Patellofemoral Pain Syndrome and Hip Strengthening

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Learning Objectives

• Identify current best practices for strengthening exercises for PFPS.
• Recommend a treatment protocol for PFPS.
• Apply hip strengthening exercises to PFPS treatment plan.
• Recognize strengths and limitations of current research.
PICO and Clinical Question

- P: Patients with Patellofemoral Pain Syndrome (PFPS)
- I: Hip Strengthening Exercises
- C: Knee Strengthening Exercises
- O: Decreased Pain

Clinical Question: Are hip strengthening exercises more effective than knee strengthening exercises in decreasing pain in patients with patellofemoral pain syndrome?
PFPS Facts

• Accounts for up to 25% of all knee conditions seen in sports medicine centers.²,⁵,¹⁰
• 2.2 times greater in females than males.²
• Peripatellar and/or retropatellar knee pain.
• Etiology:
  • Not completely clear- “overload on knee joint.”¹
  • Possible factors:
    • Increased Q angle
    • Quadriceps weakness and/or imbalance
    • Abnormal foot pronation
  • More recently looked at proximal factors:
    • Hip strength weakness and/or imbalance
    • Trunk stability¹⁻¹³
• Pathophysiology:
  • “characterized by inflammation of the synovial lining, inflammation of the fat pad, elevation of the intraosseous pressure, and an increase in the metabolic activity in the patellar joint.”¹
Muscle Groups of the Hip

• “Apart from being a strong hip extensor, the gluteus maximus is the most powerful external rotator of the hip.”

• “A weak gluteus medius can lead to an increase in the dynamic Q-angle.”

<table>
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<th>Table 1</th>
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<tr>
<td>Hip muscle anatomy</td>
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<thead>
<tr>
<th>Anatomical movements</th>
<th>Agonist muscles</th>
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<tbody>
<tr>
<td>Hip extension</td>
<td>Gluteus maximus, biceps femoris (long head), semitendinosus, semimembranosus</td>
</tr>
<tr>
<td>Hip flexion</td>
<td>Iliopsoas, rectus femoris, sartorius, pectineus</td>
</tr>
<tr>
<td>Hip abduction</td>
<td>Tensor fasciae latae, gluteus medius, gluteus minimus, sartorius</td>
</tr>
<tr>
<td>Hip adduction</td>
<td>Adductor magnus, adductor longus, adductor brevis, gracilis, pectineus</td>
</tr>
<tr>
<td>Hip internal rotation</td>
<td>Gluteus medius (anterior fibers), gluteus minimus, semitendinosus, semimembranosus, gracilis</td>
</tr>
<tr>
<td>Hip external rotation</td>
<td>Iliopsoas, gluteus maximus, gluteus medius (posterior fibers), biceps femoris (long head), sartorius, gemellus superior, gemellus inferior, obturator externus, obturator internus, quadratus femoris, piriformis</td>
</tr>
</tbody>
</table>
Patellofemoral Kinematics Study

- **Subjects**
  - 6 females, ages 15-39 y.o., lateral patellar subluxation

- **Procedure**
  - KMRI taken during weight bearing and non weight bearing

- **Results**
  - ↑ lateral displacement & tilt of patella in NWB
  - ↑ femoral IR in WB

- **Conclusion & Discussion**
  - WB - result of patella rotating laterally on horizontal femur.
  - NWB - result of patella moving laterally on fixed femur
Hip Strength in Collegiate Female Athletes with PFP.\(^5\)

- **Subjects**
  - 13 Division III Female Athletes, Unilateral PFPS
  - 13 Age, Gender and Sport-Matched Athletes, no history of knee injury &/or pain.

- **Procedure**
Hip Strength in Collegiate Female Athletes with PFP.5

- **Results**
  - Significant weakness in aBductors and external rotators compared to uninjured leg.
  - Significant weakness globally (except aDductors) in injured athletes compared to uninjured controls.

