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Isokinetic Assessment and its Relation to Muscle Power in Egyptian Patients with Osteoarthritis Knee

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Abstract

Background: Osteoarthritis (OA) of the knees can affect the muscle function and functional performance of the surrounding muscles.

Aim of Study: We aimed to investigate the concentric torque, total work and average power of knee muscles (quadriceps and hamstring) and functional status in OA patients in comparison with a matched control group.

Patients and Methods: This cross-sectional study included patients with grade II knee OA diagnosed clinically according to the American College of Rheumatology (ACR) criteria and who had radiographic evidence of grade I or II tibiofemoral OA as judged by the Kellgren and Lawrence scale and 30 matched healthy individuals. Pain, stiffness, and physical function were assessed using visual analogue scale (VAS), Western Ontario and McMaster University Arthritis Index (WOMAC) and timed walking test. Muscle strength was measured using a computer-driven isokinetic dynamometer. The isokinetic variables used in the statistical analysis were peak torque, total work, and average power.

Results: This study was conducted on thirty patients (21 females and 9 males) with mean age 44.967±4.238 diagnosed as knee osteoarthritis and 30 matched healthy subjects with mean age 46.067±3.741 and *p*-value was 0.362. The control group and the group of patients with knee OA were matched for gender and age. The independent t-test revealed statistically significant differences between the two groups with regard to isokinetic concentric peak torque, total work and average power 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.

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.

Key Words: *Knee – Osteoarthritis – Isokinetic test – Functional Status.*

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Introduction

(OA) is one of the 10 most incapacitating diseases in developed countries. Worldwide, 9.6% of men and 18% of women have OA **[1]**. Osteoarthritis is a slowly evolving and degenerative articular cartilage disease. OA is initiated in the cartilage and affects the other joint structures (underlying bones and the surrounding soft tissues including synovium). It principally affects the hand and large weight- bearing joints, such as the knees **[2]**. The disease limits motion for 80% of patients, and 25% are restricted in activities of daily living. These disabilities, mostly due to the pain **[3]**, are detected by limitations in walking, climbing stairs, doing household chores or getting up from sitting **[4]**. They are associated with reduced health-related quality of life and have an important psychological impact **[5]**. Basically, the patients' main complaints are pain, stiffness, instability and loss of function **[6]**. In addition, impaired muscle function is usually noticed in patients with OA of the hip and knee **[7].** Myers showed that adults with OA have decreased muscle strength and functional capacity **[8].** 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

Abbreviations:

OA	: Osteoarthritis.
ACR	: American College of Rheumatology.
VAS	: Visual Analogue Scale.
WOMAC	: Western Ontario and McMaster University Arthritis Index.
ROM	: Range of motion.
NM	: Newton meter.
J	: Joule.
W	: Watt.
SPSS	: Statistical package for social science.
BMI	: Body Mass Index.
ADL	: Activity of Daily Living.

of knee OA, each of which would have a significant effect on the process and prognosis of the disease. Our study aimed to investigate the concentric torque, total work and average power of knee muscles (quadriceps and hamstring) and functional status in OA patients in comparison with a matched control group.

Patients and Methods

The subjects involved in this study were 30 (21 females and 9 males) patients with knee OA and 30 age and sex matched healthy subjects as a control group.

Patients were collected from outpatient clinic of El-Helmeya physical medicine and rehabilitation center from January 2019 to March 2020.

Inclusion criteria: We included only patients.

- Diagnosed clinically with grade II knee osteoarthritis according to the American College of Rheumatology (ACR) criteria *[9]*.
- The patients who had radiographic evidence of grade I or II tibiofemoral OA as judged by the Kellgren and Lawrence scale 1957 *[10]*.

Exclusion criteria: We excluded patients with

- Regular analgesia for 2 months.
- Professional exercises.
- Knee arthroplasty.
- Inflammatory joint diseases including rheumatoid arthritis.
- Intra-articular steroid or hyaluronic acid injection within last 6 months.
- Knee mal-alignment >15 degrees.
- Recent fracture (3 months) of upper or lower extremity
- Neurologic diseases (stroke and polyneuropathy...).
- Tachycardia & hypertension.

