

Association of Eccentric Quadriceps Torque With Knee Pain, Physical Function and Extension Lag in Women With Grade \leq II Knee Osteoarthritis-A Cross-Sectional Study

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Abstract

Background

Knee osteoarthritis (OA) is a prevalent disabling disease among women. Quadriceps weakness is attributed to one of the causes of knee pain (KP) and disability. The study aimed to test the correlation of eccentric quadriceps torque (EQT) with 2 subscales of reduced WOMAC questionnaire (KP and physical function) and extension lag range of motion (ROM) at the knee joint in osteoarthritic women.

Methods

A cross-sectional design was used. A total of 70 (age 41.1 ± 7.1) female patients having grade \leq II knee OA participated in the study. Pearson's correlation coefficient was used to test the correlation between the independent variable (EQT) and dependent variables (2 subscales of reduced WOMAC questionnaire and extension lag in the knee).

Results

EQT presented a significant moderate negative correlation with the reduced WOMAC subscales (pain $r = -0.489$, $p < 0.01$ and physical function $r = -0.425$, $p < 0.01$), and low positive correlation with available ROM ($r = 0.349$, $p < 0.01$).

Conclusions

The self-reported symptoms of KP, physical function, and extension lag in the early stages of knee OA in women are associated with EQT. Thus designing a rehabilitation program having eccentric quadriceps strengthening exercises may improve KP and physical activities but further randomized controlled trials are needed to verify this.

Background

Osteoarthritis (OA) is the most common form of arthritis. [1] As it is related to the aging process therefore it has caused a great burden on the economic and social condition of our aging society [1] and has caused a considerable impact on the quality of life of aging people. [2, 3] Up to 41%, 30%, and 19% of limb arthritis were located in knees, hands, and hip joints respectively, thus making the knee joint the most commonly affected joint by OA. [4] In individuals suffering from knee OA symptoms vary from physical dysfunction to joint pain and stiffness. [5, 6] Several risk factors have been attributed to causing OA such as age, gender, genetics, ethnicity, occupation, physical activity, trauma, obesity, joint structure, and alignment. [7] Worldwide knee OA is found to be more common in women than men. [8-10] Women also differ from men in knee OA presentation as they are usually presented in more advanced stages,

have different gait patterns, and also in terms of the anatomic area affected in the knee joint. [11] Women also report more pain and disability. [12, 13]

Many studies have been performed to find the association of quadriceps muscle strength with knee pain (KP) and functional status. For example, one study performed by [Riann M Palmieri-Smith et al](#) [14] reported that quadriceps strength (Nm/kg) was 22% greater in women without radiographic OA than in women with radiographic OA. Another study by MC Hall et al. reported that the presence of pain-free radiological OA has a significant negative influence on relative quadriceps strength and disability. However, in both of these studies, the isometric strength of the quadriceps muscle was measured. Serrão PR et al examined knee eccentric extensor torque in male osteoarthritic patients and reported a moderate and negative correlation between eccentric extensor torque and three subscales of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) ($r=-0.40$ to 0.69 , $p<0.05$). [15]

Most of the studies performed on this matter examined concentric or isometric strengths of the quadriceps muscle. Not enough studies have been performed on women that tested the correlation of eccentric quadriceps torque (EQT) with two subscales of reduced WOMAC questionnaire (KP and physical function), and extension lag range of motion (ROM) in early stages of knee OA. Therefore, this study aimed to determine whether KP, physical function, and extension lag ROM correlate with EQT in women with grade \leq II knee OA. Patients with grade III and IV were excluded so that the results of this study are deduced from patients with early stages of knee OA only. If the correlation is found in the early stages of the disease, then we may be able to modify the progression of this disease by designing an appropriate rehabilitation program. Therefore, we hypothesized that EQT has a significant correlation with KP, physical function, and extension lag ROM.

