The Comparison of Knee Joint Muscle Flexibility between Women with and without Radiographic Knee Osteoarthritis

Hedieh Moallem1, PhD; Amir Hossein Barati2*, MD; Elham Shirzad Araghi3, PhD; Anoshirvan Kazemnejad4, PhD

1Department of Health and Sport Medicine, Faculty of Physical Education, Kish International Campus, University of Tehran, Iran
2Department of Sport Rehabilitation, Shahid Beheshti University, Tehran, Iran
3Department of Health and Sport Medicine, Faculty of Physical Education, University of Tehran, Tehran, Iran
4Department of Biostatistics, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran

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ABSTRACT

Background: Approximately 60% of individuals above 50 years of age are affected by knee osteoarthritis (KOA). KOA is most commonly assessed through radiographic evaluation and classified using the Kellgren - Lawrence (KL) grading system with KL Grade 0 (KLG0) indicating a definite absence of radiographic KOA (RKOA) and KLG2 presenting a definite presence of RKOA. The current study compared knee joint muscle flexibility among three groups with KLG0, KLG2, and KLG3 RKOA.

Methods: In this descriptive cross-sectional study, 94 KLG0, KLG2, and KLG3 knees on 57 women aged ≥40 years were examined. The flexibility of the quadriceps, hamstring, iliotibial band, adductor, and gastrocnemius muscles was compared.

Results: Iliotibial band flexibility was lower in subjects with KLG3 RKOA than those with KLG2 (P<0.05) or KLG0 (P≤0.001) RKOA, with the latter two groups being statistically equivalent (P=0.075). In addition, quadriceps muscle flexibility was lower in subjects with KLG3 RKOA than those with KLG2 (P≤0.001) or KLG0 (P≤0.001) RKOA, with the latter two groups being statistically different (P≤0.001). No significant differences were found between groups regarding other muscles (P>0.05).

Conclusion: In patients with RKOA, the flexibility of the iliotibial band and quadriceps muscles may decrease as the disease progresses from KLG2 to KLG3. Moreover, quadriceps and iliotibial band flexibility may be lower in KLG3 compared to KLG0, with a lower likelihood of quadriceps flexibility in KLG2 compared to KLG0. These results suggest that quadriceps and iliotibial band stretching may be potentially important components of treatment.

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Introduction

Musculoskeletal disorders are one of the main causes of disability [1], with knee symptoms ranked second in prevalence [2]. KOA is the most common cause of knee symptoms in older adults [3], and its prevalence increases with age. Higher rates of KOA are seen among women than in men [4-6]. Approximately 60% of individuals above the age of 50 years are affected by KOA [7]. The osteoarthritis (OA) burden has risen over recent decades [8] and will continue to rise in developed and developing countries which have rapidly growing elderly populations [1, 9]. OA, as the 11th highest contributor to global disability in the elderly [10], leads to functional limitations in daily activities such as walking and climbing stairs [11-13]. It has also been predicted to be the fourth leading cause of disability in the coming 20 years [3, 14]. Because of the high prevalence of OA and

*Corresponding author: Amir Hossein Barati, Department of Sport Rehabilitation, Shahid Beheshti. University of Iran, Evin, Tehran, Iran.
Tel: +98 9121930811
Email: ahbarati20@gmail.com
its effect on functional abilities, the need to identify the factors influencing this severe condition is clear [15].

From the pathogenesis perspective, OA risk factors are divided into systemic and local factors. While systemic factors involve multiple joints (generalized OA), they tend to be biochemical and lead to joint damage or impairment of the joint repair process. Local or mechanical factors involving a specific joint are biochemical and are linked to the forces encountered at the joint [16]. Systemic parameters include factors such as age, gender, genetics, ethnicity, biochemical markers of cartilage or bone metabolism, and obesity (metabolic alterations) [17]. Local factors are, in turn, classified as intrinsic or extrinsic to the joint. Local intrinsic factors have an origin internal to the joint and consist of factors such as alignment, laxity, proprioception, range of motion (ROM), and strength [18]. Conversely, local extrinsic factors like injury, sports participation, and obesity (increased load) arise from the events occurring external to the joint [19].

