Effect of Hip Rotation Stretch on the Piriformis Muscle: A Pilot Study

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ABSTRACT

Objectives: The objective of the current study was to examine, using diagnostic ultrasound (US), the effect of stretching the piriformis muscle into medial and lateral rotation in varying degrees of hip flexion on the thickness at the muscle tendon unit of the piriformis muscle. Background: Passive stretch is commonly used to assess piriformis muscle length and as a treatment to alter piriformis muscle tightness. However, current literature and practice suggests that the piriformis’ function may reverse from a hip lateral rotator to a hip medial rotator when the hip is flexed beyond 90 degrees. Anatomical studies suggest that there may be cases where the tendon’s distal attachment position on the femoral greater trochanter does not permit a reversal of function. Methods and Measures: Twenty-six subjects’ left hips were placed in increasing flexion positions (0, 60, 90, 100, 110, and 120 degrees) and maximal lateral and medial rotation. Thickness at the muscle tendon unit of the piriformis muscle was visualized and measured using diagnostic ultrasound at each hip flexion and each rotation position. Results: The data were analyzed using two-factor analysis of variance. The results demonstrated that the interaction effect, the difference between thickness during lateral or medial rotation, was not influenced by hip flexion position. Conclusion: Considering that a muscle is stretched in a position opposite of its function, the current study showed no consistent change in piriformis muscle tendon unit thickness in medial or lateral rotation with increasing hip flexion. The current findings may call into question the clinical thought of the piriformis reversing function with increased degrees of hip flexion.

Key Words: piriformis, diagnostic ultrasound, hip rotation

Background

The application of a muscle stretch is commonly used diagnostically to provide physical therapists, and other clinicians, with information regarding the tightness of a muscle. Muscle stretch applied as a diagnostic procedure or as a treatment requires passively moving the limb in a direction opposite of the muscle’s action. Passive stretch is commonly used to assess piriformis muscle length and as a treatment to alter piriformis muscle tightness. However, current literature and practice suggests that the piriformis muscle’s function may reverse from a hip lateral rotator to a hip medial rotator when the hip is flexed beyond 90 degrees. Thus, according to previous literature, the application of stretch in diagnosis or treatment of piriformis muscle dysfunction may vary between lateral and medial rotation dependent on the patient’s limb position.

Previous literature suggests that piriformis muscle function may change relative to hip position.⁴ According to Kapanji,¹¹ the piriformis muscle acts to produce lateral rotation, flexion, and abduction at the hip.
when the hip is in zero degrees of flexion. When the hip is flexed to 60 degrees, the piriformis acts to produce abduction and when the hip is “markedly” flexed the piriformis acts to produce medial rotation. Palastanga et al. also indicate that the piriformis muscle acts as a primary hip abductor in the “seated position.”

Biomechanical studies using centroid measures of muscle attachments and string placement to mimic muscle placement for the assessment of moment arm changes have reported that the piriformis muscle’s rotation function reverses with increased hip flexion beyond 90 degrees. Dostal et al. demonstrated that the piriformis muscle is a lateral rotator at 0-40 degrees of hip flexion and that the muscle has a secondary action as an medial rotator at 90 degrees of hip flexion. Delp et al. confirmed the findings of Dostal et al. demonstrating an increasing moment arm favoring medial rotation for the piriformis muscle when the hip is flexed beyond 90 degrees. Lee et al., using a string model, showed that the piriformis muscle lengthened when the hip was passively flexed or medially rotated and shortened during passive lateral rotation, or abduction. The previous studies relied on string model preparations to demonstrate muscle attachments and fiber direction. However, “straight-line” modeling of hip muscles oversimplifies a very complex anatomical region. In each case, the moment arms demonstrated for hip medial rotation, when the hip was flexed beyond 90 degrees, were small and the string placements were based upon taking a midpoint of the average size of the proximal and distal piriformis attachments.