Methods

Study design

It was a cross-sectional study. KP, physical function, and extension lag ROM were dependent variables. EQT was the independent variable. KP and physical functions were measured by reduced WOMAC questionnaire [16], [17], and extension lag ROM and eccentric quadriceps strength were measured by Biodex Isokinetic Dynamometer. [18]

Participants

Before conducting the study, the sample size was calculated using Software G*Power 3.1.9.4. Eighty-four participants were shown to be necessary based on an alpha level of 0.05 and power ($1-\beta$) of 0.80, therefore, 90 female patients between the age group 30 and 50 yrs. having OA of grade I or II as per Kellgren and Lawrence system, of unilateral/bilateral knees, were selected for participation in the study. However, out of 90 participants, 15 participants had grade \geq III OA, thus did not meet the inclusion criteria and 5 participants reported pain on their isokinetic strength measurement test and thus not recruited into

the study. Therefore, a total of 70 participants (41.1 ± 7.1 yrs.) successfully participated and completed the study (Table 1). OA was diagnosed with X-rays of the knee by a radiologist and in the case of bilateral OA, the more affected knee was chosen for the study. Kellgren and Lawrence grading system for the classification of OA was used to grade the severity of OA (Grades 0 to 4). [19]

Table 1. Demographic properties of participants with knee OA, n = 70

Characteristics	Mean \pm SD
Age (years)	41.1 ± 7.1
Height (cm)	157.8 ± 19.7
Weight (kg)	69.2 ± 13.9
BMI (kg/cm ²)	27.33 ± 5.5

BMI: Body mass index

Individuals having deformity in the ipsilateral lower extremity, previous ipsilateral lower extremity surgery, corticosteroid injection in ipsilateral knee joint in the last 6 months, other diseases of musculoskeletal, cardiovascular, neurological, and/or respiratory systems were excluded from the study. 68 participants presented with both anteroposterior and lateral x-rays of the affected knee and 12 presented with anteroposterior x-rays only. The protocol of the study has been deposited on [protocols.io](https://doi.org/10.17504/protocols.io.bqxwmxpe) (DOI: [dx.doi.org/10.17504/protocols.io.bqxwmxpe](https://doi.org/10.17504/protocols.io.bqxwmxpe))

Questionnaire

Participants read and filled the reduced WOMAC questionnaire which is a valid and reliable health instrument to assess pain and physical functions in individuals with osteoarthritis of the knee. [16, 17] The test questions were scored on a scale of 0-4, which correspond to None (0), Mild (1), Moderate (2), Severe (3), and Extreme (4). Then the scores for each subscale are summed up, with a possible score range of 0-20 for pain, and 0-28 for physical function. Higher scores on the reduced WOMAC questionnaire indicate worse pain and functional limitations.

Participants preparation and Isokinetic evaluation

Isokinetic dynamometer (Biodex Multi-Joint System 4, Biodex Medical Inc., NY, USA) was used to measure eccentric quadriceps strength. [18] Before data collection, the isokinetic dynamometer was calibrated according to the manufacturer's instructions. Then participants were made to sit (with hip and knee joints bent at 90^0) on the dynamometer chair as per the manufacturer's recommendations with trunk and thighs stabilized by a belt. The resistance was applied by knee attachments of the dynamometer at 5 cm above the medial malleolus and the rotational axis was aligned 5 cm away from the lateral

epicondyle of the femur. Then EQT was evaluated at a speed of $90^0/s$ using “The Reactive Eccentric Mode”. [15] Speed of $90^0/s$ was chosen to facilitate comparison of results of this study with a previous study performed by Serrão PR et al on male osteoarthritic patients.

Extension Lag ROM measurement

Extension lag ROM was measured using the isokinetic dynamometer by asking the participants to fully extend the knee, then lag in full extension (to achieve 0^0 knee flexion) was measured. A negative ROM score meant the subject could not bring his leg to the position defined as horizontal by the protocol for ROM measurements.

Eccentric strength measurement

Afterward, participants were familiarized with the test by performing one bout of three submaximal eccentric isokinetic contractions with a ROM from 20^0 to 90^0 (being 0^0 meaning full knee extension). After that, they performed 1 bout of 3 maximal contractions with their best possible effort. The rest between each contraction was 30-second. For statistical analysis, the average of the peak torques of the three maximal contractions was taken. No subject complained of pain during the test. Verbal commands were used to encourage the participants to produce maximum torque during the procedure. Torque was measured in Nm, then this data was normalized by body weight (in kg) using the formula: (Nm torque /kg body weight) X 100. [15] The procedure and protocol of the study are presented in figure 1.

