

Comparative Study of Hamstring and Quadriceps Strengthening Treatments in the Management of Knee Osteoarthritis

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Abstract. [Purpose] Osteoarthritis (OA) of the knee is the most common form of joint disease. It is one of the major causes of impaired function that reduces quality of life (QOL) worldwide. The purpose of this study was to compare exercise treatments for hamstring and quadriceps strength in the management of knee osteoarthritis. [Subjects and Methods] Forty patients with OA knee, aged 50–65 years were divided into 2 groups. The first group (57.65±4.78 years) received hot packs and performed strengthening exercises for the quadriceps and hamstring, and stretching exercises for the hamstring. The second group (58.15±5.11 years) received hot packs and performed strengthening exercises for only the quadriceps, and stretching exercise for the hamstring. Outcome measures were the WOMAC (Western Ontario and McMaster Universities OA index questionnaire), Visual Analogue Scale (VAS) assessment of pain, the Fifty-Foot Walk Test (FWS), and Handheld dynamometry. [Results] There was a significant difference between the groups. The first group showed a more significant result than the second group. [Conclusion] Strengthening of the hamstrings in addition to strengthening of the quadriceps was shown to be beneficial for improving subjective knee pain, range of motion and decreasing the limitation of functional performance of patients with knee osteoarthritis.

Key words: Strengthening, Stretching, Pain

(This article was submitted Oct. 28, 2013, and was accepted Jan. 7, 2014)

INTRODUCTION

Osteoarthritis (OA) is primarily a cartilage disease as it is characterized by the progressive loss of hyaline articular cartilage. Ultimately, the articular cartilage degenerates with fibrillation, fissures, ulceration, and full thickness loss of the joint surface¹⁾. Common sites developing OA include the knee, hand, hip, spine and foot. Among these, the knee is the most commonly affected joint, and knee OA patients present with a combination of inflammation, pain, stiffness, muscle atrophy and deformity²⁾.

Pain is the predominant symptom of knee OA, and the pain is generally related to joint use and it is relieved by rest. As OA progresses, pain may become more persistent and can appear also at rest and during the night³⁾. Occasional early morning stiffness is believed to be related to inflammation. Patients with knee OA describe stiffness as difficulty in rising from a chair and slowness of movements²⁾.

Knee OA is the greatest contributor to impairment of functional ability of OA patients. The disability can be extensive, including mobility limitation, difficulty with activities of daily living, and social isolation. The principal contributors to disability are believed to include pain, reduced range of joint movement, and muscle weakness^{3, 4)}.

Dynamic stability at the knee joint is provided by the muscles that surround the knee joint. Many muscles acting on the thigh have their insertions around the knee. The quadriceps femoris muscle is the principal muscle involved in knee extension^{5, 6)}. The principal muscles involved in knee flexion are the hamstring muscle group⁵⁾.

Knee OA is usually managed in primary care with analgesics and non-pharmacological options, such as exercise^{7, 8)}. Exercise has been shown to improve function, strength, walking speed, and self-efficacy and to reduce pain and the risk of other chronic conditions^{9–11)}. Progression of the disease is also prevented or retarded by physical and occupational therapy and exercise programs¹²⁾.

quadriceps weakness is one of the most common and disabling impairments seen in individuals with knee osteoarthritis (OA)¹³⁾. Sufficient quadriceps and hamstrings strength, both isometric and dynamic, is essential for undertaking basic activities of daily living, such as standing and walking¹⁴⁾. Muscle strength testing has revealed that those with knee OA have a 25% to 45% loss of knee

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extension strength and a 19% to 25% loss of knee flexion strength¹⁵⁻¹⁸), compared with similarly aged controls. There are 3 factors thought to contribute to knee extension and flexion weakness in those with knee OA: muscle atrophy, failure of voluntary muscle activity, and apparent weakness from increased antagonist muscle co-contraction¹⁹).

The quadriceps are the largest group of muscles crossing the knee joint and have the greatest potential to generate and absorb forces at the knee. Many clinical studies have shown consistent improvements in knee extension strength after training, as well as reductions in pain and physical disability of people with knee OA^{20, 21}).

Strengthening the hamstring muscle has been found to enhance the functional ability of deficient knees^{22, 23}. This is probably due to overall increases in both hamstring and quadriceps strength, increase in the hamstring to quadriceps ratio (H:Q), and minimization of anterior-lateral subluxation of the tibia^{23, 24}.

The purpose of this study was to compare hamstrings and quadriceps strengthening and quadriceps strengthening alone in the treatment of knee osteoarthritis.

