Original Report

COMPARISON OF THE CONCENTRIC TORQUE OF KNEE MUSCLES AND TIMED-WALKING TEST IN HEALTHY AND LOW GRADE TIBIOFEMORAL OSTEOARTHRITIS

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Abstract- The aim of study was to investigate and compare the concentric torque of Quadriceps and Hamstring muscles and Timed-Walking test in two groups. Thus, one group of healthy subjects and one group of patients with low grade of tibiofemoral osteoarthritis (OA) were selected. Concentric torque of Quadriceps and Hamstring were measured in both groups. Besides, pain measurement, Timed-Walking test, range of motion and the muscle bulk of thigh were assessed in both groups. The independent t-test revealed significant differences between the two groups with regard to concentric torques and Timed-Walking test. However, no significant difference in range of motion and the muscle bulk was seen. In conclusion, patients with low grade of osteoarthritis and minimum clinical signs had weaker muscles and functional limitation in comparison with the matched healthy individuals.

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Key words: Concentric torque, timed-walking test, knee osteoarthritis

INTRODUCTION

Knee osteoarthritis (OA), is one of the most common synovial joint diseases of the weight bearing joints in human (1-8).

Following knee OA, patients complain of pain, inflammation, stiffness, decrease of range of motion and instability (6, 9-14). Besides, reduced muscle strength and functional capacity are usually observed in OA (4, 8, 12-18). Although many studies provide insight into the possible muscle strength and functional deficits in these patients, they had not controlled or matched the subjects for various variables such as age**,** body type, physical activity level, and stage of knee OA.

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In the current study, concentric torques at two different angular velocities, pain measurement, timed-walking test, the muscle bulk of thigh, and the range of motion of the lower limb were assessed in OA patients and compared with data from matched healthy individuals.

MATERIAL AND METHODS

Sixty volunteers comprise of two equal groups participated in this study. Before the main study, in a pilot study, twenty patients and healthy individuals (i.e. ten in each group) repeated the test to assess the inter- and intra-tester reliability and the rest forty subjects participated in the main study.

This study was approved by the Ethical Committee of Tehran University and each subject provided informed written consent.

Descriptive characteristics of participants were as following: 44.6± 2.3 yrs., 167.84± 0.08cm, 62.9 ±4.2 kg and 44.2 ±3.1yrs. 168.6±3.8 cm., 63.5±2.5 kg.

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(Mean & SD in patients and healthy individuals respectively).

Patient Group

Exclusion Criteria: Patellofemoral OA, Knee arthroplasty, Rheumatoid arthritis Inflammatory joint diseases, Intra-articular steroid injection within 6 months, Knee malalignment>15degrees, Hip osteoarthritis, recent fracture (i.e.3 months) of upper or lower extremity Neurologic diseases (stroke, polyneuropathy and …), Abuse of drugs or alcohol, Blood pressure and heart rate higher than normal.

Inclusion Criteria: Varus alignment of greater than 0 degree, Complaint of pain primarily localized to the medial compartment, Met the criteria suggested by Altman (19), Grade 1 or 2 tibiofemoral osteoarthritis (Kellgren and Lawrence scale (20), Age:40-50 yrs., Mesomorphic body type, No regular or professional activity in last 10 years, Office employee or retired, No regular (i.e. 5 times per weak) or occasional use of analgesics and non-steroidal anti- inflammatory medications at least 2 months prior to the study, Low total score of Western Ontario and McMaster University Arthritis Index, WOMAC index, (21).

Healthy individuals

Exclusion Criteria: Older than 50 yrs., any clinical or radiologic sign of orthopedic and neurological diseases, mental or cognition disorders, blood pressure and heart rate higher than normal.

Inclusion Criteria: Age: 40-50 yrs., Independent Daily activities, mesomorphic body type, no regular leisure -time or professional activity in last 10 years, office employee or retired.

Concentric Torque Measurements

A Biodex system 2 isokinetic dynamometer (Biodex Medical System, Shirley, NY, USA) was used for all tests. On each testing day, the machine was calibrated in accordance with the manufacturer's manual. The Biodex software compensated for the effects of gravity as part of the setup with the subject positioned appropriately.

