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Isokinetic Strength and Functional Status in Knee Osteoarthritis

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Abstract. Muscle function and functional performance are affected in patients with osteoarthritis (OA). The aim of the study was to investigate and compare the concentric torque of knee muscles (quadriceps and hamstring) and functional status in two matched groups: one group of patients with low grade of tibiofemoral OA, and one group of matched healthy subjects. Concentric peak torques of quadriceps and hamstring were measured in both groups at an angular velocity of 90 and 150 degree/second. In addition, selected functional tests, selected lower extremity range of motion (ROM) and thigh girth were assessed in both groups. The independent t-test revealed statistically significant differences between the two groups with regard to isokinetic concentric peak torque at different angular velocities and for the timed walking test, as a measure of functional status. However, no significant difference in lower extremity joints' ROM and thigh girth were seen. In conclusion, patients with knee OA, even in low grades and with minimum symptoms and signs, had muscle weakness and functional limitation in comparison with the matched healthy subjects. This weakness may result from a variety of factors, leading to muscle strength loss and functional limitation.
Key words: Knee, Osteoarthritis, Isokinetic test, Functional Status

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INTRODUCTION

Osteoarthritis (OA), one of the most common joint diseases in adults[1–3], is a slowly evolving and degenerative articular cartilage disease. It appears in the cartilage and affects the underlying bones and the surrounding soft tissues including synovium. This condition principally affects the hand and large weight-bearing joints, such as the knees[4, 5]. The primary complaints of patients are pain, stiffness, instability and loss of function[6–9]. In addition, impaired muscle function is frequently observed in patients with OA of the hip and knee[6, 9–11]. Several studies suggest that adults, with OA of the knee, have reduced muscle strength and functional capacity[3, 4, 9, 11–18]. Although, these studies provide insight into the possible muscle strength and functional deficits of this group of adults, they cannot provide convincing evidence, because the subjects were not well matched for variables such as age, body type, physical activity level, and stage of knee OA, each of which would have a significant effect on the process and prognosis of the disease. In this study, in order to investigate the changes and consequences of knee OA, isokinetic torque (at two different angular velocities), functional status, thigh girth and lower extremity ROM were assessed in patients. The results were compared with similar data from a control group of matched healthy subjects with no knee OA.

METHODS

The study was independently reviewed for ethical concerns by the Research Committee of Tehran University of Medical Sciences in Iran.

Subjects

The subjects were invited to participate in the study from the public at large, using posters and interviews. They were 20 patients with knee OA and 20 matched healthy subjects (controls). The following criteria were used to match the two groups: weight, height, age, and the activity level of the subjects.

When the subjects were interviewed about their physical activity level, none of them had engaged in any regular or occasional leisure-time or professional activity such as walking, running, swimming, or other exercises in the previous 10 years. They were either employed in an office or were retired, spending most of the day sitting. The activity level for all subjects remained relatively constant during the experimental period.

The patients (20 males and females) had clinical symptoms and signs consistent with knee OA, and met the grade II criteria suggested by Altman[19]. They had grade I or II tibiofemoral OA as judged by the Kellgren and Lawrence scale[20]. The controls consisted of 20 healthy males and females. None of them had any clinical or radiological sign of patellofemoral or tibiofemoral OA. Once selected on the basis of the inclusion/exclusion criteria (Tables 2 and 3), the participants were asked to give the informed consent.

Prior to each knee joint torque measurement, resting blood pressure and heart rate in all subjects were measured under supervision of a trained person. Individuals with a higher blood pressure were excluded from the study.

Measurements

Concentric peak torques of quadriceps and hamstrings were measured in both groups at an angular velocity of 90 and 150 degree/second. In addition, selected functional tests, selected lower extremity range of motion (ROM) and thigh girth were assessed in both groups.

1) Measurement of Pain Severity

Pain severity was measured to monitor the probable ill effects of the procedure (before and after it) in both groups. It was evaluated using a visual analogue scale (VAS). The scale consisted of a 10-cm line, with anchor points of 0 (no pain) and 10 (the worst pain experienced)[21].

2) Measurement of Functional Status

Functional status of participants was assessed in two parts.

2-1) Timed-Walking test

All participants (patients and controls) were asked to walk at a normal speed along a level, unobstructed corridor on the command "GO". A hand held stopwatch was started as the subject passed a pre-determined start point, and was stopped as they passed a second point nine meters away from the start mark[22].

2-2) Western Ontario and McMaster University Arthritis Index (WOMAC)

The functional status of the patient group was assessed at baseline, using the Western Ontario and McMaster University Arthritis Index (WOMAC). The aim of the assessment was to determine low total score of WOMAC in this group (i.e. good functional status) as an inclusion criterion. The WOMAC questionnaire included three separate categories of pain experienced in the knee joints (five questions), the joint stiffness of the knee joint in the last 48 hours (two questions), and the patient's physical function (17 questions).