In addition, OA risk factors can be classified as modifiable and nonmodifiable. Although many of the aforementioned risk factors like age, gender, genetics, and ethnicity are fixed, other factors such as obesity, sports participation, strength, and ROM are modifiable [20, 21]. Although modifiable risk factors may have an essential role to prevent disease onset and progression, only a few of them have been the focus of attention. There is a paucity of literature that have explored the ROM of the knee.

Of note, decreased ROM at the knee may change forces applied to the joint. For instance, when a knee cannot fully extend during gait, the tibiofemoral joint contact area is minimized and more pressure is applied over a smaller joint surface [22]. This greater force may, in turn, lead to cartilage erosion [18]. Some studies have shown that flexion extension ROM of the knee may decrease in individuals with KOA [23-25]. This decreased flexion extension at the knee as well as tibial lateral and medial rotation decline may be related to KOA severity [23].

On the other hand, the amount of joint mobility or ROM is dependent on the muscle length as soft tissue and bony structures in the area [26]. Thus, a patient with impaired flexibility also has a limited range of motion. Nevertheless, few studies have investigated knee joint muscle flexibility in individuals with KOA. Decreased quadriceps [27, 28], hamstring [27, 29, 30], iliotibial band, adductors, and gastrocnemius flexibility [27] is reported in patients with KOA compared to healthy people. In addition, differences in knee joint muscle flexibility among different stages of the disease have not been investigated.

From the pathologic perspective, OA might be characterized as localized cartilage erosion extending to the bone underneath the cartilage with osteophytes, joint space loss, sclerosis, and cysts appearing in radiographic views [17]. Radiographic evaluation of OA, as the best method of imaging the biologic status of a joint, is used in most epidemiologic studies [31]. RKOA is mainly assessed by the KL grading scale [32, 33]. This system is the gold standard [34] of radiological classification for identifying and grading the severity of tibiofemoral KOA [35] with five global grades (0-4) [36]. KL0 indicates a definite absence of RKOA, and KL2 is used as a cutoff for a definite presence of RKOA [35]. The presence or absence of the disease diagnosed by radiographic findings demonstrates a strong dissociation with clinical symptoms. One study reported that 60% of patients with moderate RKOA and 40% of those with severe RKOA have no symptoms [37]. Thus, many people with RKOA may have no symptoms [17] but cannot be considered as a healthy control. Studies comparing knee joint muscle flexibility between KOA patients and asymptomatic controls have considered asymptomatic subjects as healthy controls.

Modifiable local intrinsic risk factors play an essential role in prevention strategies for controlling KOA incidence and progression. One of these modifiable local intrinsic risk factors may be the flexibility of knee joint muscles. Despite the evidence demonstrating strong dissociations between clinical symptoms and radiographic data in osteoarthritic knees, few studies investigating flexibility variables in these patients have compared the flexibility of knee joint muscles between subjects with RKOA and asymptomatic individuals considered as non-osteoarthritic knees. Moreover, knee joint muscle flexibility in different stages of RKOA have not been compared. The data suggests the existence of a clear need to study differences in knee joint muscle flexibility in subjects with and without RKOA as well as the differences between various stages of the disease. The current study compared the flexibility of the muscles around the knee joint in three groups of women with KL0, KL2, and KL3 RKOA in order to determine whether there is a difference between women with mild (KL2) and those with moderate (KL3) RKOA in terms of knee joint muscle flexibility as well as the differences between those with and those without RKOA.

