COLLEGE OF REHABILITATION SCIENCES

Management of the Patient with Patellofemoral Pain:
An Update on a Clinical Practice Guideline

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Disclosures

- No relevant financial relationship exists
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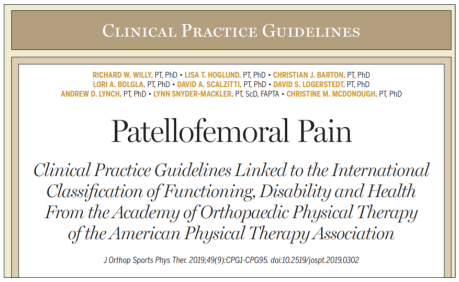
Learning Objectives

- By the end of this session, the learner will be able to:
  - Describe evidence-based criteria for diagnosis of patellofemoral pain (PFP)
  - Choose clinically-relevant tests and measures, with the best psychometric properties, to enhance clinical decision-making when treating individuals with PFP
  - Describe impairment- and function-based subcategories of PFP, to improve targeted patient management
  - Select evidence-based interventions appropriate for specific PFP subcategories
  - Given a patient case, classify the patient according to PFP subcategory diagnosis
  - Describe factors associated with patellofemoral osteoarthritis and recommended interventions



Available at: https://www.orthopt.org/content/practice/clinical-practice-guidelines

Willy 2019

Poll #1

- What test is shown to be the best for diagnosis of a person with PFP?

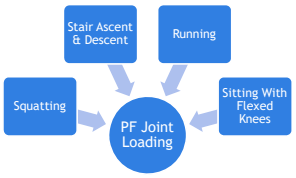
Patient Case

- 26 y.o. male
- 1-2 y h/o bilateral anterior knee pain; insidious onset; intermittent; produced by descending stairs
- Pain: current 0, best 0, worst 5
- Increases: descending stairs, stand → sit
- Relieved by: sitting, stopping activity, stretching
- Also c/o weak feeling descending stairs and stand → sit
- Denies paresthesias, night pain other symptoms
- PMH: anxiety
- Medications: none

What is Patellofemoral Pain?

- "Common musculoskeletal condition that is characterized by insidious onset of poorly defined pain, localized to the anterior retropatellar and/or peripatellar region of the knee."

Willy 2019, p. CPG5



Willy 2019

Prevalence of Patellofemoral Pain

- Varies by population
  - Annual prevalence
    - General population: 22.7%
    - Adolescents: 28.9%
      - Smith 2018
- Not just a problem for young adults & adolescents
- PearlDiver Record Database - diagnosis rates
  - PFP: 1.5%-7.3% all patients seeking medical care in USA
  - Diagnosis rates increased with age – to 50-59 years
    - Glaviano 2015

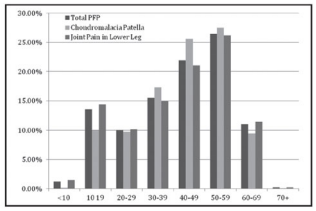


Figure 3. *Percentage of PFP by Age Group.*

From: Glaviano NR, et al. *Int J Sports Phys Ther.* 2015;10(3):281-290.

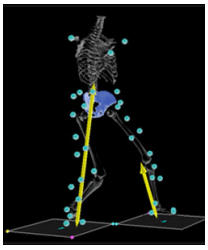
Who develops PFP?

- Risk factors
  - Isometric knee extensor weakness
  - Physically active women > physically active men
  - Participation in a single sport – young female athletes
    - Willy 2019, Glaviano 2021

https://i.insider.com/5b0601b71ad6621c008b4aa2?width=1136&format=jpeg. Accessed 10/26/2020.

What factors are associated with PFP?

- Overuse
- Weak quadriceps
- Weak hip muscles – women
  - Men?
- Tight calf muscles & reduced ankle ROM
- Excessive midfoot mobility
- Faulty biomechanics
  - Willy 2019
- Higher BMI (adults, not adolescents)
  - Hart 2017

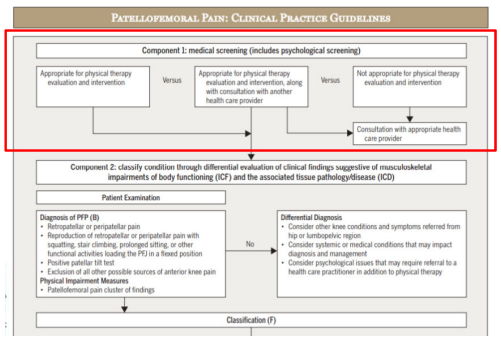


https://webhome.auburn.edu/~weimawh/taichix.jpg. Accessed 10/28/2020.

The Challenge: Diagnosis of Patellofemoral Pain

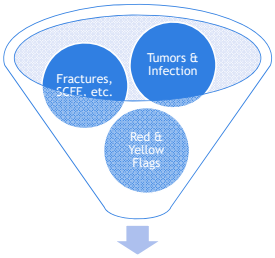
- Gold standard • None
- Diagnostic Tests • Poor Accuracy
- Test Clusters • No Improvement to Accuracy

Willy 2019



Willy 2019

Component 1: Medical Screening



Appropriate for PT?
Treat, Refer, Treat & Refer?

Willy 2019

Medical Screening

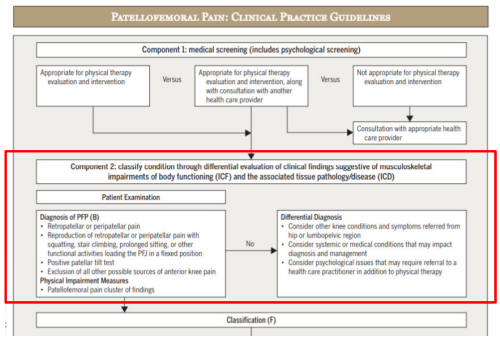
- Red Flags – Review of Systems
  - OSPRO-ROS
  - Non-mechanical pain, insidious onset, lack of improvement
- Fractures:
  - Ottawa Knee Rule
  - Pittsburgh Knee Decision Rule
- Risk Factors for Disease / Condition
  - PMH
  - Family Hx
  - Age
  - Sex

Willy 2019, George 2018, Konan 2013

Medical Screening: Psychosocial Issues

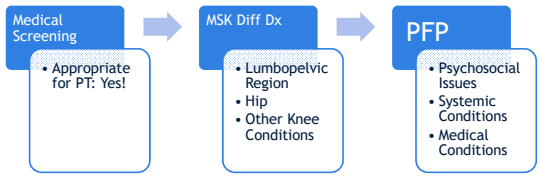
- Yellow Flags
  - OSPRO-YF: Available at: https://www.orthopt.org/yf/
- PFP – chronic condition
- Possible elevated psychological factors
  - Catastrophizing, anxiety, depression, fear avoidance
  - Kinesiophobia: high in persons with PFP who have greater disability

George 2018, Maclachlan 2017



Willy 2019

Component 2: MSK & Additional Differential Diagnosis



Maclachlan 2017, Maclachlan 2018, Willy 2019

Summary: Diagnosis of Patellofemoral Pain

1) Presence of retropatellar or peripatellar pain

AND … 2) pain reproduction with activities loading the PFJ in a flexed knee position (squatting, etc.)