For the control group:

- None of control group had any clinical or radiological signs of patellofemoral or tibiofemoral OA.

Consent was taken from both groups (patients and control group).

Before each isokinetic assessment, pulse and resting blood pressure in all subjects were measured.

Both groups underwent the following measurements to assess pain and function:

Pain assessment:

The severity of pain was assessed by using a visual analogue scale (VAS). The scale was consisted of a 10-cm line, with anchor points of 0 (no pain) and 10 (the worst pain experienced *[11]*.

Measurement of Functional Status of participants was assessed in two parts:

- *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). 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) *[12]*.

- *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 *[13]*.

Isokinetic knee muscle evaluation: Concentric peak torques, total work and average power of quadriceps and hamstrings were measured in both groups at an angular velocity of 60, 180 and 300 degree/second. In addition, selected functional tests, selected lower extremity range of motion (ROM) and thigh girth were assessed in both groups. For all patients and controls, knee muscles evaluation was done using Biodex System 3 Device. It is used for muscle evaluation and training of the knee muscles. The results of the test appear in numerical and graphical manner.

Subjects were placed in a sitting position in the chair of the equipment. The arm of the dynamometer lever positioned parallel to the subject's leg with a distally fixed resistance pad. Stabilization of the subject in the dynamometer chair will be done by straps on the thorax, hip and thigh. The procedure will be explained to the patients to be familiar with the equipment, performing flexion and extension movements of the knee at the angular velocities of 60, 180 and300 (low, moderate and high).Analysis will bilaterally performed starting with the dominant side. The parameters evaluated in all velocities are: Peak torque, total work and average power *[14,15]*.

Peak torque is the highest torque value seen from all points in the range of motion, and is the result of a force / lever arm, expressed in Newton meter (Nm).

Total work, which is defined as the action of a force through a specified distance in space, represents the action of a torque during all its amplitude; it may be computed as the area under the torque curve, and physically it can be seen as the energy developed by the muscle, expressed in Joules (J).

Average power stands for the pattern of realized work, and can be expressed in Watts (W); it can be seen as the total work divided by the actual contraction time *[15]*.

Measurement of thigh Girth to compare muscle bulk in the two groups, the following points of the thigh was selected: 15cm (6 inches) and 5cm (2 inches) above the base of the patella *[11]*.

Measurement of Selected ROM in the lower extremities was performed:

- 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 *[16]*.

- 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 *[16]*.

- 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 *[16]*.

Statistical analysis:

Data were collected, revised, coded and entered to the statistical package for social science (SPSS) version 20. The data were presented as means, standard deviations.

The comparison between two independent groups regarding quantitative data with parametric distribution was done by using independent *t*-test. Spearman correlation coefficients (*r*) were used to assess the correlation between two quantitative parameters in the same group.

Results

There were significant difference between groups regarding WOMAC, VAS and timed walking test values. However there were no significant difference between patients and controls regarding thigh girth measurements and values of ROM of lower extremity joints (Table 1).

We found significant decrease in peak torque, total work and average power in knee extensors and flexors of our OA patients group compared to control group (Table 2).

Table (1): Anthropometric and clinical characteristics of the participants.

Variables	OA (N=30)	Control (N=30)	*p*-value
Age	44.967±4.238	46.067±3.741	0.362
BMI (kg/m)	26.71±2.21	26.78±2.3	0.453
WOMAC	1.366±0.948	0.333±0.471	<0.0001
VAS	6.5±1.565	0	<0.0001
Thigh girth (point 1)	40.63±1.68	41.13±1.843	0.142
Thigh girth (point 2)	50.95±1.456	51.16±1.88	0.313
Timed walking	9.151±0.724	7.593±0.694	<0.0001

OA: Osteoarthritis. kg/m: Kilogram/meter.
N : Number. WOMAC: Western Ontario and McMas-
p-value: Probability value. ter University Arthritis Index.
BMI : Body Mass Index. VAS : Visual Analogue Scale.