- **Limitations**
  - Retrospective study
  - Self reported body weight
  - No leg length measurement

- **Conclusion & Discussion**
  - “Results support theory that proximal weakness is associated with PFPS.”
  - Does hip weakness lead to PFPS, or does PFPS lead to hip weakness?
Short-Term Effects of Hip Abductors and Lateral Rotators Strengthening in Females with PFPS: A Randomized Controlled Clinical Trial

• **Subjects**
  - 70 Female Patients, sedentary, unilateral PFPS, 20-40 y.o.
  - 25 CO (Control Group), 22 KE (Knee Exercise Group), 23 KHE (Knee and Hip Exercise Group)

• **Interventions**
  - 12 total sessions (3x week for 4 weeks)
    - CO-no Tx
    - KE-stretching (HM, PF, Quads, ITB), strengthening (SLR, seated knee extension, leg press, squats)
    - KHE- same as KE + hip aBd. exercises, hip ER exercises, & side-stepping
Short-Term Effects of Hip Abductors and Lateral Rotators Strengthening in Females with PFPS: A Randomized Controlled Clinical Trial

- **Evaluation**
  - NPRS (Numerical Pain Rating Scale), LEFS (Lower Extremity Functional Scale), AKPS (Anterior Knee Pain Scale), & Single-limb single hop test
  - Administered before and after 4 week interventions.

- **Results**
  - Improved function for both KE and KHE groups (LEFS, AKPS & Single-limb hop test).
  - Only KHE group showed significant pain reduction (NPRS-ascending & descending stairs)

- **Limitations**
  - Short-term study (only 4 weeks)
  - No education on movement patterns
Conclusion & Discussion

Most outcome measures show greater improvement in KHE than KE, but not statistically significant.

MCID numbers suggest greater clinical benefits for KHE than KE.

- LEFS (MCID 9)
  - KHE 16.6
  - KE 10.0

- AKPS (MCID 13)
  - KHE 15.0
  - KE 10.2

- NPRS (MCID 2)
  - KHE 2.2 ascending & 2.6 descending
  - KE 1.5 ascending & 1.0 descending

“We suggest that strengthening of the hip abductors and lateral rotators should be used along with strengthening of the knee musculature for women with PFPS.”
Posterolateral Hip Muscle Strengthening Versus Quadriceps Strengthening for Patellofemoral Pain: A Comparative Control Trial

Subjects
- 36 patients, not physically active, 18 men & 18 women
  - 18 Hip (Posterolateral Group) 10 bilateral, 8 unilateral
  - 18 Quad (Quadriceps Group) 12 bilateral, 6 unilateral

Interventions
- 24 total sessions (3x week for 8 weeks)
  - HIP- band resisted side lying hip aBd. & seated hip ER
  - Quad- band resisted seated knee extension & partial squat
Posterolateral Hip Muscle Strengthening Versus Quadriceps Strengthening for Patellofemoral Pain: A Comparative Control Trial

• Evaluation
  • VAS (Visual Analog Scale) & WOMAC (Western Ontario McMaster Universities Osteoarthritis Index)
  • Administered prior to Tx (baseline), at 8 weeks (postintervention), & at 6 months (follow-up)

• Results
  • VAS scores ↓ significantly for both HIP & Quad at postintervention & follow-up.
    • Lower in HIP group at postintervention & follow-up.
  • WOMAC scores ↓ significantly for both HIP & Quad at postintervention & follow-up.
    • Lower in HIP group at postintervention & follow-up.
Posterolateral Hip Muscle Strengthening Versus Quadriceps Strengthening for Patellofemoral Pain: A Comparative Control Trial

<table>
<thead>
<tr>
<th>HIP Group</th>
<th>Quad Group</th>
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<tbody>
<tr>
<td><strong>VAS</strong></td>
<td><strong>VAS</strong></td>
</tr>
<tr>
<td>• Baseline 7.63</td>
<td>• Baseline 6.91</td>
</tr>
<tr>
<td>• Postintervention 2.11</td>
<td>• Postintervention 3.27</td>
</tr>
<tr>
<td>• Follow-Up 2.00</td>
<td>• Follow-Up 4.00</td>
</tr>
<tr>
<td>• Mean change 5.53</td>
<td>• Mean change 3.64</td>
</tr>
<tr>
<td><strong>WOMAC</strong></td>
<td><strong>WOMAC</strong></td>
</tr>
<tr>
<td>• Baseline 46.83</td>
<td>• Baseline 44.11</td>
</tr>
<tr>
<td>• Postintervention 6.22</td>
<td>• Postintervention 21.89</td>
</tr>
<tr>
<td>• Follow-Up 6.94</td>
<td>• Follow-Up 23.16</td>
</tr>
<tr>
<td>• Mean change 40.61</td>
<td>• Mean change 22.22</td>
</tr>
</tbody>
</table>
Limitations

- Small study sample
- Exercises used may have influenced findings
  - Seated TKEs may have increased PF joint reaction force and stress.
  - Partial squat may have resulted in hip strength gains in quad group.

