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Association of isometric hip abductor strength with Kellgren-Lawrence grade among patients with bilateral knee osteoarthritis

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ABSTRACT

Objectives: The degree of knee osteoarthritis (OA) is usually graded with the Kellgren-Lawrence (KL) grading system. Studies have shown the effect of weak hip abductor muscle as a contributory factor to knee OA. However, there is a shortage of literature regarding the association of hip abductor strength with the KL grade.

Methods: Individuals diagnosed with bilateral knee OA between the ages 40 and 70 years, who have had a recent knee radiograph and are mobile and willing to participate, were included in the study. A brief demographic and basic screening was done following which the isometric hip abductor strength of each limb was assessed using the Jamar Handheld Dynamometer in a supine lying position across the wall. Three readings were taken, and the average was noted. The grade of OA was noted using the knee radiograph using the KL grading system.

Results: Forty participants with bilateral knee OA were recruited for the study of which 62.5% (n = 25) were female and 37.5% (n = 15) were male. There was a weak negative correlation of KL grade of the left knee with the left hip abductor isometric strength (P = 0.013, r = −0.39). However, a statistically significant difference (P = 0.021) was found in isometric hip abductor strength between lower grade of knee OA (KL grade 1, 2) and higher grade of knee OA (KL grade 3, 4).

Conclusion: There is an association between the isometric hip abductor strength and KL grade of knee OA wherein the better the strength, the lower the KL grade.

Keywords: Grade, Hip abductors, Knee, Osteoarthritis, Strength

INTRODUCTION

Osteoarthritis (OA) involves degeneration, namely, the wear and tear of cartilage and subchondral bones.[1] It can be visualized on the radiograph, which can be graded through the Kellgren-Lawrence (KL) grading system. This grading system assists healthcare providers in planning the treatment algorithm, thereby assisting in clinical decisionmaking.[2] The knee joint is the most commonly affected joint with OA due to its weightbearing function.[3] Due to the high activity demands, the knee joint has been subjected to constant stress and loadbearing over the years. It is categorized as one of the common joint problems, with a 22–39% prevalence rate among the Indian population.[4]

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The weakness of the hip abductor muscles has previously been linked to a range of lower limb pathologies.[5-7] Many disorders occur due to femoropelvic malalignment, which leads to a change in the mechanical weightbearing line. The involvement of hip abductor weakness in knee OA development is a minimally explored area. Theoretically, as indicated through various biomechanical studies, weakness of the hip abductors can lead to femoropelvic malalignment, thereby contributing to increased medial knee joint loading and thereby being a risk factor for tibiofemoral knee OA.[8,9] Rutherford *et al.* stated that in patients with knee OA, there is a strong effect on hip abductor strength and external knee adduction moment.[10]

Hip abductors, mainly the gluteus medius muscle, are responsible for maintaining the alignment of the pelvis with respect to the femur in the frontal plane during single-leg loading during gait.[8] Gluteus medius weakness on the stance limb leads to contralateral limb pelvic drop. This shifts the center of mass to the opposite side, thereby causing medial joint compression on the ipsilateral side.[11] Studies have shown that varus malalignment is due to the higher knee adductor moment.[11]

Having theoretically established that weak hip abductors are a risk factor for the causation of knee OA, there are still some lacunae on whether there is any association of the quantitative measure of hip abductor isometric strength with that of the objective grade of knee OA. To the best of our knowledge, there is a dearth of literature on finding a relationship between the grade of knee OA and that of the hip abductor isometric strength. Hence, this study aimed to check the association of hip abductor isometric strength with knee OA grade.

MATERIALS AND METHODS

Study design

It was a cross-sectional pilot study with participants recruited based on convenience sampling. The study was conducted after the approval from the Institutional Research Review Committee. Forty participants were recruited from the outpatient physiotherapy department of a tertiary care hospital.

Participants

Participants included in the study were diagnosed with bilateral knee OA, who showed the presence of symptoms such as joint pain often worsening with activity, with or without joint stiffness for <30 min, joint swelling, bony crepitations, and movement impairments, and radiological signs showing a reduction in knee joint space in weightbearing films along with degenerative changes on both sides.[12] Participants were between the ages of 40 and 70 years having had a recent knee radiograph (not more than three months-old) and were mobile and willing to participate. Those individuals, who had concomitant acute low back pain or hip pain, recent inguinal or abdominal surgeries, any surgery of the hip and knee, underlying neurological conditions (upper and lower motor neuron lesions), lower limb unhealed fracture, known osteoporosis, acute uncontrolled hypertension, acute exacerbation of the chronic obstructive pulmonary disease, on oral or intra-articular steroids, or undergoing any form of physical therapy exercises and those with thigh circumference exceeding the circumference of the handle of the Jamar Dynamometer, were excluded from the study.

