

[Athletic Training]



Influence of the Hip on Patients With Patellofemoral Pain Syndrome: A Systematic Review

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Context: Patellofemoral pain syndrome (PFPS) is one of the most common conditions limiting athletes. There is a growing body of evidence suggesting that dysfunction at the hip may be a contributing factor in PFPS.

Data Sources: MEDLINE (1950–September 2010), CINAHL (1982–September 2010), and SPORTDiscus (1830–September 2010) were searched to identify relevant research to this report.

Study Selection: Studies were included assessing hip strength, lower extremity kinematics, or both in relation to PFPS were included.

Data Extraction: Studies included randomized controlled trials, quasi-experimental designs, prospective epidemiology, case-control epidemiology, and cross-sectional descriptive epidemiology in a scientific peer-reviewed journal.

Results: PFPS is associated with decreased hip strength, specifically at the abductors and external rotators. There is a correlation between PFPS and faulty hip mechanics (adduction and internal rotation).

Conclusions: There is a link between the strength and position of the hip and PFPS. These patients have a common deficit once symptomatic. Hip strengthening and a coordination program may be useful in a conservative treatment plan for PFPS.

Keywords: patellofemoral pain syndrome; hip strength; hip position; kinematics

Patellofemoral pain syndrome (PFPS) is often used as an umbrella term for anterior or retropatellar pain.⁹ Many factors present in patients with PFPS: patellar tracking dysfunction; decreased flexibility of the quadriceps, hamstrings, iliotibial band, and gastrocnemius; decreased strength of the quadriceps and hamstrings; joint laxity; deviations in patellar mobility and tilting; and increased quadriceps angle.³⁸ While therapeutic interventions are performed to address these factors in the injured athlete, the significance of each factor to the onset of PFPS is unclear. A strong psychological component is often associated with these conditions, including higher rates of depression, fear-avoidance, and anxiety.^{25,26} Interestingly, the predominant factor for the development of PFPS may be outside the region.²⁸

A systematic review by Crossley et al⁹ evaluated popular physical interventions, including vastus medialis oblique (VMO) retraining, open kinetic chain and isokinetic strengthening, patellar realignment orthoses, patellar mobilization, sacroiliac manipulation, low-level laser, acupuncture, and patellar taping. They found little evidence in support of these interventions.

Pain reduction across all interventions was short-term at best and no more effective than a home-based exercise program.

The concept of a muscular imbalance between the VMO and the vastus lateralis is often faulted,⁵ although the literature is inconsistent.¹⁹ Laprade et al¹⁹ evaluated the recruitment of the VMO during specific open kinetic chain exercises, concluding that hip adduction, hip adduction during knee extension, medial tibial rotation, and medial tibial rotation during knee extension in open kinetic chain did not increase VMO activity. Earl et al¹² showed that it was possible to selectively bias the VMO but only during minisquats with isometric hip adduction.

METHODS

Data Sources

MEDLINE (from 1950–September 2010), CINAHL (1982–September 2010), and SPORTDiscus (1830–September 2010) were searched to identify relevant research.

[§]References 11, 14, 23, 32, 34, 39, 41.

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Table 1. Search strategy by heading and number of articles.

Medical Subject Headings	Identified	Determined as Potentially Relevant	Included in Critical Appraisal
Anterior knee pain	3220	—	—
Patellofemoral pain	3021	—	—
Patellofemoral pain syndrome	1807	—	—
Patellofemoral pain AND biomechanics	536	—	—
Patellofemoral dysfunction ^a	145	2	2
Retropatellar pain	88	2	0
Patellofemoral pain AND hip strength	87	15	13
Patellofemoral pain AND hip position	18	0	0

^aThe 2 articles identified in the *patellofemoral dysfunction* category were also identified in the *patellofemoral pain AND hip strength* category.

