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Original Article

Flexibility of Knee Joint Muscles in Women with Knee Osteoarthritis and Healthy Controls

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ABSTRACT

Background: Osteoarthritis is one of the most common diseases in synovial joints. Due to high loading forces during weight-bearing activities, the knee joint is prone to degenerative processes. This study aimed to compare the flexibility of muscles around the knee joint in patients with knee osteoarthritis with those of healthy individuals.
Methods: Twenty-three women with bilateral knee osteoarthritis and 23 healthy women matched with the patient group for age, height and weight participated in this study. Flexibility of the quadriceps, hamstring, iliotibial band, adductor and gastrocnemius muscles was evaluated with a goniometric device. Pain intensity was assessed with a visual analogue scale. The data were analyzed with independent t-tests to compare the two groups, and Pearson correlation coefficient was calculated to correlate muscle flexibility and pain intensity.
Results: significant lower flexibility of the bilateral quadriceps muscles was found in patients compared to healthy women ($P<0.05$). No significant differences were detected between groups regarding other muscles. Quadriceps flexibility correlated significantly with pain intensity in patients ($P<0.001$).
Conclusion: In patients with osteoarthritis, quadriceps flexibility may be decreased although other muscles may remain unaffected. Quadriceps stretching is thus a potentially important component of treatment, which may influence pain reduction in these patients.

Introduction

Osteoarthritis (OA) is a common joint disorder in industrial societies, and a major cause of disability. Weight-bearing joints such as the knee, hip and vertebrae are susceptible to degenerative changes that can interfere with physical activities and quality of life [1, 2]. In older people, knee OA is the main cause of pain and disability [3]. One third of individuals aged between 63 and 94 years suffer from knee OA that restricts their ability to stand, walk, rise from a chair and climb stairs [4]. The prevalence of knee OA is 10% in males and 13% in females among the population aged 60 years and older [5].

Zachezeweski has defined muscle flexibility "as the ability of a muscle to lengthen, allowing one joint to move through a range of motion" [6]. Therefore it is an important component of musculoskeletal health. The lack of muscle flexibility is generally assumed to increase the risk of injury [7]. Muscle weakness and poor flexibility are two major components of joint pain and dysfunction [8, 9]. In the knee joint, muscle imbalance plays an important role in the appearance and progression of OA. Changes

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in muscle function lead to alterations in ground reaction forces, the progression of degenerative changes and the development of pain [10]. Patients with knee OA thus have different gait kinematics and kinetics compared to asymptomatic persons [11, 12]. Alterations in gait include decreased knee excursion and different muscle activity patterns in lower extremity. Although these alterations may protect the knee joint from further degeneration they have numerous adverse effects [13].

The knee consists of two joints [14]: the patellofemoral and tibiofemoral joint. The former can be involved in biomechanical problems in the young and physically active population [15, 16]. Various factors such as abnormal lower limb biomechanics, insufficient flexibility and quadriceps deficit may lead to patellofemoral dysfunction. Previous studies have shown that the flexibility of muscles around the knee joint was decreased in patellofemoral pain syndrome (PFPS) and in athletes with anterior knee pain [7, 17, 18]. Pone et al. noted that in patients with PFPS, decreased flexibility in the quadriceps was greater than in healthy people [17]. Similar studies have documented decreased flexibility in the gastrocnemius [18], hamstring and quadriceps muscles in patients with PFPS compared to controls [7]. Research on the association between PFP and lower extremity biomechanics by Ohjeoung et al. suggested that less flexibility in the hamstring was increased in patients with PFPS compared to healthy controls [19].

In middle-aged and elderly people OA is a relatively common problem that can influence self-efficacy for physical tasks, and that is associated with a risk of falling. Muscle flexibility is an important characteristic, which deceases with age. The resulting lack of muscle flexibility can lead to changes in joint function [20], and may be a risk factor for injuries during activities that require a full range of motion [21]. Knee OA-related stiffness can be observed during walking in patients [22]. According to Oatis et al., joint stiffness showed a moderate negative correlation with stride length in patients with knee OA [23]. Thereby performing regular stretching exercises increase muscle flexibility, ROM and provide functional benefits for patients with knee OA and may delay the need for surgical interventions.

To the authors' knowledge, no previous studies have explored the flexibility of muscles around the knee joint in patients with knee OA. We accordingly designed the present study to compare the flexibility of muscles around the knee in patients with OA and healthy asymptomatic control participants. Our hypothesis was that the amount of knee joint muscles flexibility in patients with knee OA was differs from healthy subjects. Also we hypothesized that the muscle flexibility would correlate with pain intensity.

