with knee or hip osteoarthritis in the primary care setting and factors associated with general practitioners' indication for prosthetic replacement within 1 year. Osteoarthritis Cartilage. 2008;16(9):1024-31. DOI: http://dx.doi.org/10.1016/j.joca.2008.01.001
31. Ikeda S, Tsumura H, Torisu T. Age-related quadriceps-dominant muscle atrophy and incident radiographic knee osteoarthritis. J Orthop Sci. 2005;10(2):121-6. DOI: http://dx.doi.org/10.1007/s00776-004-0876-2
32. Alnahdi AH, Zeni JA, Snyder-Mackler L. Muscle impairments in patients with knee osteoarthritis. Sports Health. 2012;4(4):284-92. DOI: http://dx.doi.org/10.1177/1941738112445726
33. Ciolac EG, Greve JM. Muscle strength and exercise intensity adaptation to resistance training in older women with knee osteoarthritis and total knee arthroplasty. Clinics (Sao Paulo). 2011;66(12):2079-84. DOI: http://dx.doi.org/10.1590/S1807-59322011001200013
34. Sharma L. Proprioceptive impairment in knee osteoarthritis. Rheum Dis Clin North Am. 1999;25(2):299-314. DOI: http://dx.doi.org/10.1016/S0889-857X(05)70069-7
35. Lin DH, Lin CH, Lin YF, Jan MH. Efficacy of 2 non-weight-bearing interventions, proprioception training versus strength training, for patients with knee osteoarthritis: a randomized clinical trial. J Orthop Sports Phys Ther. 2009;39(6):450-7. DOI: http://dx.doi.org/10.2519/jospt.2009.2923
36. Liikavainio T, Lyytinen T, Tyrväinen E, Sipilä S, Arokoski JP. Physical function and properties of quadriceps femoris muscle in men with knee osteoarthritis. Arch Phys Med Rehabil. 2008;89(11):2185-94. DOI: http://dx.doi.org/10.1016/j.apmr.2008.04.012
37. Maly MR, Costigan PA, Olney SJ. Determinants of self-report outcome measures in people with knee osteoarthritis. Arch Phys Med Rehabil. 2006;87(1):96-104. DOI: http://dx.doi.org/10.1016/j.apmr.2005.08.110
38. Slemenda C, Brandt KD, Heilman DK, Mazzuca S, Braunstein EM, Katz BP, et al. Quadriceps weakness and osteoarthritis of the knee. Ann Intern Med. 1997;127(2):97-104. DOI: http://dx.doi.org/10.7326/0003-4819-127-2-199707150-00001
39. Oliveira NC, Alfieri FM. Exercícios resistidos na osteoartrite: uma revisão. Acta Fisiatr. 2014;21(3):141-6.