Selection of Articles

Searches were performed using a subject heading alone (eg, *patellofemoral pain*) or in combination with other subjects (eg, *patellofemoral pain AND hip strength*) (Table 1). If a search term generated more than 200 articles, additional searches were performed. When fewer than 200 articles were identified, abstracts were reviewed to identify relevant articles. Randomized controlled trials, quasi-experimental designs, prospective epidemiology, case-control epidemiology, and cross-sectional descriptive epidemiology were included from scientific peer-reviewed journals. In addition, the reference list of each selected article was reviewed to identify other relevant publications. Studies must have assessed hip strength, lower extremity kinetics, or both in relation to PFPS.

RESULTS

The Influence of the Hip

An increase in hip adduction or internal rotation increases the Q angle by increasing the relative valgus of the lower extremity. This increased Q angle increases the peak lateral contact pressure on the patellofemoral joint.^{16,20} An increase of 10° in the Q angle can increase contact pressure on the patellofemoral joint by 45%.¹⁶ Internal rotation of the femur or external rotation of the tibia also increases patellofemoral contact pressure.²⁰

Hip Position

Hip adduction during functional activities has been evaluated in several studies (Table 2).^{3,6,10,29,35,36,40} Females with PFPS demonstrate no difference in hip position during functional

tasks, including running, stepping down, and landing from a jump.³⁶ Bolgla et al³ reported no difference in hip position on stair descent. However, Wilson and Davis⁴⁰ reported that females with PFPS demonstrated greater hip adduction during running, hopping, and performing the single-leg squat. Dierks et al¹⁰ found an increase in hip adduction in PFPS patients after a prolonged run, suggesting that this may represent fatigue.

Dynamic magnetic resonance imaging techniques have been used to compare patellar tilting and tracking during nonweightbearing and weightbearing activities in females with lateral patellar subluxation.²⁹ In nonweightbearing, the patella tilts and tracks laterally on a stable femur. In weightbearing, the femur internally rotates, causing a stable patella to track laterally relative to the femur. Two studies compared PFPS patients with a control group, finding that the former had up to double the femoral internal rotation as the latter.^{35,36} This may be a link between PFPS and hip strength/coordination.²⁸

A prospective 3-dimensional motion analysis during a jump-landing task in over 1500 participants demonstrated an increase in femoral internal rotation in those who later developed PFPS.⁶ Wilson and Davis⁴⁰ found an increase in hip adduction in those with PFPS that demonstrated less internal rotation than controls. Bolgla et al³ found no difference in femoral internal rotation during step-down activities.

Hip Strength

Several studies demonstrate a correlation between decreased hip strength and PFPS (Tables 3 and 4).^{*} A systematic review of 5 studies^{3,8,17,27,33} assessing hip strength in patients with PFPS

^{*}References 2, 3, 6, 8, 10, 17, 21, 27, 33.

Table 2. Studies assessing the relationship between hip adduction and individuals with patellofemoral pain syndrome.^a

Study	Study Design; Level of Evidence	Participants	Activity Studied	Findings
Powers et al ²⁹	Repeated measures; 5	Six females (mean age, 32 years; range, 15-39 years) receiving treatment for PFP from a university sports medicine center. A participant must have demonstrated lateral patellar subluxation during kinematic MRI.	Weightbearing and nonweightbearing knee extension during kinematic MRI.	Significantly greater lateral patellar displacement during nonweightbearing knee extension. Significantly greater hip internal rotation during weightbearing knee extension.
Bolgia et al ³	Cross-sectional; 4	Thirty-six women: 18 symptomatic (24.5 ± 3.2 years) and 18 matched for age, body mass, and height (23.9 ± 2.8 years)	Kinematic motion analysis during stair-stepping sequence.	No kinematic differences found between groups during the stair-stepping sequence.
Dierks et al ¹⁰	Cross-sectional; 4	Forty runners: 20 with diagnosis of PFP (5 males, 15 females, 24.1 ± 7.4 years) and 20 asymptomatic sex-matched runners serving as controls (22.7 ± 5.6 years)	Kinematic motion analysis during running. Variables analyzed: knee adduction, hip adduction, and hip internal rotation peak angles.	A significant association between hip abductor weakness and hip adduction peak angle was observed in runners with a diagnosis of PFP.
Willson and Davis ⁴⁰	Cross-sectional; 4	Forty females: 20 with PFP (mean age, 23.3 years) and 20 serving as controls (mean age, 23.7 years)	Kinematic motion analysis during 3 activities: single-leg squat, run, and single-leg jump.	Females with PFP performed activities with significantly greater hip adduction and significantly less hip internal rotation. Trending toward significance, females with PFP demonstrated larger knee external rotation.
Boling et al ⁶	Prospective cohort; 2	1597 US Naval Academy midshipmen	Kinematic motion analysis during a jump-land-jump sequence (jump from box, land on force plate, vertical jump).	A risk factor associated with individuals who later developed PFP include "increased hip internal rotation angle during the jump-landing task."