Methods

Twenty-three non-athlete women with OA and 23 healthy women between 40 and 60 years of age were enrolled in this cross-sectional study. According to Kellgren and Lawrence grading system, each participant had grades 2 or 3 knee OA in bilateral tibiofemoral were included in this research [24]. Another criterion comprised experiencing pain in the majority of the days of the week during the 6 months prior to the study. All participants provided their written informed consent. Those with any history of low back pain, unilateral knee OA, trauma to the knee joint, loss of joint play in tibiofemoral and patellofemoral articulations, lower extremity fracture and surgery, neurological deficit or movement disorder, and those who were athletes or who had been treated with physiotherapy during the previous 6 months, were excluded from the study. Initially, age, weight and height were recorded on a data collection form. All measurements were obtained with a goniometer. The goniometry reliability for measuring the range of motion in limb joints is considered good to excellent [25].

In the present study joint play in knee complex was evaluated at first. If the joint play is found to be normal, the limitation of range of motion is most likely due to lack of flexibility [26].

To measure hamstring flexibility, passive knee extension tests were done in the supine position, as follows. The pelvis was immobilized, and the leg to be measured was positioned in 90-90 degree hip and knee flexion. Then one examiner extended the knee joint passively to the point where she felt resistance to movement. A second examiner placed the center (fulcrum) of a universal goniometer on the lateral femoral condyle with the stationary arm of the goniometer aligned on the lateral malleolus and the moving arm aligned with the greater trochanter, and recorded the angle as shown in figure 1 [27-32]. All measurements performed by the same examiner.

Figure 1: The measurement of hamstring flexibility.

To measure quadriceps flexibility the examiner flexed the knee joint passively in the prone position. The center of the goniometer was positioned on the femoral lateral condyle with the stationary arm aligned on the thigh and the moving arm aligned on the tibia, and the angle was recorded after 90% (figure 2) [33, 34].

To measure adductor flexibility in the supine position, the non-test leg was immobilized at the midline and the other leg was abducted passively until firm resistance was felt. The center of the goniometer was placed on the anterior superior iliac spine (ASIS), and the moving arm was positioned along the thigh midline while the stationary arm was placed along the imaginary line connecting the two ASIS (figure 3) [35].

Figure 2: The measurement of quadriceps flexibility.

Figure 3: The measurement of adductor flexibility.

As shown in figure 4, to evaluate gastrocnemius flexibility the participant was asked to lie prone with her knee extended and the foot hanging from the end of the plinth. Passive ankle dorsiflexion was done until resistance was felt. The center of the goniometer was placed on the lateral malleolus, and the stationary arm was aligned with the leg while the moving arm was positioned on the lateral side of foot [35].

Figure 4: The evaluation of gastrocnemius flexibility.

Iliotibial band flexibility was recorded with the participant lying on her side. The lowermost limb was flexed and the uppermost (test) limb was extended and abducted with the knee flexed at 90 degrees. The examiner helped to keep the test limb in the above position and prevent unwanted hip rotation. Then adduction was allowed with the force of gravity. The center of the goniometer was placed on ASIS with the stationary arm aligned with line connecting the two ASIS and the other arm positioned on the longitudinal axis of the adducted extremity [36, 37].

Pain sensation was measured with an 11 point scale (0-10) VAS.

Statistical Analysis

All statistical analyses were done with SPSS v. 16 software and $P<0.05$ was considered significant. The normality of our data was examined by using Kolmogorov-Smirnov. Independent t tests were used to compare muscle flexibility in patients with knee osteoarthritis and controls, and Pearson's correlation coefficient was calculated to search for correlations between knee muscle flexibility and pain intensity.

Results

The descriptive characteristics of participants are shown in Table 1. There were no significance differences between the groups in baseline characteristics.

Muscle flexibility differed significantly between groups only for the right ($P=0.001$) and left quadriceps ($P=0.004$) (Table 2). There were no significant difference between groups in flexibility of the hamstring, gastrocnemius, iliotibial band or adductor muscles ($P>0.05$) (Table 2).

The correlations between muscle flexibility and pain intensity are shown in table 3. We found a statistically significant negative correlation between pain intensity and right quadriceps ($r=-0.458$), left quadriceps ($r=-0.461$) and left adductor flexibility ($r=-0.314$).

Discussion

We found that quadriceps muscle flexibility in women with knee OA was lower than in healthy women –our result was consistent with the other studies on knee pain [7, 17, 18]. Piva et al. reported less flexibility in the quadriceps, hamstring, gastrocnemius and soleus muscles in individuals with PSPF compared to healthy controls [18]. In addition, Smith et al. found a relationship between quadriceps muscle flexibility and anterior knee pain in adolescent athletes [7]. It is believed that in response to joint damage or dysfunction, postural muscles such as the quadriceps tend to become shorter [38]. Lake of flexibility in quadriceps has a profound effect on patellofemoral joint alignment [39] and may cause greater stress on this structure and thus predispose individuals to developing symptoms [40]. Because of the pain, these patients apparently cannot flex their knee joint more than 100 degrees over prolonged periods during activities of daily living. On their physician's advice, they modify their activities to avoid sitting cross-legged or kneeling on the floor. In addition, a sedentary life style may influence quadriceps flexibility.