Participants were familiarized with the testing procedure 3-4 days before the main testing session. During this period, subjects performed 5 warm-up trials for each muscle group at the speed of 120°/s in both lower extremities. They were asked to rest and refrain from caffeine consumption for at least one day before the test. On the testing day, each participant performed a 3-minute warm-up on a cycle ergometer followed by stretching exercises for the lower limbs. Subjects were positioned seated with the backrest at a 90 degrees angle. Straps were placed over the shoulders and across the waist to ensure the torso was stable. An adjustable lever arm was attached to the subject's leg by a padded cuff, just proximal to the lateral malleolus.

The axis of rotation of the dynamometer arm was positioned just lateral to femoral epicondyle. Conventional concentric tests were performed for both lower extremities. During the test, the subjects continuously pushed the lever arm of the isokinetic device up and down, through the whole range of motion, between 10º and 90º (0°=straight leg).The subjects performed two sets of tests, in order of speed (22).

Each test consisted of a continuous maximal flexion-extension, and was repeated five times. The first was performed at 90º/sec, whereas the second one was performed at 150°/sec. A 1-minute rest was allowed between each 2 sets of tests, and a 3- minute rest was given after each angular speed. A 20-minute rest was allowed between the two legs. The same examiner conducted all stages of the tests, and the subjects were verbally encouraged to exert maximal effort. The selected angular speeds and ROM were determined for the subjects, based on a pilot trial and subject's safety.

Pain Measurement

Visual analogue scale (VAS) was used to evaluate the pain severity before and after the procedure in both groups. VAS consisted of a 10-cm line; with anchor points of 0 and 10 (no pain and the worst pain respectively, 23).

Functional tests

a) Western Ontario and McMaster University Arthritis Index (WOMAC)

The Western Ontario and McMaster University Arthritis Index (WOMAC) was used to assess the functional status of patients for determining the low total score of WOMAC in this group (i.e. good functional status) as an inclusion criterion.

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Table 1. Reliability of Peak Torques, the range of motions and measurements of muscle bulk between 2 groups (N=40)

Group	Peak Toque		ROM	Muscle bulk
Patient	90 degree/ sec	150 degree/ sec	0.97	0.98
	0.98	0.99		
Control	90 degree/ sec	150 degree/ sec	0.96	0.98
	0.97	0.98		

Responses were recorded as none, mild, moderate, severe, or extreme and each category was assigned a numerical scale from zero to four (21).

b) Timed-Walking test

All participants were asked to walk at a normal speed along a nine meters level corridor with the command "GO" and a chronometer was used to measure time (24).

Measurements of the muscle bulk of thigh

Muscle bulks of the thighs in two groups were measured at 15 cm and 5 cm above the base of the patella (23).

Measurements of range of motion

a) The Ankle, knee and hip joints

All of the joints ranges of motion (ROM) were assessed with a goniometer while the subject was supine with the hip and knee extended. After placing the ankle joint in neutral position (0 degree angle), the subjects then were directed to do the movements (plantar flex, knee flex and hip extension individually). The knee was bent during both movements of hip (25).

Data analysis

The data for concentric torques of the lower limbs at different speeds, timed-walking test, range of motions and measurements of muscle bulk were analyzed statistically using the independent *t*-test to ascertain any significant differences between the patient and healthy groups. Paired *t* -test was used to compare of pain level before and immediately after the torque measurement tests. Statistical significance was set at $p < 0.05$. The peak torque values were chosen in this study, since they are popular parameters among clinicians and researchers (10, 12).

Paired *t*-test showed no significant difference between the torques. Thus, the dominant and most painful side (right in all participants) was selected for all statistical analyses. Assessment of test reproducibility was made by intraclass correlation coefficient (ICC 2/1) for all measured variables (Table 1).

RESULTS

There were significant differences between the two groups with regard to the torque measurements (t-test, $p < 0.00$), (Table 2).The VAS scale in the patients and controls before the intervention were 3.05±.94 and 0, respectively. Measurements immediately after the test (3.05± 2.2 and 0, respectively) showed no significant increase ($p > 0.05$).

Table 2. Mean Values, S D of Quadriceps and Hamstring concentric torques (Newton meter, N=40).