(continued)

Table 2. (continued)

Study	Study Design; Level of Evidence	Participants	Activity Studied	Findings
Souza and Powers ³⁶	Cross-sectional; 4	Forty-one females: 21 with PFP (27 ± 6 years old) and 20 asymptomatic controls (26 ± 5 years old)	Kinematic motion analysis during 3 activities: a step down, drop jump, and running.	Females with PFP demonstrated significantly greater hip internal rotation.
Souza et al ³⁵	Cross-sectional; 4	Thirty females: 15 with PFP (30.8 ± 8.9 years old) and 15 asymptomatic controls (29.1 ± 4.2 years old)	Kinetic imaging of a single-leg squat performed in a vertically open MRI.	Significantly greater lateral patella tilt at 3 angles (30°, 15°, 0°) and lateral patella displacement in females with PFP. Significantly greater internal rotation of the femur in females with PFP (measured at 45°, 15°, 0°).

^aMRI, magnetic resonance imaging; PFP, patellofemoral pain.

found that external rotation and abduction were weaker than in controls.³⁰ Robinson and Nee³³ noted strength deficits in hip extension, while Cichanowski et al⁸ also found weakness in the adductors and internal rotators. Both studies found that the most significant difference (up to 27%) was in abductor strength.

The prospective study by Boling et al⁶ analyzed 3-dimensional motion and 6 lower extremity isometric tests: knee extension, hip external rotation, hip internal rotation, knee flexion, hip extension, and hip abduction. Those with PFPS demonstrated decreased strength in hip abduction, knee flexion, and knee extension. Interestingly, hip external rotation strength increased in those who developed PFPS compared to controls.

Baldon et al² evaluated eccentric strength between a group of females with PFPS and a control group (abduction, adduction, external rotation, and internal rotation). Peak torque was 28% lower in the abductors and 14% lower in the adductors in the PFPS group. The eccentric adduction:abduction torque ratio was also 11% higher in the PFPS group.

Hip musculature fatigue testing in runners with PFPS compared decreased strength in the hip abductors and external rotators at the end of the prolonged run.¹⁰ The PFPS group demonstrated 12% lower strength at the end of the run compared to the control group.

Long-Rossi and Salsich²¹ correlated hip strength and functional status in PFPS patients using the Anterior Knee Pain Questionnaire (Kujala score).¹⁸ They found a correlation

between strength and pain but not between external rotator strength and the Kujala score.²¹

Clinical Application

It is unknown if the hip weakness demonstrated in the reviewed studies is the cause of PFPS or the result.^{10,28} There are inconsistencies in these studies emphasizing the differences in study design measurement techniques.²⁸ Variations in hip mechanics may become much more pronounced with fatigue.³¹ Most studies evaluate peak strength and not endurance.³¹

Since the hip abductors can affect knee valgus by controlling the frontal plane position of the femur,¹⁵ increasing abduction strength may help patients with PFPS. Strengthening programs often begin with isometrics (prone heel squeezes) to encourage muscle recruitment. Manual perturbations side lying (Figure 1) may add a low-intensity random component to the early phases of rehabilitation. This exercise can also be performed to fatigue to encourage an endurance response. Patients can then be progressed to standing abduction against a resistance band.⁴ Side-to-side walking with a resistance band around the ankles (Figure 2) may further challenge the hip abductors and add an eccentric component to the training program. The pelvic drop exercise encourages high activity in the hip musculature while demonstrating low stress at the knee.¹⁴ This activity can be progressed to a lateral step-up.