Table 1. Descriptive characteristics of participants

Subject	Age (year)	Height (cm)		Weight (kg)	
		Mean	Range	Mean	Range
Patients (n=20)	44.6 ± 2.3	169.5 ± 0.08	160–175	66.15 ± 2.02	60–72
Controls (n=20)	44.2 ± 3.1	169.9 ± 0.05	160–175	64.65 ± 1.50	60–72

Values presents mean ± SD.

Table 2. Inclusion and exclusion criteria for patient group

Exclusion Criteria	Patellofemoral osteoarthritis - Knee arthroplasty - Rheumatoid arthritis - Inflammatory joint diseases - Intra-articular steroid injection within last 6 months - Knee malalignment >15 degrees - Hip osteoarthritis - Recent fracture (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 - Grade 2 by the criteria suggested by Altman - Grade I or II tibiofemoral osteoarthritis (Kellgren and Lawrence scale) - Age: 40–50 - No regular leisure time or professional activity in last 10 years - Office employee or retired - No regular (=5 times per weak) or occasional use of analgesics and non-steroidal anti-inflammatory medications for at least 2 months prior to the study. - Low total score on the WOMAC index (22 ± 2.31)

Table 3. Inclusion and exclusion criteria for control group

Exclusion Criteria	- Older than 50 - Any clinical or radiological sign of orthopedic and neurological diseases - Any radiological or clinical signs of patellofemoral or tibiofemoral osteoarthritis - Hip osteoarthritis - Abuse of drugs or alcohol - Mental or cognition disorders - Blood pressure and heart rate higher than normal
Inclusion Criteria	- Age: 40–50 - Independent Daily activities - No regular leisure-time or professional activity in last 10 years - Office employee or retired

Responses were recorded on an ordinal scale as: none, mild, moderate, severe, or extreme. Each category was assigned a numerical scale from (zero to four)[23].

3) Isokinetic Measurement

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 compensates for the effects of gravity as part of the setup with the subject positioned, appropriately.

3-1) Procedure

Participants were familiarized with the testing procedure three or four days before the main testing session. During this period, subjects performed five 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 in a seat with the backrest at a 90-degree 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 isokinetic 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 10° and 90° (0°=straight leg). The subjects performed two sets of tests, in order of speed[24]. Each test consisted of a continuous maximal flexion-extension, and was repeated five times. The first was performed at 90°/sec, whereas the second one was performed at 150°/sec. A 1-minute rest was allowed between each two 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 velocities and ROM were determined for the subjects, based on a pilot trial and subject's safety.

Before the main test, in a pilot study, another group of subjects (n=10 in each healthy and patient group) repeated the test to assess inter- and intra-tester reliability. The results showed high levels of reliability in both groups.

4) Measurement of Thigh Girth

To compare muscle bulk in the two groups, the following points of the thigh were selected: 15 cm (6 inches) and 5 cm (2 inches) above the base of the patella[21].

5) Measurement of ROM

Selected measurements of ROM in the lower extremities were performed.

5-1) Ankle ROM Measurement

Ankle ROM was assessed with a goniometer while the subject was supine with the hip and knee extended. After placing the ankle joint in the neutral position (0 degree angle), the subject was directed to plantar flex. The procedure was subsequently repeated in the reverse direction for measurement of dorsiflexion ROM[25].

5-2) Knee ROM Measurement

Flexion and extension ROM of the knee were assessed with a goniometer while the subject was supine with the hip extended. After placing the knee in the neutral position (0 degree angle), the subject was directed to flex the knee as much as possible. Then he/she was asked to extend the knee[25].

5-3) Hip ROM Measurement

For hip flexion ROM measurement by goniometer, the patient was supine, lying with the hip and knee at 0 degree neutral extension and rotation. For hip extension measurement the subject was prone, lying with the hip and knee at 0 degree neutral extension and rotation and the feet over the end of the table. He/she was directed to move the hip joint toward the desired movement. The knee was bent during both movements of the hip[25].

6) Statistical Analysis

Paired *t*-test showed no significant difference between the two lower extremity concentric peak torques at different speeds. 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 4).

The collected data for concentric peak torques at different speeds, timed walking test, lower extremity ROM and thigh girth were analyzed statistically using the independent *t*-test to ascertain any significant differences between the patient and healthy groups. The paired *t*-test was used to compare the pain level before and immediately after the isokinetic measurement test. Statistical significance was set at $p<0.05$. The peak torque values were chosen in this study, becouse they are popular parameters among clinicians and researchers[10, 12].

RESULTS

The data on the subjects' anthropometric features were normally distributed for both groups ($p>0.05$) (Table 1).

There were significant differences between the two groups with regard to isokinetic torque at both angular speeds (*t*-test, $p<0.00$) (Table 5).