Conclusion & Discussion

- Pain decreased by 70% & health status improved by 87% in HIP group.
- Improvements were maintained at 6-month follow-up.
- Results support use of hip strengthening to rehab PFPS.
Hip Strengthening Prior to Functional Exercises Reduces Pain Sooner Than Quadriceps Strengthening in Females with PFPS: A Randomized Clinical Trial

- **Subjects**
  - 33 women, 16-35 y.o. (26 completed study)
    - 17 Hip Group- 9 bilateral, 8 unilateral (13 completed study)
    - 16 Quad Group- 7 bilateral, 9 unilateral (13 completed study)

- **Interventions**
  - 24 total sessions (3x week for 8 weeks)- 1x week with investigator, 2x week at home
    - Weeks 1-4
      - Hip- stretching, side lying hip aBd. & ER, standing hip aBd. & ER, seated hip ER...progress to quadruped hydrant.
      - Quad- stretching, quad sets, SAQ, SLR...progress to TKE.
    - Weeks 5-8
      - Both- SL balance, wall slides, lateral step-downs, calf raises...increased in difficulty.
Hip Strengthening Prior to Functional Exercises Reduces Pain Sooner Than Quadriceps Strengthening in Females with PFPS: A Randomized Clinical Trial

- **Evaluation**
- VAS & LEFS
- Maximal isometric strength- hip aBd., hip ER & knee extension
- Step-down Test
- Administered prior to Tx at baseline & at completion of 4th and 8th weeks.
Hip Strengthening Prior to Functional Exercises Reduces Pain Sooner Than Quadriceps Strengthening in Females with PFPS: A Randomized Clinical Trial

• **Results**
  • VAS scores ↓ significantly for both
    • VAS scores ↓ significantly from baseline to 4 weeks for HIP only.
  • LEFS scores ↑ significantly for both
  • Hip aBd. strength significantly ↑ for HIP only
  • Hip ER strength ↑ from baseline to 8 weeks for both
  • Step-down test scores ↑ significantly for both
Hip Strengthening Prior to Functional Exercises Reduces Pain Sooner Than Quadriceps Strengthening in Females with PFPS: A Randomized Clinical Trial

• **Limitations**
  - Varying amounts of PFP among study sample
  - Based strengthening progressions on BW and not % of max force generated at baseline testing.
  - HEP for 16 of 24 sessions *my opinion*

• **Conclusion & Discussion**
  - Both groups experienced similar outcomes
  - Hip group reported less pain at 4 weeks than quad group
    - VAS scores at 4 weeks- decreased 43% for Hip and 3% for Quad
    - Theorize isolated quad exercise may cause further irritation.
Hip Posterolateral Musculature Strengthening in Sedentary Women With PFPS: A Randomized Controlled Clinical Trial With 1-Year Follow-Up

• **Subjects**
  - 54 women, sedentary, 20-40 y.o., unilateral PFP only
    - 26 Knee Group (KE)- 24 completed study
    - 28 Knee & Hip Group (KHE)- 25 completed study

• **Interventions**
  - 12 total sessions (3x week for 4 weeks)
    - KHE- same as KE + side lying hip aBd., standing hip aBd., seated hip ER, machine hip extension.
Hip Posterolateral Musculature Strengthening in Sedentary Women With PFPS: A Randomized Controlled Clinical Trial With 1-Year Follow-Up

• **Evaluation**
  - NPRS, LEFS, AKPS, & single-limb single-hop test
  - Administered prior to Tx at baseline, at 3 month, 6 month, & 12 month follow-ups.

• **Results**
  - KHE- improved NPRS, LEFS, AKPS & single-hop test scores at 3, 6 & 12 months post Tx compared to baseline.
  - KE-\(\downarrow\) pain with ascending stairs at 6 months & descending stairs at 3 & 6 months. Also improved single-hop test scores at 3, 6, & 12 months.
  - KHE group had significantly less pain and better function for all outcome measures compared to KE group.
Hip Posterolateral Musculature Strengthening in Sedentary Women With PFPS: A Randomized Controlled Clinical Trial With 1-Year Follow-Up

- Limitations
  - Investigators could not/did not monitor if patients continued exercises on own following 4 weeks of Tx.

