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# Patellofemoral Pain

## *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*

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# Summary of Recommendations*

## DIAGNOSIS

**A** Clinicians should use reproduction of retropatellar or peripatellar pain during squatting as a diagnostic test for patellofemoral pain (PFP). Clinicians should also use performance of other functional activities that load the patellofemoral joint (PFJ) in a flexed position, such as stair climbing or descent, as diagnostic tests for PFP.

**B** Clinicians should make the diagnosis of PFP using the following criteria: (1) the presence of retropatellar or peripatellar pain, (2) reproduction of retropatellar or peripatellar pain with squatting, stair climbing, prolonged sitting, or other functional activities loading the PFJ in a flexed position, and (3) exclusion of all other conditions that may cause anterior knee pain, including tibiofemoral pathologies.

**C** Clinicians may use the patellar tilt test with the presence of hypomobility to support the diagnosis of PFP.

## CLASSIFICATION

**F** Given the absence of a previously established valid classification system for PFP, the clinical practice guideline group proposes a classification consisting of 4 subcategories associated with the International Classification of Functioning, Disability and Health. The proposed classification system is based on published evidence. The subcategories are named according to predominant impairments previously documented in people with PFP. Clinicians may consider using the proposed impairment/function-based PFP classification system to guide patient/client management.

## PFP IMPAIRMENT/FUNCTION-BASED CLASSIFICATION SUBCATEGORIES

1. Overuse/overload without other impairment: a subcategory of individuals with PFP may have pain primarily due to overuse/overload. Classification into the overuse/overload without other impairment subcategory is made with a fair level of certainty when the patient presents with a history suggesting an increase in magnitude and/or frequency of PFJ loading at a rate that surpasses the ability of his or her PFJ tissues to recover.
2. Muscle performance deficits: a subcategory of individuals with PFP may respond favorably to hip and knee resistance exercises. Classification into the muscle performance deficits subcategory is made with a fair level of certainty when the patient presents with lower extremity muscle performance deficits in the hip and quadriceps.
3. Movement coordination deficits: a subcategory of individuals with PFP may respond favorably to gait retraining and movement re-education interventions leading to improvements in lower extremity kinematics and pain, suggesting the importance of assessing dynamic knee valgus during movement. The diagnosis of PFP with movement coordination deficits is made with a fair level of certainty when the patient presents with excessive or poorly controlled knee valgus during a dynamic task, but not necessarily due to weakness of the lower extremity musculature.
4. Mobility impairments: a subcategory of individuals with PFP may have impairments related to either hypermobile or hypomobile structures. The diagnosis of PFP with mobility deficits is made with a fair level of certainty when the patient presents with higher than normal foot mobility and/or flexibility deficits of 1 or more of the following structures: hamstrings, quadriceps, gastrocnemius, soleus, lateral retinaculum, or iliotibial band.

## EXAMINATION – OUTCOME MEASURES: ACTIVITY LIMITATIONS/SELF-REPORT MEASURES

**A** Clinicians should use the Anterior Knee Pain Scale (AKPS), the patellofemoral pain and osteoarthritis subscale of the Knee injury and Osteoarthritis Outcome Score (KOOS-PF), or the visual analog scale (VAS) for activity or Eng and Pierrynowski Questionnaire (EPQ) to measure pain and function in patients with PFP. In addition, clinicians should use the VAS for worst pain, VAS for usual pain, or the numeric pain-rating scale (NPRS) to measure pain. Clinicians should use one of the translations and cross-cultural adaptations with demonstrated validity, reliability, and responsiveness to change for patients in different countries and for those requiring questionnaires in languages other than English.

## EXAMINATION – ACTIVITY LIMITATIONS/PHYSICAL PERFORMANCE MEASURES

**B** Clinicians should administer appropriate clinical or field tests that reproduce pain and assess lower-limb movement coordination, such as squatting, step-downs, and single-leg squats. These tests can assess a patient's baseline status relative to pain, function, and disability; global knee function; and changes in status throughout the course of treatment.

## EXAMINATION – ACTIVITY LIMITATIONS/PHYSICAL IMPAIRMENT MEASURES

**C** When evaluating a patient with PFP over an episode of care, clinicians may assess body structure and function, including measures of patellar provocation, patellar mobility, foot position, hip and thigh muscle strength, and muscle length.

### 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.

### 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.

### 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.

### INTERVENTIONS – BIOFEEDBACK

**B** Clinicians should not use electromyography-based biofeedback on medial vastii activity to augment knee-targeted (quadriceps) exercise therapy for the treatment of PFP.

**B** Clinicians should not use visual biofeedback on lower extremity alignment during hip- and knee-targeted exercises for the treatment of patients with PFP.

### INTERVENTIONS – RUNNING GAIT RETRAINING

**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.

### INTERVENTIONS – BLOOD FLOW RESTRICTION TRAINING PLUS HIGH-REPETITION KNEE-TARGETED EXERCISE THERAPY

**F** Clinicians may use blood flow restriction plus high-repetition knee exercise therapy, while monitoring for adverse events, for those with limiting painful resisted knee extension.

### INTERVENTIONS – NEEDLING THERAPIES

**A** Clinicians should not use dry needling for the treatment of patients with PFP.

**C** Clinicians may use acupuncture to reduce pain in patients with PFP. However, caution should be exercised with this recommendation, as the superiority of acupuncture over placebo or sham treatments is unknown. This recommendation should only be incorporated in settings where acupuncture is within the scope of practice of physical therapy.

### INTERVENTIONS – MANUAL THERAPY AS A STAND-ALONE TREATMENT

**A** Clinicians should not use manual therapy, including lumbar, knee, or patellofemoral manipulation/mobilization, in isolation for patients with PFP.

### INTERVENTIONS – BIOPHYSICAL AGENTS

**B** Clinicians should not use biophysical agents, including ultrasound, cryotherapy, phonophoresis, iontophoresis, electrical stimulation, and therapeutic laser, for the treatment of patients with PFP.

### INTERVENTIONS – PATIENT EDUCATION

**F** Clinicians may include specific patient education on load management, body-weight management when appropriate, the importance of adherence to active treatments like exercise therapy, biomechanics that may contribute to relative overload of the PFJ, the evidence for various treatment options, and kinesiophobia. Patient education may improve compliance and adherence to active management and self-management strategies, and is unlikely to have adverse effects.

### INTERVENTIONS – COMBINED INTERVENTIONS

**A** Clinicians should combine physical therapy interventions for the treatment of patients with PFP, which results in superior outcomes compared with no treatment, flat shoe inserts, or foot orthoses alone in the short and medium term. Exercise therapy is the critical component and should be the focus in any

combined intervention approach. Interventions to consider combining with exercise therapy include foot orthoses, patellar taping, patellar mobilizations, and lower-limb stretching.

*These recommendations and clinical practice guidelines are based on the scientific literature accepted for publication prior to May 2018.

## List of Abbreviations

**ACLR:** anterior cruciate ligament reconstruction
**ADL:** activity of daily living
**AKP:** anterior knee pain
**AKPS:** Anterior Knee Pain Scale
**AMSTAR:** A MeaSurement Tool to Assess systematic Reviews
**APTA:** American Physical Therapy Association
**AUC:** area under the curve
**BMI:** body mass index
**CI:** confidence interval
**CMP:** chondromalacia patellae
**COP:** center of pressure
**CPG:** clinical practice guideline
**EMG:** electromyography
**EPQ:** Eng and Pierrynowski Questionnaire
**FIQ:** Functional Index Questionnaire
**FPI:** Foot Posture Index
**FPPA:** frontal plane projection angle
**GROC:** global rating of change
**GRS:** Global Rating Scale
**ICC:** intraclass correlation coefficient
**ICD:** International Classification of Diseases
**ICF:** International Classification of Functioning, Disability and Health
**IKDC:** International Knee Documentation Committee 2000 Subjective Knee Evaluation Form
**ITBS:** iliotibial band syndrome
***JOSPT*:** *Journal of Orthopaedic & Sports Physical Therapy*
**KOOS:** Knee injury and Osteoarthritis Outcome Score
**KOOS-PF:** patellofemoral pain and osteoarthritis subscale of the Knee injury and Osteoarthritis Outcome Score
**KOS-ADLS:** Knee Outcome Survey-Activities of Daily Living Scale
**KOS-SAS:** Knee Outcome Survey-Sports Activity Scale
**KQoL-26:** Knee Quality of Life 26-item questionnaire
**LEFS:** Lower Extremity Functional Scale
**–LR:** negative likelihood ratio
**+LR:** positive likelihood ratio
**MCID:** minimal clinically important difference
**MDC:** minimal detectable change
**MRI:** magnetic resonance imaging
**NPRS:** numeric pain-rating scale
**OA:** osteoarthritis
**OMERACT:** Outcome Measures in Rheumatology
**OR:** odds ratio
**OSPRO-ROS:** Optimal Screening for Prediction of Referral and Outcome-review of systems
**OSPRO-YF:** Optimal Screening for Prediction of Referral and Outcome-yellow flag assessment tool
**PEDro:** Physiotherapy Evidence Database
**PFJ:** patellofemoral joint
**PFOA:** patellofemoral osteoarthritis
**PFP:** patellofemoral pain
**PROM:** patient-reported outcome measure
**PSS:** Patellofemoral Pain Syndrome Severity Scale
**Q angle:** quadriceps angle
**RCT:** randomized controlled trial
**ROC:** receiver operating characteristic
**ROM:** range of motion
**SD:** standard deviation
**SEM:** standard error of measurement
**SF-36:** Medical Outcomes Study 36-Item Short-Form Health Survey
**SLS:** single-leg squat
**SMD:** standardized mean difference
**TIPPS:** targeted interventions for patellofemoral pain syndrome
**VAS:** visual analog scale
**WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

# Introduction

## AIM OF THE GUIDELINES

The Academy of Orthopaedic Physical Therapy of the American Physical Therapy Association (APTA), Inc has an ongoing effort to create evidence-based clinical practice guidelines (CPGs) for orthopaedic physical therapy management of patients with musculoskeletal impairments described in the World Health Organization's *International Classification of Functioning, Disability and Health* (ICF).[319]

The objectives of these clinical guidelines are as follows:

- Describe evidence-based physical therapy practice, including diagnosis, prognosis, intervention, and assessment of outcome, for musculoskeletal disorders commonly managed by orthopaedic physical therapists
- Classify and define common musculoskeletal conditions using the World Health Organization's terminology related to impairments of body function and body structure, activity limitations, and participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, activity limitations, and participation restrictions associated with common musculoskeletal conditions
- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions in body function and structure as well as in activity and participation of the individual
- Provide a description to policy makers, using internationally accepted terminology, of the practice of orthopaedic physical therapists
- Provide information for payers and claims reviewers regarding the practice of orthopaedic physical therapy for common musculoskeletal conditions
- Create a reference publication for orthopaedic physical therapy clinicians, academic instructors, clinical instructors, students, interns, residents, and fellows regarding the best current practice of orthopaedic physical therapy

## STATEMENT OF INTENT

These guidelines are not intended to be construed or to serve as a standard of medical care. Standards of care are determined on the basis of all clinical data available for an individual patient and are subject to change as scientific knowledge and technology advance and patterns of care evolve. These parameters of practice should be considered guidelines only. Adherence to them will not ensure a successful outcome in every patient, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgment regarding a particular clinical procedure or treatment plan must be made based on clinician experience and expertise in light of the clinical presentation of the patient, the available evidence, available diagnostic and treatment options, and the patient's values, expectations, and preferences. However, we suggest that significant departures from accepted guidelines should be documented in the patient's medical records at the time the relevant clinical decision is made.

## SCOPE AND RATIONALE OF THE GUIDELINE

Patellofemoral pain (PFP) is a common musculoskeletal-related condition that is characterized by insidious onset of poorly defined pain, localized to the anterior retropatellar and/or peripatellar region of the knee.[80] The onset of symptoms can be slow or acutely develop with a worsening of pain accompanying lower-limb loading activities (eg, squatting, prolonged sitting, ascending/descending stairs, jumping, or running, especially with hills).[154,234,254] Symptoms can restrict participation in physical activity, sports, and work.[74] Symptoms can recur and can persist for years.[74] Patients with PFP symptoms frequently present to health care professionals for diagnosis and treatment.[74,277] This CPG will allow physical therapists and other rehabilitation specialists to stay up to date with evolving PFP knowledge and practices, and help them to make evidence-based treatment decisions.[166]

# Methods

Content experts were appointed by the Academy of Orthopaedic Physical Therapy, APTA, Inc to conduct a review of the literature and to develop a PFP CPG as indicated by the current state of the evidence in the field. The authors of this guideline worked with research librarians with expertise in systematic reviews to perform a systematic search. The search was for concepts associated with PFP in articles published since 1960 related to classification, examination, and intervention strategies, consistent with previous guideline development methods related to ICF classification.[184] Briefly, the following databases were searched from 1960 to May 2018: MEDLINE (PubMed; 1960 to date), Scopus (Elsevier BV; 1960 to date), CINAHL (EBSCO; 1960 to date), SPORTDiscus (EBSCO; 1960 to date), Cochrane Library (Wiley; 1960 to date). See **APPENDIX A** for full search strategies and **APPENDIX B** for search dates and results, available at www.jospt.org.

# Methods *(continued)*

The authors declared relationships and developed a conflict management plan, which included submitting a conflict of interest form to the Academy of Orthopaedic Physical Therapy, APTA, Inc. Articles that were authored by a reviewer were assigned to an alternate reviewer. Funding was provided to the CPG development team for travel and expenses for CPG development training. The CPG development team maintained editorial independence.

Articles contributing to recommendations were reviewed based on specified inclusion and exclusion criteria, with the goal of identifying evidence relevant to physical therapist clinical decision making for adult persons with PFP. The title and abstract of each article were reviewed independently by 2 members of the CPG development team for inclusion. See **APPENDIX C** for inclusion and exclusion criteria, available at www.jospt.org. Full-text review was then similarly conducted to obtain the final set of articles for contribution to recommendations. The team leader (D.S.L.) provided the final decision for discrepancies that were not resolved by the review team. See **APPENDIX D** for a flow chart of articles and **APPENDIX E** for articles included in recommendations by topic, available at www.jospt.org. For selected relevant topics that were not appropriate to the development of recommendations, such as incidence and imaging, articles were not subject to the systematic review process and were not included in the flow chart. Evidence tables for this CPG are available on the Clinical Practice Guidelines page of the Academy of Orthopaedic Physical Therapy, APTA, Inc website (www.orthopt.org).

This guideline was issued in 2019 based on the published literature up to May 2018. This guideline will be considered for review in 2024, or sooner if new evidence becomes available. Any updates to the guideline in the interim period will be noted on the Academy of Orthopaedic Physical Therapy, APTA, Inc website (www.orthopt.org).

## LEVELS OF EVIDENCE

Individual clinical research articles were graded according to criteria adapted from the Centre for Evidence-Based Medicine, Oxford, United Kingdom for diagnostic, prospective, and therapeutic studies.[229] In 3 teams of 2, each reviewer independently assigned a level of evidence and evaluated the quality of each article using a critical appraisal tool. See **APPENDICES F** and **G** for the evidence table and details on procedures used for assigning levels of evidence, available at www.jospt.org. The evidence update was organized from highest level of evidence to lowest level. An abbreviated version of the grading system is provided as follows.

| | |
|---|---|
| I | Evidence obtained from high-quality diagnostic studies, prospective studies, randomized controlled trials, or systematic reviews |
| II | Evidence obtained from lesser-quality diagnostic studies, prospective studies, systematic reviews, or randomized controlled trials (eg, weaker diagnostic criteria and reference standards, improper randomization, no blinding, less than 80% follow-up) |
| III | Case-control studies or retrospective studies |
| IV | Case series |
| V | Expert opinion |

## STRENGTH OF EVIDENCE AND GRADES OF RECOMMENDATION

The strength of the evidence supporting the recommendations was graded according to the previously established methods provided below. Each team developed recommendations based on the strength of evidence, including how directly the studies addressed the question in the PFP population. In developing their recommendations, the authors considered the strengths and limitations of the body of evidence, and the health benefits, side effects, and risks of tests and interventions.

| 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 |

## DESCRIPTION OF GUIDELINE VALIDATION

Identified reviewers who are experts in PFP management and rehabilitation reviewed this CPG content and methods for integrity and accuracy and to ensure that they fully represent the condition. Any comments, suggestions, or feedback from the expert reviewers were delivered to authors and editors to consider and make appropriate revisions. These guidelines were also posted for public comment and review on the www.

## Methods *(continued)*

orthopt.org website, and a notification of this posting was sent to the members of the Academy of Orthopaedic Physical Therapy, APTA, Inc. Any comments, suggestions, and feedback gathered from public commentary were sent to authors and editors to consider and make appropriate revisions in the guideline. In addition, a panel of consumer/patient representatives and external stakeholders, such as claims reviewers, medical coding experts, academic educators, clinical educators, physician specialists, and researchers, also reviewed the guideline and provided feedback and recommendations that were given to authors and editors for further consideration and revisions. Last, a panel of consumer/patient representatives and external stakeholders and a panel of experts in physical therapy practice guideline methodology annually review the Academy of Orthopaedic Physical Therapy, APTA, Inc's ICF-based CPG policies and provide feedback and comments to the Clinical Practice Guidelines Coordinator and editors to improve the APTA's guideline development and implementation processes.

### DISSEMINATION AND IMPLEMENTATION TOOLS

In addition to publishing these guidelines in the *Journal of Orthopaedic & Sports Physical Therapy* (*JOSPT*), these guidelines will be posted on CPG areas of both the JOSPT and the Academy of Orthopaedic Physical Therapy, APTA, Inc websites, which are free-access website areas, and submitted to be available for free access on the ECRI Guidelines Trust website (https://guidelines.ecri.org). The implementation tools planned to be available for patients, clinicians, educators, payers, policy makers, and researchers, and the associated implementation strategies, are listed in **TABLE 1**.

### CLASSIFICATION

The International Classification of Diseases-10th Revision (ICD-10) codes and conditions and the primary ICF body functions, structures, and activity and participation codes associated with PFP are provided below. The ICF codes can be accessed at http://apps.who.int/classifications/icfbrowser/.

#### PFP With Overuse/Overload Without Other Impairment

| | |
|---|---|
| **ICD-10 codes** | |
| Patellofemoral disorders, unspecified knee | M22.2X9 |
| Unspecified disorder of patella, unspecified knee | M22.90 |
| Chondromalacia patellae, unspecified knee | M22.40 |
| Chondromalacia, unspecified knee | M94.269 |
| **ICF body function codes** | |
| Pain in lower limb | b28015 |
| Pain in joints | b28016 |
| **ICF body structure codes** | |
| Knee joint | s75011 |
| Ligaments and fascia of thigh | s75003 |
| **ICF activities and participation codes** | |
| Squatting | d4101 |

**TABLE 1** Planned Strategies and Tools to Support the Dissemination and Implementation of This Clinical Practice Guideline

| Tool | Strategy |
|---|---|
| *JOSPT*'s "Perspectives for Patients" and/or "Perspectives for Practice" articles | Patient-oriented guideline summary available on www.jospt.org |
| Mobile app of guideline-based exercises for patient/clients and health care practitioners | Marketing and distribution of app using www.orthopt.org |
| Clinician's Quick-Reference Guide | Summary or guideline recommendations available on www.orthopt.org |
| JOSPT's Read for Credit℠ continuing education units | Continuing Education Units available for physical therapists and athletic trainers |
| Webinars: educational offering for health care practitioners | Guideline-based instruction available for practitioners on www.orthopt.org |
| Mobile and web-based app of guideline for training of health care practitioners | Marketing and distribution of app using www.orthopt.org |
| Physical Therapy National Outcomes Data Registry | Support the ongoing usage of data registry for common musculoskeletal conditions (www.ptoutcomes.com) |
| Logical Observation Identifiers Names and Codes mapping | Publication of minimal data sets and their corresponding Logical Observation Identifiers Names and Codes for the knee region on www.orthopt.org |
| Non-English versions of the guidelines and guideline implementation tools | Development and distribution of translated guidelines and tools to JOSPT's international partners and global audience |

# Methods *(continued)*

| | |
|---|---|
| Running | d4552 |
| Climbing | d4551 |
| Maintaining a sitting position | d4153 |
| Walking on different surfaces | d4502 |
| Jumping | d4553 |
| Managing diet and fitness | d5701 |
| Sports | d9201 |

### PFP With Muscle Performance Deficits

| | |
|---|---|
| **ICD-10 codes** | |
| Patellofemoral disorders, unspecified knee | M22.2X9 |
| Pain in unspecified knee | M25.569 |
| Chronic right knee joint pain | M25.561 |
| Chronic left knee joint pain | M25.562 |
| Pain in knee | M25.56 |
| Muscle wasting and atrophy, not elsewhere classified, unspecified thigh | M62.559 |
| Muscle wasting and atrophy, not elsewhere classified, unspecified lower leg | M62.569 |
| **ICF body function codes** | |
| Pain in lower limb | b28015 |
| Pain in joints | b28016 |
| Power of isolated muscles and muscle groups | b7300 |
| Endurance of isolated muscles | b7400 |
| **ICF body structure codes** | |
| Muscles of pelvic region | s7402 |
| Muscles of thigh | s75002 |
| **ICF activities and participation codes** | |
| Squatting | d4101 |
| Running | d4552 |
| Climbing | d4551 |
| Maintaining a sitting position | d4153 |
| Walking on different surfaces | d4502 |
| Jumping | d4553 |
| Managing diet and fitness | d5701 |
| Sports | d9201 |

### PFP With Movement Coordination Deficits

| | |
|---|---|
| **ICD-10 codes** | |
| Patellofemoral disorders, unspecified knee | M22.2X9 |
| Other biomechanical lesions of lower extremity | M99.86 |
| **ICF body function codes** | |
| Pain in lower limb | b28015 |
| Pain in joints | b28016 |
| Control of complex voluntary movements | b7601 |
| Supportive functions of arm or leg | b7603 |
| Gait pattern functions | b770 |
| **ICF body structure codes** | |
| Muscles of pelvic region | s7402 |
| Muscles of thigh | s75002 |
| Muscles of lower leg | s75012 |
| **ICF activities and participation codes** | |
| Squatting | d4101 |
| Running | d4552 |
| Climbing | d4551 |
| Maintaining a sitting position | d4153 |
| Walking on different surfaces | d4502 |
| Jumping | d4553 |
| Managing diet and fitness | d5701 |
| Sports | d9201 |

### PFP With Mobility Impairments

| | |
|---|---|
| **ICD-10 codes** | |
| Patellofemoral disorders, unspecified knee | M22.2X9 |
| Contracture, unspecified joint | M24.50 |
| Contracture of muscle, unspecified thigh | M62.459 |
| Hypertrophy of (infrapatellar) fat pad | M79.4 |
| Other specified acquired deformities of unspecified lower leg | M21.869 |
| Other acquired deformities of unspecified foot | M21.6X9 |
| **ICF body function codes** | |
| Pain in lower limb | b28015 |
| Pain in joints | b28016 |
| Mobility of several joints | b7101 |
| Mobility of tarsal bones | b7203 |
| Stability of several joints | b7151 |
| Stability of joints generalized | b7152 |
| **ICF body structure codes** | |
| Hip joint | s75001 |
| Knee joint | s75011 |
| Ankle joint and joints of foot and toes | s75021 |
| Ligaments and fascia of thigh | s75003 |
| Extra-articular ligaments, fasciae, extramuscular aponeuroses, retinacula, septa, bursae, unspecified | s7703 |
| **ICF activities and participation codes** | |
| Squatting | d4101 |
| Running | d4552 |
| Climbing | d4551 |
| Maintaining a sitting position | d4153 |
| Walking on different surfaces | d4502 |
| Jumping | d4553 |
| Managing diet and fitness | d5701 |
| Sports | d9201 |

## Methods *(continued)*

### ORGANIZATION OF THE GUIDELINE

For each topic of Impairment/Function-Based Diagnosis, Examination, and Interventions, a synthesis of the recent literature, with the corresponding evidence levels, is presented. Each topic concludes with an evidence summary or recommendation and its grade. At the conclusion of the CPG, we provide a decision tree model to illustrate clinical decision making using the evidence and recommendations.

CLINICAL PRACTICE GUIDELINES

# Impairment/Function-Based Diagnosis



## PREVALENCE AND INCIDENCE

Prevalence ranges from 3% to 85% for idiopathic anterior knee pain (AKP) or PFP and its associated diagnoses,[41,207,216] with a prevalence of 25% being the most frequently cited.[41] An analysis of the PearlDiver record database (a large national database of orthopaedic conditions) reported a prevalence of PFP diagnoses between 1.5% and 7.3% of all patients seeking medical care.[119]

Patellofemoral pain occurs across the life span, from young children to older sedentary individuals.[41] The highest prevalence of PFP appears to be observed in those between 12 and 19 years of age,[41,310] but may be dependent on activity level and environmental context. However, these percentages are in contrast to the PearlDiver data analysis, which reported the highest percentage of PFP diagnosis in the 50-to-59-year age group.[119] The discrepancy in prevalence related to age may be due to an environmental context, such as treatment in a sports clinic versus in a general practice office.[119]

Varying differences in prevalence by sex have been reported. Glaviano et al[119] reported that 55% of patients with PFP in the PearlDiver database were female. Boling et al[32] reported a prevalence of 15% in female naval cadets, compared to 12% in male naval cadets, at the US Naval Academy, whereas Lakstein et al[170] reported a prevalence of 2.39% in female Israel Defense Force recruits compared to 4.56% in male Israel Defense Force recruits. The overall incidence rate for PFP in US naval cadets was 22/1000 person-years,[32] and in military recruits was 0.22/1000 training hours.[151] The incidence rate for PFP in US naval cadets was greater in women compared to men (33/1000 person-years and 15/1000 person-years, respectively).[32] In adolescent female athletes, the cumulative incidence risk and rate for the development of new unilateral PFP were 9.66 per 100 athletes and 1.09 per 1000 athletic exposures, respectively.[203] Tenforde et al[278] reported a lifetime prevalence of PFP in high school runners to be 21% in females and 16% in males. The recurrence of PFP is alarmingly high, with reports of 70% to 90% having recurrent symptoms.[270] Additionally, recent reports indicate that more than 50% of individuals diagnosed with PFP will report unfavorable outcomes 5 to 8 years following enrollment into a clinical trial.[174]

Patellofemoral pain is not a self-limiting condition.[254] Previously, PFP was considered a condition that is commonplace in adolescents and that would eventually resolve over time.[225] However, 50% to 56% of adolescents report persistent knee pain 2 years after their initial diagnosis.[244,246] This can have a substantial impact on quality of life and burden of living with PFP, such as loss of physical function, loss of self-identity, pain-related confusion and fear, and concern for the future.[266]

## PATHOANATOMICAL FEATURES

The patellofemoral joint (PFJ) comprises the articulation between the patella and the trochlear groove of the femur. The patella is a large sesamoid bone embedded in the quadriceps extensor mechanism. The roles of the patella are to increase the moment arm of the quadriceps muscles, provide bony protection to the distal joint surfaces of the femoral condyles when the knee is flexed, and prevent damaging compressive forces on the quadriceps tendon with resisted knee extension.