There were also significant differences between the two groups in the timed walking test (*t*-test, $p<0.05$) (Table 6).

However, there were no significant differences (*t*-test, $p>0.05$) in the values of lower extremity ROM (hip, knee and ankle) or thigh girth measurement (5

Table 4. Reliability of peak torque, range of motion and thigh girth

Group	Peak Torque		Lower Extremity ROM	Thigh Girth
Patients (n=20)	90 degree/sec 0.98	150 degree/sec 0.99	0.97	0.98
Controls (n=20)	90 degree/ sec 0.97	150 degree/ sec 0.98	0.96	0.98

and 15 cm above the patella base) between the two groups.

The average pain levels (on the VAS scale) experienced by 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).

DISCUSSION

The subjects in both groups were compatible for age, body type and daily activity level. The results of this study indicate considerable differences in peak torques at different angular velocities between the patients and controls. In addition, the timed-walking test showed a significant difference between the two groups. However, no statistically significant differences were detected with regard to thigh girth and lower extremity joints' ROM between the two groups. It is well known that patients with knee OA often show muscle weakness[1, 4, 5, 13–15, 17, 26–29)] and functional loss[5, 13, 14, 30, 31)].

With normal aging, there is a decrease in muscle bulk and strength[9, 13, 32–34)]. However, the weakness is not totally caused by an age-related reduction in muscle voluntary activity[4, 9)], and it may also result from various other factors.

1) Muscle Strength

1.1) Muscle Atrophy and muscle strength

Thigh girth assessment revealed no significant difference between the groups. In this study, muscle girth was selected as a possible clinical parameter for assessment of muscle atrophy or anatomical cross-section. However, it was shown that it may not necessarily be a good predictor of muscle peak torque, which means that similarity in thigh girth, would not indicate similarity in strength. Our findings on peak torque confirm the results 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.

The findings of this study indicate that patients in early stages of clinical and radiological signs, knee osteoarthritis may show muscle weakness without clinical sings of muscle atrophy. These findings indicate that the muscle weakness might result from various factors such as muscle dysfunction, not necessarily atrophy.

1.2) ROM and muscle strength

In spite of considerable differences in isokinetic torque (p<0.000), selected ROM measures between the two groups was not significant (p>0.05). In addition, all patients had grade I or II radiological tibiofemoral involvement. Based on the Kellgren and Lawrence classification, a low level of joint and cartilage degeneration is anticipated in the two grades.

In moving a segment through its ROM, all structures in the region will be affected: muscles, joint surface, capsule, fascia and nerve. The structure of the joint, as well as the integrity of the soft tissues that pass over the joint, affect the extent of the joint ROM[25, 35, 36)]. Although, the importance of joint elements' involvement in the process of knee OA can not be ignored[37, 38)], the results of this study would suggest that in these low grades of knee osteoarthritis, muscle changes, rather than joint element involvements, are one of the main sources of torque difference observed.

2) Functional Status

Functional performance measured by the timed-walking test showed a significant difference

Table 5. Mean values (Standard deviation of knee isokinetic torque (Newton meter) in both groups

Variable	Speed	Patients (n=20)	Controls (n=20)	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).

Table 6 Timed walking test results of participants

Group	Timed-Walking Test (s)
Patients (n=20)	9.53 ± 0.74
Controls (n=20)	7.89 ± 2.09

Values presents mean ± SD.

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. Quadriceps and hamstring isokinetic 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 walk as an indicator of functional status in 18 women with bilateral knee OA (grade 2 or 3) graded radiologically on the Kellgren and Lawrence scale. These authors suggest that quadriceps dysfunction due to weakness makes the patient feel weak, unstable, and unconfident. As a consequence, this impairs and limits their mobility.

The finding of this study is almost consistent with other findings. It can be said that muscle weakness affects the antero-posterior stability of the knee joint. Consequently,the patient may change the “gait pattern” in order to “consciously” control the steps. Such an effort not only increases the amount of energy consumed by the patient, but also decelerates his/her walking pace. On the other hand, any experience of muscle weakness makes the patient feel unstable, leading to decreased personal confidence, decreased performance and independence in daily activities.

3) Other Implications

Considerable attention has been recently paid to the tibiofemoral compartment as an important cause of disability and dysfunction in patients with knee OA. As mentioned abore, patients with only involvement of the tibiofemoral compartment, were selected for this study. We found that tibiofemoral osteoarthritis, even in the very early stages, can affect the function and strength. These results are consistent with those reported by Sharma et al.[3] who analyzed data of 172 patients with knee OA and found that: 1) mixed tibiofemoral and patellofemoral compartment diseases had a greater effect on function than the patellofemorel disease alone; and 2) in patients with mixed disease, tibiofemoral but not patellofemoral joint space narrowing was related to impairment of function.

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