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ORIGINAL RESEARCH

PATELLOFEMORAL PAIN SUBJECTS EXHIBIT DECREASED PASSIVE HIP RANGE OF MOTION COMPARED TO CONTROLS

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ABSTRACT

Background: Patellofemoral pain is a common condition without a clear mechanism for its presentation. Recently significant focus has been placed on the hip and its potential role in patellofemoral pain (PFP). The majority of the research has examined hip strength and neuromuscular control. Less attention has been given to hip mobility and its potential role in subjects with PFP.

Purpose/Aim: The purpose of this study was to compare passive hip range of motion (ROM) of hip extension and hip internal and external rotation in subjects with PFP and healthy control subjects. The hypothesis was that subjects with PFP would present with less total hip ROM and greater asymmetry than controls.

Design: Two groups, case controlled.

Setting: Clinical research laboratory

Participants: 30 healthy subjects without pain, radicular symptoms or history of surgery in the low back or lower extremity joints and 30 subjects with a diagnosis of PFP.

Main Outcome Measures: Passive hip extension, hip internal rotation (IR) and hip external rotation (ER). A digital inclinometer was used for measurements.

Results: There was a statistically significant difference ($p < 0.001$) in hip passive extension between the control group and the PFP group bilaterally. Mean hip extension for the control group was 6.8° bilaterally. For the PFP group, the mean hip extension was -4.0° on the left and -4.3° on the right. This corresponds to a difference of means between groups of 10.8° on the left and 11.1° on the right with a standard error of 2.1°. There was no statistically significant difference ($p > 0.05$) in either hip IR or ER ROM or total rotation between or within groups.

Conclusions: The results of this study indicate that a significant difference in hip extension exists in subjects with PFP compared to controls. These findings suggest that passive hip extension is a variable that should be included within the clinical examination of people with PFP. It may be valuable to consider hip mobility restrictions and their potential impact on assessment of strength and planned intervention in subjects with PFP.

Level of Evidence: 2b

Key Words: Hip, inclinometer, patellofemoral pain, passive range of motion

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INTRODUCTION

Patellofemoral pain (PFP) is a common condition evaluated and treated in the orthopedic setting.[1,2] The condition is sometimes referred to as anterior knee pain or patellofemoral pain syndrome.[3,4] The etiology of the condition remains unknown although many variables are thought to be contributory. Amongst the considerations are excessive Q angle, excessive foot pronation, weakness of the vastus medialis, misalignment of the patella, maltracking of the patella, joint laxity, and decreased mobility of the hamstrings and or quadriceps.[5]

Historically the focus of PFP etiology has tended to center upon distal factors, foot and ankle, and muscles directly attaching to the knee, such as the quadriceps muscle.[6] However, much of the emergent research has been focused about the hip.[7-11] Powers has discussed and provided evidence to support the notion that a significant contributor to PFP may be the hip region.[7,12] The fact that the knee and hip region are mechanically linked can be reasonably surmised by their linkage through the femur.[13] However, a considerable amount of recent literature still focuses attention primarily on the knee joint as an isolated region in the etiology and treatment of PFP.[14-18] A recent study comparing posterolateral hip muscle strengthening as compared to quadriceps strengthening in subjects with PFP found both to be helpful in reducing pain and improving functioning.[19] However the hip strengthening was found to be superior. Clearly, both the knee and hip muscles are important variables that need to be taken into consideration in subjects with PFP.

The majority of the current literature on hip region involvement in PFP is centered upon strength and neuromuscular control.[20-24] In the past few years several authors have examined the kinematics of the hip and its effect on PFP.[25,26] What has been reported is that significant differences can exist in kinematics about the knee and hip in subjects with PFP as compared to controls.[27-29] In particular some subjects with PFP have been observed to display with increased knee valgus, increased hip IR and increased hip adduction as compared to controls.[29] Additional authors have evaluated the gluteus medius and maximus motor activation patterns in subjects with PFP and found significant differences in both fatigue patterns and motor activation patterns.[30,31] In particular several investigators have found a direct correlation between PFP and altered hip movement and changes in gait and running.[32,33] What appears to be lacking is data on the role that soft tissue and joint mobility may contribute to PFP. The information that is available has focused on structures of the lower extremity such as quadriceps, hamstrings, iliotibial band, and gastrocnemius/soleus.[6,34-36] Little information is available that examines hip ROM in individuals with PFP.[37] It is reasonable to consider that the ROM of a joint, which is a general measure and takes into consideration all components of the structure, can impact the joint moment and dissipate mechanical loads.[38,39] In particular hip extension, hip IR and Hip ER ROM are of interest due to their influence from the gluteus maximus, which is noted to be a significant factor in PFP etiology.[21] It has been observed that female subjects with PFP have a significantly decreased hip extension and hip abductor torque production as compared to healthy controls.[21] In this author's opinion the mobility of hip abduction, adduction and flexion do not appear to a major variable in the condition of PFP based on current understandings of the condition, although this needs further investigation. Some evidence is available that supports the notion that static measurements of postural positioning can be predictive of dynamic function.[40]

The purpose of this study was to compare passive hip range of motion (ROM) of hip extension and hip internal and external rotation in subjects with PFP and healthy control subjects. The authors hypothesized that subjects with PFP would present with less passive hip ROM in hip extension and hip internal and external rotation than controls.