Table (2): Isokinetic tests for both patients and control groups.

	OA group	Control group	*p*-value
Right extension total work	224.8±66.9	256.7±56.3	<0.0001
Left extension total work	242.2±89.7	260.4±66.5	0.123
Right flexion total work	6.57±29.95	20.25±32.37	<0.0001
Left flexion total work	90.79±41.12	9.66±43.45	<0.0001
Right extension peak torque	71.49±26.38	80.53±24.47	0.009
Left extension peak torque	60.97±18.76	71.91±22.86	<0.0001
Right flexion peak torque	48.96±16.45	56.07±18.82	<0.0001
Left flexion peak torque	40.21±9.65	45.31±9.9	<0.0001
Right extension average power	41.76±8.86	46.37±9.06	<0.0001
Left extension average power	42.95±11.1	49±12.34	<0.0001
Right flexion average power	36.52±10.43	41.63±10.9	<0.0001
Left flexion average power	30.15±10.22	36.8±10.16	<0.0001

OA: Osteoarthritis. *p*-value: Probability value.

Correlation analyses (Table 3) revealed that the degree of VAS (r=0.374 weak to 0.932 strong) and WOMAC (r=0.375 weak to 0.884 strong) were significantly and negatively correlated with extension and flexion peak torque and average power and total work of knee extension. Timed walking test values were significantly and negatively correlated with extension and flexion peak torque (r=0.527 moderate to 0.774 strong) Right and left extensors total work (r=–0.711 moderate (RT), –0.455 weak (LT)) right knee extensor average power (r=–0.447), and left knee flexor total work (r=–0.425).

Table (3): Spearman Correlation Coefficient (r) between patients' isokinetic test results and VAS, WOMAC score and timed walking test.

Variables	VAS	WOMAC	Timed walking test
Right extension total work	r –0.448 p 0.013	–0.468 0.009	–0.711 <0.0001
Left extension total work	–0.374 0.0417	–0.534 0.0023	–0.455 0.0115
Right flexion total work	–0.007 0.970	0.128 0.499	0.0907 0.628
Left flexion total work	–0.475 0.007	–0.341 0.065	–0.425 0.01922
Right extension peak torque	–0.932 <0.0001	–0.884 <0.0001	–0.774 <0.0001
Left extension peak torque	–0.658 <0.0001	–0.814 <0.0001	–0.612 0.0003
Right flexion peak torque	–0.671 <0.0001	–0.645 0.0001	–0.527 0.0027
Left flexion peak torque	–0.601 0.0004	–0.691 0.0002	–0.572 0.0009
Right extension average power	–0.670 0.0005	–0.628 0.0002	–0.447 0.0132
Left extension average power	–0.574 0.0009	–0.587 0.0006	0.027 0.887
Right flexion average power	–0.485 0.006	–0.454 0.011	–0.348 0.059
Left flexion average power	–0.423 weak 0.019	–0.375 0.041	–0.348 0.059

VAS: Visual Analogue Scale.
WOMAC: Western Ontario and McMaster University Arthritis Index.
p : Probability value.
r : Spearman rank correlation.

Discussion

Our study aimed to investigate and compare the concentric torque, total work and average power of knee muscles (quadriceps and hamstring) and functional status between individuals with and without knee OA.

On comparing the peak torque values of quadriceps and hamstring muscles between our studied OA patients and control group, there was statistically significant decrease in patients peak torque compared to healthy controls. These results were in agreement with several study groups [17-20]. Moreover, Palmieri-Smith et al. [21] found that women with early signs of OA displayed quadriceps weakness when compared with healthy controls from the same population. Women with radiographic evidence of mild OA were ~18% weaker than the women without OA, whereas women with mild cartilage defects were ~15% weaker than women without cartilage defects. Their findings illustrate that quadriceps weakness is not only present in the later or more advanced stages of OA, but also present earlier in the disease process when radiographic and cartilaginous disease is classified as "mild". The alteration in muscle strength in OA could be attributed to muscular inhibition, which is the inability to fully and volitionally activate the muscle [22]. Articular muscle inhibition (AMI) is a reflex inhibition thought to be elicited by abnormal afferents from a damaged joint resulting in decreased motor drive to muscles and limiting a muscle's potential to generate force [23]. Inflammation of joints, pain, structural changes to articular cartilage and ligament laxity could be triggers of joint muscle suppression [5,23].