AND … 3) exclusion of all other conditions that may cause anterior knee pain

Willy 2019

PFP Diagnostic Tests: Systematic Review Results

- Provocative Tests
  - Pain with squatting
    - Sensitivity 91%, specificity 50%
    - LR+ 1.8, LR- 0.10 – 0.20

- Non-Provocative Tests
  - Patellar Tilt Test
    - Sensitivity 43%, specificity 92%
    - LR+ 5.4, LR- 0.6

Willy 2019

45-second Anterior Knee Pain Provocation Test

Fig. 1; Rathleff 2022

- Static single-leg squat – 60 deg knee flex, held 45 sec
- Able to touch wall with one hand for balance; keep slight forward lean
- NPRS immediately after AKPP-test
- Adolescents
- Cut-point 1.25
  - Sens 0.82, Spec 0.89, +LR 7.6
- Construct validity: KOOS
- Responsiveness
  - 4 wks: 0.8
  - 12 wks: 2.9
    - Rathleff 2022

Activity Limitation Assessment in PFP

Outcome Measures for PFP

PRO			PPM		
AKPS	KOOS-PF	VAS or NPRS	Squat	Eccentric Step Down Test	Frontal Plane Projection Angle

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Willy 2019

PFP Patient-Reported Outcome Measures (PRO)

- Function
  - Anterior Knee Pain Scale (Kujala Scale)
    - MCID: 8-10 pts
    - Excellent test-retest rel., construct validity, responsiveness
  - KOOS-PF
    - MCID: 14.2 pts
    - Good test-retest reliability, construct validity, fair responsiveness
      - Sufficient content validity (unpublished results)
- Pain
  - 10 cm VAS for usual (MCID:1.5-2 cm) and worst pain (MCID:2 cm)
  - NPRS (MCID: 1.2 pts)
    - Reliable, valid, responsive

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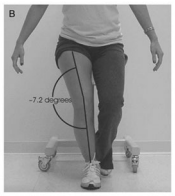
Willy 2019

PFP Physical Performance Measures (PPM)

- Provocative Tests
  - *Squatting
  - Eccentric step-down test
    - 6" step
  - 45 sec. AKPP test

- Non-Provocative Tests
  - Frontal Plane Projection Angle during SL squat



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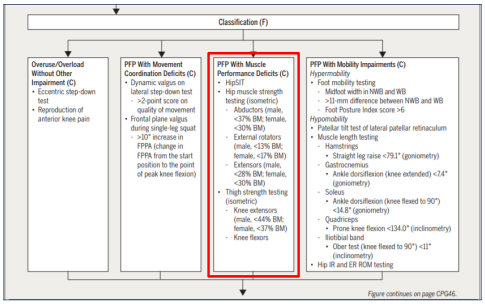
Willson 2006, Willy 2019, Rathleff 2022

Patient Case - 2

- Vital signs: HR 70, BP 118/72, PO2 100
- Posture: b/l FF abduction, mild pes planus L > R
- Squat test: (+) b/l
- Gait: WNL on levels @ normal pace; Stairs: increased genu valgus b/l with descent
- Sensation: intact to l.t. b/l
- L/S AROM WNL w/o production of LE Sxs
- LE AROM WNL x L knee ext (-5, but 0 PROM) – 5 deg ext lag
- MMT: WNL b/l LE x
  - R: hip ext, knee flex, knee ext 4+/5; hip ER 4/5; hip abd 4-/5
  - L: hip ext, knee flex 4+/5; knee ext 4/5; hip abd, hip ER 4-/5



Willy 2019

Subcategory 1: PFP With Muscle Performance Deficits


IJSPT

ORIGINAL RESEARCH

PAIN, FUNCTION, AND STRENGTH OUTCOMES FOR MALES AND FEMALES WITH PATELLOFEMORAL PAIN WHO PARTICIPATE IN EITHER A HIP/CORE- OR KNEE-BASED REHABILITATION PROGRAM

Lori A Bolgla, PT, PhD, MAcc, ATC/L[1]
Jennifer Earl-Boehm, PhD, ATC/L[2]
Carolyn Emery, PhD, PT[3]
Karrie Hamstra-Wright, PhD, ATC[4]
Reed Ferber, PhD, ATC[5]

Subgroup of responders: significant strength gains

Bolgla 2016

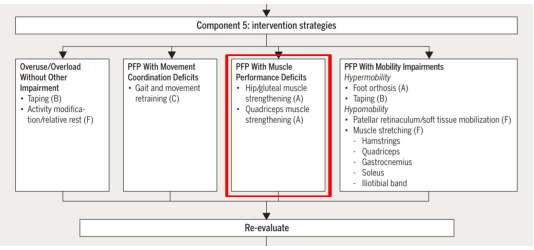
Subcategory 1: PFP With Muscle Performance Deficits (cont)

- Responders to hip and/or knee muscle strengthening: weakness of hip & knee muscles (isometric – make test)
  - Hip abductors, extensors (glut max), hip ER
  - Quads
    - Bolga 2016
- HipSIT

FIGURE 1. Hip Stability Isometric Test (HipSIT).

Almeida 2017

PFP CPG: Targeted Interventions



Willy 2019

PFP With Muscle Performance Deficits: Intervention

INTERVENTIONS – SPECIFIC MODES OF EXERCISE THERAPY

A Clinicians should include exercise therapy with combined hip- and knee-targeted exercises to reduce pain and improve patient-reported outcomes and functional performance in the short, medium, and long term. Hip-targeted exercise therapy should target the posterolateral hip musculature. Knee-targeted exercise therapy includes either weight-bearing (resisted squats) or non–weight-bearing (resisted knee extension) exercise, as both exercise techniques target the knee musculature. Preference to hip-targeted exercise over knee-targeted exercise may be given in the early stages of treatment of PFP. Overall, the combination of hip- and knee-targeted exercises is preferred over solely knee-targeted exercises to optimize outcomes in patients with PFP.

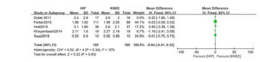
GRADES OF RECOMMENDATION	STRENGTH OF EVIDENCE
A Strong evidence	A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study
B Moderate evidence	A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation
C Weak evidence	A single level II study or a preponderance of level III and IV studies, including statements of consensus by content experts, support the recommendation
D Conflicting evidence	Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies
E Theoretical/foundational evidence	A preponderance of evidence from animal or cadaver studies, from conceptual models/principles, or from basic science/bench research supports this recommendation
F Expert opinion	Best practice based on the clinical experience of the guidelines development team supports this recommendation

Willy 2019

Strengthening Exercise

- Recent SR with MA: isolated hip- versus knee-focused strengthening
  - Both equally effective – pain & function
  - Pain

Figure 2.



Hip-strengthening exercises compared with knee-based exercises for visual analog scale pain score. IV, inverse variance.

  - Function

Figure 3.

Hip-strengthening exercises compared with knee-based exercises for function score on the Anterior Knee Pain Scale. IV, inverse variance.