Recent anatomical studies have reported variability in the size and position of the distal attachment of the piriformis muscle and variability in the joining of the tendons of the piriformis, obturator internus and gluteus medius muscles at the distal attachments to the femoral greater trochanter. The distal attachment of the piriformis muscle has been shown to vary in dimensions and position on the superior surface of the femoral greater trochanter (GT). The distal attachment spanned a range of 25% to 64% of the GT anterior-posterior length and the placement of the distal attachment varied from 57% of specimens positioned more anterior and 43% positioned more posterior to the midline of the GT. Solomon et al. demonstrated that the distal attachment of the piriformis spanned the entire medial surface of the GT in conjunction with the tendon of the obturator internus muscle. The authors described further complexity of the distal attachment as the piriformis-obturator conjoint tendon was shown to be connected to the hip joint capsule, obturator externus and gluteus medius muscles. The variability in position and breadth of the distal attachment of the piriformis muscle calls into question the concept of reversal of function.

The anatomical studies suggest that there may be cases where tendon distal attachment position on the femoral greater trochanter does not permit a reversal of function. In a condition where the piriformis muscle tendon has a posteriorly placed attachment on the greater trochanter, reversal of function would not likely occur. Therefore, stretching the piriformis muscle into lateral rotation when the hip is flexed beyond 90 degrees, based upon reversal of function, would be ineffective as a treatment or misleading as an examination technique.

Additionally, biomechanical studies have used cadaver specimens with varying amounts of tissue removed for analysis of the piriformis muscle. Each muscle examined was replaced by a series of strings representing the attachment sites and the course of the muscle fibers. Removing the surrounding tissue and simplifying each
muscle of the gluteal region to a single fiber nullifies the interactions between the muscles and fascia. Removing tissue from a specimen also decreases the likelihood that the reactions of the specimen to any manipulation will accurately reflect what may be seen in an “intact” patient.

Clinical evaluation and treatments of piriformis muscle dysfunction have been based upon the biomechanical studies and previous works that demonstrated the reversal of function phenomenon. For example, evaluation of piriformis length with the hip in less than 90 degrees of flexion requires the examiner to apply a force directed into medial rotation about the hip. Conversely, when the hip is flexed greater than 90 degrees the examiner applies a force directed into lateral rotation.\(^5,8,16\)

However, in cases where the tendon position does not permit a reversal of function, such as might be seen with a piriformis tendon that has the bulk of its distal attachment posterior to the midline of the greater trochanter tendon, modifying the direction of force applied to the hip in order to account for reversal of function would be ineffective.

The effect of stretch on the piriformis muscle, with respect to the reversal of function phenomenon, has not been examined in living subjects due to previous technological limitations. However, advances in diagnostic ultrasound technology allow visualization of the musculoskeletal system and provide an opportunity to examine the effect of stretch on muscle and tendon parameters. Diagnostic ultrasound technology offers a non-invasive method to assess musculoskeletal structures and has been an effective tool for examining tendon thickness changes in response to stretch.\(^26\)

Diagnostic ultrasound has been used in recent studies to assess changes in both tendon and muscle.\(^13,26\) Wang et al.\(^26\) used diagnostic ultrasound to document the soft tissue changes associated with a therapeutic stretch on the iliotibial band in 44 young adult subjects. The results of the study showed a strong agreement between US and MRI and also indicated that US can reliably detect changes in the tendinous part of the iliotibial band under varying levels of stretch.\(^26\) Li Q et al.\(^13\) assessed the use of US in the diagnosis of gluteal muscle contractures and were able to detect muscle thinning with a sensitivity of 92.5% and a specificity of 50% in 27 subjects with gluteal muscle contractures. The authors also found a significant correlation between US and measurements taken during surgery for the thickness of contracture strips of the gluteal muscles.\(^13\) The objective of the current study was to examine, using diagnostic ultrasound (US), the effect of stretching the piriformis on muscle thickness at the muscle tendon junction, by rotating the hip into lateral and medial rotation with varying degrees of hip flexion.

Methods

The research was approved by Mercer University’s Institutional Review Board and all subjects provided informed consent. Twenty-five subjects, aged 22-31 years (mean age 25.2 years), 13 men and 12 women, participated in the study. Inclusion criteria included: 1) younger than 40 years of age; 2) no prior history of gluteal, hip, low back, or knee pain; 3) no unresolved radicular symptoms in the lower extremities. Subjects were recruited via convenience sampling within the Department of Physical Therapy of Mercer University from March 2013 through September 2013. Sample size was determined by using subject numbers from similar studies.