Methods

Ninety-four knees of 57 women with an age of ≥40 years, body mass index BMI ≤30, and tibiofemoral KL radiographic scores of 0, 2, and 3 were enrolled in this descriptive cross-sectional study [4, 35, 36, 38-40]. All patients were referred to a single radiology center over a one-year period and had bilateral anteroposterior knee radiographs obtained in weight-bearing, full extension standardized manner. KL1 has not been included, because Dieppe [36] stated that mild KOA (KL2) characterizes the new development of OA, and this state should not yet be considered a disease, because, it does not progress for a long time. Those with a history of non-recreational or professional athletic training, knee joint trauma or surgery, loss of knee joint play, rheumatoid or other inflammatory arthritis, joint infection, neuropathic arthropathy [28, 41], generalized OA, and those with end-stage disease defined as KL4 were excluded from the study. Subjects with KL4 were excluded, because they usually cannot walk independently on a flat surface without an ambulatory assistive device. Approval was given by the Ethical Review Committee of Tehran
University. Written informed consent was obtained from each subject prior to study participation.

Data on the age, weight, and height of the subjects was collected, and body mass index was calculated for each participant (weight/height²).

**Radiographic Scoring**

Based on the KL grading scale [32, 33], radiographs were scored by a single investigator (HM) blinded to the flexibility data at the time of examination. Readings were made after holding 100 hours of training and 5 training sessions each of 2 hours duration under the supervision of an experienced orthopedic surgeon. To assess intra-rater reliability, 22 radiographs were randomly chosen, and reading was repeated one week later without knowledge of the previous results. While KLG0 indicated a definite absence of RKOA, KLG2 was chosen as a cut-off point for minimal or mild RKOA and KLG3 determined to indicate moderate RKOA [35].

**Clinical Examination**

All flexibility measurements were performed by the same examiner (HM) using universal 360 degree goniometers constructed of clear, flexible plastic and a digital inclinometer (INSIZE model 2170-1 electronic level and a protractor, 4×90°). Prior to any measurement, the accuracy of the instruments was validated against 0, 45, 90, 135, and 180 degrees [42]. All flexibility tests were performed two times with a 10-s rest between efforts. The average of two trials was recorded to the nearest 1° for all muscle tests [43]. The reliability of the flexibility measurements used in this study has been previously examined and considered good to excellent [43-46]. However, considering variations in measurement methodology, devices used (e.g., digital inclinometer against gravity inclinometer), differences between studied populations, and even the interpretation of correlation coefficients, the intra-rater reliability for all flexibility measurements was determined. Reliability studies were performed on 22 limbs using a double session (measurements taken twice each session), repeated measures design, and one examiner.

Hamstring flexibility was measured using a passive knee extension test. With the subject in supine position, the opposite knee was placed at 90° of flexion with the ankle relaxed in plantarflexion. In this position, the examiner passively extended the knee until resistance was felt. While an assistant held the position, the examiner placed the center of the goniometer on the femoral condyle and aligned the stationary arm with the shaft of the femur. Then the distal arm was brought from flexion/abduction to the neutral extension position, the examiner placed the center of the goniometer against gravity inclinometer), differences between studied populations, and even the interpretation of correlation coefficients, the intra-rater reliability for all flexibility measurements was determined. Reliability studies were performed on 22 limbs using a double session (measurements taken twice each session), repeated measures design, and one examiner.

Data Analysis

SPSS version 24 was used for all analyses. Intra-rater reliability for flexibility measurements was examined with the intra-class correlation coefficient, and measurements of intra-rater reliability for ordinal variables were evaluated using a weighted kappa coefficient. Descriptive statistics were conducted for all demographic characteristics and flexibility measures. All variables demonstrated normal distribution when examined using the Shapiro-Wilk test. Differences between subjects with KLG0, KLG2, and KLG3 were evaluated using analysis of variance (ANOVA) with a Gabriell post hoc test because of the homogeneity of all flexibility variables. All tests were performed with a level of significance of 0.05 (two-tailed).
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In the present study, 57 women with a mean age of 59.24±11.83 years (range=40 to 86 years) and mean BMI of 26.84±2.82 Kg/m² were evaluated. Subjects were divided into three groups: KLG0 (n=27), KLG2 (n=38), and KLG3 (n=29). The demographic data of each group is shown in Table 1.