Na 2021

Multi-joint vs. Single-joint Strengthening: Women with PFP

IJSPT

SYSTEMATIC REVIEW WITH META-ANALYSIS

IS MULTI-JOINT OR SINGLE JOINT STRENGTHENING MORE EFFECTIVE IN REDUCING PAIN AND IMPROVING FUNCTION IN WOMEN WITH PATELLOFEMORAL PAIN SYNDROME? A SYSTEMATIC REVIEW AND META-ANALYSIS.

Kristen Scali, SPT[1]
Jordan Roberts, SPT[1]
Megan McFarland, SPT[1]
Katie Marino, SPT[1]
Leigh Murray, PT, PhD[2]

Table 1. *Sample exercises for multi-joint and single joint protocols*[30,32,34]

Multi-Joint (Hip and Knee)	Single Joint (Knee Only)
• Standing or sidelying hip abduction • Sidelying or sitting hip external rotation • Sitting hip internal rotation • Sidelying, prone, or standing hip extension • Resisted side stepping • Forward lunge • Squats • Prone knee flexion • Seated knee extension	• Quad sets • Supine straight leg raise • Seated knee extension • Prone knee flexion • Leg press • Squats/Wall squats* • Step ups/step downs*

*Note: Because many exercises will produce muscle activation that crosses both joints (i.e. the quadriceps), single joint exercises are defined by the primary mover of the joint during the activity. For example, a squat requires some hip extension, but the main focus of the exercise is knee extension, requiring concentric activation of the quadriceps.

Scali 2018

Multi-Joint vs. Single-Joint Strengthening

- Pain
  - Multi-joint > single joint for pain reports, pain with activity
    - Short-term & Long Term

Conclusion: The results of this review show that statistically significant data are available that favor implementing a multi-joint exercise program in comparison to a single joint program for the reduction of pain in females with patellofemoral pain syndrome. Limited statistical evidence, however, is available to support a multi-joint program over a single joint program in the improvement of short-term functional performance and long-term self-reported function in females with patellofemoral pain syndrome.

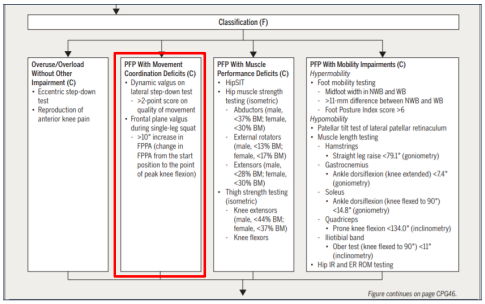
Key words: Hip, knee, multi-joint, patellofemoral pain syndrome, single-joint, strengthening program.

Level of Evidence: 1a

Scali 2018

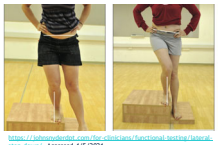
Blood Flow Restriction Training

- RCT: hip & knee strengthening vs. hip & knee strengthening + BFRT (around proximal thigh)
  - 3x/wk, 4 wks (ex group 45 min, BFRT group 60 min)
  - Both groups: increased function (AKPS), reduced pain, increased strength (MVIC) – hip ext, hip abd, knee ext
  - BFRT: at 4 wks - better "worst pain"
  - BFRT : at 2 mo - knee extensor MVIC
  - No adverse events
    - Constantinou 2022



Willy 2019

Subcategory 2: PFP with Movement Coordination Deficits



https://johnnydoddpt.com/for-clinicians/functional-testing/lateral-step-down/. Accessed 4/5/2021.

Lateral Step-Down Test Scoring
- Arm strategy: +1
- Trunk movement: +1
- Pelvis: +1
- Knee: +1 to +2
- Maintain steady stance: +1

Scoring of Movement Quality
- Good: 0-1
- Medium: 2-3
- Poor: ≥ 4

- Piva 2006

Patient Case - 3

- Lateral step down test (+) b/l
  - R: knee valgus (+1), trunk lateral flex, LOB
  - L: knee valgus (+1), trunk lateral flex, LOB
    - L: (+) ant knee pain

Subcategory 2: PFP with Movement Coordination Deficits (cont)

Journal of Back and Musculoskeletal Rehabilitation 29 (2016) 259–266
DOI 10.3233/BMR-150622
IOS Press

Relationship between frontal plane
angle of the knee and hip and trunk
in women with and without patellof
pain

Gabriel Peixoto Leão Almeida[a,b,*], Ana Paula de Moura Campos Carvalho e Silv
Fábio Jorge Renovato França[a], Maurício Oliveira Magalhães[a], Thomaz Nogueira
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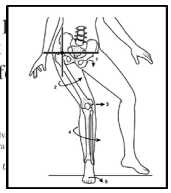
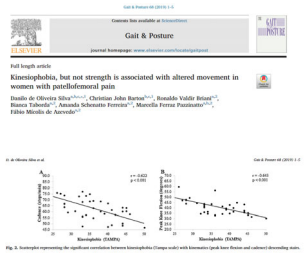


Subgroup: patients without hip/knee weakness; altered mechanics

Dynamic Q-angle

Almeida 2016;
Powers 2003

Movement Coordination Deficits & Kinesiophobia



Gait & Posture 68 (2019) 1–5
Contents lists available at ScienceDirect
Gait & Posture
journal homepage: www.elsevier.com/locate/gaitpost

Full length article

Kinesiophobia, but not strength is associated with altered movement in women with patellofemoral pain

Danilo de Oliveira Silva[a,b,c,d,*], Christian John Barton[b,e,f], Ronaldo Valdir Briani[a,g], Bianca Taborda[a,g], Amanda Schenatto Ferreira[a,g], Marcella Ferraz Pazzinatto[a,b,g], Fábio Micolis de Azevedo[a,g]

D. de Oliveira Silva et al.
Gait & Posture 68 (2019) 1–5

Fig. 2. Scatterplot representing the significant correlation between kinesiophobia (Tampa scale) with kinematics (peak knee flexion and contract descending stairs.

- Stair descent task
- Tampa Scale of Kinesiophobia
  - Strong association with kinematics
- Knee extensor strength
  - MVIC, isokinetic
  - No association with kinesiophobia
  - No association with kinematics

- De Oliveira 2019

Motor Control Exercise – for PFP

PTJ: Physical Therapy & Rehabilitation Journal | *Physical Therapy*, 2021;101:1–11
https://doi.org/10.1093/ptj/pzab072
Advance access publication date February 19, 2021
Review

Motor Control Exercises Compared to Strengthening Exercises for Upper- and Lower-Extremity Musculoskeletal Disorders: A Systematic Review With Meta-Analyses of Randomized Controlled Trials

Abstract

Objective. The purpose of this review was to compare the efficacy of motor control exercises (MCEs) to strengthening exercises for adults with upper- or lower-extremity musculoskeletal disorders (MSKDs).

Methods. Electronic searches were conducted up to April 2020 in Medline, Embase, Cochrane CENTRAL, and CINAHL. Randomized controlled trials were identified on the efficacy of MCEs compared to strengthening exercises for adults with upper- or lower-extremity MSKDs. Data were extracted with a standardized form that documented the study characteristics and results. For pain and disability outcomes, pooled mean differences (MDs) and standardized mean differences (SMDs) were calculated using random-effects inverse variance models.