Each subject was placed in a side-lying position with the left hip and greater trochanter exposed. The following procedure was performed on each subject’s
left hip with the hip in 0, 60, 90, 100, 110, and 120 degrees of flexion. The location of the piriformis muscle was identified by finding the intersection of a line extending from the greater trochanter to the ipsilateral PSIS and a second line extending from the ischial tuberosity and the ipsilateral ASIS. The femoral greater trochanter and piriformis tendon were palpated to aid in proper ultrasound probe placement. During the investigation, each subject’s thigh was passively placed and held in the desired hip flexion angle as determined using a standard goniometer (Baseline Evaluation Instruments, White Plains, New York 10602, USA) with the axis of movement at the greater trochanter and the stationary and movable arms of the goniometer aligned with the midline of the trunk and the lateral femoral epicondyle, respectively. Each subject’s femur, being held in the flexed position, was rotated into maximal lateral for each measurement and then medially rotated for the corresponding measurement by one researcher. Maximal lateral and medial rotation were determined by the appropriate firm hip joint end-feel.

Diagnostic ultrasound (US) was applied to the area of the piriformis tendon near the greater trochanter. (Terason t3200, MSK Series; Teratech Corp., Burlington MA, USA) The thickness of the piriformis tendon, seen on the diagnostic ultrasound image, was measured and recorded at maximal lateral and medial rotation for each hip flexion position. The US machine was set to hip-specific parameters. The US measurements were obtained using a linear (15L4, S/N: 7917) probe. After the piriformis muscle was located, the probe was placed perpendicular to the muscle fibers over the area of the muscle tendon junction. At various intervals during the procedure, the subject was asked to perform an isometric contraction into hip lateral rotation in order to assist with and confirm identification of the piriformis muscle and fascial structures on the diagnostic ultrasound view screen. Throughout the study the researcher applying the ultrasound continually identified, on the US view screen, the femoral greater trochanter as a main reference point combined with the visual gliding of the piriformis muscle and associated fascia during the isometric contractions.

The width of the muscle tendon junction was ascertained by placing the imaging caliper, on the view screen, across the muscle tendon junction as close to the greater trochanter as possible and perpendicular to the superficial edge of the piriformis muscle. (Figure 1) The same caliper placement was used for every image throughout each subject’s assessment. Thickness of the muscle tendon junction was determined with a focus depth of 4.0-8.0cm and a frequency 11-18Hz. Depths and frequencies were adjusted based on visual findings for each subject. For this study, the four investigators participated in each test, maintaining their permanent, respective roles. These positions included US probe placement, hip flexion positioning and measurements, hip rotation positioning and measurements, and US caliper placement. Caliper placement was agreed upon by at least two investigators for each image. The piriformis muscle tendon junction thickness, on the diagnostic ultrasound image, was measured and recorded at maximal medial and maximal lateral rotation for each hip flexion position.

Results

The data were analyzed using two-factor analysis of variance. The dependent variable was thickness at the muscle tendon junction of the piriformis muscle measured with US. The two independent variables were degree of hip flexion (five levels, 0, 60, 90, 110, and 120° flexion) and direction of hip rotation (two levels, maximal medial
The findings of the current study may have implications for the clinical setting as these results call into question the common assumption by clinicians in practice that the piriformis muscle is always a medial rotator of the hip. This would require lateral rotation of the hip above 90 degrees of hip flexion to treat patients with piriformis syndrome. Therefore, the piriformis muscle is thought of as a hip flexor and reversed function with respect to clinical treatment purposes.

Current literature and practice suggest that piriformis syndrome (PS) can be the result of the reversal of function from a hip lateral rotator to a hip flexor, which would result from two main effects, hip flexion and hip rotation of the hip above 90 degrees of hip flexion. In addition, the variability in the joining of tendons in the piriformis muscle, distal attachment of the piriformis muscle, as well as muscle (PM) function may reverse from a hip lateral rotator to a hip flexor. Therefore, a stretching program is implemented as an intervention to treat the condition. The common assumption by clinicians in practice is that the piriformis muscle is a hip flexor, resulting from two main effects, hip flexion and hip rotation of the hip above 90 degrees of hip flexion and becoming a medial rotator of the hip. This would require lateral rotation of the hip above 90 degrees for its function to be reversed, i.e., to become a flexor.