Variable	Speed	Patients	Controls	*t* test (P- value)
Q con	90 degree/sec	87.22±30.8	125.88±37.2	0.001
Q con	150 degree/sec	69.01±23.6	99.6±35.8	0.003
H con	90 degree/sec	48.77±16.8	65.12±19.4	0.007
H con	150 degree/sec	39.37±12.5	55.95±19.05	0.002

(Q= Quadriceps, H= Hamstring, con= concentric)

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Table 3. Timed-Walking Test results in participants (N=40)

Group	Timed-Walking Test
Patient	10.23 ± 0.74
Control	7.89 ± 2.09

Note. Values present Mean ±SD

Timed- walking test was also significantly different (t-test, p <0.05) in the patients and control groups (Table 3).

In addition, there were no significant differences (t-test, p > 0.05) in the values of the range of motions and measurements of muscle bulk between two groups (Table 1).

DISCUSSION

Considerable differences in peak torques of the patients and controls groups were shown in this study. Furthermore, timed-walking test showed a significant difference between the two groups.

However, no significant differences were shown with regard to the range of motions and measurements of muscle bulk between two groups. It is well known that patients with knee OA often show muscle weakness (1,4,5,13-15,17,26-27) and functional loss (5,13,14,28,29). With normal aging, there is a decrease in muscle bulk and strength (9, 13, 28-33). However, the weakness is not totally caused by an age-related reduction in muscle voluntary activity (4, 9). Rather, it may result from various other factors.

The muscle bulk of thigh assessment revealed no significant difference between the groups. In this study, the muscle bulk of thigh was selected as a possible clinical parameter for assessment of muscle cross section. However, it was shown that it may not necessarily be a good predicator of muscle peak torque, which means that similarity in the muscle bulk of thigh, would not indicate similarity in strength (37, 38). The current findings on peak torque confirm those reported by other researchers (18, 30).

Gur *et al* (30) investigated the relationships between cross-sectional area and concentric-eccentric torque in quadriceps and hamstring muscles in women with bilateral knee OA. They concluded that quantitative changes in muscle mass were not sufficient to explain the strength (torque) loss after knee OA. Also, Slemenda *et al* (18) based on their data on the relationship between lower extremity strength and lean tissue mass in elderly patients with knee OA, suggested that quadriceps weakness might occur in patients with OA but without muscle atrophy and pain.

These findings indicate that the muscle weakness might result from various factors such as muscle dysfunction-and not necessarily atrophy.

In spite of considerable differences in concentric torque (p<0.000), selected ROM measures between the two groups was not significant (p>0.05). In addition, all patients had grade 1 or 2 radiological tibiofemoral involvement. Based on Kellgren and Lawrence classification, a low level of joint and cartilage degeneration is anticipated in the two grades 20. In moving a segment through its ROM, all structures in the region will be affected: muscles, joint surface, capsule, fascia and nerve**.** Structure of joint, as well as the integrity of soft tissues that pass over the joint, affect the extent of joint ROM (25, 30, 31, 32, 33, 34)**.** Although, the importance of joint elements' involvement in the process of knee OA can not be ignored (35, 36), the results of this study would suggest that in these low grades of knee osteoarthritis, muscle changes, rather than joint element involvements, are of the main sources of torque difference observed

Timed-walking test

Timed-walking measurement, as an indicator for functional performance, showed significant differences between the two groups (p < 0.05). In other words, it took a longer time for the patients to walk along the pre-determined distance in comparison with controls. Based on the current results, quadriceps and hamstring concentric torques also showed significant decreases in the OA group. All these findings together highlight the considerable importance of musculoskeletal changes as a determinant of disability in patients with knee OA. Similar conclusions have been reported previously by some other authors (2, 5, 13, 14, 30). Gur *et al* (30) also considered a predetermined 15 m distance

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walk as an indicator of functional status in 18 women with bilateral knee OA (grad 2 or 3) graded radiologically on the Kellgren and Lawrence scale. These authors suggest that the quadriceps dysfunction due to weakness makes the patient feel weak, unstable, and unconfident. As a consequence, this can impair and limit mobility and performance in daily activities, leading to decreased personal independence.

In conclusion, based on the findings of this study, it was concluded that knee OA is associated with muscle weakness and functional impairment. The muscle weakness may result due to a variety of factors, with the final outcome being loss of strength and functional limitation (37, 38).

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