- Conclusion & Discussion
  - Hip group showed more improvement overall than knee group at each follow-up.
  - Possible that KHE group experienced ↑ motor control & balance which improved single-hop test performance.
  - Strong evidence for hip strengthening + knee strengthening Tx plan.
The effect of additional strengthening of hip abductor and lateral rotator muscles in PFPS: a randomized controlled pilot study

• **Subjects**
  - 14 patients, 10 women & 4 men, 17-40 y.o.
    - 7 Control Group (CG)- 5 women & 2 men
    - 7 Intervention Group (IG)- 5 women & 2 men

• **Interventions**
  - 30 total sessions, 5x week for 6 weeks (1x supervised, 4x HEP)
    - CG- patellar mobilization, stretching, OKC & CKC quadriceps exercises.
    - IG- same as CG + strengthening and functional training of transversus abdominis, hip aBd. & ER muscles.

• **Evaluation:**
  - VAS
  - Isokinetic Eccentric Peak Torque- knee extension, hip aBd., hip ER
  - Maximal Isometric Voluntary Contraction- gluteus medius
The effect of additional strengthening of hip abductor and lateral rotator muscles in PFPS: a randomized controlled pilot study

Results:

- IG- significantly ↓ all VAS scores except prolonged sitting, significant ↑ in glute med max isometric voluntary contraction.

- Eccentric isokinetic knee extensor peak torque significantly ↑ for both groups.

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<thead>
<tr>
<th></th>
<th>Visual analogue scale (cm)</th>
<th>Baseline</th>
<th>Final</th>
<th>Mean change</th>
<th>P-value</th>
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<tbody>
<tr>
<td><strong>Intervention group</strong> (n = 7)</td>
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<tr>
<td>Usual pain</td>
<td>3.8 ± 2.1</td>
<td>1.1 ± 1.2</td>
<td>-3.6 ± 2.6</td>
<td>0.03*</td>
<td></td>
</tr>
<tr>
<td>Worst pain</td>
<td>5.0 ± 2.1</td>
<td>1.4 ± 1.3</td>
<td>-2.6 ± 2.5</td>
<td>0.03*</td>
<td></td>
</tr>
<tr>
<td>Stair-climbing</td>
<td>3.5 ± 3.7</td>
<td>0.4 ± 0.6</td>
<td>-3.0 ± 3.2</td>
<td>0.04*</td>
<td></td>
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<tr>
<td>Descending stair</td>
<td>4.5 ± 3.1</td>
<td>0.3 ± 0.4</td>
<td>-4.1 ± 2.9</td>
<td>0.03*</td>
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<tr>
<td>Squatting</td>
<td>5.7 ± 3.2</td>
<td>0.4 ± 0.6</td>
<td>-5.4 ± 3.0</td>
<td>0.02*</td>
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<tr>
<td>Prolonged sitting</td>
<td>2.9 ± 3.2</td>
<td>1.1 ± 1.6</td>
<td>-1.9 ± 2.9</td>
<td>0.14</td>
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<th>Visual analogue scale (cm)</th>
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<tbody>
<tr>
<td><strong>Control group</strong> (n = 7)</td>
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<td></td>
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<tr>
<td>Usual pain</td>
<td>4.7 ± 2.6</td>
<td>4.0 ± 2.6</td>
<td>-1.5 ± 2.8</td>
<td>0.31</td>
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</tr>
<tr>
<td>Worst pain</td>
<td>5.5 ± 1.5</td>
<td>3.4 ± 1.9</td>
<td>-1.3 ± 3.9</td>
<td>0.20</td>
<td></td>
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<tr>
<td>Stair-climbing</td>
<td>5.0 ± 3.4</td>
<td>2.6 ± 2.8</td>
<td>-2.4 ± 3.6</td>
<td>0.13</td>
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<tr>
<td>Descending stair</td>
<td>4.7 ± 3.3</td>
<td>2.0 ± 2.4</td>
<td>-2.8 ± 2.7</td>
<td>0.43</td>
<td></td>
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<tr>
<td>Squatting</td>
<td>4.8 ± 3.0</td>
<td>3.0 ± 3.1</td>
<td>-1.8 ± 2.6</td>
<td>0.12</td>
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<tr>
<td>Prolonged sitting</td>
<td>5.2 ± 2.8</td>
<td>2.9 ± 3.1</td>
<td>-2.3 ± 3.1</td>
<td>0.09</td>
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</table>

*Statistically significant difference with P<0.05.
The effect of additional strengthening of hip abductor and lateral rotator muscles in PFPS: a randomized controlled pilot study