### Clinical Presentation

Patellofemoral pain is a common musculoskeletal-related condition that is characterized by insidious onset of poorly defined pain quality localized to the anterior retropatellar and/or peripatellar region of the knee.[80] The onset of symptoms can be slow or acutely develop, with a worsening of pain with lower-limb loading (eg, squatting, prolonged sitting, ascending/descending stairs, jumping, or running, especially with hills).[154,234,254] While many pathoanatomic correlates, such as internal derangement or cartilage softening, have been offered from as early as 1928,[106] all are poorly associated with symptoms.[94,254,288,291] Therefore, diagnosis is based on a cluster of signs and symptoms after ruling out other pathoanatomic diagnoses.[205] Because there is typically a progressive, insidious onset of symptoms, diagnosis is often delayed, and describing the typical clinical course is difficult.

#### *Pain*

Collins et al[61] conducted a retrospective review of 4 separate studies on the presence of symptoms in 459 individuals with PFP. They found that a large majority of these individuals reported at least some difficulty with squatting (93.7%), stair negotiation (91.2%), and running (90.8%).[61] People with PFP tend to ascend and descend stairs with reduced knee flexion,

and there is some debate as to whether this is consistently seen in level walking.[72] More than half (54.4%) of people with PFP reported pain with prolonged sitting; another 26.4% reported pain with sitting after exercise. Only 19.2% of people could sit without pain.[61] Pain with prolonged sitting had low to moderate diagnostic accuracy in an earlier systematic review.[64]

A systematic review of reviews concluded that AKP produced by functional tasks such as squatting, stair climbing, and sitting with flexed knees is currently the best diagnostic indicator of PFP.[222]

Sandow and Goodfellow[254] found less frequent reports of symptoms with functional tasks in their long-term follow-up of about 4 years, with 50% of participants reporting PFP on a weekly or more frequent basis. Half of the cohort reported pain with stair climbing and 39% with sport participation at the 4-year follow-up. Although symptoms of PFP may become less frequent over time, 94% still reported some degree of PFP, either at rest or with other activities such as walking. Pain during running was not assessed.[254] Sandow and Goodfellow[254] also reported that nearly 50% of their cohort had bilateral PFP.

People with PFP demonstrate some common clinical characteristics. Often, patients report pain with palpation of the distal pole or medial aspect of the patella, the medial plica, and the medial femoral condyle.[113,210] There may be pain with grinding or compressing of the patella.

### Anthropometrics

Patient characteristics, anthropometrics, and patellofemoral alignment are often postulated as important factors in the development of PFP. However, a recent systematic review of observational studies concluded that age, body mass, height, and body mass index (BMI) were not risk factors for the development of PFP.[173] Specific to lower extremity structure, the quadriceps angle (Q angle), assessed either in weight bearing or non–weight bearing, was not a risk factor for the development of PFP.[173,223]

Patellofemoral pain is often believed to be related to excessive foot pronation; however, to date, only 1 study has shown that greater navicular drop was associated with, and predictive of, the development of PFP in a military cohort.[34] Overall, excessive foot pronation does not appear to be a feature across studies examining individuals with PFP.

### Decreased Thigh Force Production

Compared with healthy, matched controls, people who develop PFP have weaker quadriceps, as measured by a dynamometer. However, quadriceps weakness has only been found to be a risk factor for the development of PFP in military populations.[173] Impaired lower extremity muscle function is common in individuals with PFP in the military. The results of the meta-analysis by Lankhorst et al[173] suggested that quadriceps strength, as measured with a dynamometer, was considerably less when compared to healthy control individuals.

Quadriceps atrophy is also a common finding in individuals with PFP, but only when it is evaluated by imaging, not by girth or visual assessment.[116] Quadriceps atrophy is consistent across the vastii musculature (ie, not isolated to the vastus medialis oblique musculature).[116] Thomeé and colleagues[283] found quadriceps inhibition (inability of the central nervous system to fully activate the quadriceps) of roughly 18% when assessed with surface electromyography (EMG), suggesting that at least some of the loss of quadriceps strength is due to inhibited central neural drive. This may be partly due to the pain generated from the PFJ through arthrogenic inhibition. With respect to quadriceps atrophy and inhibition, it is important to note that all studies listed above included individuals with current signs and symptoms of PFP.

### Decreased Hip Force Production

People with PFP have weakness of the hip abductors, extensors, and external rotators.[194,241,286] Rate of force development of the hip abductors and extensors is also reduced in people with PFP.[214] However, in a systematic review with meta-analysis, Rathleff et al[245] attempted to determine whether isometric hip strength was a definitive cause or a result of PFP by comparing outcomes of 21 cross-sectional and 3 prospective studies.[245] The authors of the 3 prospective studies reported no association between hip strength and the development of PFP. The cross-sectional studies indicated small differences between people with and without PFP for hip abduction, extension, external rotation, internal rotation, and adduction. There is a strong possibility that hip weakness is a result of PFP, and not a direct cause of PFP.[245]

### Biomechanics

Altered biomechanics are commonly observed during functional movements in people with PFP. People with PFP may walk, run,[89,238] and negotiate stairs[87] with reduced knee flexion compared to healthy controls, which may represent a compensation pattern. Clinically, patients with PFP often present with an increased frontal plane projection angle (FPPA; a 2-dimensional surrogate for the 3-D measures of hip adduction, hip internal rotation, knee abduction, and knee external rotation) during single-leg squat (SLS)[134,307] and during a hop landing.[134] Athletes who tend to move excessively into greater FPPAs during a jump landing are more likely to develop PFP.[142] Distally, altered foot and ankle biomechanics are not consistently observed in people with PFP.[240]

### Pain Sensitization

A systematic review by De Oliveira Silva et al[88] examined the

association of pain sensitization in patients with PFP (n = 315). They reviewed 9 studies that included 315 participants with PFP and 164 healthy controls. They reported that in 5 studies, patients with PFP were more sensitized (lower pressure pain thresholds) to a local pressure stimulus (standardized mean difference [SMD], −1.12; 95% confidence interval [CI]: −1.48, −0.75) and a stimulus at a remote location (SMD, −0.93; 95% CI: −1.19, −0.67) compared to healthy controls. However, patients with PFP were no more sensitive to heat or cold compared to healthy controls.

### *Rate of Recurrence of PFP*

Based on the results of a few longitudinal studies, PFP is associated with a high rate of chronicity, even after nonsurgical care. Sandow and Goodfellow[254] followed 54 adolescent girls for 2 to 8 years after diagnosis of PFP. At an average of about 4 years after diagnosis, 94% were still experiencing some form of pain, with less than half (46%) having a decrease in pain severity. Nimon and colleagues[211] followed this same cohort via questionnaires for 14 to 20 years. At the long-term follow-up, only 22% had no pain, but 71% had less pain than at initial presentation. From the individuals who completed the questionnaires at both 2 to 8 years and 14 to 20 years, the authors concluded that there are likely to be improvements in 50% of cases within the first 4 years, and an additional 23% in the next 12; however, they were not able to predict who would not improve.[211]

Blond and Hansen[29] reported an average of 6-year follow-up of 250 athletes diagnosed with PFP who were prescribed a self-training program for the lower extremity. About a quarter (27%) of athletes experienced complete pain relief, and an additional 38% had decreased pain, leaving 35% with pain that was either unchanged or worse.

Kannus and Niittymäki[154] attempted to identify predictors of people who would benefit from nonsurgical treatment of PFP. Of the 49 patients treated with avoidance of aggravating activity, quadriceps isometric exercises, stretching exercises, and nonsteroidal anti-inflammatories, 36 (73%) experienced resolution of symptoms.[152] Only being younger was predictive of improving pain, Lysholm scores, and activity.[154] Overall, these results indicate that attempts to improve the function of the quadriceps and remove aggravating factors are likely beneficial in the treatment of PFP.[152] At a 7-year follow-up of these same individuals, there were few changes in patient-reported and performance-based functions (quadriceps strength, squatting, hopping, duck walking); however, physical signs of pain with patellar compression, Clarke's test, and crepitus during patellar compression increased from 6 months to 7 years.[153] Finally, about a quarter of individuals developed symptoms in the contralateral knee during the 7-year follow-up.[153]

In an exploratory study, Lankhorst et al[174] determined that female participants and those with a longer duration of symptoms (greater than 6 months) were more likely to report worse outcomes. In the individuals who received medical advice from a physician, 68% reported no improvement after 3 months, and 54% reported no improvement after 12 months.

### PFP and Patellofemoral Osteoarthritis

A link between PFP and patellofemoral osteoarthritis (PFOA) has been suggested.[69,74,140,141,320] Patellofemoral pain and PFOA have similar presentations, including location of pain, quadriceps and hip muscle weakness, and reported pain and difficulty with similar activities (eg, stair climbing and prolonged sitting). However, long-term prospective data are presently lacking to confirm or refute this link,[69,320] with a recent consensus statement concluding that insufficient evidence exists to conclusively link a past history of PFP with PFOA.[293] However, there is retrospective evidence of a relationship between previous history of PFP and the presence of PFOA later in life. Thomas et al[282] conducted a systematic review examining the link between a history of PFP as an adolescent or young adult and subsequent development of PFOA. This systematic review included 6 prospective studies, follow-ups of 5 case series and 1 randomized controlled trial (RCT), and 1 retrospective case-control study. Only the retrospective study specifically aimed to examine the link between PFP and PFOA later in life.[285] The prospective studies were of low quality due to small sample size, low follow-up rates, inclusion of PFP due to trauma, and lack of control groups. The evidence for a link between PFP and development of PFOA was limited to 1 retrospective case-control study by Utting et al,[285] who compared the history of individuals who had a patellofemoral arthroplasty for PFOA to those who had a unicompartmental tibiofemoral arthroplasty. Those undergoing patellofemoral arthroplasty (n = 118) more frequently recalled a history of PFP (22% versus 6%), patellar instability (14% versus 1%), and patellar trauma (16% versus 6%) compared to those undergoing unicompartmental tibiofemoral arthroplasty (n = 116).

Conchie et al[62] conducted a retrospective case-control study to determine the prevalence of AKP and patellar dislocation in persons undergoing patellofemoral arthroplasty for severe, isolated PFOA (n = 190) compared to persons (n = 445) undergoing unicompartmental tibiofemoral arthroplasty for severe medial tibiofemoral osteoarthritis (OA). Of these groups, 111 (58%) people with PFOA and 234 (53%) people in the unicompartmental tibiofemoral arthroplasty control group participated. A multivariate binary regression analysis found significantly greater association between adolescent AKP and PFOA (odds ratio [OR] = 7.5; 95% CI: 1.51, 36.94). Additional significant associations were found for history of patellar dislocation (OR = 3.2; 95% CI: 1.25, 8.18), patellar

instability (OR = 3.5; 95% CI: 1.62, 7.42), and previous surgery (adjusted OR = 3.5; 95% CI: 1.75, 7.14).

Hinman and colleagues[137] compared the presence of radiographic PFOA and tibiofemoral OA in 224 individuals who had chronic PFP who were older than 40 years of age. Isolated PFOA was present in 25% of the sample, combined PFOA and tibiofemoral OA was present in 44%, and isolated tibiofemoral OA was present in only 1% of the sample. Only 30% of this sample with chronic PFP had no evidence of radiographic OA.[137]

Schiphof et al[255] examined 1518 knees of women over 45 years of age that had either no OA or only early signs of OA of the PFJ. Cartilage defects were present in 15% of these PFJs, 25% had osteophytes, 13% had cysts, and 19% had bone marrow lesions. A history of PFP (25% of the sample) was associated with current cartilage lesions, cartilage cysts, and bone marrow lesions.[255]

### Summary

Patellofemoral pain has a variable clinical presentation but is generally associated with AKP exacerbations when loading the PFJ in squatting, participation in sports, stair negotiation, prolonged sitting, and walking. Decreased knee extensor and hip musculature strength is associated with PFP compared to those without PFP. The most frequently cited predictors of poor outcomes are longer duration of symptoms before intervention, overall poorer function, and worse pain. Negative psychological stress and altered pain sensitization were present in patients with PFP. For the majority of patients, the "educate and wait" approach of avoiding pain-provoking activities is not effective in improving pain and function in the short, medium, or long term. It appears that PFP and PFOA may be related; however, there is insufficient evidence to directly state a cause-and-effect relationship.

## RISK FACTORS

The etiology of PFP is poorly understood and considered to be multifactorial. Frequently, development and persistence of symptoms are attributed to proximal, distal, or local factors that increase or alter load/stress to the PFJ, and there is a large body of research in this area. More recently, nonphysical influences on symptoms have been explored, with emerging evidence that factors such as pain sensitization and psychological state may play roles in PFP.

### Demographics

I A systematic review with a meta-analysis of 7 prospective studies reported on anthropometrics and the development of PFP.[223] In 6 studies with 905 healthy controls and 177 people with PFP, height, weight, and percentage body fat were not predictive of PFP.

II Boling et al[32] reported that female US Navy cadets were 2.23 times (95% CI: 1.19, 4.20) more likely to develop PFP compared with male US Navy cadets.

II Hall et al[129] conducted a retrospective cohort study on the relationship between sports specialization and the risk of developing PFP in young female athletes. An overall PFP incidence of 28% was reported in 546 female adolescent basketball, soccer, and volleyball players consisting of 357 multisport and 189 single-sport athletes. Participation in a single sport (basketball, soccer, or volleyball) was associated with a greater incidence of cumulative PFP disorders (incidence rate ratio = 1.5; 95% CI: 1.0, 2.2) compared to participation in multiple sports.

IV van Middelkoop et al[294] investigated differences in characteristics between adolescents (n = 20) and adults (n = 44) with PFP. At baseline, adolescents with lower BMI had greater quadriceps strength and reported more bilateral PFP symptoms compared to adults. Both groups had similar hip strength and reported similar levels of pain at rest and during activity and self-reported knee function. At 1-year follow-up, adolescents and adults had similar levels of pain, self-reported knee function, and medical consumption. Only 25% of adolescents and 23% of adults reported functional recovery at 1 year.

### Local Factors

I Seven prospective studies were included in a systematic review by Pappas and Wong-Tom.[223] Low knee extension isometric strength was predictive of the development of PFP according to a meta-analysis from 2 studies. The Q angle, static knee valgus, and dynamic measures of knee valgus were not predictive of PFP. An additional cross-sectional study that was not reported in the systematic review also reported no association between Q angle and peak knee abduction moment in healthy runners with PFP.[224]

II A prospective study of college-aged physical education students found an association of decreased quadriceps flexibility, shorter reflex response time of the vastus medialis oblique muscle, reduction of vertical jump height, and higher than normal medial patellar mobility with occurrence of PFP.[313]

III A literature review suggests that weakness in functional testing was coincident with tightness of the hamstring muscles, quadriceps muscles, and iliotibial band with AKP conditions (which included tendinopathies).[298] No coincident relationship was reported between patellar mobility and PFP in the articles retrieved in their search.

### Muscle Strength

II Giles et al[116] performed a systematic review of 10 studies (2 RCTs, 8 cross-sectional studies) with meta-analysis of 7 studies on quadriceps muscle size. For quadriceps girth measurements, the SMD between the limb with PFP and the control limb was −0.084 (95% CI: −0.44, 0.27), indicating no differences. For imaging measurements of quadriceps muscle size, the SMD was −0.44 (95% CI: −0.86, −0.029), indicating quadriceps atrophy in the limb with PFP.

II Van Tiggelen et al[295] investigated the role of muscle strength as a predisposing factor in the development of PFP. Thirty-one out of 96 male military recruits developed PFP after a strenuous military training program (8-12 h/d for 6 weeks). Recruits who developed PFP were shorter in height or had lower knee extensor strength compared to those who did not develop PFP.

III In a case-control study, 25 women with PFP and 25 asymptomatic women with PFP had between 11.1% and 30.7% inferior knee extensor, hip extensor, hip abductor, and hip external rotator strength compared to asymptomatic women. Women with PFP had greater center-of-pressure (COP) displacement and velocity during a step-up and step-down task compared to the asymptomatic women.[85]

III Guney et al[124] investigated the quadriceps-to-hamstrings strength ratio in 44 women with unilateral PFP (using the contralateral limb as the control). At 60°/s and 180°/s for the concentric quadriceps-to-concentric hamstrings ratio, the limb with PFP had mean ± SD ratios of 1.18 ± 0.21 and 1.02 ± 0.44, respectively, and the control limb had ratios of 1.36 ± 0.57 and 1.35 ± 0.32, respectively. At 60°/s and 180°/s for the eccentric quadriceps-to-concentric hamstrings ratio, the limb with PFP had ratios of 1.19 ± 0.23 and 2.56 ± 0.49, respectively, and the control limb had ratios of 1.55 ± 0.59 and 2.86 ± 0.91, respectively.

III A cross-sectional analysis of an RCT was performed to identify characteristics of men and women who responded to a 6-week hip- or knee-based rehabilitation program. Improvement was defined by either a minimum of a 2-cm reduction on a visual analog scale (VAS) for pain or at least an 8-point improvement in function on the Anterior Knee Pain Scale (AKPS). Men and women improved after completing both the hip- and the knee-based exercise programs. Those who responded to either exercise program had lower baseline hip and knee muscle strength compared to the nonresponders.[31]

III Hoglund et al[139] compared isometric hip strength in 36 men with and 36 men without PFP. Men with PFP had weaker hip extensors, but there were no differences between groups in hip abductor or external rotator strength.

### Patellofemoral Characteristics

III Carlson et al[44] used magnetic resonance imaging (MRI) to investigate the distance between the tibial tubercle and the femoral trochlear groove in a cohort of 50 knees (38 participants) with PFP and 60 (56 participants) asymptomatic knees. The distance between the tibial tubercle and the trochlear groove in fully extended knees for participants with PFP was a mean ± SD of 13.0 ± 3.6 mm, compared to 10.8 ± 3.0 mm for asymptomatic controls. Thirty percent of participants with PFP had distances between the tibial tubercle and the trochlear groove greater than 15 mm, compared to 5% of asymptomatic controls.

III Aysin et al[12] used MRI to investigate the trochlear sulcus angle, the trochlear sulcus depth, a ratio of patellar tendon length to the longest diagonal diameter of the patella (Insall-Salvati ratio), and lateral patellofemoral angle in 38 people with PFP and chondromalacia patellae (CMP) diagnosed by imaging. Although those with more advanced CMP reported higher pain severity and lower knee function compared to those with early CMP, there were no differences in MRI measures.

### Proximal Factors

I Trunk and hip mechanics and impairments have been implicated as factors in the development and persistence of PFP. Based on 3 high-quality prospective studies included in the systematic review by Rathleff et al,[245] there is moderate to strong evidence that no association exists between lower isometric strength of the hip abductors, extensors, external rotators, or internal rotators and the risk of developing PFP. In contrast, the results of multiple (n = 21) cross-sectional studies from this same systematic review provide moderate to strong evidence that individuals with PFP have lower isometric strength of the hip musculature.[245]

II Among studies that have exclusively looked at runners, the contribution of hip weakness is not clear. One systematic review of 2 cross-sectional studies and 1 prospective study found conflicting results for the relationship between hip abductor weakness and the presence of PFP.[199] A different systematic review of cross-sectional and case-control studies reported a reduction in duration of gluteus medius activation, measured using EMG signal intensity, in runners with PFP.[264] A prospective cohort study reported a lower risk for development of PFP in runners with

higher eccentric hip abductor strength.[243] This study, however, was limited by a large number of participants who did not complete the follow-up. Another prospective study found that high school runners with the weakest hip abductor strength had a higher incidence of PFP.[185]

II An earlier meta-analysis of 10 cross-sectional studies by Van Cant et al[286] reported deficits in isometric hip abduction, extension, external rotation, and flexion in people with PFP compared to healthy participants. Among studies that used the unaffected side for comparison, 2 studies reported deficits in hip abduction and 1 study reported deficits in hip extension and hip external rotation for the side with PFP.

III In a cross-sectional study, Nunes et al[214] compared the rate of force development and isometric strength of the hip abductor and extensor muscle groups in 54 (27 with PFP, 27 healthy) physically active women. The rate of force development was assessed for time to reach 30%, 60%, and 90% of peak isometric torque. Women with PFP had 10% weaker hip abductors (effect size, 0.61) and 15% weaker hip extensors (effect size, 0.76) than knee-healthy women. Their rate of force development for hip abductors was moderately slower than knee-healthy women for the time to reach 60% (effect size, 0.50) and 90% (effect size, 0.59) of peak isometric torque. The rate of force development for the hip extensors in women with PFP was markedly slower in the time to reach 30% (effect size, 0.97) and 60% (effect size, 0.81) of peak isometric torque.

III McMoreland et al[191] examined hip isometric strength and hip concentric muscle endurance in young women with mild PFP (n = 12) compared to age- and sex-matched controls (n = 12). They reported no differences in peak torque (isometric strength) and total work (endurance) for the hip abductors, external rotators, and internal rotators.

III A case-control study by Van Cant et al[287] evaluated muscle endurance of the hip abductors, trunk extensors, and ankle plantar flexors in women with PFP (n = 20) compared to healthy controls (n = 76). Women with PFP had 16% weaker hip abductors, 14% weaker trunk extensors, and 26% weaker ankle plantar flexors compared to knee-healthy women.

III Steinberg et al[271] identified factors associated with PFP in youth dancers. Dancers aged 10 to 11 years with PFP were more likely to have less hip abduction range of motion (ROM) (OR = 0.91; 95% CI: 0.83, 0.99) and less low back and hamstring flexibility (OR = 3.54; 95% CI: 1.02, 12.28). In dancers aged 12 to 14 years, those with PFP were more likely to have less ankle dorsiflexion ROM (OR = 0.89; 95% CI: 0.81, 0.99), less hindfoot varum (OR = 0.26), and greater patellar mobility (OR = 2.67; 95% CI: 1.14, 6.35). In dancers aged 15 to 16 years, those with PFP were more likely to have scoliosis (OR = 5.21; 95% CI: 1.35, 20.05) and greater ankle plantar flexion and hip internal rotation ROM (OR = 1.06; 95% CI: 1.02, 1.1).

### Distal Factors

II Lankhorst et al[172] performed a systematic review of 7 case-control or cross-sectional studies of static foot measures. Arch height index was not associated with PFP. The numbers of people with PFP with pes cavus or pes planus were not different from knee-healthy controls.

II The systematic review of 24 studies (3 prospective cohorts, 17 case-controls, and 4 case series) by Waryasz and McDermott[298] reported no association between foot alignment (pes cavus or pes planus) and PFP. Gastrocnemius tightness was reported in patients with PFP compared to controls in 2 of 3 studies.

II A systematic review of 24 case-control studies by Barton et al[20] reported that slower rate of time to peak rearfoot eversion and a greater amount of rearfoot eversion at initial heel contact during walking were characteristic of patients with PFP. Patients with PFP exhibited less rearfoot eversion motion during running.

II Neal et al[207] performed a systematic review of 4 studies investigating foot posture as a risk factor for the development of PFP. Navicular drop, measured as a continuous variable, was a risk factor for developing PFP (SMD, 0.33; 95% CI: 0.02, 0.65). When navicular drop was characterized as a dichotomous variable, pooled data indicated no relationship between pronated foot posture and an increased risk of the development of PFP. However, measures of foot mobility can discriminate between those with PFP and knee-healthy controls.[16,33,193]

II A systematic review found limited evidence from 3 studies for plantar loading (ie, plantar pressure) as a risk factor for PFP.[92] Greater lateral COP displacement and lower maximal displacement velocity of mediolateral COP during midstance of walking were demonstrated in people who developed PFP. During running, higher rates of time to peak force in the lateral heel and peak force in the central metatarsal regions were demonstrated in people who developed PFP.

III Tan et al[276] reported that people aged 40 to 50 years with PFP had less foot mobility than people aged 18 to 29 years and aged 30 to 39 years who also had PFP.

## Summary

Physically active women were more likely to develop PFP compared to physically active men. Participation by women in a single sport as opposed to participation by women in multiple sports was associated with a higher incidence of PFP. Isometric knee extensor weakness was predictive of the development of PFP. Women with PFP may have lower knee extensor, hip extensor, hip abductor, and hip external rotator strength than women without PFP.

In studies of men and women, weakness in isometric muscle strength of the hip and knee and decreased flexibility of the quadriceps, hamstrings, and gastrocnemius muscles may be present in people with PFP.

Inconclusive and conflicting evidence exists on the relationship between altered foot mechanics and the development or presence of PFP.




## Psychological Factors

II A systematic review by Maclachlan et al[186] examined the association of psychological factors in patients with PFP. They reviewed 25 studies that included 1357 participants with PFP (66% female) and 349 healthy controls (48% female), with subgroupings based on 4 psychological constructs: mental health, cognitive factors, behavioral factors, and other psychological factors. They reported that mental health (anxiety, depression), cognitive factors (pain catastrophizing), and behavioral factors (fear of movement) may be elevated in participants with PFP, and are likely associated with higher pain and lower function. A subsequent cross-sectional study by the same authors[187] compared psychological profiles between 100 participants with PFP and 50 controls who were matched for age, sex, and activity levels. This study also included a preplanned subgroup analysis according to the severity of PFP (based on the Knee injury and Osteoarthritis Outcome Score [KOOS]). No differences were seen between the PFP and pain-free groups for anxiety, depression, catastrophizing, and kinesiophobia. However, those with more severe PFP demonstrated higher levels of depression and catastrophizing compared to the controls, and higher levels of kinesiophobia, depression, and catastrophizing compared to the less severe PFP subgroup.