Results. Twenty-one randomized controlled trials (n = 1244 participants) were included. Based on moderate-quality evidence, MCEs lead to greater pain (MD = −0.41 out of 10 points; 95% CI = −0.72 to −0.10; n = 626) and disability reductions (SMD = −0.28; 95% CI = −0.43 to −0.13; n = 713) when compared to strengthening exercises in the short term; these differences are not clinically important. When excluding trials on osteoarthritis (OA) participants and evaluating only the trials involving participants with rotator cuff–related shoulder pain, shoulder instability, hip-related groin pain, or patellofemoral pain syndrome, there is moderate quality evidence that MCEs lead to greater pain (MD = −0.74 out of 10 points; 95% CI = −1.22 to −0.26; n = 280) and disability reductions (SMD = −0.40; 95% CI = −0.61 to −0.19; n = 354) than strengthening exercises in the short term; these differences might be clinically important.

Conclusions. MCEs lead to statistically greater pain and disability reductions when compared to strengthening exercises among adults with MSKDs in the short term, but these effects might be clinically important only in conditions that do not involve OA. Inclusion of new trials might modify these conclusions.

Impact. These results suggest that MCEs could be prioritized over strengthening exercises for adults with the included non-OA MSKDs; however, results are unclear for OA disorders.

Keywords: Exercise Therapy, Motor Control and Motor Learning, Muscle Strength, Musculoskeletal Pain, Physical Therapists

[3,4]

Lafrance 2021

Runners with PFP

- PFP vs. pain-free controls
  - Greater knee flexion – stance phase
  - Greater ankle DF - early stance phase
  - Acute PFP (< 3 mo): greater transverse plane hip motion
  - Chronic PFP (> 3 mo): greater frontal plane hip motion, greater hip add, greater tibial abd
    - Fox 2018
- Other studies
  - Increased hip IR & add, increased tibial IR & ER
  - Prospective study in women: increased hip add → PFP
    - Noehren 2013

PTJ: Physical Therapy & Rehabilitation Journal | *Physical Therapy*, 2021;101:1–10
https://doi.org/10.1093/ptj/pzaa207
Advance access publication date December 22, 2020
Perspective

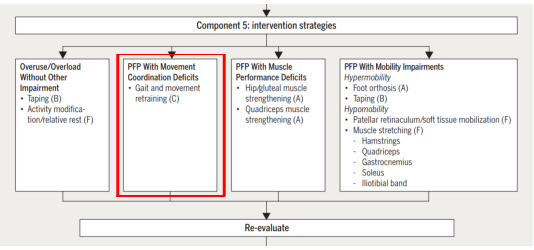
Learning Gait Modifications for Musculoskeletal Rehabilitation: Applying Motor Learning Principles to Improve Research and Clinical Implementation

Jesse M. Charlton[1,2], Janice J. Eng, PT[3,4], Linda C. Li[4,5], Michael A. Hunt, PT[2,4,*]

- Practice Structure: blocked vs. random, massed vs. distributed
  - Random & distributed → better learning
- Feedback: external vs. internal
  - External: knowledge of results vs. knowledge of performance
    - Runners with PFP – K of P successful
  - Visual vs. auditory
  - Internal vs. external foci
  - Timing: feedback interval
- Wearable-sensor systems – sport watch

Charlton 2021

PFP CPG: Targeted Interventions



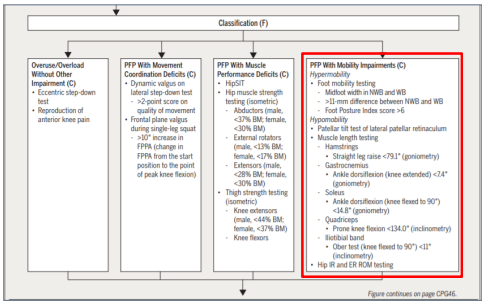
Willy 2019

Subcategory 2: PFP with Movement Coordination Deficits: Intervention

- Running gait retraining
  - Increase cadence 10% - reduce load
  - Reduce peak hip adduction (knees apart, straight ahead)
  - RF strike → FF strike pattern
    - Willy 2019
- Limit running when exhausted
  - Fatigued hip abd → increased peak hip add angles
    - Wilson 2015
- Landing technique
  - Reduce load & stiffness
  - Proper LE alignment
  - Progress complexity of task, reduce reliance on vision
    - McClinton 2020

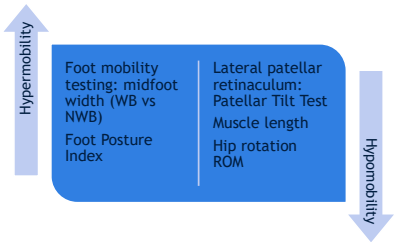
Recommendation

C Clinicians may use gait retraining consisting of multiple sessions of cuing to adopt a forefoot-strike pattern (for rearfoot-strike runners), cuing to increase running cadence, or cuing to reduce peak hip adduction while running for runners with PFP.

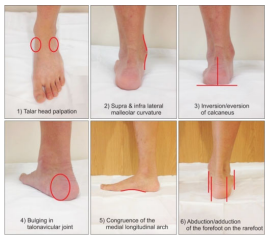


Willy 2019

Subcategory 3: PFP With Mobility Impairments



Subcategory 3: PFP With Mobility Impairments: Tests & Measures



Patient Case - 4

- Foot Posture Index: +5 b/l
- Patellar Tilt Test: (+) b/l
- SLR test (-) for pain; R 60 deg, L 50 deg
- Ober's, gastroc length, soleus length, PKF: (-) b/l

Subcategory 3: PFP with Mobility Impairments (cont)

- Foot hypermobility
  - Pronated foot subgroup
    - Selfe 2016
  - Predictor for (+) response to foot orthoses: midfoot width difference >11.25 mm
    - Mills 2012; Matthews 2017

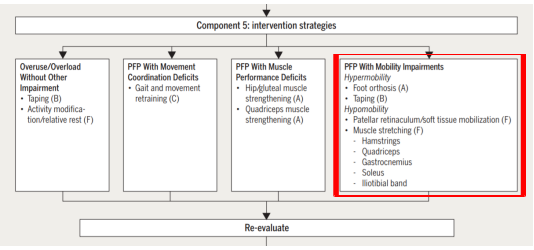
INTERVENTIONS – FOOT ORTHOSES

A Clinicians should prescribe prefabricated foot orthoses for patients with greater than normal pronation to reduce pain, but only in the short term (up to 6 weeks). If prescribed, foot orthoses should be combined with an exercise therapy program. There is insufficient evidence to recommend custom foot orthoses over prefabricated foot orthoses.