Our results disagreed with Petrella et al. [24] who assessed isometric, concentric and eccentric knee extensor torque (90°/s) through an isokinetic dynamometer on Twenty four individuals with knee OA grades I and II diagnosed radiographically and twenty subjects without knee injuries. They found no significant difference between groups regarding concentric knee extensor torque (90°/s) but they found significant difference regarding eccentric peak torque. This disagreement may be due to the difference in angular velocity used in their study (90°/s) while we assessed knee muscles at an angular velocity of 60, 180 and 300 degree/second. We also disagreed with Kumar et al. [25] who found no significant difference regarding knee flexors peak torque between OA group and control group. They assessed maximal isokinetic torque at 120°/sec between 20° – 90° of knee flexion.

We also found that the total work of knee extension and flexion significantly decreased in OA patients. Wang et al. [5] found that the total amount of knee extension and flexion work is one of the main indicators for the muscle function around the knee joint. Lee et al. [26] found that total work of the quadriceps measured at 180°/sec was the only predictor of knee adduction moment during gait in osteoarthritic knees. The knee adduction moment is considered a surrogate measure of dynamic loading on the knee joint and is thought to increase as osteoarthritis becomes more severe.

Regarding average power of knee extensors and flexors, there was significant decrease in our patients group. Valtonen et al. [27] assessed isokinetic average power of knee flexors and extensors in 56 unilateral late stage OA patients and compared it with less affected contralateral knee. They found that there was asymmetrical deficits in knee extensor and flexor power by 18% (p<.001). Carvalho et al. [28] found that individuals with isolated patellofemoral OA exhibit less total work and lower average power in the concentric mode of knee extension and flexion. The decrease in average power and total work in OA patients' muscles is attributed to inflammatory process and atrophy of muscle fibers found on knee OA.

In the current study, the knee pain of patients was evaluated by VAS, which showed that there is significant difference between patients and control group. We also found significant negative correlation between VAS values and isokinetic measurements (peak torque, average power of patients' knee extensors and flexors and total work of knee extensors). Gokcen et al. [29] studied the correlation of peak torque of knee extensor and flexor muscles and VAS in 152 OA patients. They found that the VAS of pain was weakly to moderately correlated with the parameters of isokinetic test (r-values ranging from –0.22 to –0.33). Also, Lucharkey et al. [4] found that greater quadriceps and hamstrings muscle strength was associated with less pain. Another study performed on 70 patients who had grade I or II knee OA reported that there is a significant moderate negative correlation between eccentric quadriceps torque and pain (r=–0.489, p<.001) [30]. Pain influences muscle activation as well as maximum voluntary muscle strength [31]. These findings could be explained by the complex interaction between nociception and motor output in OA patients with chronic pain. Nociceptive stimuli result in cortical delay of motor output in humans and reduced activity of the painful muscle. Nociception may prevent maximal voluntary knee muscle strength [17].

Our results as regard significant correlation of peak torque values of knee flexors and VAS score disagreed with Kim et al. [32]. This disagreement could be due to the mean age of participants were 68.3±3.2 and both knee joints with arthritic change grade 2 or higher in the Kellgren-Lawrence grading scale, While our patients mean age was 44.967± 4.238 and Kellgren-Lawrence grading scale of our patients was grade I or II.