## Prognostic Factors

I Panken et al[219] performed a systematic review to determine which clinical factors were able to predict pain, function, or recovery in patients with PFP. They reported limited evidence for several factors as predictors of pain: frequency of pain, pain catastrophizing, fear avoidance, AKPS scores, quadriceps cross-sectional area, and muscle recruitment. There was limited evidence for the following predictors of function: pain catastrophizing, anxiety, fear avoidance, AKPS scores, Functional Index Questionnaire (FIQ) scores, quadriceps cross-sectional area, and gastrocnemius muscle length. The authors also reported that there is strong evidence that pain coping skills and kinesiophobia are not predictive of PFP or patellofemoral symptoms and function. Baseline pain intensity is not predictive of pain at follow-up, and baseline activity-related pain is not predictive of function at follow-up. There is moderate evidence that the triple jump test; muscle length of the quadriceps, hamstrings, or soleus; and activities of daily living (ADLs) are not predictive of pain or function. Bilateral symptoms and the step test are not predictive of pain. There was limited evidence that BMI, anxiety, being an athlete, and movement quality were not predictive of pain or function. There was also limited evidence that gastrocnemius muscle length, depression, working status, and the single-leg jump test did not predict pain. In addition, there is limited evidence that fear avoidance at work, muscle recruitment, work type, and preferred treatment were not predictive of function.

I In a follow-up study of 2 RCTs at 5 to 8 years, 57% of participants reported unfavorable outcomes, but there was a minimal presence of knee OA.[57,173] Similar to previous studies, those with a longer duration of symptoms and poorer function were more likely to have worse outcomes at long-term follow-up.[174]

I An RCT was conducted to investigate the effects of prefabricated foot orthoses, flat inserts, and physical therapy on individuals with PFP.[57] Individuals treated with physical therapy, prefabricated foot orthoses, or a combination of both demonstrated improvement in at least 85% of cases at 6 weeks and at least 80% of cases at 52 weeks. Longer duration of symptoms and poorer function, as measured by the AKPS, were most often associated with poor outcomes.[57]

II A systematic review was performed by Matthews et al[189] to determine which factors could predict outcomes in patients with PFP. Longer duration of knee pain (greater than 4 months), older age, higher baseline pain severity, and lower patient-reported function on the AKPS were predictive of unsuccessful outcomes for pain and function.

II Collins et al[59] described the proportions of individuals with poor outcomes at 3 and 12 months after randomization in 2 different clinical trials with a total of 310 patients. More than half (55%) of individuals reported an unfavorable outcome at 3 months, and 40% reported an unfavorable outcome at 12 months. Individuals with a duration of pain greater than 2 months from randomization, worse resting or activity-related pain, and poorer

function, as measured by the AKPS, were more likely to have an unfavorable recovery.[59]

### Summary

Individuals with a longer duration of symptoms, higher baseline pain severity, and poorer function were more likely to have negative outcomes or unfavorable recovery.

## DIAGNOSIS

I Systematic reviews of diagnostic tests for PFP demonstrate that the majority of clinical tests have poor diagnostic accuracy.[64,215] Clusters of diagnostic tests were found to be no more accurate than individual tests.[215] A high-quality systematic review reported that the most accurate diagnostic tests were reproduction of retropatellar pain during squatting (positive likelihood ratio [+LR] = 1.8; 95% CI: 1.3, 2.3; negative likelihood ratio [–LR] = 0.2; 95% CI: 0.1, 0.4) and hypomobility with the patellar tilt test (+LR = 5.4; 95% CI: 1.4, 20.8; –LR = 0.6; 95% CI: 0.5, 0.8).[215]

I A systematic review of reviews concluded that functional tasks that cause AKP, such as squatting, stair climbing, and sitting with flexed knees, are currently the best diagnostic tests for PFP.[222] Accordingly, in the recent study by Collins et al,[61] a large majority of individuals with PFP reported at least some difficulty with squatting (93.7%), stair negotiation (91.2%), and running (90.8%).

II A systematic review on the accuracy of diagnostic tests for PFP reported that diagnosis is challenging in part due to the lack of a clear gold standard as a reference test.[64] Studies of diagnostic test accuracy rely on a physician's diagnosis, the presence of AKP believed to be related to the PFJ, and/or provocation of retropatellar/peripatellar pain with activity as reference standards.[64]

II A systematic review examining diagnostic test accuracy for PFP reported that this condition should be considered a diagnosis of exclusion; other conditions that may cause AKP must be ruled out prior to ruling in PFP.[64,71,311]

### Evidence Synthesis and Clinical Rationale

Diagnosis of PFP is challenging due to differing reference standards used to determine diagnostic test accuracy.[64] Regardless of reference standard, diagnostic tests for PFP have poor accuracy.[64,215,222] Clusters of diagnostic tests that have been examined to date have not improved diagnostic accuracy.[215] The best diagnostic tests at this time are those that provoke AKP during functional activities when the PFJ is loaded in a flexed-knee position.[222] Accordingly, reproduction of AKP during squatting is the diagnostic test reported to have the best sensitivity (in the absence of pain) and diagnostic accuracy.[64,215,222] The patellar tilt test is a nonprovocative test for PFP, with reduced mobility (positive test) prompting a moderate change in the likelihood of PFP being present.[215]

### Gaps in Knowledge

Additional research is needed to determine the best reference standard to be utilized for studies of diagnostic test accuracy using individual or a combination of tests.[64,215]

### Recommendations

A Clinicians should use reproduction of retropatellar or peripatellar pain during squatting as a diagnostic test for PFP.[64,215,222] Clinicians should also use performance of other functional activities that load the PFJ in a flexed position, such as stair climbing or descent, as diagnostic tests for PFP.[64,215,222]

B Clinicians should make the diagnosis of PFP using the following criteria:

1. The presence of retropatellar or peripatellar pain[64,215,222] AND
2. Reproduction of retropatellar or peripatellar pain with squatting, stair climbing, prolonged sitting, or other functional activities loading the PFJ in a flexed position[64,215,222] AND
3. Exclusion of all other conditions that may cause AKP, including tibiofemoral pathologies[64,215,222]

C Clinicians may use the patellar tilt test with the presence of hypomobility to support the diagnosis of PFP.[215]

## CLASSIFICATION

Multiple biomechanical and neuromusculoskeletal factors related to the knee, hip, ankle, and trunk/pelvis have been reported to be associated with PFP.[19,20,172,206,241,286] Similar to low back pain, clinicians recognize that PFP is not a homogeneous condition, and response to intervention varies.[18,311] As a result, several classification systems with subcategories of PFP have been proposed for nonsurgical management of patients. Many of these classification systems are based on proposed pathoanatomical diagnoses, which rely on diagnostic imaging or surgical findings.[108,144,148,195,256,306,315] These classification systems are of limited utility for physical therapists because they do not include clear diagnostic criteria for each subcategory, or they rely on imaging or surgical findings that may not always be available to the physical therapist at the initial encounter.

III Selfe et al[261] conducted a cross-sectional observational study examining a classification system consisting of 6 proposed subcategories for PFP, the targeted interventions for patellofemoral pain syndrome (TIPPS). These 6 subcategories were based on expert consensus and clinically feasible assessment tests.[258] Because the subcategories were found to not be mutually exclusive,[261] the original 6 subcategories were revised and collapsed into 3 subcategories: weak and tight, weak and pronated foot, and strong.[261] The TIPPS classification system has yet to be applied to patients to determine its efficacy in guiding treatment and improving outcomes.

IV A PFP classification system that utilizes clinical tests was proposed by Selhorst et al[262] in a case-series pilot feasibility study for targeted interventions. The authors used results from the Fear-Avoidance Beliefs Questionnaire and clinical tests of impairment and neuromuscular deficits to classify patients. This classification pilot study was conducted in adolescents with a mean ± SD age of 14.10 ± 1.38 years,[262] potentially resulting in minimal applicability to adults with PFP.

### Evidence Synthesis and Clinical Rationale

Patellofemoral pain is a heterogeneous condition; persons with PFP do not all have the same impairments, and not all persons with PFP respond to the same interventions.[18,311] At this time, there is no valid and reliable classification system for PFP that does not require imaging or surgical findings. A classification system based on symptoms and physical examination findings would be useful to guide the physical therapist's plan of care.[258,261,262] Such a classification system would be useful to select interventions for persons with PFP. It would also be useful for researchers to examine factors associated with subcategories of PFP and to determine the optimal interventions for each subcategory.

### Gaps in Knowledge

No PFP classification system exists that is based on symptoms and physical examination findings and has been shown to be valid and reliable.

### Recommendation

F Given the absence of a previously established valid classification system for PFP, the CPG group proposes a classification consisting of 4 subcategories associated with the ICF. This proposed classification system is based on published evidence; the subcategories are named according to predominant impairments previously documented in persons with PFP. Clinicians may consider using the proposed impairment/function-based PFP classification system to guide patient/client management.

### PFP Impairment/Function-Based Classification Subcategories

1. Support for the "overuse/overload without other impairment" subcategory is based on the following evidence.

III One potential factor leading to PFP is performing activities that load the patellofemoral compartment with too much load magnitude,[96] too much load frequency,[96] and/or at too great a rate of increase, that is, overuse.[55,277,278] When individuals increase the magnitude and/or frequency of PFJ loading during an activity at a rate greater than musculoskeletal tissues can adapt, they move into a zone of supraphysiologic overload and eventual pain.[96,235] Evidence of excessive physiologic loading has been reported for runners with PFP who exhibited increased patellar bone water content, suggestive of patellar swelling, compared to pain-free controls.[138] Draper et al[93] also reported elevated PFJ bone metabolic activity in individuals with chronic PFP, which may be a response to bone stress. They found a moderate positive correlation between tracer uptake in PFJ bone and pain intensity ($R^2 = 0.55$, $P = .0005$), suggesting an association between bone remodeling and PFP.[93] Individuals at risk of developing PFP due to overuse may include athletes[55,128,277,278] and the military population when undergoing basic training.[155,277]

#### *Load Magnitude*

Load magnitude refers to the amount of PFJ loading resulting from physical activity. Briani et al[37] compared reported knee pain in women with and without PFP who participated in moderate or intense physical activity. Women in the intense physical activity PFP group reported significantly higher self-reported knee pain during the previous month and before a PFJ loading protocol used in this study.[37] A regression analysis revealed that 32% of reported pain intensity was predicted by intense physical activity levels. Moderate physical activity level was not a significant predictor of pain.

One population that experiences rapid increases in the overall magnitude of PFJ loading is military recruits during basic training. Thijs et al[281] conducted a prospective study of male and female officer cadets entering a military academy and initiated a 6-week intensive physical training program. Eighty-four of the 105 cadets had no history of previous knee injury or pain (65 males). Thirty-six of these 84 (43%) cadets (25 males) developed PFP during training. The authors concluded that PFP in this population resulted from repetitive loads placed on the PFJ tissues with minimal recovery time.[281]

Overuse as a cause of PFP may be related to greater running magnitude and runner experience (eg, recreational runners and higher-caliber runners). A retrospective analysis of 2002 patients with running injuries showed that the most common running-related injury for both sexes was PFP.[277] Multivariate analysis revealed that being either a higher-caliber

runner, defined as competing at provincial/state, national, or international levels (ie, highly competitive running level), or a recreational runner who ran less than 5 hours per week was a protective factor for PFP onset in females.[277] This finding suggested that the PFJ structures in the most experienced runners most likely had adapted to, and thus were capable of tolerating, the imposed loads. Alternatively, runners with much less experience most likely did not apply the magnitude of loading necessary to adversely affect the PFJ.

An injury prevention program had no effect on PFP or other lower extremity overuse injuries in military recruits.[38] Brushøj et al[38] developed a prevention program to address common impairments (eg, gluteal and quadriceps muscle weakness, quadriceps tightness, and increased knee valgus during squatting and lunging tasks) for military recruits prior to beginning a 3-month basic training program. At the end of the basic training program, no differences existed in overuse injury rates between those who participated in the prevention program and controls.[38] This finding suggests that increased magnitude of PFJ loading during physical activity, with insufficient tissue recovery time, may be the strongest etiologic factor for PFP in the military population.

### *Load Frequency*

Load frequency refers to the amount of repetition of an activity. Recreational runners who increase not only the magnitude of loading but also the frequency of loading, with inadequate tissue recovery time, represent a cohort at high risk for developing PFP. Thijs et al[279] examined the foot posture (higher or lower arch) and motion (pronation and supination) of 102 (89 females) novice recreational runners enrolled in a 10-week start-to-run program. They prospectively followed the runners and reported that 17 participants developed PFP. Analyses showed that neither foot posture nor motion predicted PFP onset.[279] In a subsequent prospective study, Thijs et al[280] followed 77 novice female recreational runners (with no history of prior knee injury or pain) enrolled in a 10-week start-to-run program to determine the effect of peak isometric hip muscle force on PFP onset. Sixteen runners developed PFP; however, logistic regression did not identify isometric hip force as a predictive factor for onset of PFP.[280] Together, results from these studies showed that impairments commonly associated with PFP were not predictive of PFP onset. These findings suggested that beginning a new repetitive activity involving PFJ loading could have caused PFP onset.

### Summary

A subcategory of individuals with PFP may have pain primarily due to overuse/overload. Classification into the overuse/overload without other impairment subcategory is made with a fair level of certainty when the patient presents with a history suggesting an increase in magnitude and/or frequency of PFJ loading at a rate that surpasses the ability of the PFJ tissues to recover.

2. Support for the "muscle performance deficits" subcategory is based on the following evidence.

### *Hip Strength Deficits*

III

Females with PFP have hip weakness, particularly with isometric strength testing.[241,245,286] Originally thought to be a risk factor for PFP onset, hip weakness, especially of the hip abductors, extensors, and external rotators, has been shown to result from PFP.[133,245]

### *Hip/Thigh Strength Responders*

The reason for the resulting hip weakness remains unclear; however, evidence supports the importance of resistance exercises targeting the hip muscles as part of the intervention for individuals with PFP.[168,228] While an important treatment strategy, not all individuals with PFP may respond favorably. Ferber et al[105] compared outcomes for 199 individuals with PFP who completed either a 6-week hip/core- or knee-based exercise program. They found that 67% of participants responded favorably to treatment, regardless of group assignment. In a secondary analysis, the authors determined that only males and females who exhibited an increase in hip and thigh strength following treatment responded positively to the resistance exercise intervention.[31] Beginning strength values, expressed as a percentage of body mass, for males who responded favorably were, on average, 37%, 13%, 28%, and 44% of body mass for the hip abductors, hip external rotators, hip extensors, and quadriceps, respectively. Values for female responders were, on average, 30%, 17%, 30%, and 37% of body mass for the hip abductors, hip external rotators, hip extensors, and quadriceps, respectively.

### Gap in Knowledge

While we have provided average values to identify weakness, additional investigations are needed to further quantify strength values using identical methods.

### Summary

A subcategory of individuals with PFP may respond favorably to hip and knee resistance exercises. Classification into the muscle performance deficits subcategory is made with a fair level of certainty when the patient presents with lower extremity muscle performance deficits in the hip and quadriceps.

3. Support for the "movement coordination deficits" subcategory is based on the following evidence.

III

Powers[237] has theorized that increased hip adduction, hip internal rotation, and knee abduction (ie, knee valgus) during dynamic activities can increase

the dynamic Q angle. Knee abduction and external rotation also increase the Q angle by moving the tibial tubercle lateral relative to the patella. Together, these altered movements can impart increased stress to the lateral PFJ.[177,253]

Clinicians commonly observe hip and knee movement during an SLS to identify individuals with PFP and movement coordination deficits. Findings from independent investigations support that females with PFP perform the SLS with an increased FPPA[134] and greater medial knee displacement[125,307] than controls. Medial knee displacement during the SLS also has been associated with increased hip adduction and knee external rotation during running and jumping tasks.[307] It is noteworthy that these investigators did not assess hip or knee strength,[134,307] precluding the ability to discern the effect, if any, of hip and knee strength on the FPPA.

Almeida et al[5] compared hip strength and the FPPA during the SLS in individuals with and without PFP. Those with PFP demonstrated less hip strength and higher FPPA than controls. However, a significant correlation between hip strength and FPPA only existed for controls, and these correlations, while significant, were not strong for controls (hip abductor torque and peak FPPA: $P<.05$, $R^2 = 0.096$). This finding suggested that factors other than strength likely affected SLS performance in those with PFP.[242]

Decreased neuromuscular control may contribute to an increased FPPA during dynamic tasks. While we cannot conclusively make this determination, emerging data support the importance of movement retraining. Graci and Salsich[120] examined trunk, hip, and knee kinematics during the SLS in females with PFP under 2 conditions (with and without instruction for maintaining good pelvic and hip position) in a single session. With instruction, participants performed the SLS with a significant increase in contralateral pelvic elevation and decreases in hip adduction and internal rotation. Moreover, a significant association existed between decreased pain and less hip internal rotation ($r = 0.46$).

## Gaps in Knowledge

Additional studies are needed to identify the best methods and threshold values for identifying movement coordination deficits.[131] Future works also are needed to better understand the effect that movement retraining may specifically have on these measures.

## Summary

A subcategory of individuals with PFP may respond favorably to gait retraining and movement re-education interventions, leading to improvements in lower extremity kinematics and pain and suggesting the importance of assessing dynamic knee valgus during movement.[35,100,206,252] The diagnosis of PFP with movement coordination deficits is made with a fair level of certainty when the patient presents with excessive or poorly controlled knee valgus during a dynamic task, not necessarily due to weakness of the lower extremity musculature.

4. Support for the "mobility impairments" subcategory is based on the following evidence.

### Hypermobility-Related Influences

III

Although patellar instability is outside the scope of this CPG, increased foot mobility deserves attention. Selfe et al[261] classified individuals with PFP and a greater than 6-point Foot Posture Index (FPI) score as having a pronated foot. Mills et al[196] found beneficial effects with orthosis use for individuals with PFP and a greater than 11-mm difference between non–weight-bearing and weight-bearing midfoot width. Moreover, the use of foot orthoses has been recommended as an adjunctive treatment for PFP.[18]

### Hypomobility-Related Influences

Lack of flexibility of structures around the knee has been more extensively examined due to their direct or indirect potential for increasing the compressive forces at the PFJ. Commonly assessed structures have included the hamstrings, quadriceps, gastrocnemius, soleus, lateral retinaculum (using the patellar tilt test), and iliotibial band. Piva at al[232] found several significant differences when comparing flexibility between those with and without PFP. In individuals with PFP, hamstring (measured by passive hip flexion during a straight leg raise performed in supine), gastrocnemius (measured by ankle dorsiflexion performed in prone with the knee extended), and soleus (measured by ankle dorsiflexion performed in prone with the knee flexed) lengths, when measured by goniometry, were less than 79.1°, 7.4°, and 14.8°, respectively. The authors also reported values of less than 11° for iliotibial band (measured in the Ober position with the knee flexed to 90°) and 134.0° for quadriceps (measured with prone knee flexion) lengths when measured using an inclinometer. A positive patellar tilt test assessed via palpation can suggest lateral retinaculum tightness in the PFP population.[215]

## Gaps in Knowledge

Hip internal and external rotation ROM has received some attention. Specifically, limited hip external rotation ROM could place the femur in a more internally rotated position, leading to an increased dynamic Q angle and lateral PFJ loading.[130,236] Further work is needed to identify threshold values for hip ROM potentially contributing to PFP. Future studies also are needed to better understand responses to treatment specifically directed toward these structures.

## Summary

A subcategory of individuals with PFP may have impairments related to either hypermobile or hypomobile structures. The diagnosis of PFP with mobility impairments is made with a fair level of certainty when the patient presents with higher than normal foot mobility and/or flexibility deficits of 1 or more of the following structures: hamstrings, quadriceps, gastrocnemius, soleus, lateral retinaculum, or iliotibial band.


### Classification Summary

Clinicians should consider serious pathological conditions other than/separate from PFP when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis and Classification sections of this guideline, or when the patient's symptoms are not resolving with interventions aimed at normalization of the patient's impairments of body function. Clinicians should consider whether the patient corresponds to 1 or more of the following categories: (1) overuse/overload without other impairment, (2) muscle performance deficits, (3) movement coordination deficits, and/or (4) mobility impairments. In addition, clinicians should identify the level of tissue irritability and should screen for the presence of psychological factors that may impact the patient's response to physical therapy and/or require referral to another health care practitioner.

## DIFFERENTIAL DIAGNOSIS

Clinicians should consider diagnostic classifications associated with serious medical conditions, other musculoskeletal conditions, or psychosocial factors when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis and Classification sections of this guideline, or when the patient's symptoms are not resolving with interventions aimed at normalization of the patient's impairments of body function.

### *Medical Differential Diagnosis*

The following medical conditions, although not intended to be a comprehensive list, should be in the clinician's differential diagnosis for knee pain and require referral to another health care practitioner[43]:

- Tumors
- Dislocation
- Septic arthritis
- Arthrofibrosis
- Deep vein thrombosis
- Neurovascular compromise
- Fracture (local and/or at the hip)
- Slipped capital femoral epiphysis in children or adolescents

Clinicians should use review-of-systems screening tools to screen for medical and other conditions requiring referral of a patient to another health care provider.[111] The Optimal Screening for Prediction of Referral and Outcome-review of systems (OSPRO-ROS) tool was developed in a cohort study of 431 patients with primary complaints of back, neck, knee, and shoulder conditions treated in 11 outpatient physical therapy clinics.[111] Review-of-systems screening tools provide the clinician with a systematic method to screen for red flags that may indicate more sinister causes of musculoskeletal pain.[111] The score on a 10-item OSPRO-ROS improved prediction of mental health quality of life at 12 months in a follow-up validation study.[112] Adding 13 items to the OSPRO-ROS improved prediction of change in comorbidity status at 12 months.[112]

To screen for the presence of acute fracture as a cause of knee pain, clinicians should use either the Ottawa[97,163] or Pittsburgh[163,257] knee decision rules. Both of these decision rules have high sensitivity for acute knee fracture, and their use has been shown to avoid unnecessary radiography.[163] The Ottawa knee rule is reported to be more sensitive than the Pittsburgh knee rule, but it is limited to persons aged 18 years and older.[163] The Pittsburgh knee rule may be used with persons of all ages.[163]

Hip and thigh pathology has been reported to refer pain to the knee.[179] Persons who participate in high levels of physical activity (eg, military personnel undergoing physical training) may develop femoral fractures that masquerade as PFP.[45,304] Children and adolescents with knee pain may have referred pain from a slipped capital femoral epiphysis or other hip pathology.[1,316,317] In children with knee pain, a limp is a sign of possible hip pathology.[1,316]

### *Musculoskeletal Differential Diagnosis*

Following exclusion of medical conditions that require referral of the patient to a physician, the clinician must rule out other musculoskeletal conditions that may cause AKP. These conditions are appropriate for physical therapy but may require a plan of care that is different from that for the treatment of PFP. The differential diagnosis should consider conditions that are distant but may refer pain to the knee, for example, lumbar radiculopathy, peripheral nerve entrapment, or hip OA.[24,40]

The lumbar spine may refer pain to the anterior thigh and knee.[24,40] Clinicians should perform a lower-quarter screen as part of the examination of a patient with suspected PFP, including examination of the lumbar spine and sacroiliac joint regions. Clinicians should refer to the low back pain CPG published by the Academy of Orthopaedic Physical Therapy, APTA, Inc for guidance on screening for the presence of referred pain from the low back.[83]

Hip OA has been reported to present with a primary complaint of knee pain.[171,233] Clinicians should refer to the hip pain and mobility deficits—hip OA CPG published by the Academy of Orthopaedic Physical Therapy, APTA, Inc for guidance on the examination procedures and symptoms to determine the presence of hip OA.[51,52]

The differential diagnosis should also consider conditions local to the knee, for example, ligamentous (cruciate and collateral) injuries, meniscus injuries, articular cartilage injuries, OA, distal iliotibial band syndrome (ITBS), quadriceps and patellar tendinopathies, plica syndrome, patellar (Sinding-Larsen-Johansson lesion) and tibial (Osgood-Schlatter lesion) apophysitis, and patellar subluxation or dislocation (instability).

Structures that are part of the tibiofemoral articulation, such as ligament, meniscus, and articular cartilage injuries, may be a source of AKP.[227] Clinicians should refer to the CPGs published by the Academy of Orthopaedic Physical Therapy, APTA, Inc for guidance on the examination procedures for determining the presence of ligamentous, meniscal, and articular cartilage conditions/injuries.[181-184] Persons with ITBS are typically runners, complain of onset of lateral knee pain following running for 1.2 km or longer, and have pain provoked by palpation of the lateral femoral epicondyle with the knee at 30° of flexion (Noble compression test).[13]

The patellofemoral articulation may have musculoskeletal conditions other than PFP that cause knee pain.[161] The following differential diagnosis has been suggested for knee pain based on anatomical site[43]:

- Anterior knee pain
  - PFP
  - Patellar tendinopathy (jumper's knee)
  - Patellar subluxation or dislocation (instability)
  - Tibial apophysitis (Osgood-Schlatter lesion)
  - Patellar apophysitis (Sinding-Larsen-Johansson disease)

Clinicians should use information from the patient's age, history, provocative activities, and physical examination test results to screen for the presence of other possible causes of AKP.[43,293] Pain from patellar tendinopathy is typically localized to the inferior pole of the patella or near the tibial tubercle.[188] Patellar tendinopathy may be differentiated from PFP by pain located over the patellar tendon, tenderness to palpation of the patellar tendon, and symptom response. Pain from patellar tendinopathy is aggravated by activities that require higher rates of knee extensor loading, such as jumping (eg, basketball, volleyball) or high-speed sprinting (eg, football/soccer).[188] If patellar instability or a history of patellar dislocation is suspected from subjective interview, then reported apprehension with passively applied lateral patellar movement (a positive apprehension test) may provide confirmation.[162] Clinicians should refer to the consensus statement written by the international patellofemoral osteoarthritis consortium for clinical symptoms and signs to screen for the presence of PFOA.[293]

Anterior knee pain in children may be due to apophysitis of the tibial tubercle (Osgood-Schlatter disease) or the inferior pole of the patella (Sinding-Larsen-Johansson disease).[317,318] Clinicians should use the patient's age and the presence of tenderness to palpation over the tibial tubercle or inferior pole of the patella to determine the presence of these conditions.[316]

Patellofemoral pain may be experienced following surgical procedures, for example, anterior cruciate ligament reconstruction (ACLR).[76,77] Although PFP is common in persons following ACLR, this may present differently from nonsurgical PFP due to alterations in the normal knee biomechanics.[77] This guideline does not apply to PFP following surgery to the knee or other musculoskeletal regions of the lower extremity.