SUBJECTS AND METHODS

Forty patients with OA knee (57.65±4.78 years) were the subjects of this study. They had experienced knee pain for at least 6 months duration, and had moderate to severe knee pain defined as score of 4 or more on the visual analogue scale (VAS), self-reported knee crepitus, self-reported restricted range of motion and/or joint deformity of the knee, and grade 2 or 3 knee OA according to the Kellgren and Lawrence criteria²⁵). The patients were divided into 2 groups. The first group received hot pack, Transcutaneous Electrical Nerve Stimulation (TENS), active resistive strengthening exercises for the quadriceps and hamstring, and stretching exercise for the hamstring. The second group received hot packs, TENS, strengthening exercises for the quadriceps alone and stretching exercise for the hamstring. Both groups attended 3 sessions per week for 12 weeks. Subjects were diagnosed based on both clinical and radiographic findings and were referred by an orthopedic surgeon, general practitioner or consultant rheumatologist.

The outcome measures were: the WOMAC index, a disease-specific, tri-dimensional self-administered questionnaire, for assessing health status and health outcomes in knee OA^{26, 27}); the visual analogue scale (VAS) a self-reported measurement scale of pain intensity^{28, 29}); the Fifty-Foot Walk Test (FWS) a measure of gait velocity and function^{30, 31}); and handheld dynamometry a tool used to measure maximum isometric strength of knee extension and flexion³²⁻³⁴).

This study was reviewed and approved by the Department of Rehabilitation Health Sciences, College of Applied Medical Sciences, King Saud University, and the Ethical Committee of the Rehabilitation Medical Hospital, AL-Medina AL-Manwerah. Written consent forms signed by the participant were obtained before starting the study.

Statistical analyses were performed using the Statistical Package of Social Science (SPSS software version 11.0 Cary, NC, USA). The means and standard deviations were

Table 1. Pre- and post-intervention comparison of variables by group

Variables	The first group		The second group	
	Pre-test	Post-(Test	Pre-test	Post-test
VAS	7.10±1.12	3.80±1.36*	7±0.97	4.15±1.31*
50 foot walk test (seconds)	14.30±1.49	12.70±1.69*	14.85±1.87	13.15±1.66*
Hamstring strength (kg)	39.30±2.89	42.20±2.86*	38.89±2.21	41.25±3.32*
Quadriceps strength (kg)	43.11±3.19	45.89±3.70*	43.31±2.58	46.43±3.99*
WOMAC (score)	10.25±3.62	5.50±2.54*	10.75±3.8	7.6±3.66*
Stiffness (score)	4.00±2.51	1.95±1.35*	4.3±2.63	3.15±1.92*
Physical function (score)	34.60±11.13	22.85±10.49*	35.75±11.94	27.15±11.93*
Total (score)	48.80±15.45	30.30±13.76*	49.75±17.62	37.9±16.12*

VAS (Visual Analogue Scale); WOMAC (Western Ontario and McMaster Universities OA index questionnaire); *p<0.05

computed, and one sample paired t-test was used to compare pre and post intervention measures within groups, at a confidence level of p = 0.05.

RESULTS

In the first group, there were significant differences in pre and post intervention measures of pain (from 7.1±1.12 to 3.8±1.36), the FWS (from 14.3±1.49 to 12.7±1.69), muscle strength of the hamstring (from 39.3±2.89 to 42.2±2.86 kg), and muscle strength of the quadriceps (from 43.11±3.19 to 45.89±3.7 kg) (Table 1).

There were also significant differences in the WOMAC scores of pain, stiffness, physical function and total score between pre and post intervention. Pain decreased from 10.25±3.62 to 5.5±2.54, stiffness from 4±2.51 to 1.95±1.35, physical function from 34.6±11.13 to 22.85±10.49 and the total WOMAC score from 48.8±15.45 to 30.3±13.76 points (Table 1).

In the second group, there were significant differences pre and post intervention measures of pain (from 7±0.97 to 4.15±1.31), FWS (from 14.85±1.87 to 13.15±1.66), muscle strength of the hamstring from 38.89±2.20 to 41.25±3.32, and muscle strength of the quadriceps from 43.31±2.58 to 46.43±3.99 kg (Table 1).

There were also significant differences in WOMAC scores of pain, stiffness, physical function and total score between pre and post intervention. Pain decreased from 10.75±3.8 to 7.6±3.66, stiffness from 4.3±2.63 to 3.15±1.92, physical function from 35.75±11.94 to 27.15±11.93), and total WOMAC score from 49.75±17.62 to 37.9±16.12 points (Table 1).

There were differences in the significance of differences between the first group and the second group in WOMAC measures. In the first group, there were highly significant differences in the pre and post intervention measures of WOMAC of pain, stiffness, physical function, and total score: p=0.0001 for pain, p=0.0001 for stiffness, p=0.0001 for physical function, and p=0.0001 for the total score. However, in the second group, the respective values were: p=0.003 for pain, p=0.041 for stiffness, p=0.001 for physical function, and p=0.004 for the total score. There was also a significant difference in the pre and post intervention measures of muscle strength of the quadriceps, with the first group showing a p value of 0.0001 and the second group showing a p value of 0.001.