(text continues page no.462)

Table 3. Studies assessing the relationship between patients with patellofemoral pain syndrome and hip weakness.^a

Study	Study Design; Level of Evidence	Participants	Inclusion and Exclusion Criteria	Results
Ireland et al ¹⁷	Cross-sectional; 4	Thirty females: 15 patients (15.7 ± 2.7 years old) and 15 asymptomatic age-matched controls (15.7 ± 2.7 years old)	<i>Inclusion:</i> For the PFP group, “a thorough evaluation at a local orthopaedic practice.” Patients reported pain for a minimum of 3 months experienced during stair climbing, prolonged sitting, or sports and presented with “objective signs consistent with PFP.” <i>Exclusion:</i> Other comorbidities ruled out by orthopaedist during the patient’s examination, a history of significant lower extremity trauma, history of knee surgery, or history of patella dislocation.	Patients with PFPS were significantly weaker than age-matched counterparts ($P < 0.001$). Patients’ hip abduction isometric strength and hip external rotation isometric strength were reported to be 26% and 36% less than those in the control group.
Piva et al ²⁷	Case control; 4	Sixty participants: 30 patients with PFPS (females = 17, males = 13) and 30 asymptomatic sex- and age-matched controls	<i>Inclusion:</i> Age range from 20 to 42 years, experienced symptoms for at least 4+ weeks, nontraumatic onset, pain in either knee or both. In addition, reproduction of pain in a minimum of 3 of the following tests or positions: “manual compression of the patella against femur (at rest or during quad set), palpation of posteromedial or posterolateral borders of the patella, resisted isometric quad contraction at 60° of flexion, squats, stair climbing, kneeling, or prolonged sitting” (Piva). <i>Exclusion:</i> Pregnancy, history of patella dislocation, a surgery to the knee in the prior 2 years, comorbid condition of the knee, condition that affects gait.	The authors found no differences in hip external rotation and hip abduction strength between groups.
Cichanowski et al ⁸	Cross-sectional; 4	Division III female athletes who reported to the school’s sports medicine team: 13 women diagnosed with PFPS (19.3 ± 1.1 years old) and 13 sport-matched controls (19.5 ± 1.3 years old)	<i>Inclusion:</i> PFPS diagnosis based on physician examination. <i>Exclusion:</i> Previous history of knee trauma, surgery, or diagnoses.	Athletes with a diagnosis of PFPS were significantly weaker in their ipsilateral hip abductors ($P = 0.003$) and external rotators ($P = 0.049$) when compared with the contralateral side. The athletes’ involved leg was significantly weaker in all hip muscle groups, except the adductors, when compared with controls.

(continued)

Table 3. (continued)

Study	Study Design; Level of Evidence	Participants	Inclusion and Exclusion Criteria	Results
Robinson et al ³³	Cross-sectional; 4	Twenty females: 10 with unilateral PFP (mean age, 21 years) and 10 serving as controls (mean age, 26.6 years)	<i>Inclusion:</i> 12 to 35 years old, nontraumatic onset of symptoms, pain during prolonged sitting, sports, or stair climbing.	The patient's symptomatic leg was weaker than her uninjured leg, with the symptomatic leg significantly weaker in hip extension and abduction (both $P < 0.001$). The patients' symptomatic legs were significantly weaker in hip extension and external rotation when compared with the weaker legs of those in the control group.
Bolgla et al ³	Cross-sectional; 4	Thirty-six women: 18 symptomatic women (24.5 ± 3.2 years old) and 18 women matched for age, body mass, and height (23.9 ± 2.8 years old)	<i>Inclusion:</i> Experimental group—minimum of 1 month of anterior knee pain experienced during stair descent and during 2 or more of the following: squatting, stair ascent, prolonged sitting, kneeling. Control group—no previous history of knee or hip pathology and no pain with any of the aforementioned provocative activities <i>Exclusion:</i> History of knee surgery, significant injury, patellar dislocation; abnormal gait due to neurologic diagnosis; history of hip surgery, or prior injury to the hip.	Symptomatic women were weaker than controls, generating significantly less torque with the hip external rotators ($P = 0.002$) and abductors ($P = 0.006$).
Dierks et al ¹⁰	Cross-sectional; 5	Forty runners: 20 runners with diagnosis of PFP (5 males, 15 females; 24.1 ± 7.4 years old) and 20 asymptomatic sex-matched runners (22.7 ± 5.6 years old)	<i>Inclusion:</i> 18 to 45 years old, heel-strike running pattern, no foot orthoses.	Those with PFP presented with significantly lower isometric hip abduction strength than asymptomatic counterparts.