Procedure

Participants were recruited based on the inclusion-exclusion criteria. After explaining the purpose of the study, written consent was obtained from each participant. Demographic details such as name, age, and sex were noted. The participant's body mass index (BMI) was calculated.[2] The thigh circumference was measured using the measuring tape 5 cm above the lateral condyle of the femur where the Jamar hand dynamometer was placed to measure the hip abductor isometric strength.

The participants were supine with the leg to be assessed across the wall. The pelvis was stabilized using a stabilization belt. The dynamometer handle was placed 5 cm above the lateral condyle of the femur [Figure 1]. The participants were instructed to push the lateral aspect of the thigh against the dynamometer's handle for 5 s with the hip maintained in neutral. While doing so, they were asked not to rotate or move the leg or pelvis. A practice trial was provided for the patient to understand the procedure after which three

Figure 1: The position of the hand held dynamometer to assess hip abductor strength in a participants of knee osteoarthritis.

readings were taken. The readings were recorded according to the readings shown by the peak-hold needle. The isometric strength was recorded as the average of the three trials. The same procedure was repeated for the other lower limb as well.

The Rosenbergs view anteroposterior radiographs of bilateral knees were taken, which were utilized to analyze the grade of knee OA using the KL grading scale. Radiographs were scored from KL grade I to IV. Higher grades denoted increasing order of severity of OA. Grade I ranged from showing doubtful narrowing of the knee joint space with a possibility of osteophyte formation, grade II involved radiographs wherein there was possible narrowing of the joint space but with presence of definite osteophytes, grade III was defined by definite narrowing of the joint space with considerably moderate osteophyte formation, sclerosis, and deformity of bone ends while grade IV denoted large osteophyte formation and severe narrowing of the joint space with marked sclerosis, and definite deformity of bone ends.[13] Two investigators underwent an online course on the KL grading system as proposed by Hayes *et al.*[13] The KL grading system is known to have good inter-rater reliability (κw = 0.82) and is also known to have improved confidence in assessing the grade of OA among the participants.[12] Both investigators independently graded the radiological films to mitigate bias and then at the end, the findings were compared and reviewed to reach a consensus. Agreement was assessed, which came to be with k = 0.8.

Statistical analysis

Data was recorded, tabulated, and analyzed using the Statistical Package for the Statistical Sciences software version 24. The normality of that data was determined using the Shapiro–Wilks test. The data was found to be not normally distributed ($P = 0.00$). Hence, Spearman's rank correlation coefficient was used to investigate the association between the KL grade and isometric hip abductor strength. Based on the strength, the correlation coefficients were classified as strong (0.70–1.00), moderate (0.40–0.69) or weak (0.20–0.39). After that, the non-parametric Mann–Whitney U-test was used to determine the difference between the isometric hip abductor strength in participants with higher KL grades (grades 3 and 4) and lower KL grades (grades 1 and 2).

RESULTS

Forty participants were recruited of which 37.5% ($n = 15$) were male and 62.5% ($n = 25$) were female. The mean age of the participants was 57 years ± 8 years. Each participant was a case of bilateral knee OA and, hence, had two readings, namely, one for the right and one for the left knee. Therefore, 40 participants had 80 readings in all [Table 1]. The mean BMI is 28.2 ± 3.3 kg/m^2, which is, further, discussed in Table 2.

Table 1: The percentage and number of participants belonging to each grade of knee osteoarthritis.

Grade as per Kellgren-Lawrence	Number of readings (2 per participant) (%)
Grade 1	*n*=6 (7.5)
Grade 2	*n*=22 (27.5)
Grade 3	*n*=46 (57.5)
Grade 4	*n*=6 (7.5)

Table 2: Number of participants in each group as per the BMI.

Grade of BMI	Number of participants (%)
Normal (18.5–22.9 kg/m^2)	*n*=2 (5)
Overweight (23–27.5 kg/m^2)	*n*=14 (35)
Obese (≥27.5 kg/m^2)	*n*=24 (60)

BMI: Body mass index

There was a weak negative correlation of KL grade of the left knee with the left hip abductor isometric strength ($P = 0.013$, $r = -0.39$). However, there was no correlation of KL grade of the right knee with right hip abductor isometric strength ($P = 0.339$, $r = -0.155$).

A statistically significant difference was found in the hip abductor isometric strength between the higher grades of knee OA (grades 3 and 4) and lower grades of knee OA (grades 1 and 2) on applying the Mann–Whitney U-test as described in Table 3.

DISCUSSION

We found a weak negative correlation of KL grade of the left knee with the left hip abductor isometric strength but no correlation of the parameters mentioned above on the right side. Furthermore, participants with increased joint space reduction and multiple osteophytes demonstrated weaker isometric strength of hip abductors compared to those, who had less to no joint space reduction. Thus, the study proved that proximal stability of the pelvis contributed by the hip abductors is instrumental in minimizing the load dispersed on the knee joint, especially during weightbearing activities.