- **Limitations**
  - Small study sample
  - No control group
  - No follow-up
  - HEP- only 6 out of 30 sessions with investigator *my opinion*

- **Conclusion & Discussion**
  - IG ↓ perceived pain & ↑ knee extensor eccentric isokinetic peak torque & glute med max contraction.
  - Pain symptom improvement not shown to be associated with an ↑ in eccentric hip muscle torque.
  - Strengthening and functional training of hip muscles play an important role in PFPS Tx.
Strengthening of the Hip & Core Versus Knee Muscles for the Treatment of PFP: A Multicenter Randomized Controlled Trial

• **Subjects**
  - 199 subjects, 133 women & 66 men, 29 y.o. average age
    - 111 Hip Group (HIP)- 34 males & 77 females
    - 88 Knee Group (KNEE)- 32 males & 56 females

• **Interventions**
  - Minimum 6x a week for 6 weeks, met with AT up to 3x week.
    - HIP- hip + core, standing & seated aBd. & ER, DL & SL balance
    - KNEE- quad sets, squat progressions, TKEs, FWD & LAT step-downs, lunge progressions

• **Evaluation**
  - VAS & AKPS (evaluated weekly)
  - Maximal Isometric Force- Hip aBd., ER, extension & knee extension
  - Core Endurance- front plank, side bridge, horizontal extension test
Strengthening of the Hip & Core Versus Knee Muscles for the Treatment of PFP: A Multicenter Randomized Controlled Trial\textsuperscript{11}

- **Results**
  - VAS ↓ & AKPS ↑ significantly for both groups.
  - HIP group ↓ VAS 1 week before KNEE group (wk 3 vs wk 4)
Strengthening of the Hip & Core Versus Knee Muscles for the Treatment of PFP: A Multicenter Randomized Controlled Trial

• **Results**
  • Strength ↑ significantly for both (greater but nonsignificant for HIP)
  • HIP ↑ hip aBd. & ER strength more than KNEE
  • Posterior core endurance ↑ for both (greater but nonsignificant ↑ for all muscle groups for HIP)

• **Limitations**
  • No control group
  • No follow-up
  • HEP-reported 80.3% compliance for HIP & 81.7% for KNEE *my opinion*
Case Study

• **Subject**
  • 15 y.o. female softball player
  • 135.6 lbs, 5.5 ft.

• **Assessment**
  • Pn squatting, descending stairs, softball, at night
  • Gait observation- bilat. genu varum
  • Ligament & meniscus testing (−), patellar compression (+)
  • MMT- 5/5 bilat. Quads, 4-/5 bilat. Hamstrings
  • FMT- Right Trendelenburg’s sign (+)
Case Study\textsuperscript{12}

- **Treatment**
  - Wk 1-Assessment, clam shell & lateral step-down (4/10 pn)
  - Wk 2- (6/10 pn) Bike, wall slides & chair squats (DL & SL).
  - Wk 3- (0/10 pn) Bike, leg press (DL & SL), 4-way hip machine (aBd. & aDd.), & PB bridge.
  - Wk 4- (0/10 pn) Stairmaster, SL leg press, PB bridge, & SL MB chest pass.
  - Wk 5- (0/10 pn) Bike, SL leg press, SL PB bridge, & heel raises.
  - Wk 6- (0/10 pn) Stairmaster, slide board slides, lateral band walk, review of squatting technique, discharge.

- **Results**
  - Pn free & participating in sports 3 months post Tx.
Clinical Bottom Line

• Clinical Question: Are hip strengthening exercises more effective than knee strengthening exercises in decreasing pain in patients with patellofemoral pain syndrome?
  • Hip strengthening + knee strengthening is shown to be superior to just knee or hip strengthening.
  • Hip strengthening should be included in PFPS Tx.
Rehab Exercises-Hip

- Side lying hip aBd.
- Standing hip aBd.
- Seated hip ER
- Resisted walking/side-stepping
- 4-Way Hip Machine
- Glute Bridge Variations
- Clam Shells
- Banded Squats
- Barbell Hip Thrust
Rehab Exercises - Trunk + Hip

- Straddle/balance progressions\textsuperscript{13}
- BOSU/PB lateral crunch
- Side Bridge Variations\textsuperscript{14}
- SL Palloff Press
  - https://vimeo.com/97076532
Thank You!

Questions??
References


References