We used WOMAC score to assess the functional status of our participants. There was statistically significant increase in WOMAC scores of OA patients compared to healthy controls indicating functional limitation of OA patients. We also found significant negative correlation (r=0.375 weak to 0.884 strong) between WOMAC and peak torque and average power of both knee flexors and extensors in addition to total work of knee extensors. These results were in accordance with Arab et al. [30] who reported a significant moderate negative correlation between eccentric quadriceps torque and WOMAC score [r=–0.507 (p<.001)]. Also, van der Esch et al. [34] found significant negative correlation between isokinetic measurements of knee muscles and WOMAC score [r=–0.43 (p<.001)] [33]. The musculature surrounding the knee joint produces motion, modifies joint loading and provides stability. Therefore, alterations in the neuromuscular strategies associated with OA should modify muscle force distributions changing the mechanical environment of the joint. Patients with knee OA exhibit weakness in quadriceps and hamstring muscles that leads to failure of stabilizing the joint during physiological activity and greater joint loading [35].

We found that total work of right hamstring was not correlated with VAS and WOMAC scores and total work of left hamstring was not correlated with WOMAC score. These results were in agreement with Fujita et al. [36] who investigated the relationship between knee extension and flexion muscle strength and knee pain in ADL. There was moderate significant correlation between knee pain and the value of knee extension muscle strength. Knee flexion muscle strength was not significantly correlated with knee pain during any activity.

Regarding timed walking test, we found significant negative correlation between timed walking test values and extension and flexion peak torque, extensors total work, right knee extensor average power and left knee flexor total work of our OA participants. These results agreed with Gkrilias et al. [37] who found significant moderate correlation between concentric knee extensor and flexor peak torque at angular velocity 120°/s, 180°/s and 6 minute walk test values in 40 OA patients. Also, van der Esch et al. [33] who found significant correlation between isokinetic measurements and 100-meter walking test [r= –0.35 (p<.001)]. Knee OA patients demonstrate slower performance and decrease in walking pace due to multiple factors such as muscle weakness, decreased proprioception, joint and ligament structural changes. These factors affect stability of the knee during walking [38,39].

We think that this study helps in understanding the relationship between quadriceps and hamstrings muscle strength and clinical features of knee osteoarthritis including subjective and objective measures, but there are limitations that should be addressed to other researches. As our study is cross-sectional not longitudinal, the prospective relationship between quadriceps and hamstrings muscle strength and clinical features of knee osteoarthritis was difficult to be determined. We also cannot determine how other lower extremity muscles, including the gluteus medius and gluteus maximus. Also, we included only patients with grade I or II tibiofemoral osteoarthritis based upon Kellgren and Lawrence grade, therefore it is unknown how our results translate into individuals who are at risk of developing knee osteoarthritis or those with end stage disease.

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.

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تقييم كفاءة وقوة العضلات المحيطة بالركبتين لدى المرضى المصريين المصابين بخشونة الركبة

خشونة الركبتين يمكن ان تؤثر على الأداء الوظيفي للعضلات المحيطة بالركبة. الهدف من عملنا هو دراسة كفاءة وقوة العضلات المحيطة بالركبتين وتقييم الأداء الوظيفى لمرضى خشونة الركبة مقارنة بمجموعة متطابقة من الأصحاء .

وقد شملت دراستنا عل ى ثلاثين مريضاً من مرضى خشونة الركبة ذوى الدرجة المتوسطة تم تشخيصهم وفقاً لمعايير الكلية الأمريكية لأمراض الروماتيزم. وشملت أيضا ثلاثين شخصاً صحيين كمجموعة ضابطة. وكانت المجموعتان متطابقتان فيما يتعلق بكل من العمر والجنس. تم قياس كفائة العضلات المحيطة بالركبتين وتقييم مستوى الألم و الأداء الوظيفي لكلا المجموعتين. وتم تحليل النتائج إحصائياً.

نتائج الدراسة اوضحت ان مرضى خشونة الركبة، حتى فى الدرجات المنخفضة ومع الحد الأدنى من الأعراض والعلامات، يعانون من ضعف العضلات والقيود الوظيفية مقارنة بالأشخاص الأصحاء المتطابقين.