### *Screening for Psychological Factors*

Clinicians should screen for the presence of psychological issues that may require referral to a health care practitioner in addition to physical therapy, for example, a clinical psychologist.[186,187] Psychological factors including pain catastrophizing, kinesiophobia, fear avoidance, anxiety, and depression are considered yellow flags that may affect prognosis and rehabilitation treatment decision making.[178] In addition to potential referral, patients with PFP who exhibit psychological factors may require the therapist to employ specific patient education strategies to optimize outcomes from physical therapy interventions, for example, cognitive-behavioral treatment, reassurance, and graded exposure to activity.[25]

Persons with PFP may be under psychological stress and may also have chronic pain and central sensitization. Psychological stress negatively influences recovery. Fear of reinjury/pain/movement is a frequently cited reason that athletes do not return to sport or reduce their level of physical activity in other knee disorders.[9,10] A systematic review reported that catastrophization and fear avoidance had strong and consistent associations with pain and function in persons with PFP.[186] Chronic pain can be accompanied by central sensitization, which encompasses factors like hyperalgesia (reduced pressure pain threshold) to regions both at and remote to the "involved" structure. Noehren et al[213] found that females with PFP reported lower pressure pain thresholds (determined via pressure algometry) in multiple sites at the knee as well as the elbow.

Screening tools for psychological factors and other yellow flags can be used by the clinician during the examination. These tools include the Pain Catastrophizing Scale,[272] the Fear-Avoidance Beliefs Questionnaire,[297] and the OSPRO yellow flag assessment tool (OSPRO-YF).[178] The Fear-Avoidance Beliefs Questionnaire items have been modified to refer to the knee rather than to the back.[118] The OSPRO-YF is a concise, multidimensional yellow flag assessment tool, developed from a study of 431 patients with musculoskeletal conditions examined with 136 items from 11 validated questionnaires of psychological constructs.[178] The score on the OSPRO-YF was found to improve prediction of persistent musculoskeletal pain intensity, disability, and quality of life at 12 months.[112]

CLINICAL PRACTICE GUIDELINES

# Examination

## OUTCOME MEASURES

### Activity Limitations/Self-report Measures

A vast number of patient-reported outcome measures (PROMs) have been developed and used to assess a patient's perceived function and change in status over time for persons with PFP. These PROMs have varying levels of evidence to support their use for individuals with impairments of body function and structure, activity limitations, and participation restrictions associated with PFP.

#### *Systematic Reviews*

I Papadopoulos et al[222] performed a high-quality systematic review of reviews for several factors related to PFP, including outcome measurements. The authors identified 2 systematic reviews of outcome measures, by Howe et al[146] and Esculier et al,[101] which they evaluated using the A MeaSurement Tool to Assess systematic Reviews (AMSTAR) scoring tool. Results of these 2 reviews are presented individually below.

I Esculier et al[101] performed a high-quality systematic review of 24 articles on the psychometric properties of 5 PROMs. Only PROMs that had at least 5 studies evaluating their psychometric properties were included: the Knee Outcome Survey-Activities of Daily Living Scale (KOS-ADLS), AKPS (originally known as the Kujala scale), International Knee Documentation Committee 2000 Subjective Knee Evaluation Form (IKDC), Lysholm scale, and FIQ. Several aspects of validity were assessed: content validity, construct validity, discriminant (known-groups) validity, structural (factorial) validity, and floor/ceiling effects. The KOS-ADLS and Lysholm scale were found to have satisfactory content validity. The FIQ and AKPS were easy to complete and were poor and good, respectively, at depicting symptoms. Construct validity for several PFP PROMs was examined by determining correlations between scales: KOS-ADLS to Lysholm scale, IKDC to Lysholm scale, and AKPS to FIQ. These PROMs demonstrated moderate to high correlations ($r$>0.5) in samples including patients with PFP. The KOS-ADLS, AKPS, and Lysholm scale could discriminate between different patient populations of knee conditions and disability levels. All measures demonstrated adequate floor/ceiling effects (less than 15% of participants achieved the lowest or highest scores). The KOS-ADLS, IKDC, AKPS, and Lysholm scale demonstrated high test-retest reliability, with intraclass correlation coefficients (ICCs) ranging from 0.81 to 0.99 and weighted average ICCs from 0.92 to 0.96. The ICCs for the FIQ ranged from 0.48 to 0.96 (weighted average ICC = 0.61). The minimal detectable change at the 95% confidence level ($MDC_{95}$) was 8.3 for the KOS-ADLS, 8.5 for the IKDC, 9.0 for the AKPS, 3.1 for the FIQ, and 30 for the Lysholm scale. All questionnaires, except the Lysholm scale, demonstrated good internal consistency, with Cronbach alpha values greater than .81 (Lysholm scale: $\alpha$ = .66). All questionnaires were found to be moderately to highly responsive (moderate to high effect size or standardized response mean) in patients with PFP.

II A systematic review by Green et al[121] reported on 7 articles that evaluated the measurement properties of 12 PROMs. Several instruments had moderate levels of evidence for structural validity, a component of construct validity: the Flandry Questionnaire ($r$ = 0.65-0.66 with the FIQ and the Eng and Pierrynowski Questionnaire [EPQ]), the FIQ ($r$ = −0.66 with the Flandry Questionnaire and EPQ), the EPQ ($r$ = 0.66 with the Flandry Questionnaire), the AKPS ($r$ = 0.58 with the FIQ), and the VAS for "usual" pain and the VAS for "worst" pain were moderately correlated with each other ($r$ = 0.63). Limited evidence supported test-retest reliability and cross-cultural and hypothesis testing components of validity for the Persian version of the AKPS.

III Howe et al[146] performed a low-quality systematic review examining the clinimetric properties of PROMs used with patients treated for various musculoskeletal knee conditions, including ligamentous injuries, meniscal lesions, OA, and PFP. The outcome measures appraised by Howe et al[146] also included clinician-administered instruments. In addition to the low quality of the systematic review, the authors did not critically appraise the articles included in their review. Using expert consensus, Howe et al[146] concluded that the AKPS demonstrated sufficient content validity, test-retest reliability, and responsiveness to change for persons with PFP according to the Outcome Measures in Rheumatology (OMERACT) filter. They also reported that the Lower Extremity Functional Scale (LEFS) demonstrated sufficient construct validity and test-retest reliability for PFP according to the OMERACT filter.

#### *Anterior Knee Pain Scale*

The AKPS, originally known as the Kujala scale, is a 13-item questionnaire for knee function in persons of all ages with AKP, scored out of 100, with higher scores indicating less disability.

I The psychometric properties of the English version of the AKPS have been examined in 2 level I studies.[70,302] Crossley et al[70] evaluated the concurrent validity of the AKPS by correlating change in the AKPS with the global rating of change (GROC). Participants with GROC ratings of +3 or higher (scale of −7 to +7, with −7 as the worst status and +7 as the best status) were considered to have improved. Concurrent validity using Spearman's rho was 0.69. Test-retest reliability was evaluated in 2 studies[70,302] and was found to be excellent (ICC = 0.817 and 0.953, respectively). Responsiveness was reported in several studies. Crossley et al[70] reported that the AKPS median change score could discriminate between those who improved and those who were worse or stayed the same. Watson et al[302] reported that the AKPS change score had a fair association ($r$ = 0.42) with the criterion score (average of the therapist's and patient's GROC score). The AKPS demonstrated fair discriminatory ability between those with clinically meaningful reduction of patellofemoral symptoms and those who did not have a reduction (area under the receiver operating characteristic [ROC] curve [AUC] = 0.69). Crossley et al[70] reported that the treatment effect size of the AKPS was 1.15. The MDC for the AKPS was 13 points.[302] The minimal clinically important difference (MCID) for the AKPS is 8 to 10 points.[70]

I Myer et al[202] developed a 6-item short form of the AKPS in 499 girl and adolescent female athletes. The internal consistency of the 13-item form had a Cronbach alpha of .92 and a standard error of measurement (SEM) across all items of 0.003. Rasch difficulty (endorsability) estimates of the 6-item short form ranged from −3.57 to 1.27. The internal consistency of the 6-item form had a Cronbach alpha of .88 and an SEM across all items of 0.004. Criterion validity of the 6-item form against the 13-item form was $r$ = 0.96, with a point-biserial calculation of each form against the PFP diagnosis of $r$ = 0.72. The AKPS demonstrated excellent predictive ability between the 13-item long form and 6-item short form against the PFP diagnosis (AUC = 0.95 for the long form and AUC = 0.93 for the short form). A score of 4 on the short form and a score of 10 on the long form could correctly confirm a physician's diagnosis of PFP with a sensitivity of 82% and specificity of 91%.

II Ittenbach et al[149] evaluated the reliability and validity of the AKPS in 414 girl, adolescent female, and woman athletes (11.0-18.1 years of age). Criterion validity of the AKPS was evaluated against the physician's diagnosis of knee pain. The median classification rates were high in both healthy athletes (86%) and in athletes with PFP (99%). The AKPS demonstrated good internal consistency for both the 13-item long form (Cronbach $\alpha$ = .91) and 6-item short form (Cronbach $\alpha$ = .84). The equivalence of the short form with the long form was high ($r$ = 0.98). The SEM for the long form was 3.0 points and for the short form was 1.2 points.

### AKPS Cross-cultural Translations

The AKPS has been translated and cross-culturally adapted into 10 languages, with psychometric evidence to support the use of the translations. These include Brazilian Portuguese,[78] French,[39] Persian,[209] Turkish,[167] Spanish,[117] Greek,[220] Arabic,[6] Dutch,[284] Chinese,[49] and Thai.[8] The MDC of the Dutch AKPS is reported to be 11 points.[284]

### *KOS-ADLS and Knee Outcome Survey-Sports Activity Scale*

The KOS-ADLS is a 14-item questionnaire for knee symptoms and function during ADLs due to a variety of knee disorders, including PFP. It is scored out of 70 points, then converted to 100 points to yield percentages, with higher scores indicating less disability. The Knee Outcome Survey-Sports Activity Scale (KOS-SAS) is an 11-item questionnaire for knee symptoms and function during sports activities due to a variety of knee disorders. It has a total score of 55 points, converted to 100 points to yield percentages, with higher scores indicating less disability.

I Piva et al[231] assessed the responsiveness of the KOS-ADLS in 60 individuals with PFP before and after an intervention program by comparing KOS-ADLS scores to GROC scores. The KOS-ADLS had a moderate standardized effect size (0.63) and demonstrated excellent discrimination between those whose GROC scores worsened and those whose scores did not (AUC = 0.83). The MCID for the KOS-ADLS was estimated from a ROC curve and was found to be a 5-point change in raw score or 7.1 percentage points on the KOS-ADLS.

III Bradbury et al[36] reported on the association between KOS-ADLS and KOS-SAS scores with the Global Rating Scale (GRS) of perceived knee function. In a group of 15 patients with PFP, the GRS was strongly associated with the KOS-ADLS ($r$ = 0.85) and with the KOS-SAS ($r$ = 0.88).

IV Siqueira et al[265] evaluated the KOS-ADLS and IKDC in 31 patients with PFP. The KOS-ADLS and IKDC were moderately correlated with each other ($r$ = 0.46). Test-retest reliability of the KOS-ADLS was excellent (Spearman $\rho$ = 0.99). The KOS-ADLS was deemed more reliable than the IKDC.

### KOS-ADLS Cross-cultural Translations

The KOS-ADLS has been translated and cross-culturally adapted into Turkish, with psychometric evidence to support its use.[103] The MDC of the Turkish KOS-ADLS was 2.59 points out of a total score of 70 points.

### The FIQ and Modified FIQ

The FIQ is an 8-item questionnaire for knee function due to a variety of knee disorders, including PFP. It is scored out of 16 points, with higher scores indicating less disability. The modified FIQ is a 10-item questionnaire for knee pain and function for a variety of knee disorders, including PFP. The modified FIQ is scored out of 100 points, with higher scores indicating greater disability and worse pain.

I The psychometric properties of the English version of the FIQ have been examined in 2 level I studies.[47,70] The test-retest reliability was fair in both studies: Chesworth et al[47] ($r$ = 0.48) and Crossley et al[70] (ICC = 0.49). Concurrent validity was assessed in comparison with the GROC, and the Spearman rho was 0.65.[70] Responsiveness was defined as the perceived rating of change. The FIQ median change score could discriminate between those who improved and those who were worse or stayed the same.[70] The treatment effect size was 0.49.[70] The FIQ had an MCID of 2 points or 13% of the total score.[70]

IV Selfe et al[259,260] investigated the reliability and validity of the modified FIQ in 77 participants (66.2% female). The modified FIQ is a 10-item questionnaire whose language was modified for a European population and that includes additional questions modified from the AKPS. Internal consistency, measured with Cronbach's alpha, was .83.[260] Test-retest reliability was assessed by calculating the mean of 2 modified FIQ scores and then subtracting each individual score from the mean to determine the error for each individual score. Using the Kolmogorov-Smirnov $Z$ statistic, the error scores were found to be normally distributed, indicating acceptable test-retest reliability (1.24; $P$ = .09).[260]

### FIQ Cross-cultural Translations

The FIQ has been translated and cross-culturally adapted into Brazilian Portuguese[78] and Persian,[208] with psychometric evidence to support their use.

### Patellofemoral Pain Syndrome Severity Scale

The Patellofemoral Pain Syndrome Severity Scale (PSS) is a 10-item VAS questionnaire for knee pain severity during various activities in persons with AKP, scored out of 100, with higher scores indicating less disability.

I Laprade and Culham[175] developed the PSS and evaluated its validity and test-retest reliability in 29 military participants with PFP (7 females). Concurrent validity was assessed by comparison to the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Hughston Clinic subjective knee questionnaire, showing strong positive correlations with both questionnaires (Spearman $\rho$ = 0.72 and 0.83 for the WOMAC and Hughston Clinic subjective knee questionnaire, respectively).[175] Test-retest reliability of the PSS was excellent when assessed in a sample of 24 of the original 29 participants (Spearman $\rho$ = 0.95).[175]

### PSS Cross-cultural Translations

The PSS has been translated and cross-culturally adapted into Brazilian Portuguese,[78] Greek,[221] and Chinese,[48] with psychometric evidence to support their use. The MDC for the Greek PSS was 1.87 points.[221] The MDC for the Chinese PSS was 6.34 points.[48]

### Pain VAS and EPQ

I The 10-cm VAS has been evaluated for reliability, validity, and responsiveness for ratings of "usual" pain, "worst" pain, and pain during activity (VAS for activity, also known as the EPQ).[47,70] Chesworth et al[47] evaluated the test-retest reliability of the VAS for worst pain in 18 patients with PFP and found moderate reliability ($r$ = 0.60). Crossley et al[70] evaluated the test-retest reliability of the VAS for worst pain and the VAS for usual pain in 17 patients with PFP and found moderate reliability for both measures (ICC = 0.76 and 0.56, respectively). Crossley et al[70] also evaluated the test-retest reliability for VAS pain during 6 aggravating activities (walking, running, squatting, sitting, ascending stairs, and descending stairs), with the combined score being referred to as the VAS for activity or EPQ. The VAS for activity's test-retest reliability was excellent (ICC = 0.83).[70] Concurrent validity, assessed with correlation of change (Spearman rho), in each outcome instrument with the GROC was −0.67 for the VAS for usual pain, −0.68 for the VAS for worst pain, and −0.68 for the VAS for activity. Responsiveness was defined as the perceived rating of change. Each outcome measure's median change score could discriminate between those who improved and those who were worse or stayed the same. The treatment effect size was 0.95 for the VAS for usual pain, 1.09 for the VAS for worst pain, and 0.76 for the VAS for activity. The MCID for each measure was 1.5 to 2 cm for the VAS for usual pain, 2 cm for the VAS for worst pain, and 8 to 13 cm for the VAS for activity.

### Numeric Pain-Rating Scale

I Piva et al[231] assessed the responsiveness of the 11-point numeric pain-rating scale (NPRS), with 0 being "no pain" and 10 being the "worst imaginable pain," in 60 individuals with PFP before and after an intervention program. The NPRS had a moderate standardized effect size (0.74) and demonstrated excellent discrimination between those whose scores worsened and those whose scores did not (AUC = 0.84). The MCID for the NPRS was −1.2 points for a decrease in pain score, according to the ROC curve.

### *Patellofemoral Pain and Osteoarthritis Subscale of the KOOS*

I Crossley et al[73] developed and evaluated a new KOOS subscale, the patellofemoral pain and osteoarthritis subscale (KOOS-PF). The KOOS-PF is an 11-item questionnaire for pain, stiffness, and quality of life in persons with PFP and knee OA. It is scored out of 100 points, with higher scores meaning less disability.[73] In evaluating the measurement properties of the KOOS-PF in 132 patients, the internal consistency was .86 (Cronbach's alpha), the test-retest reliability was 0.86 (ICC), and the SEM was 6.8. The structural validity loaded mostly on 1 factor, "knee pain relating to activities that load the PF joint," with an eigenvalue of 4.29. The KOOS-PF demonstrated moderate to good construct validity (convergent validity) with the AKPS ($r$ = 0.74) and Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) physical component summary ($r$ = 0.45). Construct validity was also established by a hypothesized low correlation of the KOOS-PF score with the SF-36 mental component summary ($r$ = 0.07) (divergent validity). The KOOS-PF demonstrated good discriminant validity; those with higher levels of baseline pain had lower baseline KOOS-PF scores, and vice versa. The KOOS-PF change scores had fair responsiveness compared to GROC scores ($r$ = 0.52). The individual MDC of the KOOS-PF was 16 points. The minimal important change was 14.2 points. No floor or ceiling effects were reported.

### *The IKDC*

The IKDC is a 10-item questionnaire for knee symptoms, function, and sports participation, with a maximum score of 100 points (least disability). The IKDC is designed for persons with orthopaedic conditions of the knee, including PFP.

IV Siqueira et al[265] evaluated the IKDC in 31 patients with PFP. Criterion validity of the IKDC was examined through comparison of scores with the KOS-ADLS using a Spearman correlation test. The IKDC was moderately correlated with the KOS-ADLS ($\rho$= 0.46). Test-retest reliability of the IKDC was excellent (Spearman $\rho$ = 0.96).

### *Lysholm Scale*

The Lysholm scale is an 8-item questionnaire for knee symptoms, signs, and disability scored out of 100 points (100 is the least disability). It was originally designed for patients following knee ligament surgery but has been studied in other populations, including patients with PFP.[101] Psychometric properties of the Lysholm scale are reported in the Systematic Reviews section under Esculier et al.[101]

### Lysholm Scale Cross-cultural Review

The Lysholm scale has been translated and cross-culturally adapted into Turkish, with psychometric evidence to support its use.[46]

### Evidence Synthesis and Clinical Rationale

There are many PROMs for use with persons with PFP. Several have been translated and cross-culturally adapted from English to various languages and cultures. At this time, the strongest evidence for validity, reliability, and responsiveness to change exists for the AKPS, KOOS-PF, and VAS for activity (EPQ). The AKPS has several translated and cross-culturally adapted versions, with varying levels of evidence to support their validity, reliability, and responsiveness to change. The VAS for worst pain and VAS for usual pain have moderate reliability, concurrent validity, and responsiveness to change. The NPRS has evidence for responsiveness to change. Several additional PROMs have varying evidence to support their use as measures of pain and function in persons with PFP.

### Recommendation

A Clinicians should use the AKPS, KOOS-PF, or VAS for activity (EPQ) questionnaires to measure pain and function in patients with PFP. In addition, clinicians should use the VAS for worst pain, the VAS for usual pain, or the NPRS to measure pain. Clinicians should use one of the translations and cross-cultural adaptations with demonstrated validity, reliability, and responsiveness to change for patients in different countries and for those requiring questionnaires in languages other than English.

## ACTIVITY LIMITATIONS

### Physical Performance Measures

I The most accurate diagnostic clinical test for PFP is reproduction of pain with squatting.[64,215] The squatting maneuver is performed in a manner that feels normal to the individual. The test has a high –LR of 0.10 to 0.20 (95% CI: 0.1, 0.4) (**TABLE 2**), indicating that the probability of PFP being present when there is a negative test is moderately decreased.[63,215,303]

I Sensitivity, specificity, and likelihood ratios were calculated for pain with stair climbing and pain with kneeling. These tests demonstrated moderate to high sensitivity and –LR (**TABLE 2**), suggesting that the probability of PFP is moderately decreased when there is a negative test.[63,65,205]

I Collins et al[61] conducted a retrospective review of 4 separate studies of persons with PFP, including 459 total participants, and found that 54.4% of persons with PFP reported increased knee pain with prolonged sitting. Pain with prolonged sitting was found to have low to moderate diagnostic accuracy in an earlier systematic review,[64] which suggests that its presence may be a diagnostic indicator for PFP (**TABLE 2**).

I The eccentric step-down test demonstrates moderate specificity (0.82; 95% CI: 0.62, 0.93) and +LR (2.3; 95% CI: 1.9, 2.9), suggesting that the probability of PFP being present when there is a positive test is moderately increased (**TABLE 2**).[215] Reproduction of AKP during the test is considered a positive test result.[210]

II Another test to assess movement quality is the FPPA during the SLS. The FPPA, a measure of knee valgus, is calculated by drawing a line on a photo from the anterior superior iliac spine to the midpoint of the tibiofemoral joint, and another line from the midpoint of the tibiofemoral joint to the midpoint of the ankle mortise, and measuring the resulting angle.[308] The FPPA has acceptable between-day reliability for healthy men (ICC = 0.88; 95% CI: 0.82, 0.93) and women (ICC = 0.72; 95% CI: 0.56, 0.82) as a test for increased knee valgus during the SLS (**TABLE 2**).[201]

II Harris-Hayes et al[131] performed a cross-sectional study of 30 athletes to determine the reliability of video assessments of lower extremity movement patterns (FPPA) and the construct validity of the measurement. Observers classified lower extremity movement patterns as dynamic valgus (greater than 10° in the positive direction), dynamic varus (greater than 10° in the negative direction), or no change (less than 10° in either direction). They reported kappa values ranging from 0.80 to 0.90 for intratester reliability and 0.75 to 0.90 for intertester reliability.

III Piva et al[230] developed an assessment of the quality of movement during a lateral step-down test to assess lower extremity biomechanics during a dynamic task in individuals with PFP. Intertester reliability varies from 0.67 to 0.81 (95% CI: 0.58, 0.94),[81,230,242] with 80% rater agreement (**TABLE 2**).[230]

### Recommendation

B Clinicians should administer appropriate clinical or field tests that reproduce pain and assess lower-limb movement coordination, such as squatting, step-downs, and the SLS. These tests can assess a patient's baseline status relative to pain, function, and disability; global knee function; and changes in the patient's status throughout the course of treatment.

## PHYSICAL IMPAIRMENT MEASURES

### *Patellar Provocation Tests*

III Patellar pain provocation tests (compression test, Waldron test phases 1 and 2, patellar grind test, and Clarke's sign) have shown low diagnostic value.[63,65,126,210,215] Sensitivity, specificity, and likelihood ratios are available in **TABLE 3**.

### *Patellar Mobility Tests*

II The patellar tilt test, a measure of lateral retinacular tightness, has low to moderate intratester ($\kappa$ = 0.28-0.50) and intertester reliability ($\kappa$ = 0.19-0.71).[300,301] Yet, Haim et al[126] reported high specificity (0.92; 95% CI: 0.75, 0.98) and a moderate +LR of 5.4 for the patellar tilt test, meaning that a positive finding would be useful for ruling in a diagnosis of PFP.

II The vastus medialis coordination test was designed to assess the mobility of the patella during an active non–weight-bearing maneuver. Nijs et al[210] reported high specificity (0.93; 95% CI: 0.75, 0.99) and +LR (2.26; 95% CI: 1.9, 2.9) for this test (**TABLE 3**).

III There is a paucity of reliability and validity data for a number of tests to assess passive accessory motion of the patella relative to the femur (passive gliding patella, lateral pull test, patellar inferior pole test), with the reported data indicating poor to fair reliability ($\kappa$ = 0.31-0.59).[126,275,300] These patellar mobility tests demonstrate low diagnostic accuracy for PFP (**TABLE 3**).

### *Foot Position Tests*

II The navicular drop test is used to assess the amount of subtalar pronation.[263] Interrater and intrarater reliability (ICC = 0.87-0.93 and ICC = 0.78-0.81, respectively) for the navicular drop test in patients with PFP is good to excellent (**TABLE 3**).[16,230]

II Selfe et al[261] used the FPI to identify patients with pronated feet. The FPI is a 6-item scale that assesses foot position based on talar head palpation, the curvature above and below the lateral malleolus, rearfoot inversion/eversion, and forefoot abduction/adduction. Patients with higher scores have more pronated feet.[248,249,261] The reliability and validity of this measure are fair to good (ICCs from 0.52 to 0.93) (**TABLE 3**).[16,66,249]

III Midfoot width measured in a non–weight-bearing and a weight-bearing position has been used to measure foot mobility. Like the FPI, the midfoot width measurement has excellent reliability and validity (ICC = 0.97-0.99).[192] The $MDC_{95}$ is 0.14 cm for the midfoot difference in weight bearing and 0.31 cm for the midfoot difference in non–weight bearing.[192] Mills et al[196] reported that individuals with PFP who had a 1.1-cm or greater difference on the test had significantly greater improvements in pain with the use of foot orthoses compared to controls.