METHODS

A convenience sample of 30 volunteer subjects without PFP (13 males and 17 females; mean age 34.0 +/- 13.1 years; mean height, 171.5 cm +/- 11.9, mean body mass, 72.0 kg +/- 13.9, and 30 subjects with a diagnosis of PFP(9 males and 20 females; mean age 36 +/- 13.7 years; mean height, 171.5 cm +/- 10.7, mean body mass, 69 kg +/- 13.8 were recruited. Control subjects were included if they reported no history of surgery of the spine, hips, knees; no history

of neurological insult to the musculoskeletal system; and had no current acute pain of the hips, low back, or knees. PFP subjects selected for this study met the following inclusion criteria: generalized anterior, anterior/medial knee or retropatellar pain for 1 month or longer associated with prolonged sitting, ascending/descending stairs, sports activity, and/or running. Exclusion criteria for both groups included a history of patellar dislocation, cartilage or ligamentous damage, surgery for trauma to the knee, and a known history of osteoarthritis. All subjects were informed of the purpose of the study and signed an informed consent document prior to data collection.

Study Design
All data collection took place in research institute. All testing was completed in a single session by the primary investigator. The investigator is a licensed physical therapist with 20 years of experience in the musculoskeletal practice environment. During evaluation, the investigator measured extension (EXT), internal (IR) and external rotation (ER) on both left and right hip. A digital inclinometer was used to measure hip ROM. The digital inclinometer was a Digital Protractor Pro 3600 manufactured by Miutoyo America, Aurora, Illinois with an accuracy of $0.1°$. The digital inclinometer has been found to be possess good reliability and concurrent validity with the universal goniometer which is the standard tool in clinical practice.[41] The reliability of the device in previous work on hip ROM was noted to be .90.[42] No practice or warm up was performed prior to measurements.

During EXT measurement, the subjects were positioned on their back and a modified Thomas test, typically a test for length of hip flexors to measure hip extension PROM, was performed. The modified Thomas test has been found to possess good reliability.[42-44] The hip being measured was positioned at the end of the treatment table and the tested leg was then cantilevered over the edge of table with the end feel resulting from the effects of gravity. No manual contact was made with the tested leg. The opposite leg was held actively by the subjects with the hip and knee in a flexed position against the chest. Instructions were provided for subjects to pull their knee straight toward their head to avoid any abduction. In addition, subjects were provided feedback, both verbal and tactile to maintain a low back flat against table to avoid

lumbar and pelvic tilting throughout the evaluation. The inclinometer measurement was taken from the anterior mid femur position with midpoint between the greater trochanter and lateral femoral condyle. Measurements were noted as negative if they were above the horizon (more flexed than neutral position) and positive if they fell below the horizontal position (more extended than neutral position).

For IR and ER measurements, the subjects were positioned in the prone position on the treatment table and the following standard protocol was used.[42] The investigator passively flexed both the knees to 90 degrees while both hips were positioned in neutral for measuring hip internal rotation. Next, the investigator instructed the subjects to relax and allow the shank of both legs out for IR until reaching passive end feel of this joint region under the effects of gravity. For ER, the investigator passively flexed one knee to 90 degrees and then instructed the subject to relax the shank towards the midline and leg crossed over midline until reaching passive end feel, also determined per effects of gravity. The non- measured leg was positioned in extension on the table. The investigators assistant stabilized the subject's pelvis during hip ER measures to prevent pelvic rotation. Additionally, the subjects that displayed with greater ER (motion blocked by presence of opposite leg) had their non-tested leg abducted slightly to allow for full measurement. Measurements with the inclinometer were taken with device placed at midline of medial shaft of tibia between the medial malleoli and medial tibial condyle.

Each measurement was performed three times and the average of the three was calculated and recorded. The order of the collection trial was randomized in each position. Additionally, the inclinometer measurements were verbally given by the investigator and recorded by an assistant.

Statistical Analysis
A two-way analysis of variance (ANOVA) was conducted to determine whether differences in hip range of motion existed between groups. Simple effects analyses were conducted for significant interaction effects. Tukey post-hoc procedures were conducted in the case of significant main effects. Alpha level was set to 0.05.