- Soft tissue/joint hypomobility
  - Weak & tight subgroup
    - Selfe 2016
  - Muscle length
    - Piva 2005
  - Lateral retinaculum tightness
    - Patellar tilt test
      - Nunes 2013
  - Hip ER ROM
    - Hamstra-Wright 2017

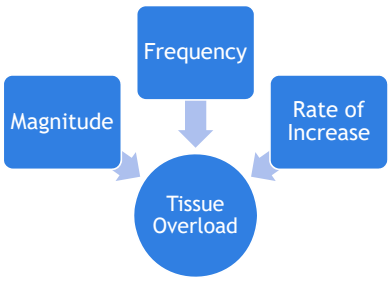
Subgroup: patient's foot hypermobility and pronation OR hypomobility of soft tissues or joints

PFP CPG: Targeted Interventions



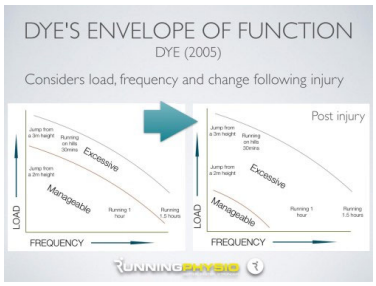
Willy 2019

Subcategory 4: PFP With Overuse/Overload Without Other Impairment



Willy 2019

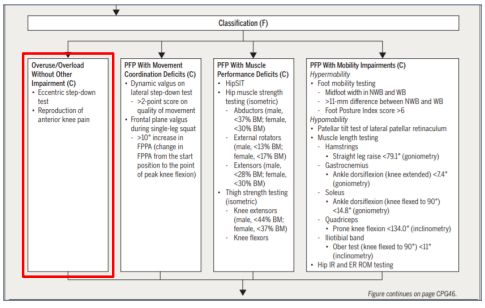
Tissue Overload / Overuse



Dye 2005

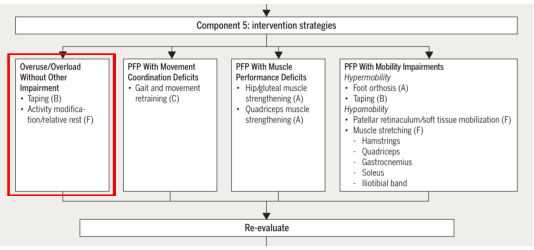
Subcategory 4: PFP With Overuse/Overload Without Other Impairment (cont)

- High intensity of physical activity
  - Briani 2017
- Repetitive loads, little recovery time – military recruits
  - Thijs 2007
- Novice recreational runners
  - ~~Foot posture or motion~~
  - ~~Hip muscle isometric strength~~
  - Thijs 2008; Thijs 2011



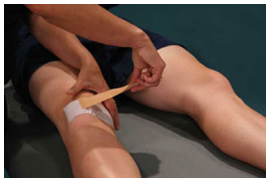
Willy 2019

PFP CPG: Targeted Interventions



Willy 2019

Subcategory 4: PFP With Overuse/Overload Without Other Impairment: Intervention



INTERVENTIONS – PATELLAR TAPING

B Clinicians may use tailored patellar taping in combination with exercise therapy to assist in immediate pain reduction, and to enhance outcomes of exercise therapy in the short term (4 weeks). Importantly, taping techniques may not be beneficial in the longer term or when added to more intensive physical therapy. Taping applied with the aim of enhancing muscle function is not recommended.

INTERVENTIONS – PATELLOFEMORAL KNEE ORTHOSES (BRACING)

B Clinicians should not prescribe patellofemoral knee orthoses, including braces, sleeves, or straps, for patients with PFP.

Patient education: load management

Willy 2019

Subcategory 4: PFP With Overuse/Overload Without Other Impairment: Intervention (cont)

- Load Management
- Consider peak PFJRF during activities & exercise
- Sys Rev -Meta-Analysis results
- Healthy
  - Walking: 0.9 ± 0.4 BW
  - Stair ascent: 3.2 ± 0.7 BW
  - Stair descent: 2.8 ± 0.5 BW
  - Running: 5.2 ± 1.2 BW
- PFP
  - Walking: 0.8 ± 0.2 BW
  - Stair ascent: 2.5 ± 0.5 BW
  - Stair descent: 2.6 ± 0.5 BW
  - Running: 4.1 ± 0.9 BW
    - Hart 2022
- PFJ Stress (F/A)
- OKC 90 → 40 deg
  - Seated knee ext
- CKC 0 → 20 deg
  - Minisquats
  - Standing wall slides
    - Powers CM, JOSPT; 2014:44:320-327.

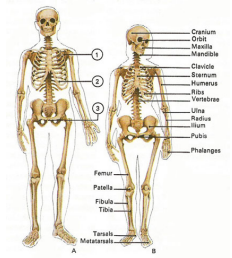
Load Progression – PFJRF

- Lunge Exercise – Lower → Higher PFJRF
  - Forward lunge – 0-30 deg
    - Ground level & 10 cm platform
  - Forward lunge – 0-60 deg to 10 cm
  - Forward lunge – 0-60 deg at ground
  - Side lunge – 0-60 deg to 10 cm
  - Side lunge – 0-60 deg at ground
  - Forward lunge – 0-100 deg to 10 cm
  - Forward lunge – 0-100 deg at ground
  - Side lunge – 0-100 deg to 10 cm
  - Side lunge – 0-100 deg at ground
    - Escamilla 2022

Poll #2

- What PFP subcategory is best for this patient? (Remember that this may change over the course of care.)

What about men with PFP?

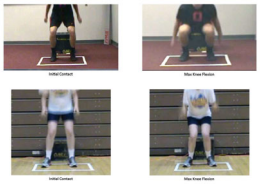


https://www.davidderling.info/images3/differences_between_male_and_female_skeleton.jpg. Accessed 10/28/2020.

- Sex-determined differences
  - Skeleton
  - Muscles
  - Neuromuscular

https://globalsportmatters.com/wp-content/uploads/2019/12/knee-pain.jpg. Accessed 10/28/2020.

Sex Differences: Lower Extremity Biomechanics

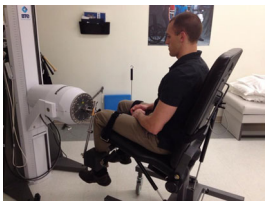


- Runners
  - Females: greater peak hip adduction, hip IR, knee abduction than males
    - Ferber R, 2003
- Walking & running
  - Females: greater peak hip adduction & hip IR
  - Females: greater gluteus maximus muscle activity
    - Chumanov ES, 2008

https://primalgait.com/wp-content/uploads/2014/03/LER-Figure3.jpg. Accessed 10/28/2020.

