

Effect of Isometric Quadriceps Exercise on Muscle Strength, Pain, and Function in Patients with Knee Osteoarthritis: A Randomized Controlled Study

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Abstract. [Purpose] The aim of present study was to investigate the effects of isometric quadriceps exercise on muscle strength, pain, and function in knee osteoarthritis. [Subjects and Methods] Outpatients (N=42, 21 per group; age range 40–65 years; 13 men and 29 women) with osteoarthritis of the knee participated in the study. The experimental group performed isometric exercises including isometric quadriceps, straight leg raising, and isometric hip adduction exercise 5 days a week for 5 weeks, whereas the control group did not performed any exercise program. The outcome measures or dependent variables selected for this study were pain intensity, isometric quadriceps strength, and knee function. These variables were measured using the Numerical Rating Scale (NRS), strength gauge device, and reduced WOMAC index, respectively. All the measurements were taken at baseline (week 0) and at the end of the trial at week 5. [Results] In between-group comparisons, the maximum isometric quadriceps strength, reduction in pain intensity, and improvement in function in the isometric exercise group at the end of the 5th week were significantly greater than those of the control group ($p < 0.05$). [Conclusion] The 5-week isometric quadriceps exercise program showed beneficial effects on quadriceps muscle strength, pain, and functional disability in patients with osteoarthritis of the knee.

Key words: Isometric exercise, Osteoarthritis, Rehabilitation

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INTRODUCTION

Osteoarthritis (OA) is the most common musculoskeletal condition affecting the quality of life of older adults^{1, 2}. A recent survey in India reported that the prevalence of OA in older adults more than 65 years of age was 32.6% in the rural population and 60.3% in the urban population³. Knee OA is likely to become the eighth most important cause of disability in men and the fourth most important cause of disability in women according to the World Health Organization report on global burden of disease⁴. Three major physical impairments, such as knee pain, stiffness, and decreased quadriceps strength, are highly associated with knee OA and are believed to contribute to physical disability and progression of the disease^{5–7}.

Strength of the quadriceps musculature is one of the intrinsic factors that has been shown to affect the knee joint functions. It is evident that lower extremity strength has a major role in knee joint shock attenuation during weight bearing activities; however, research is still ongoing

regarding investigation of the role of strengthening in the treatment of OA of the knee⁸. There is increased risk of development or progression of disease due to greater or uncontrolled loading on the joint; therefore, quadriceps strength needs to be considered in the study of knee OA. A reduced quadriceps strength has been shown to be associated with the presence of OA in the knee^{5, 9}.

Reduction of pain and disability is the main aim of any treatment approach in the management of knee OA. Combinations of treatment approaches including both pharmacological and non-pharmacological methods are often preferred¹⁰. The Osteoarthritis Research Society International (OARSI) recommended non-pharmacological methods including patient education programs, weight reduction, coping strategies, and exercise programs for treatment of knee OA¹¹.

There are three types of basic therapeutic exercise: isotonic, isokinetic, and isometric exercise. Of these three, isometric exercise might be the most appropriate and easy to understand by the patients and can be easily and safely performed at home because it requires no or minimal apparatus. Further, isometric exercise causes the least intra-articular inflammation, pressure, and bone destruction¹². Norden, Leventhal, and Schumacher reported that “isometric exercises” are simple and inexpensive to perform and that they rapidly improve strength¹³. Hence, the purpose of this study was to investigate whether isometric quadriceps

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exercise has a beneficial effect in patients with knee osteoarthritis.

SUBJECTS AND METHODS

Subjects

The criteria for inclusion were as follows: prediagnosed case of knee OA as per the American College of Rheumatology (ACR) and radiological evidence of primary osteoarthritis of grade 3 or less on the Kellgren Lawrence scale; age between 40–65 years, unilateral or bilateral involvement (in the case of bilateral involvement, the more symptomatic knee was included), and pain in and around the knee. Subjects were excluded if they had any deformity of the knee, hip or back, had any central or peripheral nervous system involvement, had received steroids or intra-articular injection within the previous three months, were uncooperative patients, or received physiotherapy treatment in the past 6 months. The study was approved by our Institutional Ethical Committee (IEC), and written consent was obtained from all the participants. All experiments were conducted according to the Declaration of Helsinki. Patients who met the inclusion criteria were randomly assigned to one of two groups (Fig. 1). Neither group was aware of the treatment that the other group was receiving. All measurements of dependent variables were obtained by another therapist who was blinded to group assignment.

Methods

All the subjects in the experimental group performed isometric exercises including isometric quadriceps, straight leg raising, and isometric hip adduction exercise. All the subjects also received ultrasound therapy as per the patient's requirement with 1.5 watts/cm² for 7 minutes in continuous mode at the tender point around the knee joint prior to exercise.

The subjects in the experimental group performed the following sets of exercise for 5 weeks (5 days/week). All exercises were performed in sets of 10 repetitions; 1 set of all exercises was performed twice a day for the 1st week, and this progressed to 2 sets twice a day until the 3rd week and then 3 sets twice a day until the 5th week.