RESULTS

Mean hip extension for the control group was 6.8° on the left side, and 6.8° on the right. For the PFP group, the mean hip extension was -4.0° on the left and -4.3° on the right. This corresponds to a difference of means between groups of 10.8° on the left and 11.1° on the right with a standard error of 2.1°. A significant difference ($p < 0.001$) was detected in hip extension angle between the control group and the PFP group on both the left and right sides, while no statistically significant differences existed between groups in rotation ranges of motion (Figure 1). Figure 2 illustrates
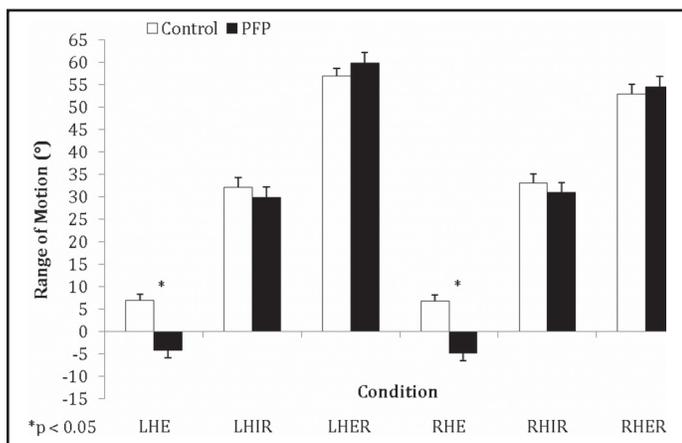
Figure 1. *Hip range of motion between control and patellofemoral pain patients comparing left and right hip extension, internal rotation, and external rotation.*
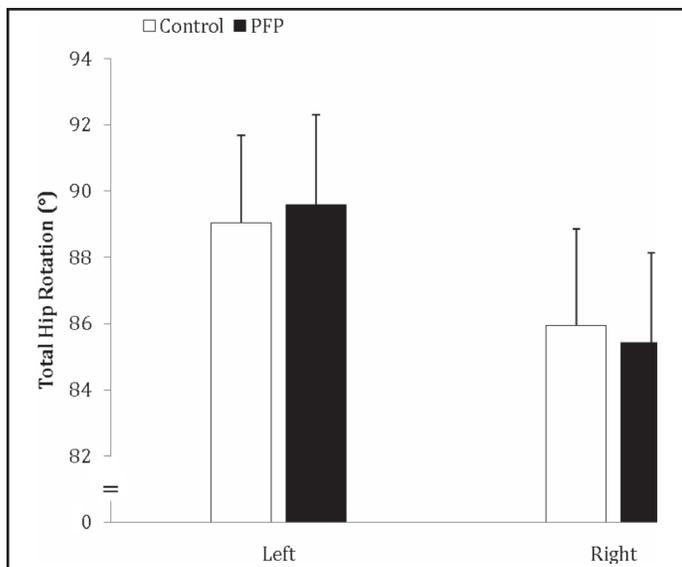
Figure 2. *Total hip rotation range of motion between control and patellofemoral pain (combination of external and internal rotation on the same side).*

total hip ROM with no significant difference between control and PFP group ($p > 0.05$).

DISCUSSION

The primary purpose of this study was to compare passive hip ROM in controls to subjects with PFP. Our data identified a significant difference in hip extension between the experimental and control groups. The PFP group on average demonstrated with 11° less hip extension than the control group. No additional significant differences were recorded in any of the other hip ROM variables measured in PFP group when comparing affected and unaffected extremity. These findings suggest that hip extension is a variable that should be evaluated when assessing subjects with PFP during clinical assessment.

This study was conducted utilizing a digital inclinometer due to its ease of use and good reliability in measurements of the lower extremities.[45,46] The digital inclinometer is noted to be a valid tool in assessing passive hip mobility.[42] The known validity and ability to quickly assess hip mobility may encourage clinicians to use the inclinometer on more regular basis.