The current findings call into question the clinical treatment purpose of the piriformis muscle as an intervention to treat the condition. Therefore, a stretching program is implemented as an intervention to treat the condition. The common assumption by clinicians in practice is that the piriformis muscle is a hip flexor, which would result from two main effects, hip flexion and hip rotation of the hip above 90 degrees of hip flexion. In addition, the variability in the joining of tendons in the piriformis muscle, distal attachment of the piriformis muscle, as well as muscle function may reverse from a hip lateral rotator to a hip flexor. Therefore, a stretching program is implemented as an intervention to treat the condition.

Table 1: Tests of between-subject effects where the dependent variable is piriformis tendon thickness.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
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<tbody>
<tr>
<td>Corrected Model</td>
<td>3.599</td>
<td>9</td>
<td>0.400</td>
<td>3.352</td>
<td>0.001</td>
</tr>
<tr>
<td>Intercept</td>
<td>97.694</td>
<td>1</td>
<td>97.694</td>
<td>819.106</td>
<td>0.000</td>
</tr>
<tr>
<td>hipflex</td>
<td>0.923</td>
<td>4</td>
<td>0.231</td>
<td>1.934</td>
<td>0.105</td>
</tr>
<tr>
<td>hiprotate</td>
<td>2.544</td>
<td>1</td>
<td>2.544</td>
<td>21.332</td>
<td>0.000</td>
</tr>
<tr>
<td>hipflex * hiprotate</td>
<td>0.132</td>
<td>4</td>
<td>0.033</td>
<td>0.276</td>
<td>0.893</td>
</tr>
<tr>
<td>Error</td>
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<td>240</td>
<td>0.119</td>
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<td></td>
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<tr>
<td>Total</td>
<td>129.917</td>
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<tr>
<td>Corrected Total</td>
<td>32.223</td>
<td>249</td>
<td></td>
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</tr>
</tbody>
</table>

a. R Squared = .112 (Adjusted R Squared = .078)
Figure 1a. Hip position at 120 degrees of flexion and 24 degrees of medial rotation. Caliper position designated by +——+.
Figure 1b. Hip position at 110 degrees of flexion and 0 degrees of rotation. Caliper position designated by + ———+.
Figure 1c. Hip position at 0 degrees of flexion and 30 degrees of medial rotation. Caliper position designated by +———+. 
rotation and maximal lateral rotation). The statistics analyzed muscle tendon junction thickness changes resulting from two main effects, hip flexion and hip rotation and one interaction effect, tendon thickness changes resulting from combined hip flexion and rotation. The results for the main effect of hip flexion showed that muscle tendon thicknesses, averaged for each hip rotation position, was not statistically different between hip flexion positions. The main effect of hip rotation showed a statistically significant difference for a hip rotation position averaged through all hip flexion positions (p<.0001). The interaction effect, the difference between muscle tendon junction thickness of lateral or medial rotation, was not influenced by hip flexion position (Table 1).

**Discussion**

The objective of the current study was to determine changes in thickness at the muscle tendon junction of the piriformis muscle resulting from hip medial and lateral rotation stretches at varying degrees of hip flexion using diagnostic ultrasound.

The validity of US to examine thickness at the muscle tendon junction has been demonstrated. Diagnostic ultrasound has been used in recent studies to assess changes in both tendon and muscle.\(^{13,26}\) Wang et al.\(^{26}\) used diagnostic ultrasound to document the soft tissue changes associated with a therapeutic stretch on the iliotibial band in 44 young adult subjects. The results of the study showed a strong agreement between US and MRI and also indicated that US can reliably detect changes in the tendinous part of the iliotibial band under varying levels of stretch.\(^{26}\) Li Q et al.\(^{13}\) assessed the use of US in the diagnosis of gluteal muscle contractures and were able to detect muscle thinning with a sensitivity of 92.5% and a specificity of 50% in 27 subjects with gluteal muscle contractures.

Diagnostic ultrasound was used in the present study to assess changes in thickness at the muscle tendon junction of the piriformis muscle resulting from stretched and shortened positions. According to earlier works, a tendon placed on stretch will demonstrate a decreased thickness on the US image.\(^{13,26}\) Therefore, a decrease in the thickness of the muscle tendon junction viewed in the current study indicated that the tendon was being stretched in that position. Conversely, an increase in the thickness of the muscle tendon junction indicated that the muscle and tendon were in a shortened position.