Men with PFP: Muscle Weakness

- Quadriceps weakness
  - Willy 2019
- Hip Muscles: conflicting findings
  - No difference from pain-free, knee extensor force: PFP < control
    - Bolgla 2015
  - Hip extensor peak isometric force: PFP < control; hip abd and hip ER no difference
    - Hoglund 2018
- Trunk Endurance
  - Anterior, lateral – no difference from pain-free
    - Botta 2021



Current Study at Jefferson: Men with PFP vs. Men without Knee Pain – Biomechanics (unpublished preliminary results)

Table 1. Participant Characteristics, Group Averages

Characteristics	PFP/Control (mean [SD])	*P* value
Age(yr)	30.38 [6.11]/ 26.30 [4.18]	0.032**
Mass(kg)	82.42 [13.14]/ 79.52 [20.72]	0.606
Height(m)	1.79 [0.08]/ 1.79 [0.08]	0.918
BMI*	25.80 [4.60]/ 23.20 [7.80]	0.2
Current pain, 0-10*	1.00 [2.00]/ 0.00 [0.00]	0.001**
Worst pain, 0-10*	6.00 [3.00]/ 0.00 [0.00]	<0.001**
Pain duration (mo)*	60.00 [100.00]/ 0.00 [0.00]	<0.001**
KOOS-PF, 0-100*	63.64 [32.72]/ 100.00 [0.00]	<0.001**
Tegner, 0-10	5.00 [1.27]/ 5.95 [1.99]	0.106

* Median (Interquartile Range)
** Significant difference (*P*<0.05, 2-tailed)
Abbreviations: SD, standard deviation; BMI, body mass index; KOOS-PF, Knee injury and Osteoarthritis Outcome Score – Patellofemoral Scale; Tegner, Tegner Activity Level Scale

https://media.springernature.com/lw685/springer-static/image/art%3A10.1186%2F1471-2474-13-207/MediaObjects/12891_2012_Article_1505_Fig1_HTML.jpg. Accessed 10/28/2020.

Unpublished Preliminary Results: Men with PFP vs. Pain-free Men

Table 2. Stance Hip Joint Angles During Single Leg Squat, Group Avg

Plane		PFP/Control (median [IQR])	*P* value
Sagittal	Max	34.6 [20.0] / 42.1 [26.8]	0.046*
	Min	-21.0 [15.6] / -16.4 [15.1]	0.482
Frontal	Max	16.8 [12.3] / 13.3 [12.8]	0.001*
	Min	0.2 [5.7] / -2.0 [8.2]	<0.001*
Transverse	Max	2.8 [9.4] / 3.1 [16.9]	0.093
	Min	-7.3 [12.3] / -10.1 [23.4]	0.991

* Significant difference ($P<0.05$, 2-tailed)
Angular values: +Flexion/Adduction/Internal Rotation (Sagittal/Frontal/Transverse respectively)
Abbreviations: Avg, Average; IQR, interquartile range; Max, maximum; Min, minimum

Table 3. Stance Knee Joint Angles During Single Leg Squat, Group Avg

Plane		PFP/Control (median [IQR])	*P* value
Sagittal	Max	-5.3 [11.9] / -3.1 [11.4]	0.204
	Min	-66.9 [17.4] / -72.4 [16.3]	0.049*
Frontal	Max	4.6 [6.3] / 7.2 [7.6]	<0.001*
	Min	-3.5 [6.8] / -1.3 [5.3]	<0.001*
Transverse	Max	8.7 [10.2] / 8.4 [9.2]	0.076
	Min	-4.6 [7.9] / -3.9 [11.4]	0.115

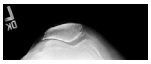
* Significant difference ($P<0.05$, 2-tailed)
Angular values: +Extension/Adduction/Internal Rotation (Sagittal/Frontal/Transverse respectively)
Abbreviations: Avg, Average; IQR, interquartile range; Max, maximum; Min, minimum

- Hips: PFP group: less hip flex, less hip abd, greater hip add
- Knees: PFP group: less knee flex, less knee add, greater knee abd

Patellofemoral Osteoarthritis

- Possible long-term result of PFP
  - PFP and PF OA – possible continuum
    - Lack of longitudinal studies
    - One retrospective review – persons undergoing PFJ arthroplasty
      - Crossley 2014, Thomas 2010, Utting 2005, Macri 2020
  - Similar symptoms, impairments, functional limitations
    - Crossley 2016, van Middelkoop 2018
  - Radiographic & MRI signs of PF OA: 20-30% of adults aged 26-50 yrs with persistent PFP
    - Collins 2019

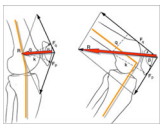
Patellofemoral Osteoarthritis: Imaging & Prevalence



- Radiographic findings
  - Joint space narrowing, osteophytes
    - Van Middelkoop 2018
- MRI
  - Abnormal cartilage morphology, bone marrow lesions
    - Hart 2017
  - PF OA patellar cartilage damage, osteophytes, BMLs – associated with anterior knee pain (not TF OA signs)
    - Macri 2021

- Highly prevalent in adults
  - 25% (population-based)
  - 39% (symptom-based)
  - Females > males
    - Van Middelkoop 2018

Patellofemoral Osteoarthritis (cont.)



- Anterior knee pain – stair climbing
  - Min-no pain – level ambulation
    - van Middelkoop 2018
- Significant cause of disability
  - Stair ascent & descent, sit-to-stand, car & bathtub transfers
    - Hoglund 2015, van Middelkoop 2018, Macri 2020
- Reduced QOL
    - Macri 2020
- Risk Factor: quad weakness
  - Sex-specific – women greater risk for PF cartilage damage progression
    - Crossley 2016, Culvenor 2019

Muscle and Alignment Factors Associated with PF OA

- Proximal muscle weakness:
  - Knee extensors
  - Hip abd, hip ER, hip ext
    - Systematic Review with Meta-Analysis – Siqueira 2022
    - Hoglund 2014, Stefanik 2011, van Middelkoop 2018, Carvalho 2021
- LE static malalignment
    - Elahi 2000, Cahue 2004
  - More TF valgus, patella more laterally displaced
    - Macri 2020

PFOA Treatment – Systematic Review Results

- Multimodal PT
  - Exercise
  - Patellar taping – medial glide
    - Reduced pain – short-term
- Foot orthoses
  - Improved function – KOOS-ADL scale
- Knee braces –
  - No significant pain reduction
    - Callaghan 2021

PF OA: Exercise Intervention

- Multimodal approach
  - Hip abductor strengthening, VMO retraining, jt mobilization, patellar taping
    - Crossley 2016
- Principles for treating patients with PFP → hip focus → hip + knee

Hoglund et al. Pilot and Feasibility Studies (2018) 4:70
https://doi.org/10.1186/s40814-018-0262-z

Pilot and Feasibility Studies

RESEARCH Open Access

A 6-week hip muscle strengthening and lumbopelvic-hip core stabilization program to improve pain, function, and quality of life in persons with patellofemoral osteoarthritis: a feasibility pilot study

Lisa T. Hoglund[1*], Laura Pontiggia[2] and John D. Kelly IV[3]

Hoglund 2018

PF OA: Exercise Focus

- 6 weeks, 2x/week + home program
- Hip focus + abdominal strengthening/stabilization – lying
  - Decreased PFJ stress
- Progressed to standing hip, knee, pelvic/trunk stabilization
  - Neuromuscular reeducation
  - Functional ex: sit → stand

PF OA Exercise Intervention: Results

Table 4 PFJ OA participant pain rating and KOOS scores: baseline, 6-week follow-up, and change (n = 10)