### Muscle Strength Tests

III The Hip Stability Isometric Test (HipSIT) is designed to measure the strength of the entire posterolateral hip musculature.[4] The HipSIT has demonstrated moderate to good concurrent validity compared to individual posterolateral hip muscles ($r$ = 0.51-0.65), with excellent intratester and intertester reliability (ICC = 0.98-0.99). The $MDC_{95}$ has been established for healthy controls (0.036 kg of force/kg of body mass) and those with PFP (0.034 kg of force/kg of body mass) (**TABLE 3**).[4]

IV Quadriceps strength testing with a mechanical dynanometer using a maximum voluntary isometric contraction is highly reliable (ICC = 0.97-0.98) (**TABLE 3**).[50]

A challenge is to measure hip and thigh strength to identify weakness. To date, isometric muscle testing with a handheld dynamometer has been the most widely used assessment tool.[286] Proper testing methods are key to reliable and accurate measurement (**TABLE 3**).[2,30,165]

### Muscle Length Tests

I Limited data exist regarding hip flexor length and hip internal and external rotation ROM. Hamstra-Wright et al[130] theorized that limited hip external rotation could contribute to increased femoral internal rotation during weight-bearing activities and increased lateral PFJ loading.

III Piva et al[230] established interrater reliability for tests commonly used to assess flexibility in patients with PFP. Hamstring, quadriceps, gastrocnemius, and iliotibial band length tests had poor to excellent reliability, with ICCs ranging from 0.29 to 0.97 (**TABLE 3**).[16,230] Piva et al[230] also performed a multivariate stepwise discriminant analysis to determine which measures were best for distinguishing between individuals with and without PFP. Of the flexibility measures, only the gastrocnemius and soleus lengths were identified. Weight-bearing ankle dorsiflexion ROM was the only factor associated with an increased FPPA during the SLS,[242] suggesting that gastrocnemius length may impact movement during the SLS.

### PFP Cluster of Findings

III A cluster of findings using a combination of history elements and common physical examination tests can be used to identify whether or not knee complaints are likely due to PFP.[81] Décary et al[81] proposed 2 clusters based on age, pain location, and clinical examination to help in the diagnosis of PFP. These clusters had a +LR of 8.70 (95% CI: 5.20, 14.58). Similarly, 3 clusters were identified to exclude PFP (−LR = 0.12; 95% CI: 0.06, 0.27) (**TABLE 4**).

### Recommendation

C When evaluating a patient with PFP over an episode of care, clinicians may assess body structure and function, including measures of patellar provocation, patellar mobility, foot position, hip and thigh muscle strength, and muscle length.

## BEST-PRACTICE POINT

### Essential Data Elements

Clinicians should document the following measures, at least at baseline and discharge or at 1 other follow-up point, for all patients with PFP to support standardization for quality improvement in clinical care and research.

### Diagnosis of PFP

- Retropatellar or peripatellar pain
- Reproduction of retropatellar or peripatellar pain with squatting, stair climbing or descent, prolonged sitting, or other functional activities loading the PFJ in a flexed-knee position
- Exclusion of all other possible sources of AKP
- Patellofemoral pain cluster of findings

### Classification of PFP

- Overuse/overload without other impairment
  - Eccentric step-down test
- PFP with muscle performance deficits
  - HipSIT
  - Thigh strength testing
- PFP with movement coordination deficits
  - Dynamic valgus on lateral step-down test
  - Frontal plane valgus
- PFP with mobility impairments
  - Hypermobility
    - Foot mobility testing
      - Midfoot width in non–weight bearing and weight bearing
      - FPI
  - Hypomobility
    - Lateral patellar retinaculum (patellar tilt test)
    - Muscle length testing
      - Hamstrings
      - Gastrocnemius
      - Soleus
      - Quadriceps
      - Iliotibial band
    - Hip internal and external rotation ROM testing

### Activity Limitations—Physical Performance Measures

- Pain with squatting

### Activity Limitations—Patient-Reported Measures

- AKPS or KOOS-PF for function
- VAS for usual pain and VAS for worst pain or NPRS

## TABLE 2 Activity Limitations: Physical Performance Measures

| Measure/Study | Level of Evidence | Reliability* Intratester | Reliability* Intertester | Diagnostic Accuracy† Sensitivity | Diagnostic Accuracy† Specificity | Diagnostic Accuracy† +LR | Diagnostic Accuracy† −LR |
|---|---|---|---|---|---|---|---|
| Pain with squatting[a] | | | | | | | |
| Cook et al[64] | I | | | 0.91-0.94 | 0.46-0.50 | 1.7-1.8 (1.3, 2.3) | 0.1-0.2 (0.1, 0.4) |
| Pain with stair climbing[b] | | | | | | | |
| Cook et al[64] | I | | | 0.75-0.94 | 0.43-0.45 | 1.3-1.7 (1.0, 1.9) | 0.1-0.6 (0.03, 1.1) |
| Pain with kneeling[c] | | | | | | | |
| Cook et al[63] | I | | | 0.84 (0.73, 0.92) | 0.50 (0.31, 0.69) | 1.7 (1.2, 2.4) | 0.3 (0.2, 0.6) |
| Lateral step-down test[d] | | | | | | | |
| Piva et al[230]; Rabin et al[242]; Décary et al[82] | III | | 0.67-0.81 (0.58, 0.94) | | | | |
| Frontal plane projection angle[e] | | | | | | | |
| Munro et al[201] | II | 0.72-0.88 | | | | | |
| Eccentric step-down test[f] | | | | | | | |
| Nunes et al[215] | I | | | 0.42 (0.25, 0.61) | 0.82 (0.62, 0.93) | 2.3 (1.9, 2.9) | 0.7 (0.6, 0.9) |

*Abbreviations: ICC, intraclass correlation coefficient; −LR, negative likelihood ratio; +LR, positive likelihood ratio.*
**Values are intraclass correlation coefficient (95% confidence interval).*
*†Values in parentheses are 95% confidence interval.*
*[a]The individual performs a squatting maneuver that feels normal to him or her.*
*[b]The individual climbs stairs in a manner that feels normal to him or her.*
*[c]The individual kneels in a manner that feels normal to him or her.*
*[d]The individual stands with the foot of the leg to be tested near the edge of a 20-cm-high step, with hands on hips and the contralateral leg over the floor and the knee in extension. She or he bends the knee of the leg on the step, lowering the contralateral leg until the foot lightly touches the floor, and then straightens the tested knee and returns to the start position. This motion is repeated 5 times. The examiner stands in front of the individual to observe the quality of movement. Each repetition is scored using the following point system: (a) 1 point for an arm strategy to maintain balance, (b) 1 point for trunk lean to either side, (c) 1 point for pelvic elevation and/or rotation to one side, (d) 1 point if the tibial tuberosity moves medial to the second toe or 2 points if the tibial tuberosity moves past the medial longitudinal arch of the foot, and (e) 1 point if the affected limb wavers from side to side. Total quality-of-movement scores are interpreted as follows: 0 to 1, good; 2 to 3, moderate; and 4 or greater, poor.*
*[e]A measure of knee valgus formed by a line drawn from the anterior superior iliac spine to the midpoint of the tibiofemoral joint, and another line drawn from the midpoint of the tibiofemoral joint to the midpoint of the ankle mortise.*
*[f]The individual steps down anteriorly with one leg from the platform as slowly and with as much control as possible.*

## TABLE 3 Physical Impairment Measures

| Measure/Study | Reliability* Intratester | Reliability* Intertester | Diagnostic Accuracy* Sensitivity | Diagnostic Accuracy* Specificity | Diagnostic Accuracy* +LR | Diagnostic Accuracy* −LR | $MDC_{95}$ |
|---|---|---|---|---|---|---|---|
| Patellar tilt test[a] | | | | | | | |
| Watson et al[300,301]; Haim et al[126] | $k$ = 0.28-0.50 | $k$ = 0.19-0.71 | 0.43 (0.31, 0.55) | 0.92 (0.75, 0.98) | 5.4 (1.4, 20.8) | 0.6 (0.5, 0.8) | |
| Patella alta test[b] | | | | | | | |
| Haim et al[126] | | | 0.49 | 0.72 | 1.75 | 0.71 | |
| Compression test[c] | | | | | | | |
| Cook et al[64]; Nunes et al[215] | | | 0.68-0.83 (0.54, 0.92) | 0.18-0.54 (0.06, 0.72) | 1.0-1.5 (0.8, 2.3) | 0.6-1.0 (0.3, 3.6) | |
| Waldron test: phase 1[d] | | | | | | | |
| Nijs et al[210] | | | 0.45 (0.28, 0.64) | 0.68 (0.48, 0.83) | 1.4 (0.6, 3.2) | 0.8 (0.4, 1.8) | |
| Waldron test: phase 2[e] | | | | | | | |
| Nijs et al[210] | | | 0.23 (0.10, 0.42) | 0.79 (0.59, 0.91) | 1.1 (1.0, 1.1) | 1.0 (0.9, 1.1) | |
| Patellar grind test (Clarke's sign)[f] | | | | | | | |

*Table continues on page CPG31.*

**TABLE 3** Physical Impairment Measures (continued)

| | Reliability* | | Diagnostic Accuracy* | | | | |
|---|---|---|---|---|---|---|---|
| **Measure/Study** | **Intratester** | **Intertester** | **Sensitivity** | **Specificity** | **+LR** | **−LR** | **$MDC_{95}$** |
| Nijs et al[210] | | | 0.48 (0.31, 0.67) | 0.75 (0.55, 0.89) | 1.9 (1.1, 3.6) | 0.7 (0.4, 1.3) | |
| Passive gliding patella: medial/lateral[g] | | | | | | | |
| Sweitzer et al[275] | | $\kappa$ = 0.59 (0.42, 0.72) | 0.54 (0.47, 0.59) | 0.69 (0.52, 0.83) | 1.8 (0.9, 3.6) | 0.7 (0.5, 1.0) | |
| Passive gliding patella: superior/inferior[g] | | | | | | | |
| Sweitzer et al[275] | | $\kappa$ = 0.55 (0.37, 0.69) | 0.63 (0.56, 0.69) | 0.56 (0.39, 0.72) | 1.4 (0.9, 2.5) | 0.7 (0.4, 1.1) | |
| Lateral pull test[h] | | | | | | | |
| Watson et al[300]; Haim et al[126] | $\kappa$ = 0.39-0.47 | $\kappa$ = 0.31 | 0.25 (0.17, 0.37) | 1.00 (0.87, 1.00) | Unable to calculate due to specificity of 1.00 | 0.8 (0.6, 0.9) | |
| Patellar inferior pole test[i] | | | | | | | |
| Sweitzer et al[275] | | $\kappa$ = 0.48 (0.27, 0.61) | 0.19 (0.13, 0.22) | 0.83 (0.68, 0.93) | 1.1 (0.4, 3.0) | 0.9 (0.8, 1.3) | |
| Vastus medialis coordination test[i] | | | | | | | |
| Nijs et al[210] | | | 0.16 (0.06, 0.35) | 0.93 (0.75, 0.99) | 2.26 (1.9, 2.9) | 0.90 (0.6, 0.98) | |
| Foot Posture Index[k] | | | | | | | |
| Cornwall et al[66] | ICC = 0.92-0.93 | ICC = 0.52-0.65 | | | | | |
| Barton et al[16] | ICC = 0.88-0.93 (0.67, 0.99) | ICC = 0.79-0.88 (0.47, 0.96) | | | | | |
| Midfoot width: weight bearing[l] | | | | | | | |
| McPoil et al[192] | ICC = 0.98-0.99 | ICC = 0.99 (0.98, 1.00) | | | | | 0.14 cm |
| Midfoot width: non–weight bearing[l] | | | | | | | |
| McPoil et al[192] | ICC = 0.97-0.98 | ICC = 0.97 (0.95, 0.98) | | | | | 0.31 cm |
| Navicular drop[m] | | | | | | | |
| Piva et al[230]; Barton et al[16] | ICC = 0.87-0.93 (0.55, 0.98) | ICC = 0.78-0.81 (0.34, 0.94) | | | | | |
| Hip Stability Isometric Test[n] | | | | | | | |
| Almeida et al[4] | ICC = 0.98-0.99 (0.97, 0.99) | ICC = 0.98 (0.97, 0.99) | | | | | 0.034-0.036 kg of force/kg of BW |
| MVIC quadriceps strength testing[o] | | | | | | | |
| Logerstedt et al[183,184] | | ICC = 0.97-0.98 | | | | | |
| Hamstrings length: knee extension angle[p] | | | | | | | |
| Gajdosik and Lustin[109]; Gajdosik et al[110]; Davis et al[79] | ICC = 0.94 | 0.99 | | | | | >20° indicated hamstrings muscle tightness |
| Quadriceps length[q] | | | | | | | |
| Piva et al[230] | ICC = 0.91 (0.80, 0.96) | | | | | | 10.53° |
| Gastrocnemius/soleus length[r] | | | | | | | |
| Piva et al[230]; Barton et al[16] | ICC = 0.38-0.92 (0.12, 0.96) | ICC = 0.29-0.76 (−0.18, 0.92) | | | | | 4.43° |

*Table continues on page CPG32.*

**TABLE 3** Physical Impairment Measures (continued)

| | Reliability* | | Diagnostic Accuracy* | | | | |
|---|---|---|---|---|---|---|---|
| Measure/Study | Intratester | Intertester | Sensitivity | Specificity | +LR | −LR | $MDC_{95}$ |
| Iliotibial band length (Ober test)[s] | | | | | | | |
| Piva et al[230] | ICC = 0.97 (0.93, 0.98) | | | | | | 5.82° |

*Abbreviations: BW, body weight; ICC, intraclass correlation coefficient; −LR, negative likelihood ratio; +LR, positive likelihood ratio; $MDC_{95}$, minimum detectable change at the 95% confidence level; MVIC, maximum voluntary isometric contraction.*

**Values in parentheses are 95% confidence interval.*

[a]*The individual is supine, with knees extended. The therapist attempts to tilt the lateral aspect of the patella beyond the horizontal position, using the thumbs on the lateral patellar border and the index fingers on the medial patellar border. The test is performed by moving the patella out of the trochlear groove laterally so that the anterior patella faces slightly medial.*

[b]*The individual is supine, with knees extended. The therapist compresses the inferior pole of the patella while flexing the knee.*

[c]*The individual is in a supine position, and the therapist pushes the patella directly into the femoral trochlea.*

[d]*The individual is in a supine position, and the therapist pushes the patella against the femur with one hand while passively flexing the knee with the opposite hand.*

[e]*The individual is in a standing position, and the therapist gently pushes the patella against the femur with one hand while the patient slowly performs a full squat.*

[f]*The individual is supine, with the knee in slight flexion (not full extension, as this is reported to possibly cause pinching of the suprapatellar pouch). The clinician glides the patella inferiorly and the individual contracts the quadriceps muscles.*

[g]*The individual is supine, with knees extended. The therapist glides the patella superiorly/inferiorly and medially/laterally.*

[h]*The individual is in a supine position, with the therapist stabilizing the test extremity in a neutral position, with the knee at 0° to 15° of flexion. The individual performs an isometric quadriceps muscle contraction while the therapist observes the movement of the patella, with and without slight pressure to the superior aspect of the patella.*

[i]*The individual is supine, with knees extended. The therapist applies posteriorly directed pressure to the superior patella to tilt the patella anteriorly at its inferior pole.*

[j]*The individual is supine, with knee extended. The therapist places a fist under the knee of interest and the individual then slowly extends the knee to full end-range extension.*

[k]*The individual stands in a relaxed-stance position on both legs and is instructed to stand still, with arms by the side and looking straight ahead. The assessor needs to be able to move around the individual during the assessment and to have uninterrupted access to the posterior aspect of the leg and foot. If an observation cannot be made (eg, because of soft tissue swelling), indicate on the data sheet that the item was not scored. A 5-point Likert-type scale, where lower scores represent a more supinated foot position and higher scores represent a more pronated position, is used.*

[l]*The individual stands in a relaxed-stance position on both legs. A caliper is used to measure the width of the midfoot at the point of 50% of the total foot length. Following weight-bearing measurements, the individual is seated on the end of a table so that both lower legs hang in a perpendicular position to the floor, with the feet non–weight bearing and the ankles slightly plantar flexed. In this position, the non–weight-bearing measurements of midfoot width are recorded.*

[m]*The individual is in weight bearing and the subtalar joint is positioned in a neutral position, based on the clinician's palpation. The distance from the floor to the navicular tubercle is then measured. The patient then relaxes from this position (ie, relaxed calcaneal stance) and the measure is repeated. The difference in distance from the navicular tubercle to the floor in both positions represents the amount of navicular drop.*

[n]*The individual is sidelying, with both legs positioned at 45° of hip flexion and 90° of knee flexion, with the limb to be tested superior to the opposite limb. The individual is instructed to lift the knee of the superior leg while keeping the heels in contact, so that the hip is in 20° of hip abduction. The dynamometer is laterally positioned 5 cm above the lateral tibiofemoral joint line. To ensure that the individual is exerting a maximal effort, he or she is familiarized with the procedure and receives verbal encouragement from the tester.*

[o]*The individual is seated, with hips and knees in 90° of flexion. The distal tibia is secured to the dynamometer force arm just proximal to the lateral malleolus, and rigid straps are used to stabilize the thigh and pelvis. The axis of rotation is adjusted to align with the lateral epicondyle of the femur. To ensure that the individual is exerting a maximal effort, he or she is familiarized with the procedure and receives verbal encouragement from the tester and visual feedback from the dynamometer's real-time force display. The individual performs 3 practice trials, and testing is initiated after 5 minutes of rest. For the test, the individual is instructed to maximally contract his or her quadriceps for 5 seconds. To avoid the influence of fatigue, the individual is given 2 to 3 minutes of rest between trials. A quadriceps index is calculated as a strength test score after testing is completed: (involved-side maximum force/uninvolved-side maximum force) × 100.*

[p]*The individual assumes a supine position on a mat table, with the hip of the tested leg flexed to 90° and the contralateral limb flush on the mat table. The knee of the tested leg is flexed to 90°. The clinician then extends the knee to the maximum position, per the patient's tolerance. The stationary arm of the goniometer is aligned with the greater trochanter. The axis of the goniometer is aligned with the lateral epicondyle of the knee. The movable arm of the goniometer is aligned with the lateral malleolus of the ankle. An additional measurement method is to use an inclinometer, which is zeroed on a horizontal surface prior to the measurement.*

[q]*The individual assumes a prone position. The ipsilateral knee is passively flexed to the maximum position, per the patient's tolerance, and anterior tilt of the pelvis and/or extension of the lumbar spine is avoided. The stationary arm of the goniometer is aligned with the greater trochanter. The axis of the goniometer is aligned with the lateral epicondyle of the knee. The movable arm of the goniometer is aligned with the lateral malleolus of the ankle. An additional measurement method is to use an inclinometer, which is zeroed on a horizontal surface prior to the measurement.*

[r]*The individual assumes a supine position on a mat table, with the ankle and foot suspended over the edge of the table and the ankle dorsiflexed in a subtalar joint neutral position. The stationary arm of the goniometer is aligned with the fibular head. The axis of the goniometer is placed just distal to the lateral malleolus. The movable arm of the goniometer is aligned parallel with the plantar aspect of the calcaneus and fifth metatarsal. To measure gastrocnemius length, the knee is extended to 0° and a measurement of ankle dorsiflexion is recorded. To measure soleus length, the knee is flexed to 45° and a measurement of ankle dorsiflexion is recorded.*

[s]*The individual assumes a sidelying position on a mat table, with the pelvis, trunk, and shoulders aligned in the vertical plane. The tested leg is positioned superiorly and the ipsilateral knee flexed to 90°. The clinician stabilizes the pelvis with the proximal hand while the inferior hand grasps just inferior to the knee. The clinician moves the individual's ipsilateral hip first in flexion, then through abduction and extension, until the hip is positioned in midrange abduction and neutral flexion and extension. The clinician then lowers the thigh into adduction (toward the table) until the thigh stops moving. A positive test is indicated when the thigh remains in an abducted position (above the horizontal) when the hip abductor muscles are not contracting. An additional measurement method is to use an inclinometer, which is zeroed on a horizontal surface prior to the measurement.*

**TABLE 4** Patellofemoral Pain Cluster of Findings[81]*

| | Sensitivity | Specificity | PPV | +LR | NPV | −LR |
|---|---|---|---|---|---|---|
| Two clusters in diagnosis of PFP | | | | | | |
| Cluster 1 | 0.64 (0.52, 0.75) | 0.93 (0.88, 0.96) | 0.76 (0.64, 0.86) | 8.70 (5.20, 14.58) | | |
| Aged <40 y<br>AND<br>Isolated anterior knee pain<br>OR<br>Medial patellar facet tenderness | | | | | | |
| Cluster 2 | | | | | | |
| Aged 40-58 y<br>AND<br>Isolated anterior or diffuse knee pain<br>AND<br>Mild to moderate difficulty descending stairs<br>AND<br>Medial patellar facet tenderness<br>AND<br>Full passive knee extension | | | | | | |
| Three clusters to exclude PFP | | | | | | |
| Cluster 1 | 0.92 (0.83, 0.97) | 0.65 (0.58, 0.71) | | | 0.96 (0.91, 0.98) | 0.12 (0.06, 0.27) |
| Aged <58 y<br>AND<br>Medial, lateral, or posterior knee pain<br>AND<br>No medial or lateral patellar facet tenderness | | | | | | |
| Cluster 2 | | | | | | |
| Aged <58 y<br>AND<br>Diffuse or lateral knee pain<br>AND<br>Medial or lateral patellar facet tenderness<br>AND<br>Restricted passive knee extension | | | | | | |
| Cluster 3 | | | | | | |
| Aged ≥58 y | | | | | | |

*Abbreviations:–LR, negative likelihood ratio; +LR, positive likelihood ratio; NPV, negative predictive value; PFP, patellofemoral pain; PPV, positive predictive value.*
**Values in parentheses are 95% confidence interval.*

CLINICAL PRACTICE GUIDELINES

# Interventions

## INTRODUCTION

The literature on nonsurgical interventions for individuals with PFP includes individual and combined interventions. The goal of trunk, hip, thigh, and lower extremity strengthening and stretching exercises is to address muscle performance deficits, movement coordination deficits, and mobility impairments. Exercise therapies consist of knee- and/or hip-targeted exercises performed in weight-bearing or non–weight-bearing positions, or both. Due to the heterogeneous nature and combination of multiple interventions for the treatment of individuals with PFP, results are often provided based on combined interventions. Combined interventions consist of 3 or more adjunctive interventions, such as foot orthoses, manual therapy, or patellar taping, with exercise therapy. Finally, adjunctive interventions such as biophysical agents, gait retraining, and dry needling were reviewed in isolation from exercise therapies when possible.

Each body of evidence was synthesized separately and then overall to support the overarching recommendation for each intervention. To maintain consistency with the most recent international expert consensus meeting on the treatment of PFP published in 2016,[75] systematic reviews and RCTs were assigned levels of evidence. These levels of evidence corresponded with the respective AMSTAR and Physiotherapy Evidence Database (PEDro) scores: high quality (7/10 or greater), moderate quality (4-6/10), and low quality (3/10 or less). Studies were assessed for outcomes in the short term (less than 3 months), medium term (3-12 months), and long term (greater than 12 months), as described by Lack et al.[168]

## SPECIFIC MODES OF EXERCISE THERAPY COMPARED WITH CONTROL

I A high-quality systematic review identified 38 level I and level II studies supporting combined interventions of exercise therapy, consisting of knee-targeted exercise therapy or knee- and hip-targeted exercise therapy, combined with foot orthoses, patellar taping, patellar mobilization, and/or vasti biofeedback for the treatment of PFP compared with no care or with placebo.[143] Four additional systematic reviews also support the use of combined interventions for the treatment of PFP.[54,164,168,289] Further, a 2016 Cochrane review concluded that exercise therapy reduces pain (SMD, –1.46; 95% CI: –2.39, –0.54) and improves function (SMD, 1.62; 95% CI: 0.31, 2.94) with moderate to large effect sizes, when compared with control or sham therapies, in the short term.[290] In the medium to long term, exercise therapy results in large reductions in usual pain (SMD, 4.32; 95% CI: 0.89, 7.75) and large improvements in function (SMD, 1.1; 95% CI: 0.58, 1.63) in individuals with PFP, when compared with control or sham therapies.[290]

### Gaps in Knowledge

Although exercise therapy is recommended for PFP to reduce pain in the short, medium, and long term, and to improve function in the medium and long term, optimal dosage is currently unclear, in part due to inadequate exercise reporting in the literature.[143] Further research is needed to understand which dosage parameters (eg, session duration and frequency, exercise intensity, etc) are associated with better pain, function, and quality-of-life outcomes.

### Knee-Targeted Exercise Therapy

#### *Non–Weight Bearing (Open Chain) Versus Weight Bearing (Closed Chain)*

Evidence suggests that weight-bearing and non–weight-bearing quadriceps-strengthening exercises result in differential patterns of PFJ loading.[98,239] Therefore, non–weight-bearing and weight-bearing exercises each have theoretical advantages and disadvantages that may influence a patient's response.

#### *Short-term Outcomes*

II Two moderate-quality RCTs have compared short-term outcomes in individuals with PFP who completed programs of either non–weight-bearing or weight-bearing knee-targeted exercises. In a moderate-quality RCT, Herrington and Al-Sherhi[135] reported equivalent reductions in pain and improvement in function at 6 weeks in individuals who completed weight-bearing versus non–weight-bearing knee-targeted exercises. Most importantly, both weight-bearing and non–weight-bearing knee-targeted exercises were superior to control (wait and see).[135]

Similarly, a moderate-quality RCT by Bakhtiary and Fatemi[14] reported large pain reductions in individuals with PFP who completed a 6-week program of either non–weight-bearing or weight-bearing knee-targeted (quadriceps-strengthening) exercises, with no differences between the 2 exercise modes. Bakhtiary and Fatemi[14] did not include a no-intervention control group, and therefore it is unclear whether findings of pain reductions in either exercise group would exceed "wait and see."