The paucity of literature on hip mobility and its effects on the knee are puzzling. The ability of the hip to effect knee kinematics has been well established.[7] A good portion of literature has focused in particular on the need to address the role of the gluteus maximus in subjects with PFP.[21,30,47-49] It is reasonable to consider that if the hip is limited in its mobility that this could affect joint moments.[39] The authors of the current study recorded an average of 11° less hip extension in subjects with PFP as compared to controls, with left and right hip averaging -4.0° and -4.3° respectively (meaning the hip was flexed with relation to the neutral position). Several authors have noted that hip extension in healthy subjects varied between +2° to +13.7°.[50-53] A lack of hip extension may lead to adaptive shortening of anterior hip structures including, but not limited to, the hip flexor musculature. It could be that the converse situation may occur as well, with anterior hip structure shortening leading to decreased hip extension. Deficits of hip extension therefore may possibly result in two potential negative mechanical outcomes. One, lack of ability to generate full contractile force of the gluteus maximus by altering

the hip joint moment potential and two, decreased ability to store full potential of elastic strain energy of the anterior hip soft tissue. This second variable could result in decreased energy efficiency and potentially the overuse of anterior hip muscles to initiate swing phase of gait.[54,55]

Another issue worth consideration is to what degree does passive ROM measures of the hip reflect active or dynamic activity patterns. Schache et al. examined the relationship between passive hip extension, measured with a goniometer using the Thomas test, and anterior pelvic tilt, using a Vicon motion analysis system during running in 14 elite track and field athletes.[56] They found no significant correlation between passive ROM and hip extension during running. This study however used a small unique subset of individuals running at a submaximal speed that may not be reflective of the general population. Recently Moreside and McGill conducted a study examining the relationship between increased passive hip ROM (extension and rotation) and transfer into functional movement patterns in normal healthy males.[57] They found no evidence of increased functional ROM despite using interventions that significantly improved passive hip ROM. The conclusion of the authors were that further interventions in the form of motor control strategies to create new movement patterns may be necessary for carryover of passive gains into dynamic activities. This is certainly an area in need of future study for both normal and PFP subjects.

No significant differences were noted in hip rotation between groups. There were no significant differences in ER or IR within the PFP group. A literature review on hip mobility and PFP found little from which to compare this finding. Cibulka noted in a case study involving a 15 year old female with PFP, decreased IR and increased ER on side of involvement.[58] The majority of literature examining for hip asymmetries in physical medicine have focused on subjects with non- specific chronic low back pain.[59-61]

It is likely that hip mobility plays a strong role in influencing multiple proximal and distal regions such as the knee and or low back. This concept has been referred to as regional interdependence by Wainner et al.[13] Regional interdependence, in regards to the muscu-

loskeletal system, is defined as " seemingly unrelated impairments in a remote anatomical region may contribute to, or be associated with, the patient's primary complaint".[13] It could be hypothesized that deficits in hip mobility in multiple planes may result in altered mechanical loading of segments above and below the joint. The questions that arise from this scenario are many and varied. If an individual continues to place large mechanical loads on the body through work or sports related activity, they would need to compensate when mobility within segments are restricted. As an example, this compensation could result in muscle cell damage and potential for myofascial trigger point (MTrP) development.[62,63] Subsequently, there could be an alteration in motor control as has been demonstrated in the presence of MTrPs.[64] In one study it has been observed that subjects with PFP have a higher prevalence of MTrPS in bilateral gluteus medius and quadratus lumborum muscles.[65] This is an area that merits future investigation.

Future studies could examine the relevance of the findings of the current study through simple interventions and outcome measures in those with losses of hip extension in the presence of PFP. Although the current study did not find any differences in hip ER or IR, Cibulka et al noted that correcting asymmetrical hip rotation resulted in good improvement in an individual with PFP.[37] Cibulka et al have also advised that evaluating for hip rotation asymmetries is important prior to muscle testing and strengthening as asymmetries can influence hip rotator strength.[66] No studies to the authors' knowledge have tested this possibility with hip extension. It may be possible that many practitioners are overlooking this variable and proceeding to strengthening. A simple follow up study could examine for hip extension strength in presence and absence of restrictions. This could be followed up with a simple stretching routine to address the tight hip flexors. Studies have demonstrated that correcting for hip flexor tightness is possible with a short course of intervention.[67,68]

Study Limitations
The main limitation during data collection was in proper stabilization of pelvis during measurements. As other authors have noted, stabilizing the pelvis during the modified Thomas test, and for passive hip ROM in general, is very important in order to

achieve consistency during hip measurement and limit lumbar spine involvement.[69,70] All efforts were made to limit this involvement and it was felt that verbal and tactile cues given to subjects was sufficient to achieve this goal. Additionally, the main investigator was not blinded to subjects condition. This had the potential to bias measurements and blinding would reduce this risk. Lastly, would be the fact that patellofemoral knee pain was not directly measured. This could have been assessed with tools such as the anterior knee pain scale or the Western and McMaster Universities Osteoarthritis Index (WOMAC).[71,72]

Conclusion

The results of this study indicate that subjects presenting with PFP had significantly less passive hip extension than controls, when measured using the Thomas test. These findings suggest that passive hip extension is an important variable that should be included within the clinical examination of people with PFP. It may be important to consider hip mobility restrictions and their potential impact on assessment of strength.

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