(continued)

Table 3. (continued)

Study	Study Design; Level of Evidence	Participants	Inclusion and Exclusion Criteria	Results
Baldon et al ²	Cross-sectional; 4	Twenty females: 10 patients with PFPS (22.9 ± 5.2 years old) and 10 asymptomatic females matched for age (23.9 ± 2.4 years old), height, and body mass serving as controls	<p><i>Inclusion (for patients with PFPS):</i> Anterior knee pain in typical provocative activities (at least 3), nontraumatic onset with symptoms for at least 4 weeks, pain response with palpation of facets when one performs a squat or a step-down maneuver.</p> <p><i>Exclusion:</i> History of knee surgery to patellofemoral joint, history of patella dislocation or patellar apprehension sign, history and signs/symptoms of intra-articular dysfunction, patella tendon pain with palpation, iliotibial band tenderness, apophysitis, knee swelling, or proximal joint pain.</p>	Patients presented with lower eccentric hip adduction and abduction peak torque scores than controls. While the differences were not significant, there was a trend toward significance.
Boiling et al ⁶	Prospective cohort; 2	1597 US Naval Academy midshipmen	<p><i>Inclusion:</i> Enrolled in freshman year with no current injury that would prevent one from performing baseline tests.</p>	Increased hip external rotation strength is a potential risk factor for midshipmen who developed PFPS.
Long-Rossi and Salisch ²¹	Observational, cohort; 4	Twenty-one women (26 ± 7 years old) with PFP	<p><i>Inclusion:</i> Pain from the patellofemoral joint reproduced during unilateral squat and step down and during a quadriceps muscle manual test; in addition, pain for at least 2 months.</p> <p><i>Exclusion:</i> History of previous traumatic knee injury, knee surgery, current knee pathology.</p>	Increased hip external rotation strength correlates with higher functional scores in patients with PFPS.

^aPFP, patellofemoral pain; PFPS, patellofemoral pain syndrome.