### Medium-term Outcomes

II In the medium term, a moderate-quality RCT by Witvrouw et al[314] reported that 5 months of weight-bearing knee-targeted exercise resulted in only slightly greater reductions in pain, rated on a VAS, in individuals with PFP compared with those treated with non–weight-bearing knee-targeted exercise. They reported no differences in functional outcomes between the 2 groups in the medium term.[314] However, it should be noted that there was no control group. Therefore, it is unclear whether medium-term outcomes for either weight-bearing or non–weight-bearing knee-targeted exercises are greater than "wait and see."

### Long-term Outcomes

I Five-year outcomes from a high-quality RCT[312] reported that while both non–weight-bearing and weight-bearing exercises reduced PFP, neither was superior. At the 5-year follow-up, slightly higher functional scores on the AKPS were reported in those treated with non–weight-bearing exercises.

### Gaps in Knowledge

While neither weight-bearing nor non–weight-bearing knee-targeted exercise therapy demonstrated superiority compared to one another in the short, medium, and long term,[132,164,250,289] it is not yet known whether either is superior to control in the medium and long term.

## High Versus Low Volume of Knee-Targeted Exercise Therapy While Avoiding Pain

II A single moderate-quality RCT reported greater short- and medium-to-long-term reductions in pain and improvements in function with the step-down test using a high-volume (3 sets of 30 or more repetitions, 3 times per week for 12 weeks), knee-targeted exercise therapy program (deloaded, unweighted) that avoided any pain exacerbation; it was coupled with 30 minutes of aerobic cycling and compared with a low-volume exercise program (3 sets of 10 repetitions, 3 times per week for 12 weeks) that also avoided pain exacerbation and included 10 minutes of aerobic cycling.[217,218,289]

### Gaps in Knowledge

The cited evidence to support high-volume exercise is from a single cohort and lacked a control group of wait and see. Thus, additional research is needed to make a definitive recommendation regarding high- versus low-volume knee-targeted exercise therapy.

## Hip-Targeted Exercise Therapy Compared With Control

### Short-term Outcomes

II A single moderate-quality RCT compared a group that received 8 weeks of non–weight-bearing, hip-targeted exercise therapy utilizing elastic bands to a group that received a control therapy of nutritional supplementation for the treatment of PFP.[159] In the short term, large reductions in pain (SMD, 2.80; 95% CI: 1.71, 3.88) and improvements in function on the WOMAC (SMD, 2.88; 95% CI: 1.78, 3.98) were reported for the hip-targeted exercise therapy group when compared with the control.

### Gaps in Knowledge

Due to the moderate quality of evidence supporting hip-targeted exercise therapy compared with control, further high-quality RCTs evaluating the efficacy of hip-targeted exercise therapy in the medium and long term, along with consideration of optimal dosage parameters, may allow a more definitive recommendation.

## Hip-Targeted Exercise Therapy Compared With Knee-Targeted Exercise Therapy

### Short-term Outcomes

I A high-quality RCT assessed an 8-week intervention of hip-targeted exercises compared with knee-targeted exercises and reported superior outcomes for pain and function in the group that completed the hip-targeted exercises.[84] It should be noted that weight-bearing exercises, including leg presses, step-downs/step-ups, and squats, were considered, in addition to resisted non–weight-bearing knee extension exercises, to be knee-targeted exercises. Indeed, these weight-bearing exercises result in high levels of gluteal activity.[251] The hip-targeted exercise group completed exercises that included non–weight-bearing hip-strengthening exercises but also several weight-bearing exercises, such as the SLS and lunges, that have previously been reported to result in high levels of quadriceps muscle activity (greater than 50% to 60% maximal voluntary isometric contraction).[26,104]

I In a high-quality RCT,[3] individuals with PFP randomized to 4 weeks of isolated hip-targeted exercise therapy prior to 4 weeks of isolated knee-targeted exercise therapy experienced greater improvements in hopping performance and functional scores (via the Kujala questionnaire) compared with individuals who received 4 weeks of knee-targeted exercise therapy prior to 4 weeks of hip-targeted exercise therapy. Regardless of group assignment, all exercises were performed for 3 sets of 10 repetitions at 60% of 10-repetition maximum.

I Two high-quality meta-analyses found small short-term effects favoring hip-targeted exercises over knee-targeted exercises for improving pain (SMD, 0.36; 95% CI: 0.13, 0.59) and function (SMD, 0.18; 95% CI: 0.05, 0.42) in individuals with PFP.[168,289] Caution is urged, as these meta-analyses included the studies by Ferber et al[105] and de Marche Baldon et al[84] as hip-targeted exercises versus

knee-targeted exercises, despite the confounding nature of their respective exercise programs.

II In a moderate-quality trial, Ferber et al[105] reported that 6 weeks of hip-targeted exercises or knee-targeted exercises both reduced pain and improved function via AKPS scores in individuals with PFP, but there were no differences between the groups. The hip-targeted exercise group performed standing exercises that used a cable column to provide external resistance to the hip abductors and hip internal and external rotator musculature. The knee-targeted exercise group performed non–weight-bearing and weight-bearing exercises. Non–weight-bearing exercises included isometric quadriceps exercises and knee extension exercises, whereas weight-bearing exercises included step-downs, the SLS and double-leg squats, and forward lunges. Care should be taken when interpreting the findings,[105] as high levels of hip muscle activity (greater than 60% maximal voluntary isometric contraction) were previously reported in the weight-bearing knee exercises used in this study.[99,251] No wait-and-see control group was included in this study.[105]

II Two moderate- and 1 high-quality RCTs compared hip exercises that targeted the posterolateral hip musculature (eg, sidelying hip abduction) to knee-targeted exercises that targeted the quadriceps musculature (eg, non–weight-bearing knee extension).[90,105,158] All 3 studies reported that hip-targeted exercise therapy resulted in superior outcomes relating to pain reduction and improved function compared with knee-targeted exercise therapy.

In contrast, a moderate-quality RCT[31] found improvements in pain and function, assessed via a VAS and the AKPS, in individuals who received 6 weeks of either knee-targeted exercise therapy or hip- and core-targeted exercise therapy. However, there were no between-group differences. Because a control group was not included, it is unknown whether improvements with either exercise protocol were greater than "wait and see."

### *Medium-term Outcomes*

I Based on 2 high-quality RCTs,[83,158] a 2015 high-quality systematic review concluded that hip-targeted exercise resulted in medium effects of greater pain reduction (SMD, 1.07; 95% CI: 0.55, 1.59) and PROMs (SMD, 0.87; 95% CI: 0.36, 1.37) compared with knee-targeted exercise in the medium term.[167]

### *Gaps in Knowledge*

While short- and medium-term outcomes favor hip-targeted exercise therapy over knee-targeted therapy, long-term outcomes are currently unknown. Further research should include evaluation of long-term outcomes across diverse populations, in particular high-demand athletes and adolescents, as nothing is known about the effectiveness of hip-targeted versus knee-targeted exercise therapy for PFP treatment in these population subsets. Finally, greater consistency in the delineation of hip-targeted exercise therapy and knee-targeted exercise therapy will assist with interpretation and implementation of results from future clinical trials.

## Combined Hip- and Knee-Targeted Exercise Therapy Compared With Knee-Targeted Exercise Therapy Alone

### *Short-term Outcomes*

I Compared with knee-targeted exercise therapy, 3 high-quality meta-analyses agree that the combination of hip- and knee-targeted exercise therapy resulted in better outcomes in the short term.[168,204,289] Specifically, 1 meta-analysis found small effects favoring combined hip- and knee-targeted exercises compared with knee-targeted exercises with respect to usual pain (SMD, 0.55; 95% CI: 0.22, 0.59) and patient-reported function (SMD, 0.42; 95% CI: 0.03, 0.81).[168] However, it is noteworthy that the majority of the RCTs included in the meta-analyses did not control for exercise volume in the respective knee-targeted and combined hip- and knee-targeted exercise protocols. Therefore, the differences in patient outcomes may be due to greater exercise volume in the combined hip- and knee-targeted exercise protocols.

### *Medium-term Outcomes*

I Based on 2 high-quality RCTs,[90,107] 2 high-quality meta-analyses reported large effects for pain reduction in the medium term in favor of combined hip- and knee-targeted exercise therapy over knee-targeted exercise therapy.[168,289] Similarly, these meta-analyses[168,289] reported large effects in favor of combined hip- and knee-targeted exercise therapy for improvements in patient-reported function, based on 2 high-quality RCTs.[90,107] A high-quality RCT reported a large effect in favor of combined hip- and knee-targeted exercise therapy over knee-only exercise therapy on single-leg hop scores in the medium term (SMD, 1.54; 95% CI: 0.89, 2.18).[107]

### *Long-term Outcomes*

I To date, only 1 high-quality RCT compared long-term outcomes for pain, patient-reported function, and functional performance between patients who received either combined hip- and knee-targeted exercise therapy or knee-only targeted exercise therapy. Fukuda et al[107] reported a large effect in favor of combined hip- and knee-targeted exercise therapy over knee-targeted exercise alone on pain reduction (SMD, 2.99; 95% CI: 2.16, 3.83), patient-reported function on the LEFS (SMD, 2.65; 95% CI: 1.86, 3.43) and AKPS (SMD, 1.78; 95% CI: 1.12, 2.45), and on the single-leg hop test (SMD, 2.1; 95% CI: 1.40, 2.79).

### Gaps in Knowledge

More high-quality RCTs are needed in specialized populations, such as high-demand athletes or adolescents, and to determine optimal dosage parameters for combined hip- and knee-targeted exercise. Future RCTs should also match exercise volume between knee-targeted and combined hip- and knee-targeted exercise programs.

### Recommendation

A Clinicians should include exercise therapy with combined hip- and knee-targeted exercises in the treatment of individuals with PFP 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.

## Patellar Taping

Many taping protocols for individuals with PFP have been proposed and evaluated in the literature, with each aimed at altering PFJ kinematics to reduce PFJ stress.[67] Common methods include the tailored McConnell taping technique, where rigid taping is applied with the aim of reducing any combination of lateral patellar glide, tilt, and rotation,[67] to reduce pain during a functional task (eg, step-down) during the clinical consultation. Other common methods include untailored medial patellar glide–only taping[156] and taping aimed at enhancing vastii muscle activation and synergy.[176]

I Pooled data from 6 high-quality studies indicate that tailored patellar taping provides large reductions in pain (SMD, 2.43; 95% CI: 1.98, 2.89) during a range of functional tasks in the immediate term.[15] Specifically, tailored patellar taping involves a combination of techniques to support patellar tilt, glide, and rotation, tailored to optimize pain outcomes during a functional task (eg, step-down). Pooled data from 3 high-quality studies indicate that untailored medially directed taping (ie, 1 strip of tape) produces immediate, small pain reductions (SMD, 0.50; 95% CI: 0.22, 0.79) during functional tasks.

I There are conflicting findings from 4 high-quality systematic reviews regarding the potential value of patellar taping beyond the immediate term.[15,42,60,274] Specifically, systematic reviews have reported no benefit, conflicting evidence, and large positive benefits of patellar taping for pain.[15,42] The inconsistencies relate to different meta-analysis processes and definitions of time points, types of taping (tailored and untailored), and subsequent pooling. For example, Callaghan and Selfe's[42] Cochrane review reported no benefit from taping, but defined "short term" as 3 months or less and pooled findings of various taping techniques and time points from 1 week to 3 months. Collins et al[60] and Barton et al[15] considered taping techniques and time points separately. Both reviews reported limited evidence from 1 high-quality study[305] indicating that tailored patellar taping combined with exercise produces large reductions in pain (effect size unable to be estimated, as the taping group was pain free) in the short term (4 weeks). Additionally, these reviews reported limited evidence from 1 high-quality study[53] that combining medially directed, untailored taping does not provide any additional benefit to exercise and education, or education alone. Taping applied with the aim of enhancing muscle function does not provide any benefits in relation to pain and function when combined with exercise therapy.[15]

II A 2018 moderate-quality RCT reported no added improvements in pain or function when patellar taping was combined with intensive physical therapy (12 sessions over 4 weeks), including knee-targeted exercise and manual therapy.[114] However, interpretation of how to apply these findings is challenging because taping methods were poorly described in this study.

II A 2017 moderate-quality RCT reported equivalent outcomes for pain or function after comparing supervised exercise therapy targeting the hip and knee (12 sessions over 6 weeks), when combined with taping to facilitate medial quadriceps activity, to sham taping and no taping.[123]

### Gaps in Knowledge

Although tailored patellar taping in conjunction with exercise therapy appears to improve outcomes in the short term for individuals with PFP, long-term evaluation of taping approaches for PFP is needed.

### Recommendation

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.

## Patellofemoral Knee Orthoses (Bracing)

I Comparing patellofemoral knee orthoses (knee brace, sleeve, or a patellar strap) plus exercise therapy versus exercise therapy alone, a high-quality 2015 Cochrane review[267] concluded that patellofemoral knee orthoses did not have a meaningful effect on pain in the short term (mean difference, −0.46; 95% CI: −1.16, 0.24). The Cochrane review noted the very low quality of evidence and heterogeneity of the types of braces (knee brace, sleeve, and strap) across the various studies.[267]

### *Gaps in Knowledge*

Considering the low quality of research on patellofemoral knee orthoses, further high-quality clinical trials are needed to compare the impact of different types of braces on pain and functional outcomes when combined with exercise.

### *Recommendation*

B Clinicians should not use patellofemoral knee orthoses, including braces, sleeves, or straps, for the treatment of individuals with PFP.

## Foot Orthoses

The presence of excessive static or dynamic foot pronation has traditionally been the rationale for prescribing foot orthoses for individuals with PFP[122]; however, the results are inconsistent. Some studies indicate a likelihood of success with signs of greater dynamic pronation[22] or foot mobility,[21,196,273,296] some report success with signs of less foot mobility,[21,196,273,296] and others report success unrelated to foot posture and mobility.[21,196,273,296] Based on moderate- and high-quality systematic reviews and panel voting, the 2016 international expert consensus meeting[75] concluded that prescribing prefabricated foot orthoses may be useful for short-term pain reduction.

I A high-quality Cochrane review of 2 studies involving 210 participants reported that foot orthoses resulted in better improvements in knee pain (risk ratio = 1.48; 95% CI: 1.11, 1.99) compared with flat orthoses at the 6-week time point, but not at 1-year follow-up.[145] The combination of physical therapy and foot orthosis intervention demonstrated no significantly greater improvements in PROMs than physical therapy alone at any time point.

I A high-quality systematic review by Matthews et al[189] reported 14 factors associated with a successful outcome after foot orthosis treatment across 6 studies. Barton et al[21] reported that the presence of any 3 of 4 predictors (footwear motion-control properties greater than 5.0, usual pain on a VAS less than 22.0/100 mm, weight-bearing ankle dorsiflexion ROM less than 41.3° with the knee flexed, and reduced pain during the SLS) increased the likelihood of success for foot orthoses for PFP by 11.1 times (95% CI: 2.7, 46.9). Vicenzino et al[296] reported that the presence of any 3 of the following 4 predictors (age greater than 25 years, midfoot-width difference greater than 10.96 mm, height less than 165 cm, and worst pain on a VAS less than 53.25/100 mm) increased the likelihood of success for foot orthoses for PFP by 8.8 times (95% CI: 1.2, 66.9).

I In 2 high-quality RCTs, prefabricated foot orthoses modified to optimize comfort were reported to provide greater global improvement in patients with PFP when compared to flat inserts at 6 weeks.[56,196] However, one of these high-quality studies indicated that there was no clear benefit of adding prefabricated foot orthoses to a combined physical therapy program over a combined physical therapy program alone in the short (6 weeks), medium (12 weeks), or long (52 weeks) term.[56]

I A 2018 high-quality RCT indicated that in a subgroup of people with PFP and excessive static rearfoot eversion (greater than 6°), supervised foot-targeted exercises (12 sessions over 3 months) and customized foot orthoses, combined with 3 sessions of physical therapy (education, manual therapy, and knee-targeted exercises), produced superior pain and function outcomes at 4 months compared with 3 sessions of physical therapy alone.[197] No between-group differences were found at 12 months. Due to the study design, it is unclear whether superior outcomes were the result of the additional foot-targeted exercise, foot orthoses, or additional extensive physical therapy contact.

II A moderate-quality systematic review of 7 studies involving 700 participants (76.8% female) reported that, despite limited evidence, prefabricated foot orthoses, as compared with flat inserts, provided greater short-term (6 weeks) improvements in function as measured by self-reported outcomes and global improvement scores.[23] The addition of physical therapy interventions to the foot orthosis intervention demonstrated significantly greater improvements in the FIQ in the short term and in the AKPS in the intermediate term.

### *Gaps in Knowledge*

Due to the study design and findings of Mølgaard et al,[197] future research should aim to determine whether customized foot orthoses, coupled with supervised foot-targeted exercises, are superior to education, manual therapy, and knee-targeted exercise therapy in the short and medium term, provided that the dosage of physical therapy is matched between interventions. None of the clinical prediction studies have been validated with appropriate follow-up methodology, indicating that further work is necessary before guidance on who is most likely to benefit from foot orthoses can be provided to help guide clinical practice.

*Recommendation*

A Clinicians should prescribe prefabricated foot orthoses for those with greater than normal pronation to reduce pain in individuals with PFP, 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.

## Biofeedback

### *EMG-Based Biofeedback-Assisted Knee Exercise Therapy*

II Electromyography-based biofeedback has been proposed to encourage preferential recruitment of the medial vastii musculature to reduce lateral patellofemoral tracking in individuals with PFP.[180] Two moderate-quality RCTs have examined whether EMG-based biofeedback can improve therapeutic outcomes in individuals with PFP; both reported no added benefit over knee-targeted (quadriceps) exercise alone.[94,321] Subsequent low- and high-quality meta-analyses concluded that biofeedback-assisted quadriceps exercise therapy had no added benefit over knee-targeted (quadriceps) exercise therapy alone for the treatment of PFP. Because there was no control group in these studies, it is not possible to determine whether the knee-targeted exercise programs used in these studies were superior to wait and see.[60,169,299]

*Recommendation*

B Clinicians should not use EMG-based biofeedback on medial vastii activity to augment knee-targeted (quadriceps) exercise therapy for the treatment of PFP.

## Hip- and Knee-Targeted Exercise Therapy Completed With Visual Biofeedback Compared With Hip- and Knee-Targeted Exercise Therapy in the Absence of Visual Biofeedback

### *Short-term and Medium-term Outcomes*

I A single high-quality RCT found that improvements in reported pain and function (assessed via the AKPS) were noted after 4 weeks of rehabilitation and at 3 and 6 months post rehabilitation in individuals with PFP, regardless of whether visual biofeedback on lower extremity alignment was provided during combined hip and knee exercises, such as the SLS.[90] Furthermore, there were no differences in trunk and lower extremity mechanics between the 2 treatment groups during a single-leg step-down task after rehabilitation was completed. Last, while both groups exhibited increased posterolateral hip and quadriceps isometric strength after the intervention, there were no differences between groups.

*Recommendation*

B Clinicians should not use visual biofeedback on lower extremity alignment during hip- and knee-targeted exercises for the treatment of individuals with PFP.

## Running Gait Retraining

I One high-quality RCT studied patient education focused on load management (avoid running hills and reduce run-session volume while increasing session frequency) combined with five 10-minute sessions of instruction on running modification. The running modification education consisted of instruction to increase running cadence, reduce audible sound of foot strike, and/or alter foot strike from rearfoot to forefoot. However, combining patient education on load management with running modification was no more effective in the medium term than patient education on load management alone for runners with PFP, and was no more effective than hip- and knee-targeted exercise therapy plus patient education.[100] There was no control group included in this study. Therefore, it is unknown whether the improvements noted with the 3 interventions exceeded "wait and see."

II In a moderate-quality RCT, 8 sessions of gait retraining over 2 weeks in rearfoot-strike runners, consisting of cuing to alter foot strike from rearfoot to forefoot using a faded-feedback design, were more effective at reducing pain immediately following the conclusion of the retraining period and at short-term follow-up (4 weeks) compared with a control group that received a graded increase in running volume matching the gait retraining group.[252]

II A moderate-quality RCT reported that runners treated with 10 sessions of gait retraining to increase running cadence by 10%, combined with the use of minimalist, barefoot-mimicking footwear for 20% of running volume, had greater pain reductions compared with runners treated with foot orthoses prescribed to optimize comfort.[35]

III A 2016 systematic review based on 2 moderate-quality case series[212,309] concluded that 8 sessions of gait retraining using visual feedback and a faded-feedback design on what were deemed to be excessive proximal running mechanics (ie, peak hip adduction) during running resulted in large reductions in pain as assessed with a VAS (SMD, 3.84; 95% CI: 2.70, 4.98), with concurrent large increases in function as measured by the LEFS (SMD, 2.16; 95% CI: 1.29, 3.03).[206]

*Gaps in Knowledge*

Further research should include comparisons of running gait retraining, patient education, and hip- and knee-targeted exercise therapy, with an adequate length of interventions and long-term follow-up. It should be determined whether gait retraining needs to be targeted to a specific running mechanism thought to contribute to the etiology of PFP, or whether

gait retraining can be applied evenly across runners regardless of running mechanics. It is currently unknown which criteria identify patients with PFP who would benefit the most from the addition of gait retraining to their rehabilitation programs. Because the retraining interventions that resulted in a reduction in pain were associated with more intensive retraining (ie, more retraining sessions), future research should also assess optimal dosage of retraining sessions. With the majority of this research involving small RCTs (10 per group) or case series, it is unclear which gait retraining intervention is most effective, and whether it is superior to patient education on load management.

### *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.

## Blood Flow Restriction Training Plus High-Repetition Knee-Targeted Exercise Therapy

I A single level I high-quality RCT reported no difference in Kujala score or worst pain between healthy adults with PFP who received 8 weeks of standard knee exercise therapy (3 sets of 7 to 10 repetitions at approximately 70% of 1-repetition maximum) and those who received 8 weeks of blood flow restriction training plus high-repetition knee exercise therapy (1 set of 30 repetitions or volitional failure, followed by 3 sets of 15 repetitions, all at 30% of 1-repetition maximum).[115] While a significantly greater reduction in pain VAS score during ADLs was observed in the blood flow restriction group compared with standard knee-targeted exercise therapy, between-group differences on the VAS did not exceed the MCID (20 mm).[58] A subgroup analysis revealed that those with painful resisted knee extension experienced greater increases in quadriceps strength with blood flow restriction therapy plus knee exercise therapy than did those who received only standard knee exercise therapy.

### *Evidence Synthesis and Gaps in Knowledge*

Additional studies are required to make a definitive recommendation regarding the use of blood flow restriction training in conjunction with high-repetition knee exercise therapy for the treatment of individuals with PFP. Future high-quality RCTs should utilize appropriately powered sample sizes to more clearly identify subgroups of people, such as individuals with painful resisted knee extension, who may experience greater improvements with blood flow restriction training and across various demographics. While blood flow restriction therapy appears to be safe and to present no greater risk than standard strengthening programs in healthy, active individuals, less active individuals may be at greater risk for adverse events, such as rhabdomyolysis.[147]

### *Recommendation*

F Clinicians may use blood flow restriction plus high-repetition knee exercise therapy, while monitoring for adverse events, for those with limiting painful resisted knee extension.

## Needling Therapies

Two common forms of needling used in practice have been evaluated in the literature. These include acupuncture (Eastern medicine) and dry needling (Western medicine). While acupuncture is not practiced by physical therapists in the United States, it is practiced by physical therapists in other countries, such as the United Kingdom and Australia.

I A single high-quality RCT reported no added improvements in patient pain or function after 3 sessions of trigger point dry needling of the vastii musculature when combined with knee exercise therapy and manual therapy targeting the PFJ.[102]

I A single high-quality RCT comparing trigger point dry needling (6 sites in the quadriceps) to sham (same 6 sites using a sharp object with a plastic guide tube, but not puncturing the skin) reported no benefit of dry needling on pain or disability in individuals with PFP immediately or 72 hours following treatment.[273]

II A single moderate-quality RCT, synthesized in a high-quality systematic review, indicates that acupuncture produces a moderate positive effect on pain reduction compared to no treatment in the medium term (5 months) (SMD, 0.65; 95% CI: 0.13, 1.16).[60]

### *Evidence Synthesis and Gaps in Knowledge*

Although 1 study points to the effectiveness of acupuncture, this was in comparison to no treatment, highlighting the need for a placebo/sham-controlled trial. Additionally, acupuncture has not been evaluated in comparison to, or in combination with, exercise therapy. Therefore, it is unclear whether similar findings to those identified with dry needling may occur (ie, no added value to exercise therapy). No studies have compared acupuncture to dry needling approaches in individuals with PFP. These gaps in research should be addressed to allow clearer recommendations in relation to acupuncture.

### *Recommendations*

A Clinicians should not use dry needling for the treatment of individuals with PFP.

C Clinicians may use acupuncture to reduce pain in individuals with PFP. However, caution should be exercised with this recommendation, as the superiority of acupuncture over placebo or sham treatments is unknown. This recommendation should only be incorporated in settings where acupuncture is within the scope of practice of physical therapy.

### Manual Therapy as a Stand-Alone Treatment

A 2018 low-quality systematic review concluded that there is no benefit from manual therapy (patellar or lumbar) in isolation.[150]

Patellar mobilization has been combined with other physical therapy interventions with reported effectiveness. There is a high degree of variance in the practice of manual therapy in clinical practice and when evaluated in research, with each having different rationales for its use, including improved local and remote joint mobility and reduced muscle and fascial tension.

I A high-quality RCT reported greater reduction in pain following retropatellar and peripatellar ischemic pressure (15 sessions) compared to hip musculature ischemic pressure (15 sessions), but no control group was included.[127]

II A low-quality RCT[226] synthesized in 2 systematic reviews (1 of high quality and the other of low quality)[60,150] concluded that 2 weeks of treatment with medial glides, tilt mobilizations, and local lateral retinacular massages did not result in reduced levels of pain when compared with a no-intervention control.

II A moderate-quality RCT[269] synthesized in a high-quality systematic review[60] yielded no benefit by adding spinal manipulation to patellar mobilization over 4 weeks.

II A moderate-quality RCT reported greater reduction in resting pain when exercise was combined with knee mobilization with movement (tibiofemoral) compared to exercise combined with an elastic taping method.[85]

II A moderate-quality RCT reported that the addition of 12 patellar taping applications may be more beneficial for reducing pain than 12 sessions of patellar mobilization, when combined with an exercise program of stretching and combined knee- and hip-targeted exercise.[160] The time frame for delivery of these sessions could not be determined.

