

Impact of exercise on the functional capacity and pain of patients with knee osteoarthritis: a randomized clinical trial

Aline Mizusaki Imoto de Oliveira¹, Maria Stella Peccin², Kelson Nonato Gomes da Silva¹, Lucas Emmanuel Pedro de Paiva Teixeira³, Virgínia Fernandes Moça Trevisani⁴

ABSTRACT

Background: Muscle weakness, especially of the quadriceps muscle, is one of the major musculoskeletal effects of knee osteoarthritis. Exercises are considered one of the main interventions in the conservative treatment of those patients. **Objective:** To assess the effectiveness of quadriceps strengthening exercises on functional capacity and symptoms related of knee osteoarthritis by use of the Timed Up and Go test (TUG), the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the Lequesne Index. **Methods:** One hundred patients were randomized into two groups: 1) Exercise Group (n = 50), which included stationary bicycle, hamstrings stretching, and quadriceps strengthening; 2) Instruction Group (n = 50), which received a manual with information about knee osteoarthritis and instructions on how to deal with knee symptoms in daily activities. The manual did not include exercise instructions. **Results:** The Exercise Group showed statistically significant improvement regarding the TUG test, the WOMAC aspects of pain, function, and stiffness, and the Lequesne Index, as compared with the Instruction Group. **Conclusion:** Quadriceps strengthening exercises for eight weeks are effective to improve pain, function, and stiffness in patients with knee osteoarthritis.

Keywords: osteoarthritis, knee osteoarthritis, rehabilitation, randomized clinical trial.

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INTRODUCTION

Osteoarthritis (OA) is characterized by joint degeneration, being the major cause of chronic musculoskeletal pain and mobility limitation in the elderly worldwide.^{1,2} Of the rheumatic diseases, OA accounts for approximately 30%–40% of the patients' visits to rheumatology outpatient clinics. In addition, its importance can be demonstrated by the Brazilian Social Security data, as it accounts for 7.5% of all leaves of absence; it ranks second among the diseases that require initial benefit, representing 7.5% of the total; it also ranks second regarding sick leave, representing 10.5%; and it is the fourth cause of retirement (6.2%).³

Muscle weakness, especially of the quadriceps muscle, is one of the major musculoskeletal repercussions of knee OA.⁴ The strength deficit in the population with OA is 15%–18% at the beginning of the disease, 24% in individuals with grade II knee OA (according to the Kellgren & Lawrence grading scale for knee OA), and 38% in individuals with grade IV knee OA.⁴ Hurley et al.⁵ have suggested that degenerative changes in the OA knee structure might result in altered sensory input to joint mechanoreceptors, thus decreasing quadriceps activation. Thus, the quadriceps weakness of patients with OA is worth noting.⁴

Because the quadriceps muscle acts as a shock absorber in the knee joint, its weakness is believed to reduce

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1. PhD in Sciences, Universidade Federal de São Paulo – Unifesp

2. PhD in Sciences, Unifesp; Adjunct Professor, Unifesp; Researcher at the Cochrane Center Brazil – Cochrane Collaboration

3. PhD in Sciences, Unifesp; Adjunct Professor, Universidade Federal do Amazonas – UFAM

4. PhD in Rheumatology, Unifesp; Assistant-PhD, the Discipline of Emergency Medicine and Evidence-Based Medicine, Unifesp; Supervising Professor, Post-graduation Program in Internal Medicine and Therapeutics, Unifesp

Correspondence to: Aline Mizusaki Imoto de Oliveira. Universidade Federal de São Paulo. Departamento de Medicina Interna e Terapêutica. Rua Pedro de Toledo, 598 – Vila Clementino. CEP: 04039-001. São Paulo, SP, Brazil. E-mail: aline.mizusaki@globo.com

functional capacity, predisposing the knee to structural damage.⁶ The origin of the quadriceps weakness in patients with OA is not clear. Hurley et al.⁵ have shown that some patients with OA cannot completely activate the quadriceps muscle, a condition that can be called quadriceps activation failure (QAF).