	Baseline	6-week follow-up	Participant score change from baseline	*P* value
NPRS (0–10)	3 (3, 6)	1 (0, 3)	−2.50 (−3, −2)	*0.0195*
KOOS Pain (0–100)	63.89 (47.22, 66.67)	77.78 (69.44, 86.11)	16.67 (5.56, 25.00)	*0.0039*
KOOS Symptom (0–100)	60.71 (53.57, 67.86)	75.00 (57.14, 89.29)	14.29 (10.71, 17.86)	*0.0156*
KOOS ADL (0–100)	68.38 (47.06, 76.47)	83.82 (79.41, 94.12)	15.44 (14.71, 17.65)	*0.0020*
KOOS Sport/Rec (0–100)	30 (20, 50)	57.50 (50.00, 75.00)	25.00 (0, 45.00)	*0.0195*
KOOS QOL (0–100)	37.50 (25, 43.75)	50.00 (31.25, 62.50)	15.63 (6.25, 25.00)	*0.0195*

Data are expressed as median (IQR). Values in italics indicate significant change at the 0.05 significance level in the exploratory analyses (Wilcoxon Signed Rank test). KOOS scored from 0 to 100, 100 = best status. NPRS scored from 0 to 10, 10 = worst pain
PFJ OA patellofemoral joint osteoarthritis, *n* number, *NPRS* numeric pain rating scale, *KOOS* Knee Injury and Osteoarthritis Outcome Score, *ADL* activity of daily living, *Rec* recreation, *QOL* quality of life, *IQR* interquartile range

Table 5 PFJ OA participant peak isometric muscle torque and TUG at baseline and 6-week follow-up

	Baseline	6-week follow-up	Change from baseline	*P* value
Hip Ext Rot Torque	0.16 (0.13, 0.16)	0.19 (0.17, 0.24)	0.04 (0.02, 0.08)	*0.0137*
Hip Abd Torque	0.33 (0.31, 0.41)	0.34 (0.28, 0.46)	−0.04 (−0.11, 0.07)	0.6953
Hip Ext Torque	0.11 (0.07, 0.21)	0.16 (0.12, 0.38)	0.06 (−0.01, 0.10)	0.1309
Knee Ext Torque	0.43 (0.37, 0.62)	0.68 (0.37, 0.75)	0.06 (−0.03, 0.24)	0.3223
TUG (s)	7.61 ± 1.70	6.63 ± 1.36	−0.98 ± 0.84	*0.0052*
Pre-TUG Pain (0–10)	2.00 (0.00, 4.00)	0 (0, 3)	−1 (−3, 0)	0.1719
Post-TUG Pain (0–10)	2.00 (1.00, 4.00)	0 (0, 3)	−2 (−3, 0)	0.1250

Data are expressed as median (IQR) except for TUG which is expressed as mean ± SD. Values in italics indicate significant change at the 0.05 significance level in the exploratory analyses (Wilcoxon Signed Rank test (median (IQR) results) or paired *t* test (mean ± SD) results)
PFJ OA patellofemoral joint osteoarthritis, *Ext Rot* external rotator, *Abd* abductor, *Ext* extensor, *TUG* Timed-Up-and-Go, *IQR* interquartile range, *SD* standard deviation

Hoglund 2018

Questions?

References - 1

- Willy R, Hoglund LT, Barton CJ, et al. Patellofemoral Pain: 2019. Clinical practice guidelines linked to the International Classification of Functioning, Disability, and Health from the Academy of Orthopaedic Physical Therapy of the American Physical Therapy Association. *J Orthop Sports Phys Ther.* 2019:49(9).CPG1-CPG95.
- Smith BE, Selfe J, Thacker D, et al. Incidence and prevalence of patellofemoral pain: a systematic review and meta-analysis. *PLoS ONE.* 2018;13(1):e0190892. https://doi.org/10.1371/journal.pone.0190892
- Glaviano NR, Kew M, Hart JM, et al. Demographic and epidemiological trends in patellofemoral pain. *Int J Sports Phys Ther.* 2015;10(3):281-290.
- Glaviano NR, Boling MC, Fraser JJ. Anterior knee pain risk in male and female military tactical athletes. J Athl Train. 2021;56(11):1180-1187.
- Hart HF, Barton CJ, Khan KM, et al. Is body mass index associated with patellofemoral pain and patellofemoral osteoarthritis? A systematic review and meta-regression and analysis. British J Sport Med. 2017;51:781-790.
- George SZ, Beneciuk JM, Lentz TA, et al. Optimal screening for prediction of referral and outcome (OSPRO) for musculoskeletal pain conditions: results from the validation cohort. *J Orthop Sports Phys Ther.* 2018;48(6):460-475.
- Konan S, Zang TT, Tamimi N, et al. Can the Ottawa and Pittsburgh rules reduce requests for radiography in patients referred to acute knee clinics? *Ann R Coll Surg Engl.* 2013;95(3):188-191.
- Maclachlan LR, Collins NJ, Matthews MLG, et al. The psychological features of patellofemoral pain: a systematic review. *Br J Sports Med.* 2017;51:732-742.

References - 2

- Maclachlan LR, Matthews M, Hodges PW, et al. The psychological features of patellofemoral pain: a cross-sectional study. *Scand J Pain.* 2018;18(2):261-271.
- Rathleff MS, Holden S, Krommes K, et al. The 45-second anterior knee pain provocation test: a quick test of knee pain and sporting function in 10-14-year-old adolescents with patellofemoral pain. Phys Ther Sport. 2022;53:28-33.
- Willson JD, Davis IS. Core strength and lower extremity alignment during single leg squats. *Med Sci Sports Exercise.* 2006;38(5):945-952.
- Bolgla LA, Earl-Boehm J, Emery C, et al. Pain, function, and strength outcomes for males and females with patellofemoral pain who participate in either a hip/core or knee-based rehabilitation program. *Int J Sports Phys Ther*. 2016;11(6):926-935.
- Almeida GPL, das Neves Rodrigues HL, de Freitas BW, et al. Reliability and validity of the Hip Stability Isometric Test (HipSIT): a new method to assess hip posterolateral muscle strength. *J Orthop Sports Phys Ther.* 2017;47:906-913.
- Na Y, Han C, Shi Y, et al. Is isolated hip strengthening or traditional knee-based strengthening more effective in patients with patellofemoral pain syndrome? A systematic review with meta-analysis. *Orthop J Sports Med.* 2021;9(7):23259671211017503.
- Scali K, Roberts J, McFarland M, et al. Is multi-joint or single joint strengthening more effective in reducing pain and improving function in women with patellofemoral pain syndrome? A systematic review and meta-analysis. *Int J Sports Phys Ther.* 2018;13(3):321-334.
- Piva SR, Fitzgerald K, Irrgang JJ, et al. Reliability of measures of impairments associated with patellofemoral pain syndrome. *BMC Musculoskelet Disord.* 2006;7:33.