Data analysis

The data were analyzed using the SPSS statistical software version 26 (SPSS Inc., Chicago, IL, USA). Data collected for dependent variables (reduced WOMAC subscales for pain and physical function, and extension lag) and independent variable (the normalized mean EQT) showed normal distribution ($p>0.05$) therefore the parametric test was chosen. Pearson’s correlation coefficient was used to analyze the correlation between the independent and dependent variables. The correlation was considered significant at the p -value < 0.01 . Following categories were used to interpret the r values: none/mild = 0.00 to 0.19; low = 0.20 to 0.39; moderate = 0.40 to 0.69; strong = 0.70 to 0.89; and very strong = 0.9 to 1.00. [20]

Results

Descriptive statistics for dependent and independent variables are presented in Table 2. The data analysis of the study showed a significant correlation between EQT and the reduced WOMAC questionnaire subscales (pain and physical function) and extension lag in the knee joint, in women with grade \leq II knee OA (Table 3). EQT presented a significant moderate negative correlation with both the reduced WOMAC subscales [pain $r = -0.489$ ($p<0.01$) and physical function $r = -0.425$ ($p<0.01$)] and a

significant low positive correlation with available ROM [$r = 0.349$ ($p < 0.01$)]. Additionally, EQT also presented a significant moderate negative correlation with BMI [$r = -0.480$ ($p < 0.01$)] and a significant moderate negative correlation with the comprehensive WOMAC score [$r = -0.507$ ($p < 0.01$)].

Table 2. Descriptive statistics, mean, and Std. Deviation, for dependent and independent variables, $n = 70$.

	Mean	Std. Deviation
EQT (Nm/kg x 100)	105.50	46.837
BMI (kg/cm ²)	27.37	5.554
Pain (points)	8.74	3.586
Physical function (points)	11.80	4.793
Extension Lag ROM (degrees)	-6.128	3.03
WOMAC (points)	23.81	8.850

EQT: Eccentric quadriceps torque; BMI: Body mass index; ROM: Range of motion; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

Table 3: Pearson's Correlation Coefficient (r) between EQT and BMI, pain, physical function, available ROM, WOMAC score.

	Eccentric Quadriceps Torque (EQT)	
	r	p-value
BMI (kg/cm ²)	-0.480	$p \leq 0.001^*$
Pain (points)	-0.489	$p \leq 0.001^*$
Physical function (points)	-0.425	$p \leq 0.001^*$
Available ROM at knee (degrees)	0.349	$p \leq 0.001^*$
WOMAC (points)	-0.507	$p \leq 0.001^*$

*Significant ($p < 0.01$)

BMI: Body mass index; ROM: Range of motion; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

Discussion

The present study aimed to find out how EQT is associated with KP, physical functions, and extension lag in women having grade \leq II knee OA. The data analysis revealed correlation of EQT with KP as moderate negative ($r = -0.489$, $p < 0.01$), with physical function as moderate negative ($r = -0.425$, $p < 0.01$), and with available knee ROM as low positive ($r = 0.349$, $p < 0.01$). Additionally, the correlation of EQT with BMI was revealed as moderate negative ($r = -0.480$, $p < 0.01$) and with comprehensive WOMAC score also as moderate negative ($r = -0.507$, $p < 0.01$). The negative correlations indicated that the individuals having higher EQT, had lower KP, physical dysfunction, and BMI. The positive correlations indicated that the individuals having higher EQT had higher available ROM at the knee joint. Results of the present study showed that the eccentric strength of the quadriceps muscle may have important roles to play in the knee joint.

The findings of the present study are supported by earlier research also. One of the studies performed on American women reported that women having radiographic knee OA have 22% lesser quadriceps strength (Nm/kg) than women without knee OA ($P < 0.05$). [14] Another study performed by Serrão PR et al on volunteers having grade I or II knee OA, reported that there is a moderate negative correlation of EQT with 3 subscales of WOMAC ($r = -0.40$ to 0.69 , $p < 0.05$). [15] Similarly, Hortobágyi et al [21] reported the correlation between time spent by the patients of knee OA (grade \geq II), to perform certain functional tasks and quadriceps muscle strength (sum of maximum eccentric, concentric and isometric contractions) as moderate negative.

Many previous studies have highlighted the contribution of the quadriceps muscle in knee joint stability such as studies by Winby CR et al and Mikesky AE et al reported that for both the functional knee joint stability [22] and knee joint loading, [23, 24] the primary contribution comes from quadriceps muscles. The quadriceps muscles also provide dynamic knee joint stability by controlling tibial translation during ambulation, thus if quadriceps muscles are weak, the risk of damage to joint structures will increase.