Exercises are considered one of the major interventions in the conservative treatment of patients with knee OA.⁷ The major objectives are as follows: pain reduction; function improvement; and improvement in social and occupational aspects.⁸ Doi et al.⁹ have compared the effect of home-based exercises for quadriceps strengthening and the use of non-steroidal anti-inflammatory drugs (NSAIDs) for eight weeks. No improvement difference between the two groups was observed according to the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). The authors have concluded that home-based exercise for quadriceps strengthening improves knee OA no less than the use of NSAIDs. Moderate exercise may be a good treatment not only to improve joint symptoms and function, but also to improve knee cartilage glycosaminoglycan in patients at high risk of developing OA.¹⁰

The high prevalence of knee OA and its impact on the function and quality of life show the importance of developing strategies for the prevention and treatment of that clinical condition.¹¹ This study aimed at assessing the effect of femoral quadriceps strengthening on the functional capacity and pain of patients with knee OA.

METHODS

The present study was performed at the Interlagos Outpatient Clinics of Specialties, city of São Paulo, Brazil. The physicians of the Department of Rheumatology referred the patients to participate in the study according to inclusion and exclusion criteria. A statistician was responsible for assigning the patients to each group by means of computed numerical randomization. To avoid selection bias, one third person, not involved in the study, numbered opaque envelopes and sealed them. The patients were allocated to two groups as follows: 1) Exercise Group (ExG, n = 50); and 2) Instruction Group (IG, n = 50). The patients' medication was standardized and not modified during the study. Paracetamol was the analgesic prescribed; the medications for OA treatment were diacerein and chloroquine. All patients provided written informed consent to participate in the study, which was approved by the Ethics Committee of the Universidade Federal de São Paulo (CEP 0141/07).

Sample size

The calculation of the sample size established that 40 individuals would provide a study power of 80% to detect a minimal clinical difference in the Timed Up and Go test (TUG) of 1 ± 3 seconds. Paired comparison between the three groups was performed, with significance level of 0.05 (Student *t* test) and using ANCOVA. To minimize the effect of possible losses, the present study met the gold level of evidence-based rheumatology, allocating 50 patients to each group.¹²

Inclusion and exclusion criteria

The inclusion criteria were as follows: age between 50 and 75 years; OA classified as grade II and over based on the Kellgren & Lawrence radiological classification;¹³ and knee OA diagnosed according to the American College of Rheumatology criteria. The exclusion criteria were as follows: pacemaker use; unstable heart conditions; to participate in another physical activity program; inability to pedal a stationary bike; inability to walk; previous knee or hip arthroplasty; diagnosis of fibromyalgia; epilepsy; and presence of a tumor or cutaneous lesion that could interfere with the procedure.

Intervention


Patients of both groups (ExG and IG) received a manual with instructions to prevent knee overload during daily activities and instructions about the use of knee ice pack for pain with inflammation, and warm dressing for pain with no inflammatory signs (Figure 1). In addition, patients in both groups were prescribed the already cited medication.

Exercise group (ExG)

In the ExG, the intervention was performed twice a week for a period of eight weeks. The exercise protocol included the following: warm up for 10 minutes with a stationary bike; stretching of the hamstring muscle with the aid of an elastic band (three sets of 30 seconds); and three sets of 15 repetitions of knee extension exercises, with 30–45-second intervals between the sets. The exercise was performed at the sitting position, with the hip and knees flexed at 90°.

The load to be used for the strengthening exercise was defined based on the ten-repetition maximum test rather than on the one-repetition maximum test, to prevent damage caused by an excessive muscle contraction. Fifty to sixty percent of the estimated maximum load was used.¹⁴


**MANUAL FOR PATIENTS WITH KNEE
OSTEOARTHRITIS**



This manual was aimed at providing you with instructions about osteoarthritis and how to adjust your daily activities according to your knee symptoms. Follow the instructions carefully to your own benefit!

THE KNEE

The knee joint is formed by three bones: the femur (thighbone), the patella (knee cap), and the tibia (shinbone). It also comprises muscles, a capsule, ligaments, menisci, and the joint cartilage that covers the bones and protects them against impact. The knee joint supports e great part of your body weight.



WHAT IS OSTEOARTHRITIS?

It is disease that wears out the joint cartilage. Over the years, the joint cartilage is damaged, no longer ensuring that the joint bone surfaces easily slide over each other. Pain results from the contact of the bone surfaces in the absence or reduction of the joint cartilage.

What are the signs and symptoms?

Patients with osteoarthritis can have pain, especially when starting to move, which is called morning stiffness, or after inactivity. Over time, the pain can increase and persist throughout the day. Knee cracking in frequent.

What difficulties can I experience during my daily activities?

The daily difficulties vary according to the patients symptoms. Usually, patients feel pain when the affected knee has to bear full body weight, when going up and down stairs or when walking.

What should I do in case of pain?