The results of the present study demonstrated no significant difference in thickness at the muscle tendon junction of the piriformis muscle between hip medial rotation (MR) and lateral rotation (LR) as a result of changes in degree of hip flexion. There was a difference between muscle tendon junction thicknesses in MR and LR when averaged across all hip flexion ranges, however, the difference was not specific to any one hip flexion angle. No interaction was found between hip flexion and medial or lateral rotation. The current results, suggesting that there is no significant difference in thickness at the muscle tendon junction of the piriformis muscle in either MR or LR at any angle of hip flexion, are contrary to the findings of previous biomechanical studies.\(^{3,4}\) The biomechanical studies also used cadaveric specimens in varying degrees of dissection with most or all of the surrounding muscle and fascia removed thus negating any tissue connections or interactions and failing to account for the interaction of all other surrounding tissues.

In this study, the thickness of the piriformis at the musculotendinous junction was observed near the distal insertion of the piriformis muscle at the greater trochanter for multiple reasons. First, insertion at the
greater trochanter is more reproducible because it is more easily found using diagnostic ultrasound. The bony landmark of the greater trochanter assisted in accurate identification of the piriformis from other muscle bellies in the area, and the piriformis muscle is most superficial at this anatomical location. One potential limitation of this study was that because changes were observed at the muscle tendon junction of the piriformis muscle near its insertion, the authors were unable to observe changes occurring more proximally at the muscle belly. Future studies aimed at observing changes in the piriformis muscle belly during hip medial and lateral rotation at various points of hip flexion may shed more light on the function of the piriformis muscle when the hip is flexed beyond 90 degrees.

The findings of the current study can be explained, in part, by the anatomical complexity of the musculotendinous attachments of the piriformis, obturator internus and gluteus medius muscles. Pine et al.\textsuperscript{19} categorized four variations of the piriformis and obturator internus (OI) distal tendon attachments onto the femoral greater trochanter. Fifty-five percent of the specimens had the Type 1 insertion, where both tendons approached the greater trochanter individually, with the piriformis tendon attaching horizontally and the OI tendon attaching almost perpendicular to the piriformis tendon. In Type 1 attachments the piriformis tendon attaches to the medial edge of the superior surface of the femoral greater trochanter, and the OI tendon attaches anterior, inferior, and slightly medial to the antero-superior part of the medial surface, with overlap of the two tendons on the surface of the femoral greater trochanter.\textsuperscript{19} Seventeen percent of the specimens were categorized as Type 2 insertion, where both tendons again approached independently, and the piriformis tendon attached horizontally while the OI was less than 90 degrees of rotation in relation to the piriformis tendon and presented the greatest crossing angle and overlap of the four insertion Types.\textsuperscript{19} Type 3 insertion occurred in 17% of specimens, and again the two tendons approached independently to the greater trochanter; however, the piriformis tendon attached almost directly superior to the OI tendon resulting in significant overlap and the piriformis tendon being surrounded posteriorly and anteriorly by OI tendon.\textsuperscript{19} The final 10% of the specimens were classified as Type 4 where the tendons of the piriformis and OI combined into a significantly larger tendon prior to their attachment to the greater trochanter and covered between 59% and 80% of the superior surface of the greater trochanter.\textsuperscript{19} Variation in the expanse of the piriformis distal attachment on the surface of the femoral greater trochanter was also shown in a cadaver study by Fabrizio et al.\textsuperscript{6} This study revealed five hips with piriformis distal attachment sites between 25% to 66.4% of the superior surface, four limbs anterior to the midline and three limbs posterior to the midline of the femoral greater trochanter.\textsuperscript{6} Thus the anatomic variability of the distal attachment of the piriformis muscle may, in part, account for the lack of an interaction effect seen in the current study.