Table 4. Summary of strength testing methodology.^a

Study	Testing Procedure	Muscle Groups Assessed	General Strength Test Positions
Ireland et al ¹⁷	Isometric strength with HHD (make test); peak value of 3 tests	Hip abduction, ER	<i>Abduction</i> : side lying, hip abduction to 10°. <i>ER</i> : sitting, hips and knees at 90°.
Piva et al ²⁷	Isometric strength with HHD (make test); average score of 2 tests recorded	Hip abduction, ER	<i>Abduction</i> : side lying, abduction to approximately 30°. <i>ER</i> : prone, knee flexed to 90°.
Cichanowski et al ¹⁸	Isometric strength with HHD (make test); best score of 2 tests	Hip flexion, abduction, adduction, extension, ER, IR	<i>Flexion, IR, ER</i> : sitting, hip and knee flexed to 90°. <i>Abduction and adduction</i> : side lying. <i>Extension</i> : prone, leg extended.
Robinson and Nee ³³	Isometric strength with HHD (break test); average score of 3 tests recorded	Hip abduction, extension, ER	<i>Abduction</i> : side lying, hip abduction to 30°. <i>Extension</i> : prone, knee flexed to 90°. <i>ER</i> : sitting, hips and knees at 90°.
Bolgla et al ³	Isometric strength with HHD (make test); average score of 3 tests	Hip abduction, ER	<i>Abduction</i> : side lying, hip abduction to 10°. <i>ER</i> : sitting, hips and knees at 90°.
Dierks et al ¹⁰	Isometric strength with HHD performed prior to and right after a run (make test); 5 tests performed	Hip abduction, ER	<i>Abduction</i> : side lying, hip abduction to 10°. <i>ER</i> : sitting, hips and knees at 90°.
Baldon et al ²	Isokinetic strength with isokinetic dynamometer (mean peak torque); 2 sets of 5 repetitions	Eccentric hip abduction, adduction, IR, ER	<i>Abduction and adduction</i> : side lying. <i>ER and IR</i> : sitting.
Boling et al ⁶	Isometric strength with HHD (make test); average score of 2 tests	Hip ER, IR, extension, abduction	<i>Abduction</i> : side lying. <i>ER, IR, extension</i> : prone, knee flexed to 90°.
Long-Rossi and Salsich ²¹	Isometric strength with HHD (break test); average score of 3 tests	Gluteus maximus, gluteus medius, hip ER	<i>Gluteus maximus</i> : prone, knee flexed to 90°. <i>Gluteus medius</i> : side lying. <i>Hip ER</i> : sitting, hip and knee flexed to 90°.

^aHHD, handheld dynamometer; ER, external rotation; IR, internal rotation.

Research has shown that increasing squat depth progressively increases the activity in the gluteus medius⁷ and may be a good functional progression for athletes. Adding single-leg squats on a physioball (Figure 3) may address lower extremity coordination and hip position in relation to the knee.

In the later phases of rehab, progressing through higher level exercises, such as the modified single-leg squat,²⁴ side bridge,¹³ and lunge while twisting (Figure 4), provides a higher level of challenge. The Smith machine may minimize challenges to stability, but it allows a higher resistance for building strength.



Figure 1. Manual perturbations applied against the hip musculature in side lying.



Figure 2. Side-to-side walking with a resistance band around the ankles.

CONCLUSIONS

There is a link between the strength and position of the hip and PFPS. Common deficits are often seen in these patients. Incorporating a hip strengthening and coordination program may be a useful component of a treatment plan for PFPS.

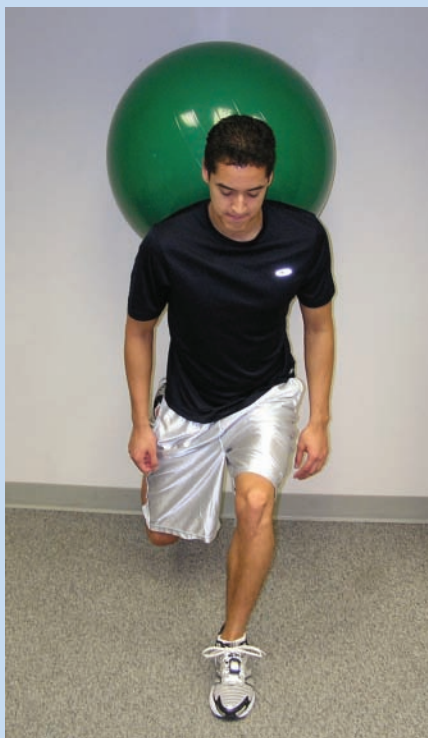


Figure 3. Single-leg squats with a physio ball. The focus should be on proper knee and hip position with this activity.



Figure 4. Lunge with twist.



Clinical Recommendations

SORT: Strength of Recommendation Taxonomy

A: consistent, good-quality patient-oriented evidence

B: inconsistent or limited-quality patient-oriented evidence

C: consensus, disease-oriented evidence, usual practice, expert opinion, or case series

Clinical Recommendation	SORT Evidence Rating
There is a correlation between hip strength and position and PFPS. ^{2-6,8,10,16,17,20,21,27,29,33,35,36,40}	B
Implementing a hip strength and coordination program is an effective component of a conservative PFPS treatment plan. ^{5,9,11,22,37}	B

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