Osteoarthritis can be treated. This should be done under medical supervision. One simple way to decrease pain is to place a warm dressing on the knee joint (be careful not to get burned, protect your skin, and check water temperature before applying the dressing).

And if I have a swollen knee?

You should rest, apply an ice pack to your knee for 20 minutes and keep your leg elevated above heart level.

What else should I do?

- If you are overweight, losing a few pounds will reduce the overload on your knee joint.
- Wear comfortable rubber-soled shoes and no high heels.
- If you experience pain walking, use a cane.
- Try to sleep well.

NOTE
EIGHT WEEKS AFTER RECEIVING THIS MANUAL (DAY: ___/___/___), YOU SHOULD RETURN FOR REASSESSMENT

Figure 1
Manual for patients with knee osteoarthritis.

Instruction group (IG)

The IG patients followed the instruction manual. Around the second and sixth weeks, they were phoned and encouraged to follow the instructions. The instruction manual was explained to patients in a simple and easy way to improve its understanding.

Primary and secondary endpoints

The pre- and post-intervention assessments were performed by a physiotherapist masked to the information regarding the patients' groups. The primary endpoints were the TUG test¹⁵ and the self-reported WOMAC aspects of functionality, pain, and stiffness^{16,17} (validated and recommended by the Osteoarthritis Research Society, and chosen to assess adults with knee OA).^{16,17} The Lequesne Index was defined as secondary outcome.^{18,19} In their study, Faucher et al.¹⁸ have reported that the Lequesne Index has good reproducibility. It is worth emphasizing that versions of the WOMAC and Lequesne Index translated into Brazilian Portuguese and validated were used.¹⁶⁻¹⁹

Timed Up and Go test (TUG)

The TUG is a simple and low-cost test developed to assess the functional mobility of patients during daily activities. The test comprises the following sequence of movements: to stand up from a standard chair, walk a distance of 3 meters, turn, walk back to the chair and sit down again. The time taken by patients to perform the sequence of movement is recorded and compared before and after treatment.¹⁵ In our study, patients got acquainted with the test before their performance was timed. The best time of three attempts was used.

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

The WOMAC questionnaire contains 17 questions regarding the degree of difficulty to perform daily activities, such as stair use, to assess the physical function of patients. Patients are asked to rank the degree of difficulty in the last 72 hours in a scale from 0 (none) to 4 (severe). The individual score for the 17 questions is added up to a score that can range from 0–68. The greater the score, the worse the function. The WOMAC questionnaire also includes questions about pain and stiffness. The WOMAC questionnaire translated into Portuguese and validated¹⁷ was recommended by the Osteoarthritis Research Society as the measuring tool to assess adults with knee OA.¹⁶ In this study, the WOMAC scores of pain, stiffness, and function were analyzed separately.

Lequesne Index

The Lequesne Index was translated into Portuguese and validated in 2006.¹⁹ It contains ten questions specific for patients with knee OA and related to pain, maximum distance walked, and daily activities. The score ranges from 0–24, and the higher the score, the worse the function.¹⁸

Medication

The patients were asked to record the days they used analgesics on a sheet to be returned on reassessment. Paracetamol was prescribed for pain by the physicians of the Department of Rheumatology of the Interlagos Outpatient Clinics of Specialties. To OA control, the patients of the study received chloroquine and diacerein.

Statistical analysis

Statistical analysis was performed according to the principles of the intent-to-treat (ITT) analysis, which encompasses all patients who were randomized. A mixed model of analysis of variance (ANOVA) with repeated measures, occasion measure as intragroup factor and intervention as intergroup factor, was used. The effect size was computed as the difference between the means divided by the standard deviation, using Cohen's *d*. The analyses were performed using Proc GLM and Proc Mixed procedures (SAS 9.2 for Windows). The Kruskal-Wallis test was used to compare the groups regarding the number of days in which the patients used analgesics.

RESULTS

The demographic characteristics of the patients [sex, body side treated, age, and body mass index (BMI)], the TUG test values, the self-reported WOMAC aspects of functionality, pain, and stiffness, and the Lequesne Index are shown in Table 1. The groups were homogeneous regarding sex, body side treated, age, BMI, and OA grade. Eighty-two patients completed the assessment. The loss percentage was 14% (*n* = 43) in ExG and 24% (*n* = 38) in IG (Figure 2).

Timed Up and Go test (TUG)

No statistically significant difference was observed in the pre- and post-intervention assessment in IG. In ExG, however, statistically significant differences were observed in the TUG test scores ($P < 0.0001$). Comparing the groups, a statistically greater TUG test improvement ($P = 0.0008$) was observed in ExG as compared to IG.