In terms of reliability, the KL grading scale showed a high value for intra-rater reliability with a kappa coefficient κ=0.88 [49]. The flexibility measurements demonstrated excellent intra-rater reliability with ICCs ranging from 0.84 to 0.98 [49]. ANOVA results found no difference between subgroups for hamstring, adductor, and gastrocnemius flexibility, but quadriceps and iliotibial band flexibility was found to be different between groups. Thus, post hoc analysis was made to determine which groups statistically differed for the two parameters. Results of the Gabrielle test revealed that iliotibial band flexibility was significantly lower in subjects with KLG3 RKOA -13.10±6.00 (P<0.001) compared to those who had KLG2 RKOA. Moreover, the mean quadriceps muscles flexibility was lower in the KLG3 RKOA group (10.29±15.63) than in those with KLG0 RKOA -6.42±5.80 (P<0.001), with the latter two groups being statistically equivalent (P=0.075). Therefore, there are no head-to-head studies with which to compare the results. Because poor flexibility is a major cause of joint dysfunction [50], the results of the present study may be considered as evidence consistent with population-based longitudinal studies that have revealed the association of RKOA progression as measured by KL grade with physical function decline [13, 51-54]. Taking into account the association between disease progression and function reduction as well as the effect of poor flexibility in joint dysfunction, it can be concluded that disease severity may have an association with knee joint muscle flexibility. Thus, the current study investigated the difference in knee joint muscle flexibility between subjects with mild and moderate RKOA. Significant lower quadriceps and iliotibial band flexibility was found in those with KLG3 RKOA compared with those who had KLG2 RKOA. These results may be considered as evidence confirming the association between disease severity and knee joint muscle flexibility that could be considered a therapeutic target.

To the best of the authors’ knowledge, few studies have documented the differences in knee joint muscle flexibility between subjects with and without KOA. Two studies investigated quadriceps muscle flexibility and reported lower quadriceps length in patients with KOA compared to healthy controls [27, 28]. The current results were consistent with these studies for both mild and moderate RKOA, suggesting the role of the quadriceps muscles in knee function.

One earlier study reported decreased iliotibial band flexibility in subjects with KOA (disease severity not mentioned) compared to healthy individuals [27]. However, another study noted no significant iliotibial band length difference between grades 2 and 3 KOA (included in 1 group) and healthy controls [28]. After separating KLG2 patients from those with KLG3 RKOA, the current study found lower iliotibial band flexibility between KLG2 and KLG3 (P<0.001).

### Results

Ninety-four knees of 57 women with a mean age of 59.24±11.83 years (range=40 to 86 years) and mean BMI of 26.84±2.82 Kg/m² were evaluated in the present study. Subjects were divided into three groups: KLG0 (n=27), KLG2 (n=38), and KLG3 (n=29). The demographic data of each group is presented in Table 1.

In terms of reliability, the KL grading scale showed a high value for intra-rater reliability with a kappa coefficient κ=0.88 [49]. The flexibility measurements demonstrated excellent intra-rater reliability with ICCs ranging from 0.84 to 0.98 [49]. ANOVA results found no difference between subgroups for hamstring, adductor, and gastrocnemius flexibility, but quadriceps and iliotibial band flexibility was found to be different between groups. Thus, post hoc analysis was made to determine which groups statistically differed for the two parameters. Results of the Gabrielle test revealed that iliotibial band flexibility was significantly lower in subjects with KLG3 RKOA -13.10±6.00 (P<0.001) compared to those who had KLG2 RKOA. Moreover, the mean quadriceps muscles flexibility was lower in the KLG3 RKOA group (10.29±15.63) than in those with KLG0 RKOA -6.42±5.80 (P<0.001), with the latter two groups being statistically equivalent (P=0.075).