It has been found that a reduction in the strength of hip abductor muscles can contribute to the development of knee OA as a consequence of contralateral pelvic drop.[14] This thereby causes a shift in the center of mass and increases the load over the medial tibiofemoral joint.[14] Another study showed that knee OA leads to weaker isometric and isokinetic hip abductor strength.[15] In a static single-leg posture, the gluteus medius and other hip abductors contract to keep the femur and pelvis aligned in the sagittal, frontal, and transverse planes. The mechanical weightbearing

Table 3: Table describing the difference in isometric strength between the high grade of knee osteoarthritis with low grade of knee osteoarthritis.

	Median hip isometric strength	Interquartile range of hip isometric strength	Z-value	*P*-value
Higher grade of OA	5.00	2.00–6.00	−2.308	0.021
Lower grade of OA	3.00	2.00–5.00		

OA: Osteoarthritis

axis and knee adductor moments are altered when these muscles are weak, which affects the knee joint. The medial side of the knee experiences higher joint loading due to the center of mass shifting further medially.[16,17] This puts more strain on the knee joint, which eventually leads to cartilage deterioration and a reduction in joint space.

Walking is a dynamic activity that requires a substantial amount of hip abductor activation. During a single gait cycle, the lower limb is subjected to single-limb support, which involves body progression over the foot and weightbearing stability. The first single-leg support occurs during the midstance, which is seen during 12–31% of the gait cycle. The next stage of single limb support occurs during the terminal stance, which goes from 31% to 50% of the gait cycle.[17] During this phase, the hip abductors help maintain the proximal stability and equal weight distribution over the distal segments. Therefore, hip abductor weakness, as observed in our study, may contribute to ipsilateral pelvic drop, which, in turn may increase knee adductor moment, which in turn may increase the load on the knee joint resulting in excessive wear and tear on the joint cartilage and eventually causing knee OA to develop and progress.

There was a weak negative association between the left isometric hip abductor strength and left knee KL grade but no correlation between right isometric hip abductor strength and right knee KL grade, which could be because most participants in the study were right dominant, and previous studies have shown that there is a preponderance of knee OA on the sides, which are non-dominant as compared to dominant. It was seen that the medial/lateral displacement of the center of pressure was more on the non-dominant side as compared to the dominant side. This shows higher changes in OA on the non-dominant side and weaker isometric hip abductor strength.[18,19]

Knee OA is known to have the multifactorial etiology.[20] Aging, activity levels, obesity, bone density, and nutrition are all factors that play a major role along with hip abductor weakness in the severity of the grade of OA. In our study, 60% (n = 24) belonged to the obese category with BMI >27.5 kg/m^2 and 35% (n = 14) belonged to the overweight category with BMI between 23 kg/m^2 and 27.5 kg/m^2 (according to the Asian classification of BMI).[20,21] Increased fat deposition could accelerate the processes of fibrillation and deterioration by increasing the load and impact placed on the knee's articular cartilage. Over time, this wear and tear could lead to increasing the severity of OA seen in the form of radiographical changes with further degeneration.[22] A study by Valenzuela *et al.* on the effect of obesity on muscle quality and strength showed that obese individuals had poor muscle quality. They explained that the potential determining factors could include metabolic abnormalities, a transition toward slow oxidative muscle fibers and increased muscle fat accumulation.[22] These factors could alter the results of our study and need to be considered during further research. Another factor affecting muscle activation is the intensity of the pain experienced by the subject at the time of the assessment. Research shows that increased pain intensity can cause muscle inhibition leading to submaximal performance of the hip abductors.[23]

Another aspect, which is the limitation of our study, is that there was an uneven distribution of participants in each grade of knee OA, thereby causing a skewed effect in the results. Furthermore, the small sample size and uneven distribution of samples in each group/grade of knee OA can be addressed in the future. In fact, there is further scope to check the effect of hip isometric strengthening protocol on the grade of knee OA.

CONCLUSION

There is an association between the isometric hip abductor strength and the grade of knee OA. Thus, it gives us an idea that the better the isometric hip abductor strength, the lesser the forces on the knee, thereby preventing further increase in the grade of knee OA.

RECOMMENDATIONS

More robust findings can be obtained by recruiting larger samples with a more homogenous population in each grade of knee OA. Furthermore, with a larger sample size, further analysis can be done based on obesity grades to avoid the effects of obesity on the knee OA. An experimental study can further be devised to check for any improvement in the grade of knee OA with a good hip abductor strengthening protocol.

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AUTHORS' CONTRIBUTIONS

RRK, PW, VP, and VK were involved in the conception, design, data analysis, and manuscript editing. HDG was involved in data collection and compilation of the first draft. All authors have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

ETHICAL APPROVAL

The study is approved by the Institutional Review Board at Institutional Research Review Committee of the Mahatma Gandhi Missions College of Physiotherapy, Navi Mumbai, number MGM/COP/IRRC/10/2022, dated 16/06/2022.

DECLARATION OF PATIENT CONSENT

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY FOR MANUSCRIPT PREPARATION

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

CONFLICTS OF INTEREST

There are no conflicting relationships or activities.

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