Table 1
Data of the initial assessment: mean (SD) or n (%)

	Instruction group (n = 50)	Exercise group (n = 50)	P
Age	58.78 (9.60)	61.50 (6.94)	0.10
Gender			
Female	47 (94.00)	45 (90.00)	0.71
Male	3 (6.00)	3 (6.00)	
Body side treated			
Right	17 (34.00)	11 (22.92)	0.44
Left	22 (44.00)	23 (47.92)	
Bilateral	11 (22.00)	14 (29.17)	
BMI	30.00 ± 5.05	29.72 ± 4.11	0.83
KL grade (2–4)			
2	91.18	92.68	0.85
3	5.88	4.88	
4	2.94	2.44	
TUG test	10.08 ± 2.96	9.34 ± 2.47	
Lequesne Index	13.39 (3.26)	13.63 (3.88)	0.73
WOMAC pain	8.90 (4.38)	10.32 (3.54)	0.07
WOMAC stiffness	3.64 (2.28)	3.66 (2.64)	0.88
WOMAC function	33.40 (12.58)	35.15 (11.88)	0.47

BMI: body mass index; KL: Kellgren & Lawrence; TUG: Timed Up and Go; WOMAC: Western Ontario McMaster Universities Osteoarthritis Index; SD: standard deviation.

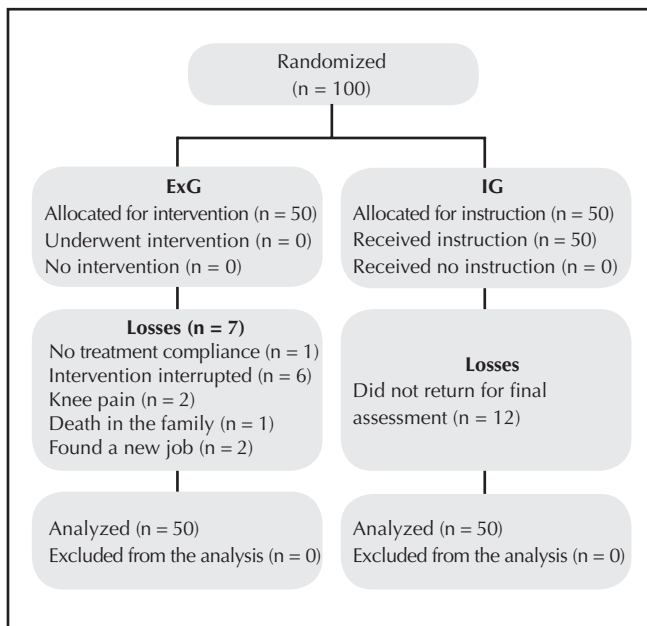


Figure 2
Flow diagram of the study patients.
ExG: Exercise group; IG: Instruction group.

Aspects of the WOMAC questionnaire and Lequesne Index

The pre- and post-intervention assessments in the ExG showed a statistically significant improvement in the WOMAC scores of pain (P < 0.0001), functionality (P < 0.0001), and stiffness (P = 0.0009), and in the Lequesne Index (P < 0.0001). The comparison between the pre- and post-intervention assessments of the IG patients showed no statistically significant changes in the WOMAC scores of pain, functionality, and stiffness. The Lequesne Index showed a statistically significant difference in the pre- and post-intervention assessments (P = 0.043). Comparing the groups according to the ITT analysis, the ExG (P = 0.0026) showed a statistically significant improvement as compared to the IG in the WOMAC scores of functionality, pain (P = 0.0041), and stiffness (P = 0.017) (Table 2). Regarding the Lequesne Index, the ExG also showed a statistically significant improvement as compared to IG (P = 0.0078).

Medication used

No statistically significant difference was observed between the groups regarding the number of days analgesics were used (P = 0.92) (Table 3).

Adverse events

Two ExG patients did not tolerate the exercises, because of pain and inflammation increase, being, thus, excluded.