Another purpose of our study was to document the relationship between muscle flexibility and pain intensity in patients with OA. The results supported our hypothesis that flexibility would correlate with pain intensity. In other

Table 1: Baseline characteristics of the women who participated in the patient and control groups

Group	Patient (n=23)	Healthy (n=23)	P value
Variable	Mean±SD	Mean±SD	
Age (years)	3.89±49.6	5.71±48.72	0.590
Weight (kg)	11.07±68.52	8.9±68.04	0.873
Height (cm)	6.23±1.58	6.56±1.61	0.265

Table 2: Comparison of muscle flexibility in patients with knee osteoarthritis and controls

Group	Patient	Healthy	P. value
Muscle Flexibility (degrees)	SD±Mean	SD±Mean	
RT Hamstring	13.83±69.04	13.75±69.6	0.890
LT Hamstring	12.08±69.34	13.71±68.26	0.777
RT Quadriceps	13.14± 26.52	8.97±39.73	0.001*
LT Quadriceps	12.05±27.13	7.64±36.17	0.004*
RT Iliotibial band	7.28±17.47	8.4±20.65	0.120
LT Iliotibial band	6.18 ±17.17	9.07±18.00	0.720
RT Adductor	7.92±32.30	12.31±34.86	0.405
LT Adductor	6.46±28.95	9.96±33.26	0.089
RT Gastrocnemius	9.22 ±35.08	10.93±31.95	0.300
LT Gastrocnemius	8.24 ±30.73	10.39±30.86	0.963

RT, Right; LT, Left, *P. value<0.05

Table 3: Correlation between flexibility of muscles around the knee joint and pain intensity

Correlation	r	P. value
VAS (cm) × RT Hamstring (P)	-0.017	0.911
VAS (cm) × LT Hamstring (P)	0.020	0.894
VAS (cm) × RT Quadriceps (P)	-0.458	0.001*
VAS (cm) × LT Quadriceps (P)	-0.461	0.001*
VAS (cm) × RT Ilitibial band (P)	-0.046	0.759
VAS (cm) × LT Iliotibial band (P)	-0.003	0.986
VAS (cm) × RT Adductor (P)	-0.258	0.084
VAS (cm) × LT Adductor (P)	-0.314	0.033*
VAS (cm) × RT Gastrocnemius (P)	0.085	0.575
VAS (cm) × LT Gastrocnemius (P)	-0.054	0.719

RT, Right; LT, Left; VAS, Visual analog scale; *P. value<0.05

words, quadriceps flexibility was lower in patients with more intense perceived pain. One possible explanation is that to prevent pain, the patients flex their knee joint less than 100 degrees and this behavior leads to a decline in quadriceps flexibility, patella alta and recurrent pain – all of which create a vicious cycle [41]. In contrast to our results, some researchers have found a relationship between hamstring tightness and pain in adolescent athletes with anterior knee pain [7]. A possible explanation for these different findings is that the participants in the study by Smith et al. were young athletes with anterior knee pain due to jumper's knee, Osgood Schlatter disease, patellofemoral pain or combinations of these whereas the participants in the present study were middle-aged women with tibiofemoral joint OA. Therefore the pattern of muscle tightness in athletes and patients with knee OA may be dissimilar.

We found no significant differences between groups in hamstring, iliotibial band, gastrocnemius or adductor muscle flexibility. One probable reason is that all participants in both groups were non-athletes and middle–aged and therefore probably experienced a similar trend toward loss of contractile function and flexibility [20, 42]. Another hypothesis is that the central nervous system' ability to voluntary activation of quadriceps impaired in individuals with knee OA. Muscle activation failure can result in abnormal articular afferent inputs being sent to α.motor neurons and this may occur due to joint degeneration [43].

Our results for iliotibial band flexibility showed no significant differences between the two groups. We are aware of no previous studies of iliotibial band flexibility in patients with knee OA. One earlier study found no differences in flexibility between patients with PFPS and healthy individuals [18]. However, Hudson et al. reported decreased iliotibial band flexibility in these patients [44]. We believe this difference with our results may exist because all participants in our study had knee OA. According to comprehensive approach in dysfunction of lumbopelvic-hip, shortening of iliotibial band trends to occur in low back pain patients and necessarily not be seen in all of patients with knee OA [45].

Our patients with knee OA did not differ significantly from asymptomatic controls in hamstring muscle flexibility. A previous study, however, noted that hamstring tightness may be one of the contributing factors to PFPS [27]. The discrepancy between our results and those reported by White et al. may be attributed to differences in the age ranges of the participants, and differences in the pathological mechanisms and differences in gender in these two studies. Unlike previous study, the participants in the present research were women aged 40-60 years and had tibiofemoral OA.

A few limitations of this study should be taken into account. First, the participants in this study were women aged 40 and 60 years, so we cannot generalize our results to other age groups. We suggest further research in larger groups including both genders. A second limitation is that all goniometric readings were made and recorded by the same examiners, neither of whom was blinded.

Conclusion

Quadriceps muscle flexibility was reduced in women with knee OA. Treatments should be designed to take into account the association between pain intensity and quadriceps tightness as well as muscle flexibility.

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