Isometric quadriceps exercise: Patients lay in a supine position. A rolled up towel was put beneath the knee. They were instructed to maximally activate their thigh muscles in order to straighten their knee and hold the contraction for 5 seconds.

Straight leg raising (SLR) exercise: Patients lay in a supine position. They were instructed to perform a maximum isometric quadriceps contraction prior to the lifting phase of the exercise. Then they were instructed to lift the leg up to 10 cm above the plinth and hold the contraction during the lifting phase for 10 seconds.

Isometric hip adduction exercise: Patients lay in a supine position. A small pillow was put between the knees. They were instructed to perform isometric hip adduction exercise while pressing the pillow between the knees and to maintain the adduction with contraction for 5 seconds.

The control group received ultrasound therapy as per the

patient's requirement with an intensity of 1.5 watts/cm² for 7 minutes in continuous mode at the tender point around the knee joint. They were told to continue their normal daily activities, and no extra exercises were applied.

The outcome measures or dependent variables selected for this study were pain intensity, knee function, and isometric quadriceps strength. These variables were measured using the Numerical Rating Scale (NRS)^{14, 15}, a reduced WOMAC index^{16, 17}, and a strength gauge device^{18–21}, respectively. All the measurements were taken at baseline (week 0) and at the end of the trial at week 5.

Statistical analysis was performed using the SPSS 15.0 Software (SPSS Inc., Chicago, IL, USA). A Shapiro-Wilk test was used to assess whether the dependent variable conformed to a normal distribution and so that parametric testing could be undertaken. The results of the Shapiro-Wilk tests suggested that the dependent variable was not normally distributed ($p < 0.05$). Thus, a non-parametric test was used to analyze the data. The Mann-Whitney U test was used to compare the pain intensity, functional disability, and isometric quadriceps strength between the two groups at baseline and at the end of the 5th week. The Wilcoxon signed-rank test was used to study the changes in these dependent variables in each group over time. The level of statistical significance was set at $p < 0.05$.

RESULTS

A total of 50 subjects were assessed for eligibility. Six subjects did not satisfy the inclusion criteria and two refused to participate. Forty-two subjects were enrolled in the study, with 21 subjects divided in each group. Their demographic details including age, weight, height, and body mass index (BMI) were recorded (Table 1). These variables showed no significant difference between the two groups ($p > 0.05$).

On comparing the isometric quadriceps strength values between baseline and at the end of the 5th week, a significant improvement was noted in the experimental group ($p < 0.001$). The baseline reading of quadriceps strength did not show a significant between-group difference ($p = 0.320$).

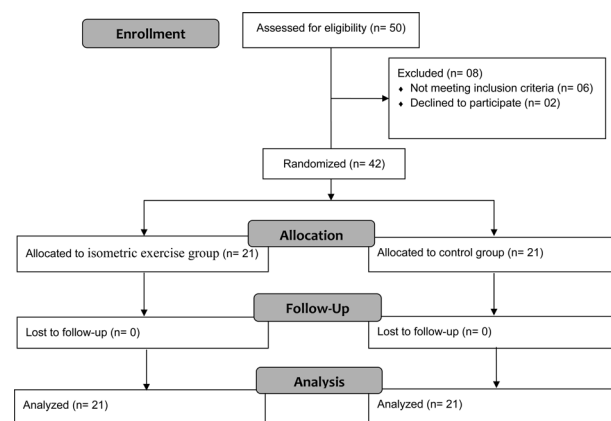


Fig. 1. CONSORT diagram showing the flow of the study participants through each stage of the randomized trial.

At the end of the 5th week, a significant between-group difference in quadriceps muscle strength was found ($p < 0.001$) (Table 2). During the 5-week treatment period, the mean (SD) improvements in quadriceps strength in the experimental group and control group were found to be 3.00 (0.18) and 0.04 (0.01), respectively.

For both groups, the baseline NRS score was statistically insignificant ($p = 0.958$). On comparing the NRS scores between baseline and at the end of the 5th week, a significant improvement was noted in the experimental group ($p < 0.001$). At the end of the 5th week, the between-group difference in NRS score was found to be significant ($p < 0.001$). During the 5-week treatment period, the mean (SD) improvements in NRS score in the experimental group and control group were found to be 4.81 (0.10) and 1.71 (0.23), respectively.

For both the groups, the baseline WOMAC score was statistically insignificant ($p = 0.889$). On comparing the WOMAC scores between baseline and at the end of the 5th week, a significant improvement was noted in the experimental group ($p < 0.001$). At the end of the 5th week, the between-group difference in WOMAC score was found to be significant ($p < 0.001$). During the 5-week treatment period, the mean (SD) improvements in WOMAC score in the experimental group and control group were found to be 16.66 (1.09) and 6.47 (0.13), respectively.

DISCUSSION

The objective of this study was to evaluate whether isometric quadriceps exercise has beneficial effect in patients with knee osteoarthritis. The results of this study demonstrated that isometric quadriceps exercise brought significant improvements in all the parameters after the 5-week training program.