Anatomical differences and variable relationships in individuals need to be considered in conjunction with force transmission in muscles and relationships across an entire joint.\textsuperscript{9,15} Previous literature reports the role of the piriformis as part of the rotator cuff of the hip, similar to the rotator cuff of the shoulder.\textsuperscript{18} Force transmission of the piriformis is typically that of lateral rotation; however, the muscle and tendon fibers are confined to a relatively small, and crowded, space posterior to the greater trochanter. The relationship between obturator internus and piriformis has been
described as variable with tendon fibers crossing one another in varying degrees. Further, Akita et al., described the gluteus medius muscle as adhered to the piriformis muscle in one specimen but also described a fascial connection between gluteus medius and piriformis muscles. The fascial connections between gluteus medius, piriformis, obturator externus and obturator internus tendons have also been described by Solomon et al. Thus, there is the potential mechanism of force coupling not only between innervation compartments of the same muscle, but also between the connection of adjacent muscles. These mechanisms are present because of the continuous connection between bone, tendon, muscle, fascia and nerve. Muscle and joint connective tissue should not be considered separate entities and may function in a way that provides new muscular-connective tissue units. According to Riewald and Delp, it is possible to transmit forces for function through mechanisms other than the designated muscle. Two pathways for intramuscular force transmission have been described. The first is between muscle sarcomeres and tendon, also known as myo-tendinous transmission, and the second is between sarcomeres to the myo-fascial complex. When there has been an interference or disturbance, such as a myotendinous tear or fasciotomy, the first mechanism of force transmission is no longer viable. It is in this instance that the sarcomere to myo-fascial complex pathway may make up for the function that has been compromised. The sarcomere to myo-fascial complex method of transmission could be spontaneous and without instigation from disturbance. In the current study, the variability of results between subjects could be due to differing anatomical relationships, or it could be due to differing mechanisms of force transmission through the relationships and connections of the piriformis, obturator internus, obturator externus, and gluteus medius tendons. The variability demonstrated and thus the variability in force transmission suggests that the designated muscle may not be the functional unit in everyone.

The findings of the current study may have implications for clinical practice in the diagnosis and treatment of piriformis syndrome. Piriformis syndrome (PS) can be the result of the piriformis muscle shortening or being in spasm and causing compression on the sciatic nerve. The compression or irritation to the sciatic nerve is referred by Jankovic et al. as the neuropathic component of PS and occurs as the sciatic nerve passes through the infrapiriform foramen. Tonley et al., report that spasm of the piriformis muscle can be caused by overuse, direct trauma to the gluteal region, post-surgical injury, lumbar and sacroiliac joint pathologies. Additional signs and symptoms that may be present are gluteal atrophy, shortening of limb on affected side, trigger point tenderness in the piriformis muscle and sacroiliac tenderness.

The common assumption by clinicians in practice is that the piriformis muscle is shortened or in spasm. Therefore, a stretching program is implemented as an intervention to treat the condition. In the clinical setting the piriformis muscle is believed among some clinicians to reverse its function beyond 90 degrees of hip flexion and become a medial rotator of the hip. This would require lateral rotation of the hip above 90 degrees of hip flexion to obtain a stretch of the piriformis muscle for treatment purposes. With the results of the study showing no interaction between hip flexion and medial or lateral rotation, this method to stretch the piriformis muscle may not be effective. Therefore, it is important to account for the patient’s response to stretching because different modes of stretching the piriformis muscle may be
required through all hip flexion angles to acquire a positive response to treatment. It is also important to consider during examination of a patient with symptoms of PS that the FAIR/Piriformis special test may not always yield reliable results for diagnosis. The FAIR test involves placing the patient’s lower limb in flexion, adduction, and medial (internal) rotation. However, in the current study it was demonstrated that an interaction between hip flexion and rotation was not present thus the piriformis muscle may not be placed on a stretch during the FAIR test. Fishman et al. found that patients with a negative FAIR test improved 54.8%, with a 54.8% reduction in disability post 10.2 months’ follow-up after conservative treatment. Thus, patients without a positive FAIR/Piriformis test with symptoms of PS may respond positively to PS treatment.

Conclusion

The results of the current study demonstrated no significant difference in thickness at the muscle tendon junction between hip medial or lateral rotation at any angle of hip flexion and thus indicate no interaction between hip flexion and hip medial or lateral rotation. The findings are contrary to findings of previous biomechanical studies. However, evidence of variability in anatomical attachments sites of the piriformis tendon and the interaction of other structures in the area lend to the understanding of the results of this study. The combination of these factors may be a source for the explanation of the results of the current study. The current findings suggest that the piriformis muscle attachments and functions may be more complex than previously thought and that lack of consistency in hip positions that stretch the piriformis call into question the common clinical thought of reversal of function with hip flexion beyond 90 degrees.

Conflicts of Interest

The authors have no competing financial interests, or conflicts of interest and have read and accept responsibility for the manuscript’s contents.

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