### Discussion

The aim of this study was twofold: First, to determine the difference in knee joint muscle flexibility between women with KLG2 (mild) and KLG3 (moderate) RKOA, and second, to investigate whether there is a difference between women with and without RKOA. The findings did not demonstrate a significant difference in hamstring, adductors, or gastrocnemius muscle flexibility between mild and moderate RKOA groups, however, significant differences were found in the flexibility of quadriceps and iliotibial band between these two groups (P<0.001, P<0.05, respectively). Few studies were found to have assessed knee joint muscle flexibility in patients with different grades of RKOA. Therefore, there are no head-to-head studies with which to compare the results. Because poor flexibility is a major cause of joint dysfunction [50], the results of the present study may be considered as evidence consistent with population-based longitudinal studies that have revealed the association of RKOA progression as measured by KL grade with physical function decline [13, 51-54]. Taking into account the association between disease progression and function reduction as well as the effect of poor flexibility in joint dysfunction, it can be concluded that disease severity may have an association with knee joint muscle flexibility. Thus, the current study investigated the difference in knee joint muscle flexibility between subjects with mild and moderate RKOA. Significant lower quadriceps and iliotibial band flexibility was found in those with KLG3 RKOA compared with those who had KLG2 RKOA. These results may be considered as evidence confirming the association between disease severity and knee joint muscle flexibility that could be considered a therapeutic target.

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in subjects with KLG3 compared to those with KLG0, but iliotibial band length was equivalent in the KLG0 and KLG2 groups (P=0.075). This data suggests that the distinction between different grades of the disease may better reveal the differences between knees with and without OA.

No difference was observed in hamstring, adductors, or gastrocnemius muscle flexibility between the female groups in the current study. These results were consistent with another study that examined female participants [28], but contrary to the results of previous studies that included both males and females in terms of hamstring [27, 29, 30], adductors [27], and gastrocnemius [27] muscle lengths.

We believe these discrepancies may first be attributed to the gender difference between these studies. Nagaosa et al. [55] noted different mean widths in the tibiofemoral joint between men and women. Given the importance of joint space narrowing as one of the two major cardinal features of RKOA, joint space width difference between men and women may affect the results. In addition, BMI was not controlled in any of those studies. The lack of weight control in epidemiologic studies may increase the systemic and mechanical effects of weight on joint tissue damage [56], confounding the outcomes. Moreover, differences in participant characteristics such as age may affect the results [39]. These variations make it difficult for such data to be properly compared.

As mentioned before, many people with RKOA have no symptoms. Healthy case selection in previous studies investigating differences in knee joint muscle flexibility between healthy and osteoarthritic knees has relied on symptom definition. Moreover, differences in flexibility factors in various stages of the disease had not been previously investigated. Furthermore, many studies have found RKOA severity to be a baseline risk factor for functional decline in older adults, while OA is one of the highest contributors to global disability, with the highest OA burden being attributed to hip and KOA. Therefore, the urgent need to conduct studies with the focus on modifiable risk factors of the disease such as flexibility parameters is highlighted. This research was the first to investigate knee joint muscle flexibility differences between subjects with and without RKOA as well as between those with mild and moderate RKOA. These findings, based on quadriceps and iliotibial band length differences among our three groups of KLG0, KLG2, and KLG3, may have implications for disease incidence and progression prevention.

This study had several limitations. First, its participants were women, so the results cannot be generalized to male patients. Further research on groups of males is recommended. Second, the measurements in this study were made and recorded by the same examiners, neither of whom was blinded. Third, the study population comprised symptomatic patients who had been referred to a radiology center because of knee pain. Thus, another study with a symptom-free population without RKOA included as the control group may better detect differences between patients with and without RKOA.

Conclusion

Quadriceps and iliotibial band lengths were found to be reduced in women with moderate RKOA compared to those with mild RKOA. Also, lower quadriceps and iliotibial band flexibility was found in subjects with moderate RKOA compared to non-RKOA subjects. Quadriceps flexibility also showed a decreased value in subjects with mild RKOA compared to non-RKOA subjects. Quadriceps and iliotibial band tightness can be useful targets in developing interventions to treat or prevent KOA.

Conflict of Interest: None declared.

References

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