References - 3

- Almeida GPL, Silva AP, Franca FJ, et al. Relationship between frontal plane projection angle of the knee and hip and trunk strength in women with and without patellofemoral pain. *J Back Musculoskelet Rehabil*. 2016;29:259-266.
- Powers CM. The influence of altered lower-extremity kinematics on patellofemoral joint dysfunction: a theoretical perspective. *J Orthop Sports Phys Ther.* 2003;33:639-646.
- Willson JD, et al. Sex differences in running mechanics and patellofemoral joint kinetics following an exhaustive run. *J Biomech*. 2015 Nov 26;48(15):4155-9.
- Selfe J, Janssen J, Callaghan M, et al. Are there three main subgroups within the patellofemoral pain population? A detailed characterization study of 127 patients to help develop targeted intervention (TIPPS). *Br J Sports Med*. 2016;50:873-880.
- Piva SR, Goodnite EA, Childs JD. Strength around the hip and flexibility of soft tissues in individuals with and without patellofemoral pain syndrome. *J Orthop Sports Phys Ther.* 2005;35:793-801.
- Hamstra-Wright KL, Earl-Boehm J, Bolgla L, et al. Individuals with patellofemoral pain have less hip flexibility than controls regardless of treatment outcome. *Clin J Sport Med*. 2017;27:97-103.
- Matthews M, Rathleff MS, Claus A, et al. Does foot mobility affect the outcome in the management of patellofemoral pain with foot orthoses versus hip exercises? A randomized clinical trial. *Br J Sports Med*. 2020 Dec;54(23):1416-1422.
- Dye S. The pathophysiology of patellofemoral pain. A tissue homeostasis perspective. *Clin Orthop Rel Res*. 2005;436:100-110.
- Briani RV, Pazzinatto MF, De Oliveira D, Azevedo FM. Different pain responses to distinct levels of physical activity in women with patellofemoral pain. *Braz J Phys Ther*. 2017;21:138-143.

References - 4

- Thijs Y, Van Tiggelen D, Roosen P, et al. A prospective study on gait-related intrinsic risk factors for patellofemoral pain. *Clin J Sport Med*. 2007;17:437-445.
- Thijs Y, De Clercq D, Roosen P, Witvrouw E. Gait-related intrinsic risk factors for patellofemoral pain in novice recreational runners. *Br J Sports Med*. 2008;42:466-471.
- Thijs Y, Pattyn E, Van Tiggelen D, et al. Is hip muscle weakness a predisposing factor for patellofemoral pain in female novice runners? A prospective study. *Am J Sports Med*. 2011;39:1877-1882.
- Macri EM, Crossley KM, Hart HF, et al. Clinical findings in patellofemoral osteoarthritis compared to individually-matched controls: a pilot study. *BMJ Open Sport Exerc Med*. 2020;6(1):e000877.
- Fox A, Ferber R, Saunders N, et al. Gait kinematics in individuals with acute and chronic patellofemoral pain. Med Sci Sports Exerc. 2018;50(3):502-509.
- Noehren B, Hamill J, Davis I. Prospective evidence for a hip etiology in patellofemoral pain. Med Sci Sports Exerc. 2013;45(6):1120-4.
- Botta AFBB, Waiteman MC, Perez VO, et al. Trunk muscle endurance in individuals with and without patellofemoral pain: sex differences and correlation with performance tests. Phys Ther Sport. 2021;52:248-255.
- de Oliveira Silva D, Barton CJ, Briani RV, et al. Kinesiophobia, but not strength is associated with altered movement in women with patellofemoral pain. Gait Posture 2019;68:1-5.

References - 5

- Constantinou A, Mamais I, Papathanasiou G, et al. Comparing hip and knee focused exercises versus hip and knee focused exercises with the use of blood flow restriction training in adults with patellofemoral pain: a randomized controlled trial. Eur J Phys Rehabil Med.2022; Jan 5. doi: 10.23736/S1973-9087.22.06691-6. Online ahead of print.
- McClinton SM, Cobian DG, Heiderscheit BC. Physical therapist management of anterior knee pain. Curr Rev Musculoskeletal Med. 2020;13:776-787.
- Collins NJ, Oei EHG, de Kanter JL, et al. Prevalence of radiographic and magnetic resonance imaging features of patellofemoral osteoarthritis in young and middle-aged adults with persistent patellofemoral pain. Arthritis Care Res. 2019;71(8):1068-1073.
- Culvenor AG, Segal NA, Guermazi A, et al. Sex-specific influence of quadriceps weakness on worsening patellofemoral and tibiofemoral cartilage damage: a prospective cohort study. Arthritis Care Res. 2019;71(10):1360-1365.
- Carvalho C, Serrao FV, Mancini L, da Silva Serrao PRM. Impaired muscle capacity of the hip and knee in individuals with isolated patellofemoral osteoarthritis: a cross-sectional study. Ther Adv Chronic Dis. 2021;12:1-15.
- Siqueira MdS, Souto LR, Martinez AF, Serrão FV, de Noronha M, Muscle activation, strength, and volume in people with patellofemoral osteoarthritis: a systematic review and meta-analysis. Osteoarthritis Cart https://doi.org/10.1016/j.joca.2022.01.013
- Lafrance S, Ouellet P, Alaoui R, et al. Motor control exercise compared to strengthening exercise for upper- and lower-extremity musculoskeletal disorders: a systematic review with meta-analyses of randomized controlled trials. Phys Ther. 2021;101(7):pzab072, https://doi.org/10.1093/ptj/pzab072.

References - 6

- Charlton JM, Eng JJ, Li LC, Hunt MA. Learning gait modifications for musculoskeletal rehabilitation: applying motor learning principles to improve research and clinical implementation. Phys Ther. 2021;101(2):pzaa207, https://doi.org/10.1093/ptj/pzaa207
- Hart HF, Patterson BE, Crossley KM, Culvenor AG, Khan MCM, King MG, Sritharan P. May the force be with you: understanding how patellofemoral joint reaction force compares across different activities and physical interventions-a systematic review and meta-analysis. Br J Sports Med. 2022 Feb 3:bjsports-2021-104686. doi: 10.1136/bjsports-2021-104686. Epub ahead of print. PMID: 35115309.
- Powers CM, Ho KY, Chen YJ, et al. Patellofemoral joint stress during weight-bearing and non-weight-bearing quadriceps exercises. J Orthop Sports Phys Ther. 2014;44(5):320-327.
- Van Middelkoop M, Bennell KL, Callaghan MJ, et al. International patellofemoral osteoarthritis consortium: consensus statement on the diagnosis, burden, outome measures, prognosis, risk factors and treatment. Sem Arthritis Rheum. 2018;47:666-675.
- Escamilla R, Zheng N, MacLeod TD, et al. Patellofemoral joint loading during the performance of the forward and side lunge with step height variations. Int J Sport Phys Ther. 2022;17(2):174-184.
- Macri EM, Neogi T, Roemer F, et al. Can MRI-defined osteoarthritis features explain anterior knee pain in individuals with, or at risk for, knee osteoarthritis? The MOST Study. Arthritis Care Res. Accepted Author Manuscript. https://doi.org/10.1002/acr.24604

References - 7

- Callaghan MJ, Palmer E, O'Neill, T. Management of patellofemoral joint osteoarthritis using biomechanical device therapy: a systematic review with meta-analysis. Syst Rev 10, 173 (2021). https://doi.org/10.1186/s13643-021-01708-3.
- Hoglund LT, Pontiggia L, Kelly JD. A 6-week hip muscle strengthening and lumbopelvic-hip core stabilization program to improve pain, function, and quality of life in persons with patellofemoral osteoarthritis: a feasibility pilot study. Pilot Feasibility Studies. 2018;4:70. https://doi.org/10.1186/s40814-018-0262-z.

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