The results of the study demonstrated that isometric quadriceps exercises brought significant gains in strength of the quadriceps muscle in the experimental group after the 5-week training program. In the between-group analysis, the improvement in strength in the experimental group was 33% greater than that of the control group at the end of the training period.

Our findings concur with those obtained in previous studies that have demonstrated the benefits of isometric exercise in strength training. Uganet Hernández Rosa et al.²²⁾ compared the effect of isokinetic versus isometric exercise in patients with osteoarthritis of the knee. They reported that both groups showed significant improvement in muscle strength at the end of the trial. However, the isokinetic exercise group showed slightly greater improvement compared with the isometric exercise group. Similarly, Masatsugu Miyaguchi et al.²³⁾ reported a significant increase in muscle strength after 8 weeks of isometric quadriceps exercise in patients with knee OA.

The results of the present study showed that the 5 week period of intervention brought about a significant reduction in knee pain and improvement in function in the experimental group at the 5th week. The significant reduction in pain and improvement in function in the experimental group may be attributed to improved quadriceps strength and therefore increase stability of the knee joint.

The findings are consistent with the findings of previous investigators who have reported that exercise can reduce pain and increase the functional abilities of OA patients. The Fitness Arthritis and Seniors Trial²⁴⁾ reported a modest 8% to 10% improvement in pain and functioning scores as a result of 18 months of aerobic or resistance exercise among their sample of knee OA patients. Further Deyle et al.²⁵⁾, Falconer et al.²⁶⁾ and Fisher et al.²⁷⁾ found the same positive effects of exercise programs on pain and function. It is well documented in the literature that impaired quadriceps strength has been found to be the greatest single predictor of lower limb functional limitation⁷⁾.

Further study done by Boon Whatt LIM et al.²⁸⁾ concluded that quadriceps strengthening has beneficial effect on pain and function in patients with OA knee. The study done by Shreyasee Amin et al.²⁹⁾ reported that subjects having stronger quadriceps strength had less knee pain and better physical function as compared with those with the least strength. Strong muscles stabilize the joints in a proper alignment, attenuate shocks that are transmitted to the

Table 1. Subject characteristics

Characteristics	Experimental group N=21	Control group N=21
Age (years)	54.9 (7.7)	56.0 (6.8)
Weight (kg)	65.0 (5.0)	65.6 (4.5)
Height (m)	1.57 (0.43)	1.55 (0.34)
BMI (kg/m ²)	26.5 (1.8)	27.1 (1.3)

Values are means (SD)

Table 2. Comparison of isometric quadriceps strength, pain intensity, and functional disability

Variables		Baseline	Week 5	Diff
Strength	Exp. Group	8.93 (1.68)	11.93 (1.86)*	3.00 (0.18)†
	Cont. Group	9.28 (1.71)	9.32 (1.72)	0.04 (0.01)
NRS	Exp. Group	6.05 (0.86)	1.24 (0.76)*	4.81 (0.10)†
	Cont. Group	5.95 (1.11)	4.24 (0.88)	1.71 (0.23)
WOMAC	Exp. Group	24.71 (3.42)	8.05 (2.33)*	16.66 (1.09)†
	Cont. Group	24.52 (4.43)	18.05 (4.30)	6.47 (0.13)

Values are means (SD). †Significant at $p < 0.05$ (Mann-Whitney U test). * Significant at $p < 0.05$ (Wilcoxon signed-rank test). Diff, difference pre-post; Exp, experimental; Cont, control; NRS, Numerical rating scale

joints and minimize the effect of impact by spreading the forces out over a greater area so it may be hypothesized that improvement in muscle strength is one of the main causes of reduced pain and disability. In the present study, the reduction in pain and disability in the experimental group may be attributed to increased quadriceps muscle strength and thereby improved stability, which leads to reduction of pain and disability.

Moreover, the subjects of both groups received ultrasound therapy (UST) with an intensity of 1.5 watts/cm² for 7 minutes in continuous mode at the tender point around the knee joint prior to exercise. The reduction in soft tissue pain by UST could result from increased blood flow to muscles in spasm or the rise in temperature causing relaxation of muscle guarding. In a review of the effectiveness of UST in treating musculoskeletal conditions, Falconer et al.³⁰ found that most reports indicate that therapeutic ultrasound appears to relieve OA pain. Further, Centin N et al.³¹ concluded in their study that exercise and physical agents can reduce pain and improve function and health status in patients with knee OA. Since pain and disability are interdependent, a reduction in one will cause a reduction in the other. All three exercises, isometric quadriceps exercise, straight leg raising, and isometric hip adduction, were necessary for the results of this study to happen. It is recommended to see which one has more influence on the increase in muscle strength in a future study. In conclusion, the 5-week of isometric quadriceps exercise program for patients with knee OA showed beneficial effects on quadriceps muscle strength, pain, and functional disability, but future parametric studies are needed with larger subject numbers to confirm this finding.

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