The pathomechanics behind the association of an increase in KP, functional disability, and extension lag in knee OA patients with decreased quadriceps muscle's eccentric strength could be explained as follows: During ambulation quadriceps muscle's eccentric function is to absorb the body weight while landing the foot on the ground or lowering the body to the ground. It also provides dynamic stability to the lower quadrant of the body during ambulation. The ability of the quadriceps muscle to generate force in OA patients is significantly affected especially during lengthening (when it contracts eccentrically) than the force generation during concentric or isometric contractions. [21] This shows why the eccentric function of the quadriceps is important for the knee joint. Thus the neuro-muscular functions around the knee joint are impaired in the form of decreased quadriceps recruitment and increased hamstring muscle activity (during late stance and early swing phase) during ambulation due to osteoarthritic changes. This results in impaired load distribution in the joint and thus further facilitates disease progression. [25] The increased joint loading and decreased shock absorption due to cartilage erosion lead to more stress on the static stabilizers of the joint causing excessive stretching of ligaments and capsule which could further contribute to increased KP, decreased ROM, and more disability. [26]

However, some studies do not support the findings of the present study, such as a study performed by Zacaron KAM et al on elderly people with knee OA reported no correlation between the pain variable and the total work of quadriceps muscle. [27] The possible reason might be that they used a visual analog scale for pain assessment, which does not actually represent the pain perception during the patient's usual daily activities.

The present study has a few limitations and scope for future studies also. This study well highlighted the fact that self-reported symptoms of KP, physical function, and extension lag ROM in the early stages of knee OA are associated with EQT. However, the cross-sectional design of the present study precludes it from making a definite inference that the increase in KP, physical dysfunctions, and extension lag are due to a decrease in eccentric quadriceps strength or vice versa. Thus we can only infer from this study that if a rehabilitation program involving eccentric quadriceps strengthening exercises is started early in the initial stages of the disease then we may be able to reduce the KP and improve the activities of daily living in those individuals. But to make a definite clinical recommendation a separate proper randomized controlled trial is needed that involves eccentric quadriceps strengthening exercises as an intervention in such patients. The sample size in the present study also fell short by 14 participants as the minimum sample size calculated was 84. Therefore, further studies are needed on larger sample size. The inclusion criteria in the present study did not take into consideration the occupation, previous and current activity levels of participants. Thus if some patients with grade \leq II knee OA have a high physical activity level then they may have more eccentric quadriceps strength than those patients that have low physical activity levels. Therefore, future researches are needed that includes participants having an equivalent occupation and physical activity levels. Further research is also needed to compare correlation results between different ethnic groups to know any geographical, cultural, genetic, or economic variations.

Conclusions

To conclude, the self-reported symptoms of KP, physical function, and extension lag in the early stages of knee OA in women are associated with EQT. Thus including eccentric quadriceps strengthening exercises in the rehabilitation program for patients with early stages of knee OA may improve KP, physical functions, and extension lag, but further randomized controlled trials are needed to confirm this hypothesis.

List Of Abbreviations

OA
Osteoarthritis
KP
Knee pain
EQT
Eccentric Quadriceps torque
WOMAC

Western Ontario and McMaster Universities Osteoarthritis Index

ROM

Range of motion

BMI

Body mass index

Declarations

Disclosure:

The abstract of this paper was presented at the 6th Global Conference on Physiotherapy, Physical Rehabilitation and Sports Medicine as a poster presentation/conference talk with interim findings. The poster's abstract was published in "Poster Abstracts" in *Journal of Aging and Geriatrics Psychiatry*: ([Correlation between Eccentric Quadriceps Torque with Pain, Physical Function and Range of Motion in Women with Grade II Osteoarthritis \(alliedacademies.org\)](#))

Ethics approval and consent to participate: All participants gave their informed consent for inclusion before they participated in the study. The study conforms to "The Code of Ethics of the World Medical Association (Declaration of Helsinki)". The ethics subcommittee of the Rehabilitation Research Chair (File ID: RRC-2019-23 and date of approval 21/11/2019) approved this study.

Consent for publication: Not applicable.

Availability of data and materials: The data associated with the paper are not publicly available but are available from the corresponding author on reasonable request.