DISCUSSION

The present study showed the efficacy of quadriceps strengthening exercises, performed twice a week for eight weeks, to improve the pain and functionality of patients with knee OA as compared with a group that received only instructions. One study compared a group undergoing isokinetic quadriceps strengthening exercises versus another group receiving only instructions.²⁰ After eight weeks, a statistically significant improvement was observed in the WOMAC score of pain in the group undergoing exercise as compared with that of the control group. However, the groups did not differ in the WOMAC score of functionality. This might have been due to the reduced diversity of the intervention performed, consisting only of isokinetic exercises, with description of neither stretching nor bike or treadmill exercise or any other type of ergometry. Another study²¹ has reported no statistically significant difference in the Knee injury and Osteoarthritis Outcome Score, which includes the WOMAC questionnaire, between

Table 2

Intra- and intergroup changes (intention-to-treat analysis), mean (SD)

	Instruction group		Exercise group		Difference between the means	P
	Eight weeks	Change 95% CI	Eight weeks	Change 95% CI		
TUG test	9.22 ± 3.31	-0.57 (1.20; 0.06)	7.42 ± 1.70	-2.00 (-2.54; -1.46)	0.81 (0.33; 1.28)	0.00*
Lequesne Index	11.76 (4.04)	-1.26 (-2.49; -0.03)*	9.78 (4.94)	3.95 (-5.39; -2.50)**	2.52 (0.67; 4.37)	0.00*
WOMAC pain	7.06 (4.24)	-1.05 (-2.35; 0.23)	6.29 (3.96)	-3.87 (-5.02; -2.72)**	2.56 (0.82; 4.28)	0.00*
WOMAC stiffness	3.38 (2.39)	-0.14 (-1.14; 0.85)	2.10 (2.26)	-1.51 (-2.36; -0.65)***	1.33 (0.23; 2.42)	0.01*
WOMAC function	29.44 (15.45)	-1.97 (-6.56; 2.63)	23.83 (15.49)	-10.95 (-14.84; -7.05)**	8.53 (3.04; 14.02)	0.00*

*P < 0.05 statistically significant difference; **P < 0.0001; ***0.0009.

TUG: Timed Up and Go; WOMAC: Western Ontario McMaster Universities Osteoarthritis Index; CI: confidence interval; SD: standard deviation.

Table 3

Number of days of analgesic use

Groups	Mean (SD)	P
IG	7.71 ± 13.69	0.92
ExG	6.05 ± 9.31	

IG: Instruction group; ExG: Exercise group; SD: standard deviation.

a group of patients with knee OA undergoing high-intensity exercises for six weeks and a non-intervention control group. Possible reasons for that result include the short-time intervention and the high intensity of the exercises, which might have overloaded the patients with moderate to severe OA.

Our results are in accordance with the systematic review about the efficacy of exercises for patients with knee OA published by the Cochrane Library,²² in which the authors have concluded that there is platinum level of evidence that therapeutic exercise provides short-term benefit in pain reduction and function improvement in patients with knee OA. The treatments used in the studies included in that review were as follows: strengthening of the quadriceps muscle and lower limbs as a whole; stationary bike; walking; and exercises with specific emphasis on neither strengthening nor aerobic capacity increase. The comparison between a walking protocol and a muscle strengthening program has shown that both are effective, and no statistically significant difference between them was evidenced after 18 month of follow-up.²³ Thus, a combination of aerobic exercises and muscle strengthening is recommended for a more complete rehabilitation program, always considering the patients' characteristics and preferences. It is worth noting that patient's pain and physical tiredness should always be respected.

The outcomes used in the present study are in accordance with the International Consensus on Outcomes for clinical trials of phase III OA, which reports that randomized clinical trials should include at least the outcomes pain and physical function, both reported by the patient.²²

It is worth noting that the present study considered important methodological aspects, such as concealed allocation, sample size and masking of the observers, essential for the good quality of a clinical trial. According to the systematic review about the effectiveness of exercises in knee OA,²² 56% of the 32 studies included claimed their assessments were blind; 28% were considered studies with low bias level; 14% were considered of moderate risk; and 28% were considered of high risk. The authors of the present randomized clinical trial followed the Consolidated Standards of Reporting Trials Statement (CONSORT),²⁴ which aims at improving the quality of reporting of randomized clinical trials. That statement consists of a checklist of essential items that should be included when reporting randomized clinical trials and a flow diagram to document the patients' entry in the study, their loss, and conclusions.²⁴

To develop the present randomized clinical trial, ITT analysis, which considers all patients in a group, was used in the statistical analysis of the results. According to CONSORT, the ITT analysis is extremely important.²⁴

CONCLUSION

Quadriceps strengthening exercises for eight weeks are effective to improve pain, physical function, and stiffness of patients with knee OA. Strengthening exercises combined with stretching and stationary bike should be implemented in rehabilitation programs of patients with knee OA.

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