#### *Gaps in Knowledge*

Low-quality systematic reviews on manual therapy have frequently included studies in which the effects of manual therapy could not be differentiated from exercise therapy, indicating a need for greater stringency with inclusion criteria and methodological design. With most of the current evidence relating to single moderate-quality RCTs, further high-quality RCTs evaluating the efficacy of combining manual therapy with exercise therapy are needed to allow more definitive recommendations.

#### *Evidence Synthesis and Clinical Rationale*

Based on evidence from high-quality systematic reviews and panel voting, the most recent international expert consensus meeting[75] concluded that manual therapy, including lumbar, knee, or patellofemoral manipulation/mobilization, may not improve outcomes, particularly when used in isolation. Although manual therapy has been used in evidence-based combined interventions, its use may not improve outcomes, particularly when used in isolation, and thus is not recommended. Because exercise therapy is the consistent component in combined intervention studies, manual therapy should not reduce the time available to provide appropriate exercise therapy in patients with PFP.

#### *Recommendation*

A Clinicians should not use manual therapy, including lumbar, knee, or patellofemoral manipulation/mobilization, in isolation for patients with PFP.

### Biophysical Agents

#### *Neuromuscular Electrical Stimulation–Assisted Quadriceps Exercise Therapy Compared With Quadriceps Exercise Therapy Alone*

II A single moderate-quality RCT reported no added benefit of neuromuscular electrical stimulation targeting the vastus medialis musculature plus knee-targeted (quadriceps) exercise therapy when compared to exercise therapy alone.[27]

II A low-quality systematic review subsequently concluded that neuromuscular electrical stimulation does not have any added benefit when combined with quadriceps exercise therapy for the treatment of PFP.[169]

### Ultrasound and Other Electrophysical Agents

Based on evidence from low- and moderate-quality systematic reviews and panel voting, the 2016 international expert consensus meeting[75] concluded that ultrasound and other electrophysical agents may not improve outcomes.

II A low-quality systematic review of 12 studies evaluated the use of several different electrophysical agents for PFP treatment.[169] One low-quality study

evaluated the effects of multimodal interventions (ultrasound and ice massage, ice bags, phonophoresis, and iontophoresis) on symptoms and thigh muscle strength, functional measures, and thigh muscle activation; 3 studies evaluated the effects of electrical stimulation on pain; and 1 study reported on the effects of laser therapy. This review reported no additional benefits from these electrophysical agents for the management of PFP.

### Recommendation

**B** Clinicians should not use biophysical agents, including ultrasound, cryotherapy, phonophoresis, iontophoresis, electrical stimulation, and therapeutic laser, for the treatment of patients with PFP.

## Patient Education

Currently, there is no evidence from RCTs to support the benefits of education compared to control, wait and see, or in addition to interventions such as exercise therapy when treating PFP. Previous investigations evaluating patient education have used it as a comparison intervention or in addition to other interventions like exercise therapy. The majority of this research generally indicates that combining exercise therapy with education produces superior outcomes to education alone.[53,198,247,268,292] However, the specifics of education provided in these studies are not clear, and, as such, value and quality are unable to be determined. In a recent moderate-quality RCT by Esculier et al[99] in runners with PFP, education related to load management alone produced similar outcomes for running-related pain when compared with education combined with 8 weeks of exercise therapy, and education combined with running retraining primarily focused on increasing cadence. This highlights the potential value of education, but more research is needed in this area. Regardless of the limited evidence base to support patient education in the management of PFP, international experts suggest that it may be the key to successful management.[18]

### Gaps in Knowledge

Due to the limited and low quality of evidence available, further research is needed to determine the effectiveness of patient education for individuals with PFP. It is presently unknown whether tailored patient education is superior to universal patient education. Recently, it was determined that tailored online education delivered every other week was more effective than a single session of general education on injury prevention strategies for runners[136]; however, the effects on risk of PFP were not studied. Thus, the most effective frequency and mode of delivery of patient education are also in need of further study.

### Recommendation

**F** Clinicians may include specific patient education on load management, body-weight management when appropriate, the importance of adherence to active treatments like exercise therapy, biomechanics that are thought to contribute to relative overload of the PFJ, the evidence for various treatment options, and kinesiophobia. Patient education may improve compliance and adherence to active management and self-management strategies and is unlikely to have adverse effects.

## Combined Interventions

Combined interventions consist of combining 3 or more of the following interventions: foot orthoses, EMG biofeedback for vastii retraining, patellar mobilizations, patellar taping, and exercise therapy.

### Short-term Outcomes

**I** Based on 2 high-quality RCTs,[57,68] a high-quality meta-analysis concluded that 6 weeks of combined interventions (knee- and hip-targeted exercise therapy combined with directional patellar taping, patellar mobilizations, and EMG biofeedback) is superior to placebo (sham shoe inserts or sham physical therapy), with moderate effects (SMD, 1.08; 95% CI: 0.73, 1.43).[60] Exercise therapy combined with foot orthoses resulted in significant moderate effects for pain reduction compared with foot orthoses alone.[23,57]

### Medium-term Outcomes

**I** Combined interventions, consisting of patellar taping, EMG biofeedback for the quadriceps musculature, knee-targeted exercise therapy, patellar mobilizations, and lower-limb stretching plus foot orthoses, resulted in significant moderate effects for pain reduction compared with foot orthoses alone.[23,56] In the medium to long term, combined interventions that included exercise therapy resulted in large reductions in usual pain (SMD, 4.32; 95% CI: 0.89, 7.75) and large improvements in function (SMD, 1.1; 95% CI: 0.58, 1.63) in individuals with PFP compared with control or sham therapies.[290]

### Long-term Outcomes

**I** Six weeks of combined interventions, consisting of patellar taping, patellar mobilizations, EMG biofeedback for the quadriceps musculature, knee-targeted exercise therapy, and lower-limb stretching, resulted in a moderate treatment effect (SMD, 0.44; 95% CI: 0.01, 0.88) with respect to pain compared with placebo shoe inserts or foot orthoses at 1-year follow-up.[60] Adding foot orthoses to the same 6-week combined intervention also resulted in a moderate effect (SMD, 0.77; 95% CI: 0.33, 1.21) compared with placebo at 1-year follow-up. However,

there were no differences in 1-year outcomes between the combined intervention and the combined intervention plus foot orthoses.[60]

### Evidence Synthesis

While combined interventions were different across studies, exercise therapy was present in all successful combined intervention programs.

### Gaps in Knowledge

While investigations demonstrate that combining interventions for the treatment of individuals with PFP is beneficial, the best combination of exercise therapy and adjunctive treatments is still unclear. It is likely that tailoring various components of combined interventions may result in the best patient outcomes. As of this guideline, it is yet unknown which criteria are most helpful in prescribing an intervention with the fewest components that yields the best patient outcomes.

### Recommendation

**A** Clinicians should combine physical therapy interventions for the treatment of individuals with PFP, which results in superior outcomes compared with no treatment, flat shoe inserts, or foot orthoses alone in the short and medium term. Exercise therapy is the critical component and should be the focus in any combined intervention approach. Interventions to consider combining with exercise therapy include foot orthoses, patellar taping, patellar mobilizations, and lower-limb stretching.

## DECISION TREE MODEL

A pathoanatomical/medical diagnosis of PFP can provide valuable information in describing tissue pathology and may assist in nonoperative planning and prognosis. The proposed model for examination, diagnosis, and treatment planning for patients with PFP uses the following components: (1) medical screening, (2) classification of the condition through evaluation of clinical findings suggestive of musculoskeletal impairments of body functioning (ICF) and associated tissue pathology/disease (ICD), (3) determination of irritability stage and psychosocial factors that may impact treatment, (4) evaluative outcome measures, and (5) nonoperative intervention strategies. This model is depicted in the **FIGURE**.

### Component 1

Medical screening incorporates the findings of the history and physical examination to determine whether the patient's symptoms originate from a condition that requires referral to another health care provider. Prior to diagnosing a person with PFP, it is necessary to rule out all other possible medical conditions that may cause AKP. Clinicians should recognize the key signs and symptoms associated with serious pathological knee conditions, continually screen for the presence of these conditions throughout treatment, and immediately initiate referral to the appropriate medical practitioner when a potentially serious medical condition is suspected (Guide to Physical Therapist Practice 3.0; http://guidetoptpractice.apta.org/). Medical conditions for which physical therapy is not indicated must be considered as possible etiologies of a patient's symptoms.

### Component 2

Differential evaluation of musculoskeletal clinical findings determines the most relevant physical impairments associated with the patient's reported activity limitations and medical diagnosis.[157] Clusters of these clinical findings are described as impairment patterns in the physical therapy literature, and are labeled according to the key impairment(s) of body function associated with that cluster. The authors propose a classification system for PFP, with subcategories named according to the primary impairments. These impairment-pattern subcategories for PFP are described in the Diagnosis and Classification sections of this CPG. The ICD-10 and primary and secondary ICF codes associated with PFP are provided in the Methods section of this CPG. These impairment patterns impact the selection of interventions, which focus on normalizing the key impairments of body function, which in turn should improve the movement and function of the patient and lessen or alleviate the activity limitations commonly reported by the patients who meet the diagnostic criteria of that specific pattern. The **FIGURE** lists the key clinical findings used to rule in or rule out the common impairment patterns and their associated medical conditions. Impairment-based classification is critical for matching the intervention strategy that is most likely to provide the optimal outcome for a patient's clinical findings.[157] However, it is important for clinicians to understand that the impairment pattern, the most relevant impairments of body function, and the associated intervention strategies often change during the patient's episode of care. Thus, continual re-evaluation of the patient's response to treatment and the patient's emerging clinical findings is important for providing optimal interventions throughout the patient's episode of care.[28]

### Component 3

*Irritability* is a term used by rehabilitation practitioners to reflect the tissue's ability to handle physical stress,[190,200] and is presumably related to physical status and the extent of injury and inflammatory activity that is present. McClure and Michener[190] proposed operational definitions for tissue irritability for persons with shoulder pain that could be used to guide intensity and selection of interventions. These include high, moderate, and low irritability levels, which are characterized by pain intensity and disability level, as well as provocation of

pain with ROM.[190] Because irritability level and the duration of symptoms do not always match, clinicians may be required to make judgments when applying time-based research results to individual patients.[28] Diagnosis of tissue irritability is important for guiding clinical decisions regarding treatment frequency, intensity, duration, and type, with the goal of matching the optimal dosage of treatment to the status of the tissue being treated.[28,157] Using an approach similar to that proposed by McClure and Michener,[190] clinicians should use tissue irritability as a factor to consider when determining intervention type and intensity. Patients with PFP with high irritability (fairly constant pain greater than 5/10 that fluctuates related to activity) may benefit from interventions to reduce physical stress to the knee structures (eg, patellar taping). Those patients with low irritability (intermittent low-level pain less than 3/10 not easily aggravated) may benefit from interventions that apply more physical stress to the tissues of the knee, such as weight-bearing strengthening exercises, and thus provide appropriate stress to result in adaptation of structures to increased load.[200]

### Component 4

Outcome measures are standardized tools used for measuring a specific domain, whether it is a body structure or function, activity limitation, or participation restriction, or for determining a specific end point. They are important in direct management of individual patient care, and they provide the opportunity to collectively compare care and determine effectiveness through the repeated application of a standardized measurement. Outcomes in clinical practice provide the mechanism by which the health care provider, the patient, the public, and the payer are able to assess the end results of care and its effect on the health of the patient and society. Outcome measurements can identify baseline pain, function, and disability, assess global knee function, determine readiness to return to activities, and monitor changes in status throughout treatment. Outcome measures can be classified as PROMs, physical performance measures, and physical impairment measures. Information for outcome measures is detailed in this CPG's Examination section.

### Component 5

Clinical signs and symptoms have typically guided the clinical decision making of treatment interventions. These clinical signs and symptoms guide the clinician to classify the patient with one of the proposed impairment-based categories of PFP. Interventions targeting the patient's impairments are listed in the **FIGURE** according to the PFP category. Because irritability level often reflects the tissue's ability to accept physical stress, clinicians should match the most appropriate intervention strategies to the irritability level of the patient's condition.[28,157] Additionally, clinicians should consider influences from psychosocial factors[9-11,186,187] in patients with conditions in all stages of recovery.

## LIMITATIONS AND FUTURE DIRECTIONS

More research is needed to determine whether any long-term differences in pain or PROMs occur in patients with PFP who receive either hip- or knee-targeted exercise therapy. More research is needed to gain greater understanding of outcome differences between patients who receive a combination of hip- and knee-targeted exercise therapy versus those who receive knee-targeted exercise therapy alone. In addition, a standardized approach is needed for future research when delineating either knee- or hip-targeted exercise.

Despite compelling evidence for the use of exercise therapy in the treatment of people with PFP, exercise programs reported to be effective are unable to be replicated.[143] Therefore, clinicians treating PFP are encouraged to use accepted exercise prescription principles, as recommended by the American College of Sports Medicine,[7,322] to guide exercise prescription targeting the hip and knee, based on individual deficits identified in each patient. Specifically, the treating clinician should assess, consider, and address appropriate neuromotor control, along with muscular endurance, strength, and power. Further guidance related to this is provided at https://ipfrn.org/exercise-guide/.

There is a long-held belief among experts that tailoring and targeting treatment to individual patients may improve the effectiveness of physical therapy.[18,80,310] However, to date, there is little evidence for a validated approach to achieve this. Nonetheless, the physical therapist is encouraged to use clinical reasoning to target interventions toward individuals when possible,[18] and to use a shared decision-making process during plan-of-care development.[17]

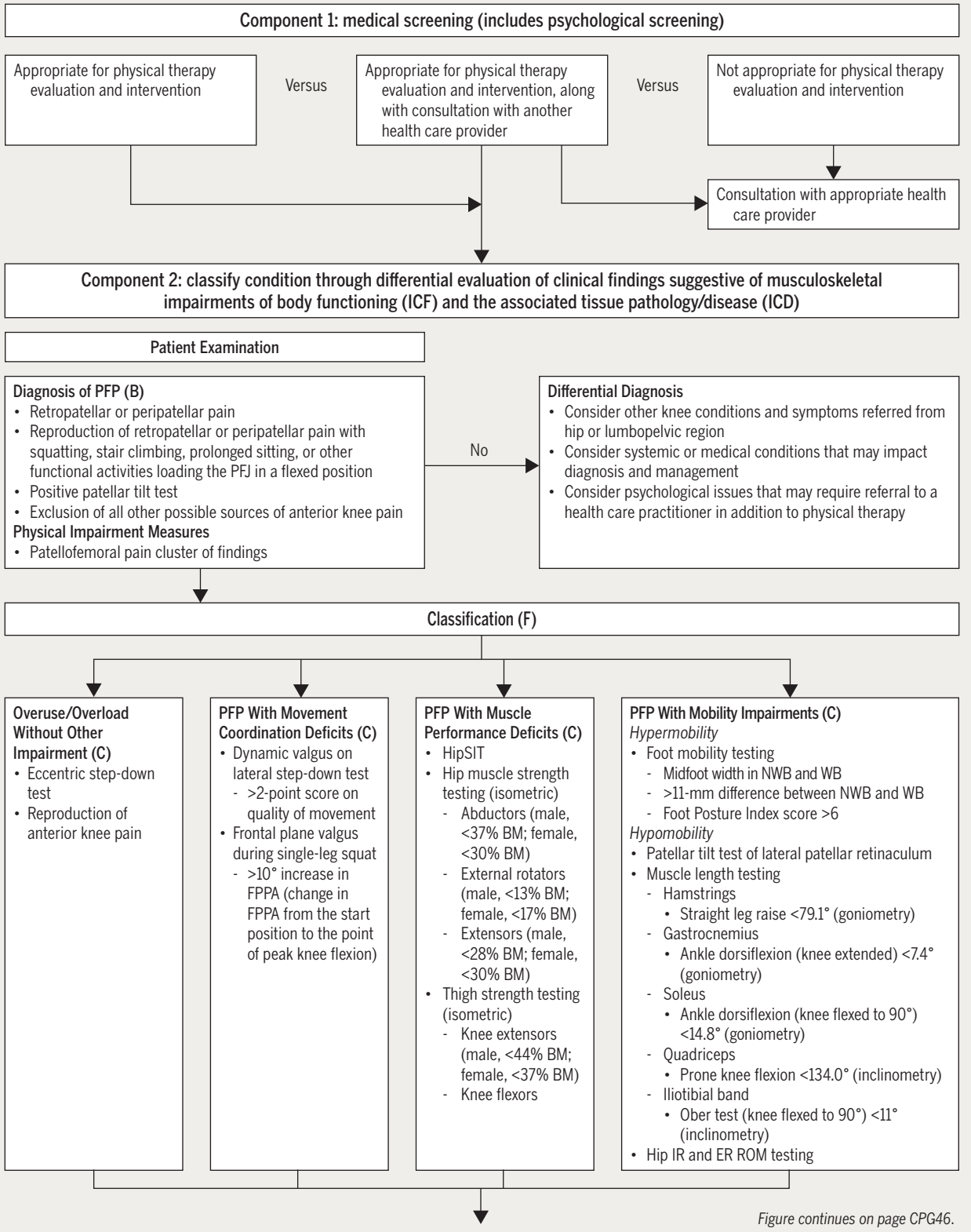


*Figure continues on page CPG46.*

**FIGURE.** Decision tree model. *Letters in parentheses reflect the grade of evidence on which the recommendation for each item is based: (A) strong evidence, (B) moderate evidence, (C) weak evidence, (D) conflicting evidence, (E) theoretical/foundational evidence, and (F) expert opinion. Abbreviations: AKPS, Anterior Knee Pain Scale; BM, body mass; ER, external rotation; FPPA, frontal plane projetion angle; HipSIT, Hip Stability Isometric Test; IR, internal rotation; KOOS-PF, Knee injury and Osteoarthritis Outcome Score-patellofemoral pain and osteoarthritis subscale; NPRS, numeric pain-rating scale; NWB, non–weight bearing; PFJ, patellofemoral joint; PFP, patellofemoral pain; ROM, range of motion; WB, weight bearing.

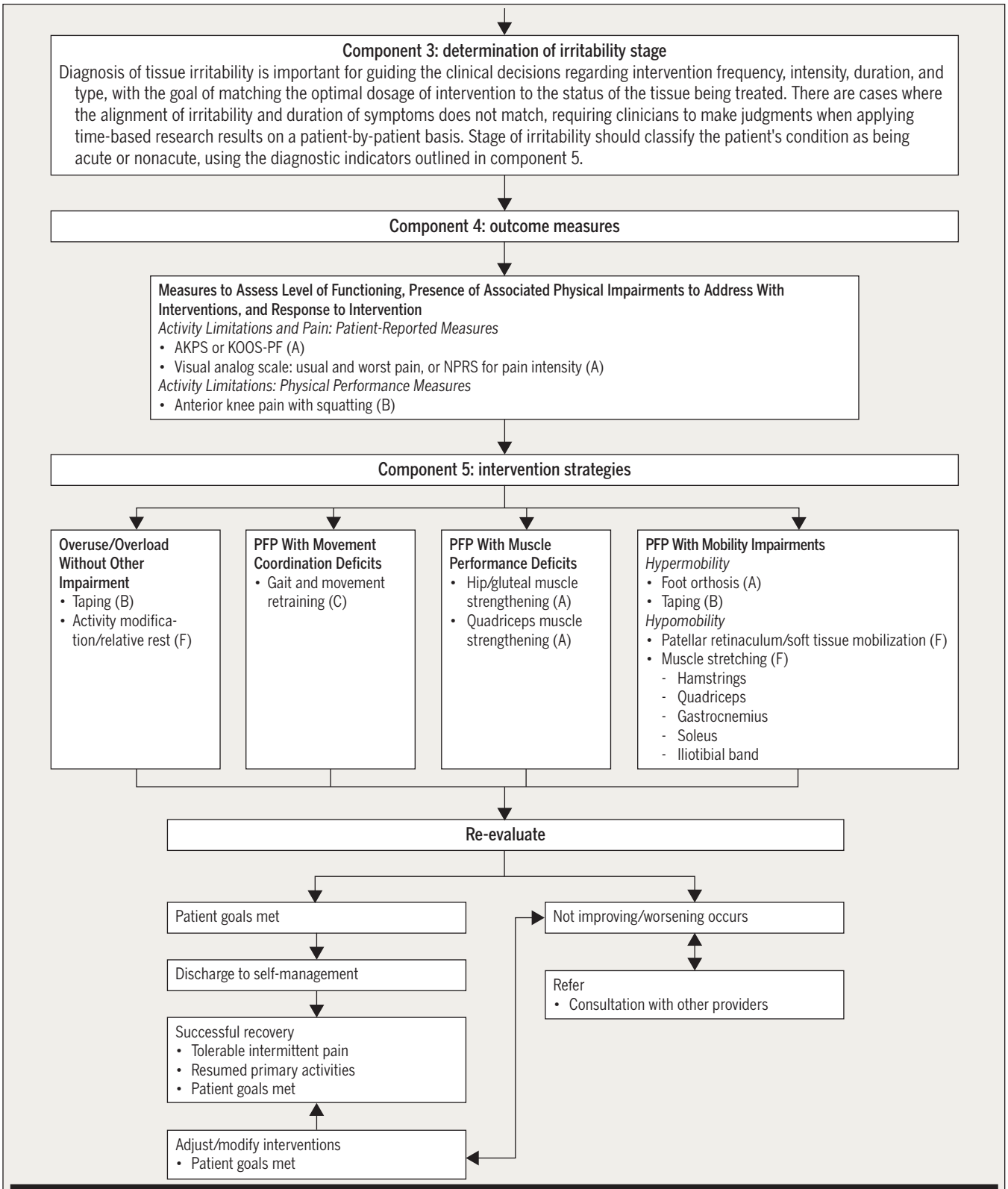


**FIGURE (CONTINUED).** Decision tree model. *Letters in parentheses reflect the grade of evidence on which the recommendation for each item is based: (A) strong evidence, (B) moderate evidence, (C) weak evidence, (D) conflicting evidence, (E) theoretical/foundational evidence, and (F) expert opinion. Abbreviations: AKPS, Anterior Knee Pain Scale; BM, body mass; ER, external rotation; FPPA, frontal plane projetion angle; HipSIT, Hip Stability Isometric Test; IR, internal rotation; KOOS-PF, Knee injury and Osteoarthritis Outcome Score-patellofemoral pain and osteoarthritis subscale; NPRS, numeric pain-rating scale; NWB, non–weight bearing; PFJ, patellofemoral joint; PFP, patellofemoral pain; ROM, range of motion; WB, weight bearing.