Competing interests: The author reports no competing interest in this work.

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Authors' contributions:

FA, NQ, and SAK conceptualized the study, its methodology and were involved in data collection also. MK and FA did the data analysis, wrote and edited the manuscript. NQ, SAK, and AHA were also involved in supervision. All authors read and approved the final manuscript.

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Figures

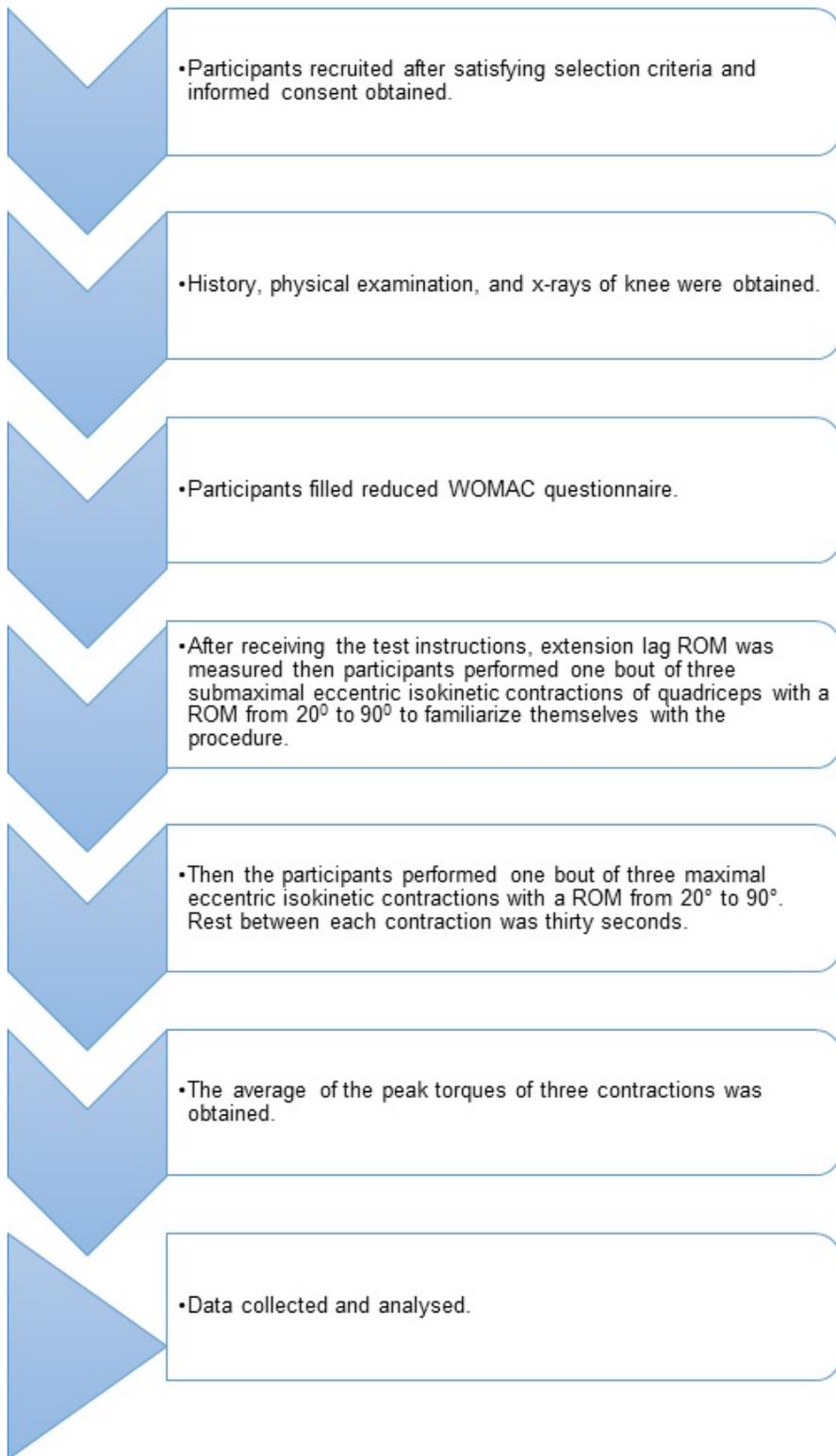


Figure 1

Flowchart showing the procedure and protocol of the study.