DISCUSSION

The purpose of this study was to investigate the strength of the hamstrings and quadriceps, and the importance of strengthening exercises for both muscles in the treatment of patients with knee OA. Our subjects were divided into two groups. The first group received hot packs, TENS, strengthening exercise for the quadriceps and hamstring, and stretching of the hamstring. The second group received hot packs, TENS, strengthening exercise for the quadriceps only, and stretching of the hamstring program of treatment lasted for 12-weeks.

Muscle plays a major role in the structure and function of joints as evidenced by disuse atrophy of the quadriceps femoris muscle that accompanies knee joint pain³⁵. Weakness of the quadriceps muscle has been noted by the American Academy of Orthopaedic Surgeons as a risk factor of structural damage to the knee joint³⁶.

Quadriceps weakness is associated with disability in subjects with knee pain. As the quadriceps mechanism is of key importance in walking, standing, and using stairs, muscle weakness may be direct cause of impaired function. It may also explain the large increase in odds of disability for those with particularly weak muscles. The association of quadriceps strength with pain and disability in the community has been confirmed³⁷.

OA knee affects the hamstring muscle more than the quadriceps muscle. Therefore, there is a need for physiotherapists who have hitherto concentrated almost exclusively on quadriceps strengthening in OA patients to include hamstring strengthening in their management protocol. The ratio of quadriceps to hamstring muscle strength is important for the stability of the knee and for protection from excessive stress^{36, 38}.

In the present study, we found that there were significance differences between pre and post intervention measures in both groups. In pain assessed by VAS, FWS, muscle strengths, and WOMAC scores. The differences were more significant between pre and post intervention measures of WOMAC in the first group (pain, stiffness, physical function, total) than in the second group, and there was also a more significant difference between pre and post intervention measures of muscle strength of quadriceps in the first group than in the second group, due to muscle balance between quadriceps and hamstring muscles.

The improved range of motion we observed might have been due to the influence of the stretching exercise, which would have led to increased muscle flexibility, thereby minimizing shortening, decreasing pain, and increasing the range of motion. Increased ROM would have been maintained by the strengthening exercises, resulting in patients being able to do more practice and activities of daily living, and improvements in functional performance.

Altered muscle coordination strategies in persons with knee osteoarthritis (OA) result in an increase in co-contraction of the quadriceps and hamstrings during walking. This may increase inter-segmental joint contact force and expedite disease progression³⁹.

The quadriceps and hamstrings muscles have the potential to provide dynamic frontal-plane knee stability because

of their abduction and/or adduction moment arms⁴⁰. Using a neuromuscular biomechanical model, Lloyd et al. noted that the quadriceps and hamstrings not only have the potential to support frontal-plane moments, but also provide support for abduction-adduction moments⁴¹. Furthermore, they observed that these muscle groups appear capable of supporting up to 100% of the applied abduction-adduction loads.

Previous studies of OA on conservative treatment have documented the effectiveness of exercise in reducing pain and disability^{12, 42, 43}. Evidence suggests that stretching and strengthening exercise decrease pain and improve muscular strength, functional ability and psychological well-being⁴⁴. Exercise increases muscle endurance, improves proprioceptive acuity and decreases arthrogenic muscle inhibition of the quadriceps⁴⁵.

Sufficient quadriceps and hamstrings strength, both isometric and dynamic, is essential for undertaking basic activities of daily living such as standing and walking¹⁵. Muscle strength testing has revealed that those with knee OA have a 25% to 45% loss of knee extension strength and a 19% to 25% loss of knee flexion strength¹⁶⁻¹⁹.

The strengthening exercises on the hamstring muscle has been found to enhance the functional ability of a deficient knee^{22, 23}. This is probably due to an overall increase in both the hamstring and quadriceps strength, increase in the hamstring to quadriceps ratio (H:Q), and minimization of anterior-lateral subluxation of the tibia²⁴.

The stretching exercises should be carried out in conjunction with strengthening exercises. If a specific muscle group is restricted, more emphasis may be placed on that area, but there must be stretching of all the major muscle groups of the lower limb, because they all have an effect on the biomechanics of the knee. Patients should be instructed to hold a stretch for 20–30 seconds in order for it to be effective⁴⁶. In addition to its sedative effect, stretching exercise increases knee capsule extensibility and joint range of motion⁴⁷.

Stretching of hamstrings muscles increases the ROM of end extension of the knee giving more power and stability to the joint, thereby decreasing pain, and increasing ROM resulting in improvement of activities of daily living.

The strength relationship between the quadriceps femoris and hamstring muscles has been measured and reported by various researchers, and it is important for the stability of the knee and for protection from excessive stress³⁶. Thus, we conclude that strengthening of the hamstring in addition to strengthening of the quadriceps is beneficial for improving subjective knee pain, range of motion, and decreases the limitation of functional performance of patients with knee osteoarthritis.

ACKNOWLEDGEMENTS

The authors would like to extend their appreciation to the Deanship of Scientific Research at College of Applied Medical Sciences, King Saud University for supporting this research.

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