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**MORE INFORMATION**
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## APPENDIX A

### SEARCH STRATEGIES FOR ALL DATABASES SEARCHED: MAY 2018

#### MEDLINE/PubMed

((patellofemoral pain* [tw] OR patellofemoral syndrom* [tw] OR patello-femoral pain* [tw] OR patello-femoral syndrom* [tw] OR anterior knee pain* [tw] OR patellofemoral disorder* [tw] OR patello-femoral disorder* [tw] OR chondromalacia patellae [TW] OR Sinding-Larsen-Johansson disease* [TW] OR Sinding Larsen Johansson disease* [TW] OR Sinding-Larsen-Johansson syndrom* [TW] OR Sinding Larsen Johansson syndrom* [TW] OR runner's knee [TW] OR PFPS [TW] OR extensor mechanism disorder* [tw]) OR ((arthralg* [tw] OR pain* [tw]) AND (patell* [tw] OR femoropatell* [tw] OR femoro-patell* [tw] OR retropatell* [tw] OR retro-patell* [tw] OR lateral facet* [tw] OR lateral compr* [tw] OR lateral press* [tw] OR odd facet* [tw]) AND (syndrom* [tw] OR dysfunct* [tw] OR disorder* [tw] OR chondromal* [tw] OR chondropath* [tw]))) AND (classif* [TW])

((patellofemoral pain* [tw] OR patellofemoral syndrom* [tw] OR patello-femoral pain* [tw] OR patello-femoral syndrom* [tw] OR anterior knee pain* [tw] OR patellofemoral disorder* [tw] OR patello-femoral disorder* [tw] OR chondromalacia patellae [TW] OR Sinding-Larsen-Johansson disease* [TW] OR Sinding Larsen Johansson disease* [TW] OR Sinding-Larsen-Johansson syndrom* [TW] OR Sinding Larsen Johansson syndrom* [TW] OR runner's knee [TW] OR PFPS [TW] OR extensor mechanism disorder* [tw]) OR ((arthralg* [tw] OR pain* [tw]) AND (patell* [tw] OR femoropatell* [tw] OR femoro-patell* [tw] OR retropatell* [tw] OR retro-patell* [tw] OR lateral facet* [tw] OR lateral compr* [tw] OR lateral press* [tw] OR odd facet* [tw]) AND (syndrom* [tw] OR dysfunct* [tw] OR disorder* [tw] OR chondromal* [tw] OR chondropath* [tw]))) AND (associat* [tw] OR risk* [tw] OR probabil* [tw] OR odds* [tw] OR relat* [tw] OR prevalen* [tw] OR predict* [tw] OR caus* [tw] OR etiol* [tw] OR interact* [tw])

((patellofemoral pain* [tw] OR patellofemoral syndrom* [tw] OR patello-femoral pain* [tw] OR patello-femoral syndrom* [tw] OR anterior knee pain* [tw] OR patellofemoral disorder* [tw] OR patello-femoral disorder* [tw] OR chondromalacia patellae [TW] OR Sinding-Larsen-Johansson disease* [TW] OR Sinding Larsen Johansson disease* [TW] OR Sinding-Larsen-Johansson syndrom* [TW] OR Sinding Larsen Johansson syndrom* [TW] OR runner's knee [TW] OR PFPS [TW] OR extensor mechanism disorder* [tw]) OR ((arthralg* [tw] OR pain* [tw]) AND (patell* [tw] OR femoropatell* [tw] OR femoro-patell* [tw] OR retropatell* [tw] OR retro-patell* [tw] OR lateral facet* [tw] OR lateral compr* [tw] OR lateral press* [tw] OR odd facet* [tw]) AND (syndrom* [tw] OR dysfunct* [tw] OR disorder* [tw] OR chondromal* [tw] OR chondropath* [tw]))) AND (prevalence [MH] OR incidence [MH] OR epidemiology [MH])

((patellofemoral pain* [tw] OR patellofemoral syndrom* [tw] OR patello-femoral pain* [tw] OR patello-femoral syndrom* [tw] OR anterior knee pain* [tw] OR patellofemoral disorder* [tw] OR patello-femoral disorder* [tw] OR chondromalacia patellae [TW] OR Sinding-Larsen-Johansson disease* [TW] OR Sinding Larsen Johansson disease* [TW] OR Sinding-Larsen-Johansson syndrom* [TW] OR Sinding Larsen Johansson syndrom* [TW] OR runner's knee [TW] OR PFPS [TW] OR extensor mechanism disorder* [tw]) OR ((arthralg* [tw] OR pain* [tw]) AND (patell* [tw] OR femoropatell* [tw] OR femoro-patell* [tw] OR retropatell* [tw] OR retro-patell* [tw] OR lateral facet* [tw] OR lateral compr* [tw] OR lateral press* [tw] OR odd facet* [tw]) AND (syndrom* [tw] OR dysfunct* [tw] OR disorder* [tw] OR chondromal* [tw] OR chondropath* [tw]))) AND (sensitiv* [tiab] OR sensitivity and specificity [MH] OR diagnos* [tiab] OR diagnosis [MeSH:noexp] OR diagnostic [MeSH:noexp] OR diagnosis, differential [MeSH:noexp] OR diagnosis [Subheading:noexp] OR questionnaires [MH] OR "disability evaluation" [mesh:noexp] OR questionnaire [tiab] OR questionnaires [tiab] OR instrument [tiab] OR instruments [tiab] OR scale [tiab] OR scales [tiab] OR measurement [tiab] OR measurements [tiab] OR index [tiab] OR indices [tiab] OR score [tiab] OR scores [tiab])

((patellofemoral pain* [tw] OR patellofemoral syndrom* [tw] OR patello-femoral pain* [tw] OR patello-femoral syndrom* [tw] OR anterior knee pain* [tw] OR patellofemoral disorder* [tw] OR patello-femoral disorder* [tw] OR chondromalacia patellae [TW] OR Sinding-Larsen-Johansson disease* [TW] OR Sinding Larsen Johansson disease* [TW] OR Sinding-Larsen-Johansson syndrom* [TW] OR Sinding Larsen Johansson syndrom* [TW] OR runner's knee [TW] OR PFPS [TW] OR extensor mechanism disorder* [tw]) OR ((arthralg* [tw] OR pain* [tw]) AND (patell* [tw] OR femoropatell* [tw] OR femoro-patell* [tw] OR retropatell* [tw] OR retro-patell* [tw] OR lateral facet* [tw] OR lateral compr* [tw] OR lateral press* [tw] OR odd facet* [tw]) AND (syndrom* [tw] OR dysfunct* [tw] OR disorder* [tw] OR chondromal* [tw] OR chondropath* [tw]))) AND (prognos* [tw] OR return to work [tw] OR return to work [mh] OR return to sport [tw])

((patellofemoral pain* [tw] OR patellofemoral syndrom* [tw] OR patello-femoral pain* [tw] OR patello-femoral syndrom* [tw] OR anterior knee pain* [tw] OR patellofemoral disorder* [tw] OR patello-femoral disorder* [tw] OR chondromalacia patellae [TW] OR Sinding-Larsen-Johansson disease* [TW] OR Sinding Larsen Johansson disease* [TW] OR Sinding-Larsen-Johansson syndrom* [TW] OR Sinding Larsen Johansson syndrom* [TW] OR runner's knee [TW] OR PFPS [TW] OR extensor mechanism disorder* [tw]) OR ((arthralg* [tw] OR pain* [tw]) AND (patell* [tw] OR femoropatell* [tw] OR femoro-patell* [tw] OR retropatell* [tw] OR retro-patell* [tw] OR lateral facet* [tw] OR lateral compr* [tw] OR lateral press* [tw] OR odd facet* [tw]) AND (syndrom* [tw] OR dysfunct* [tw] OR disorder* [tw] OR chondromal* [tw] OR chondropath* [tw]))) AND (physical therapy modalities [MH] OR recovery of function [MH] OR rehabilitation [MH] OR therapeutics [MH] OR physical therap* [TW] OR physiother* [TW] OR recov-

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er* [TW] OR restor* [TW] OR re-educat* [TW] OR early ambulation [MH] OR strengthen* [TW] OR resistance training [MH] OR resistance method* [TW] OR exercise therapy [MH] OR stretch* [TW] OR biofeedback, psychology [MH] OR neuromuscular electrical stimulation* [TW] OR pain management [MH] OR pain measurement [MH] OR mobiliz* [TW] OR muscle stretching exercises [MH] OR manipulation, spinal [MH] OR ultrasonograph* [TW] OR ultrasound* [TW] OR acupunctur* [TW] OR laser* [TW] OR patient education as topic [MH] OR electrical stimulation [MH] OR electrical stimulation therapy [MH] OR Transcutaneous electric nerve stimulation [MH] OR tap* [TW] OR brac* [TW] OR orthotic* [TW] OR weight-bearing [MH] OR Range of motion [MH] OR Treatment Outcome [MH] OR Exercise [MH] OR physical therapy treatment* [TW] OR training program* [TW])

### Scopus

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ABS-KEY ("lateral press*") OR TITLE-ABS-KEY ("odd facet*")) AND (TITLE-ABS-KEY (syndrom*) OR TITLE-ABS-KEY (dysfunct*) OR TITLE-ABS-KEY (disorder*) OR TITLE-ABS-KEY (chondromal*) OR TITLE-ABS-KEY (chondropath*))))) AND (TITLE-ABS-KEY (sensitiv*) OR TITLE-ABS-KEY (specificity) OR TITLE-ABS-KEY (diagnos*) OR TITLE-ABS-KEY ("disability evaluation") OR TITLE-ABS-KEY (questionnaire) OR TITLE-ABS-KEY (questionnaires) OR TITLE-ABS-KEY (instrument) OR TITLE-ABS-KEY (instruments) OR TITLE-ABS-KEY (scale) OR TITLE-ABS-KEY (scales) OR TITLE-ABS-KEY (measurement) OR TITLE-ABS-KEY (measurements) OR TITLE-ABS-KEY (index) OR TITLE-ABS-KEY (indices) OR TITLE-ABS-KEY (score) OR TITLE-ABS-KEY (scores))

((TITLE-ABS-KEY ("patellofemoral pain*") OR TITLE-ABS-KEY ("patellofemoral syndrom*") OR TITLE-ABS-KEY ("patello-femoral pain*") OR TITLE-ABS-KEY ("patello-femoral syndrom*") OR TITLE-ABS-KEY ("anterior knee pain*") OR TITLE-ABS-KEY ("patellofemoral disorder*") OR TITLE-ABS-KEY ("patello-femoral disorder*") OR TITLE-ABS-KEY ("chondromalacia patellae") OR TITLE-ABS-KEY ("Sinding-Larsen-Johansson disease*") OR TITLE-ABS-KEY ("Sinding Larsen Johansson disease*") OR TITLE-ABS-KEY ("Sinding-Larsen-Johansson syndrom*") OR TITLE-ABS-KEY ("Sinding Larsen Johansson syndrom*") OR TITLE-ABS-KEY ("runner's knee") OR TITLE-ABS-KEY (PFPS) OR TITLE-ABS-KEY ("extensor mechanism disorder*")) OR ((TITLE-ABS-KEY (arthralg*) OR TITLE-ABS-KEY (pain*)) AND (TITLE-ABS-KEY (patell*) OR TITLE-ABS-KEY (femoropatell*) OR TITLE-ABS-KEY ("femoro-patell*") OR TITLE-ABS-KEY (retro-patell*) OR TITLE-ABS-KEY ("retro-patell*") OR TITLE-ABS-KEY ("lateral facet*") OR TITLE-ABS-KEY ("lateral compr*") OR TITLE-ABS-KEY ("lateral press*") OR TITLE-ABS-KEY ("odd facet*")) AND (TITLE-ABS-KEY (syndrom*) OR TITLE-ABS-KEY (dysfunct*) OR TITLE-ABS-KEY (disorder*) OR TITLE-ABS-KEY (chondromal*) OR TITLE-ABS-KEY (chondropath*))))) AND (TITLE-ABS-KEY (prognos*) OR TITLE-ABS-KEY ("return to work") OR TITLE-ABS-KEY ("return to sport"))

((TITLE-ABS-KEY ("patellofemoral pain*") OR TITLE-ABS-KEY ("patellofemoral syndrom*") OR TITLE-ABS-KEY ("patello-femoral pain*") OR TITLE-ABS-KEY ("patello-femoral syndrom*") OR TITLE-ABS-KEY ("anterior knee pain*") OR TITLE-ABS-KEY ("patellofemoral disorder*") OR TITLE-ABS-KEY ("patello-femoral disorder*") OR TITLE-ABS-KEY ("chondromalacia patellae") OR TITLE-ABS-KEY ("Sinding-Larsen-Johansson disease*") OR TITLE-ABS-KEY ("Sinding Larsen Johansson disease*") OR TITLE-ABS-KEY ("Sinding-Larsen-Johansson syndrom*") OR TITLE-ABS-KEY ("Sinding Larsen Johansson syndrom*") OR TITLE-ABS-KEY ("runner's knee") OR TITLE-ABS-KEY (PFPS) OR TITLE-ABS-KEY ("extensor mechanism disorder*")) OR ((TITLE-ABS-KEY (arthralg*) OR TITLE-ABS-KEY (pain*)) AND (TITLE-ABS-KEY (patell*) OR TITLE-ABS-KEY (femoropatell*) OR TITLE-ABS-KEY ("femoro-patell*") OR TITLE-ABS-KEY (retropatell*) OR TITLE-ABS-KEY ("retro-patell*") OR TITLE-ABS-KEY ("lateral facet*") OR TITLE-ABS-KEY ("lateral compr*") OR TITLE-ABS-KEY ("lateral press*") OR TITLE-ABS-KEY ("odd facet*")) AND (TITLE-ABS-KEY (syndrom*) OR TITLE-ABS-KEY (dysfunct*) OR TITLE-ABS-KEY (disorder*) OR TITLE-ABS-KEY (chondromal*) OR TITLE-ABS-KEY (chondropath*))))) AND (TITLE-ABS-KEY ("physical therapy modalit*") OR TITLE-ABS-KEY ("recovery of function") OR TITLE-ABS-KEY (rehab*) OR TITLE-ABS-KEY (therapeutic*) OR TITLE-ABS-KEY ("physical therap*") OR TITLE-ABS-KEY (physiother*) OR TITLE-ABS-KEY (recover*) OR TITLE-ABS-KEY (restor*) OR TITLE-ABS-KEY ("re-education*") OR TITLE-ABS-KEY ("early ambulation") OR TITLE-ABS-KEY (strengthen*) OR TITLE-ABS-KEY ("resistance training") OR TITLE-ABS-KEY ("resistance method*") OR TITLE-ABS-KEY ("exercise therap*") OR TITLE-ABS-KEY (stretch*) OR TITLE-ABS-KEY (biofeedback) OR TITLE-ABS-KEY ("neuromuscular electrical stimulation*") OR TITLE-ABS-KEY ("pain management") OR TITLE-ABS-KEY ("pain measurement*") OR TITLE-ABS-KEY (mobiliz*) OR TITLE-ABS-KEY ("muscle stretching exercise*") OR TITLE-ABS-KEY ("spinal manipulation*") OR TITLE-ABS-KEY (ultrasonograph*) OR TITLE-ABS-KEY (ultrasound*) OR TITLE-ABS-KEY (acupunctur*) OR TITLE-ABS-KEY (laser*) OR TITLE-ABS-KEY ("patient education*") OR TITLE-ABS-KEY ("electrical stimulation") OR TITLE-ABS-KEY ("electrical stimulation therap*") OR TITLE-ABS-KEY ("Transcutaneous electric nerve stimulation") OR TITLE-ABS-KEY (tap*) OR TITLE-ABS-KEY (brac*) OR TITLE-ABS-KEY (orthotic*) OR TITLE-ABS-KEY ("weight-bearing") OR TITLE-ABS-KEY ("Range of motion") OR TITLE-ABS-KEY ("Treatment Outcome*") OR TITLE-ABS-KEY (Exercise*) OR TITLE-ABS-KEY ("training program*"))

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(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism

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disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((TI (classif*) OR SU (classif*) OR AB (classif*)))

(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((TI (associat*) OR AB (associat*) OR SU (associat*)) OR (TI (risk*) OR AB (risk*) OR SU (risk*)) OR (SU (probabil*) OR TI (probabil*) OR AB (probabil*)) OR (TI (odds*) OR AB (odds*) OR SU (odds*)) OR (TI (relat*) OR AB (relat*) OR SU (relat*)) OR (SU (prevalen*) OR TI (prevalen*) OR AB (prevalen*)) OR (TI (predict*) OR AB (predict*) OR SU (predict*)) OR (TI (caus*) OR AB (caus*) OR SU (caus*)) OR (TI (etiol*) OR AB (etiol*) OR SU (etiol*)) OR (TI (interact*) OR AB (interact*) OR SU (interact*)))

(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((TI (pre-

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val*) OR SU (preval*) OR AB (preval*)) OR (TI (inciden*) OR SU (inciden*) OR AB (inciden*)) OR (TI (epidemiolog*) OR SU (epidemiolog*) OR AB (epidemiolog*)))

(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((TI (sensitiv*) OR AB (sensitiv*) OR SU (sensitiv*)) OR (TI (specificity) OR AB (specificity) OR SU (specificity)) OR (TI (diagnos*) OR AB (diagnos*) OR SU (diagnos*)) OR (SU (questionnaire) OR TI (questionnaire) OR AB (questionnaire)) OR (SU (questionnaires) OR TI (questionnaires) OR AB (questionnaires)) OR (SU ("disability evaluation") OR TI ("disability evaluation") OR AB ("disability evaluation")) OR (TI (instrument) OR AB (instrument) OR SU (instrument)) OR (TI (instruments) OR AB (instruments) OR SU (instruments)) OR (SU (scale) OR TI (scale) OR AB (scale)) OR (SU (scales) OR TI (scales) OR AB (scales)) OR (TI (measurement) OR AB (measurement) OR SU (measurement)) OR (TI (measurements) OR AB (measurements) OR SU (measurements)) OR (TI (index) OR AB (index) OR SU (index)) OR (TI (indices) OR AB (indices) OR SU (indices)) OR (TI (score) OR AB (score) OR SU (score))OR (TI (scores) OR AB (scores) OR SU (scores)))

(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((SU (prognos*) OR TI (prognos*) OR AB (prognos*)) OR (TI (return to work) OR AB (return to work) OR SU (return to work)) OR (SU (return to sport) OR TI (return to sport) OR AB (return to sport)))

(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*))

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OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((TI (physical therapy modalit*) OR AB (physical therapy modalit*) OR SU (physical therapy modalit*)) OR (TI (recovery of function) OR AB (recovery of function) OR SU (recovery of function)) OR (SU (rehab*) OR TI (rehab*) OR AB (rehab*)) OR (SU (therapeutic*) OR TI (therapeutic*) OR AB (therapeutic*)) OR (SU (physical therap*) OR TI (physical therap*) OR AB (physical therap*)) OR (TI (physiother*) OR AB (physiother*) OR SU (physiother*)) OR (SU (recover*) OR TI (recover*) OR AB (recover*)) OR (TI (restor*) OR AB (restor*) OR SU (restor*)) OR (TI (re-education*) OR AB (re-education*) OR SU (re-education*)) OR (SU (early ambulation) OR TI (early ambulation) OR AB (early ambulation)) OR (TI (strengthen*) OR AB (strengthen*) OR SU (strengthen*)) OR (SU (resistance training) OR TI (resistance training) OR AB (resistance training)) OR (TI (resistance method*) OR AB (resistance method*) OR SU (resistance method*)) OR (SU (exercise therap*) OR TI (exercise therap*) OR AB (exercise therap*)) OR (SU (stretch*) OR TI (stretch*) OR AB (stretch*)) OR (SU (biofeedback) OR TI (biofeedback) OR AB (biofeedback)) OR (SU (neuromuscular electrical stimulation*) OR TI (neuromuscular electrical stimulation*) OR AB (neuromuscular electrical stimulation*)) OR (TI (pain management) OR AB (pain management) OR SU (pain management)) OR (SU (pain measurement*) OR TI (pain measurement*) OR AB (pain measurement*)) OR (TI (mobiliz*) OR AB (mobiliz*) OR SU (mobiliz*)) OR (TI (muscle stretching exercise*) OR AB (muscle stretching exercise*) OR SU (muscle stretching exercise*)) OR (TI (spinal manipulation*) OR AB (spinal manipulation*) OR SU (spinal manipulation*)) OR (SU (ultrasonograph*) OR TI (ultrasonograph*) OR AB (ultrasonograph*)) OR (TI (ultrasound*) OR AB (ultrasound*) OR SU (ultrasound*)) OR (SU (acupunctur*) OR TI (acupunctur*) OR AB (acupunctur*)) OR (SU (laser*) OR TI (laser*) OR AB (laser*)) OR (SU (patient education*) OR TI (patient education*) OR AB (patient education*)) OR (SU (electrical stimulation) OR TI (electrical stimulation) OR AB (electrical stimulation)) OR (TI (electrical stimulation therap*) OR AB (electrical stimulation therap*) OR SU (electrical stimulation therap*)) OR (SU (Transcutaneous electric nerve stimulation) OR TI (Transcutaneous electric nerve stimulation) OR AB (Transcutaneous electric nerve stimulation)) OR (SU (tap*) OR TI (tap*) OR AB (tap*)) OR (TI (brac*) OR AB (brac*) OR SU (brac*)) OR (SU (orthotic*) OR TI (orthotic*) OR AB (orthotic*)) OR (SU (weight-bearing) OR TI (weight-bearing) OR AB (weight-bearing)) OR (SU (Range of Motion) OR TI (Range of motion) OR AB (Range of motion)) OR (SU (treatment outcome*) OR TI (treatment outcome*) OR AB (treatment outcome*)) OR (SU (exercise*) OR TI (exercise*) OR AB (exercise*)) OR (SU (training program*) OR TI (training program*) OR AB (training program*)))

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(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB

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(runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((TI (classif*) OR SU (classif*) OR AB (classif*)))

(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((TI (associat*) OR AB (associat*) OR SU (associat*)) OR (TI (risk*) OR AB (risk*) OR SU (risk*)) OR (SU (probabil*) OR TI (probabil*) OR AB (probabil*)) OR (TI (odds*) OR AB (odds*) OR SU (odds*)) OR (TI (relat*) OR AB (relat*) OR SU (relat*)) OR (SU (prevalen*) OR TI (prevalen*) OR AB (prevalen*)) OR (TI (predict*) OR AB (predict*) OR SU (predict*)) OR (TI (caus*) OR AB (caus*) OR SU (caus*)) OR (TI (etiol*) OR AB (etiol*) OR SU (etiol*)) OR (TI (interact*) OR AB (interact*) OR SU (interact*)))

(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR

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SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((TI (preval*) OR SU (preval*) OR AB (preval*)) OR (TI (inciden*) OR SU (inciden*) OR AB (inciden*)) OR (TI (epidemiolog*) OR SU (epidemiolog*) OR AB (epidemiolog*)))

(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((TI (sensitiv*) OR AB (sensitiv*) OR SU (sensitiv*)) OR (TI (specificity) OR AB (specificity) OR SU (specificity)) OR (TI (diagnos*) OR AB (diagnos*) OR SU (diagnos*)) OR (SU (questionnaire) OR TI (questionnaire) OR AB (questionnaire)) OR (SU (questionnaires) OR TI (questionnaires) OR AB (questionnaires)) OR (SU ("disability evaluation") OR TI ("disability evaluation") OR AB ("disability evaluation")) OR (TI (instrument) OR AB (instrument) OR SU (instrument)) OR (TI (instruments) OR AB (instruments) OR SU (instruments)) OR (SU (scale) OR TI (scale) OR AB (scale)) OR (SU (scales) OR TI (scales) OR AB (scales)) OR (TI (measurement) OR AB (measurement) OR SU (measurement)) OR (TI (measurements) OR AB (measurements) OR SU (measurements)) OR (TI (index) OR AB (index) OR SU (index)) OR (TI (indices) OR AB (indices) OR SU (indices)) OR (TI (score) OR AB (score) OR SU (score))OR (TI (scores) OR AB (scores) OR SU (scores)))

(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB (patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((SU (prognos*) OR TI (prognos*) OR AB (prognos*)) OR (TI (return to work) OR AB (return to work) OR SU (return to work)) OR (SU (return to sport) OR TI (return to sport) OR AB (return to sport)))

(((SU (patellofemoral pain*) OR TI (patellofemoral pain*) OR AB

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(patellofemoral pain*)) OR (SU (patellofemoral syndrom*) OR TI (patellofemoral syndrom*) OR AB (patellofemoral syndrom*)) OR (SU (patello-femoral pain*) OR TI (patello-femoral pain*) OR AB (patello-femoral pain*)) OR (SU (patello-femoral syndrom*) OR TI (patello-femoral syndrom*) OR AB (patello-femoral syndrom*)) OR (SU (anterior knee pain*) OR TI (anterior knee pain*) OR AB (anterior knee pain*)) OR (SU (patellofemoral disorder*) OR TI (patellofemoral disorder*) OR AB (patellofemoral disorder*)) OR (SU (patello-femoral disorder*) OR TI (patello-femoral disorder*) OR AB (patello-femoral disorder*)) OR (TI (chondromalacia patellae) OR SU (chondromalacia patellae) OR AB (chondromalacia patellae)) OR (TI (Sinding-Larsen-Johansson disease*) OR SU (Sinding-Larsen-Johansson disease*) OR AB (Sinding-Larsen-Johansson disease*)) OR (SU (Sinding Larsen Johansson disease*) OR TI (Sinding Larsen Johansson disease*) OR AB (Sinding Larsen Johansson disease*)) OR (TI (Sinding-Larsen-Johansson syndrom*) OR SU (Sinding-Larsen-Johansson syndrom*) OR AB (Sinding-Larsen-Johansson syndrom*)) OR (SU (Sinding Larsen Johansson syndrom*) OR TI (Sinding Larsen Johansson syndrom*) OR AB (Sinding Larsen Johansson syndrom*)) OR (SU (runner's knee) OR TI (runner's knee) OR AB (runner's knee)) OR (SU (PFPS) OR TI (PFPS) OR AB (PFPS)) OR (SU (extensor mechanism disorder*) OR TI (extensor mechanism disorder*) OR AB (extensor mechanism disorder*))) OR (((SU (arthralg*) OR TI (arthralg*) OR AB (arthralg*)) OR (TI (pain*) OR SU (pain*) OR AB (pain*))) AND ((TI (patell*) OR SU (patell*) OR AB (patell*)) OR (TI (femoropatell*) OR SU (femoropatell*) OR AB (femoropatell*)) OR (TI (femoro-patell*) OR SU (femoro-patell*) OR AB (femoro-patell*)) OR (TI (retropatell*) OR SU (retropatell*) OR AB (retropatell*)) OR (TI (retro-patell*) OR SU (retro-patell*) OR AB (retro-patell*)) OR (TI (lateral facet*) OR SU (lateral facet*) OR AB (lateral facet*)) OR (TI (lateral compr*) OR SU (lateral compr*) OR AB (lateral compr*)) OR (TI (lateral press*) OR SU (lateral press*) OR AB (lateral press*)) OR (TI (odd facet*) OR SU (odd facet*) OR AB (odd facet*))) AND ((TI (syndrom*) OR SU (syndrom*) OR AB (syndrom*)) OR (TI (dysfunct*) OR SU (dysfunct*) OR AB (dysfunct*)) OR (TI (disorder*) OR SU (disorder*) OR AB (disorder*)) OR (TI (chondromal*) OR SU (chondromal*) OR AB (chondromal*)) OR (TI (chondropath*) OR SU (chondropath*) OR AB (chondropath*))))) AND ((TI (physical therapy modalit*) OR AB (physical therapy modalit*) OR SU (physical therapy modalit*)) OR (TI (recovery of function) OR AB (recovery of function) OR SU (recovery of function)) OR (SU (rehab*) OR TI (rehab*) OR AB (rehab*)) OR (SU (therapeutic*) OR TI (therapeutic*) OR AB (therapeutic*)) OR (SU (physical therap*) OR TI (physical therap*) OR AB (physical therap*)) OR (TI (physiother*) OR AB (physiother*) OR SU (physiother*)) OR (SU (recover*) OR TI (recover*) OR AB (recover*)) OR (TI (restor*) OR AB (restor*) OR SU (restor*)) OR (TI (re-education*) OR AB (re-education*) OR SU (re-education*)) OR (SU (early ambulation) OR TI (early ambulation) OR AB (early ambulation)) OR (TI (strengthen*) OR AB (strengthen*) OR SU (strengthen*)) OR (SU (resistance training) OR TI (resistance training) OR AB (resistance training)) OR (TI (resistance method*) OR AB (resistance method*) OR SU (resistance method*)) OR (SU (exercise therap*) OR TI (exercise therap*) OR AB (exercise therap*)) OR (SU (stretch*) OR TI (stretch*) OR AB (stretch*)) OR (SU (biofeedback) OR TI (biofeedback) OR AB (biofeedback)) OR (SU (neuromuscular electrical stimulation*) OR TI (neuromuscular electrical stimulation*) OR AB (neuromuscular electrical stimulation*)) OR (TI (pain management) OR AB (pain management) OR SU (pain management)) OR (SU (pain measurement*) OR TI (pain measurement*) OR AB (pain measurement*)) OR (TI (mobiliz*) OR AB (mobiliz*) OR SU (mobiliz*)) OR (TI (muscle stretching exercise*) OR AB (muscle stretching exercise*) OR SU (muscle stretching exercise*)) OR (TI (spinal manipulation*) OR AB (spinal manipulation*) OR SU (spinal manipulation*)) OR (SU (ultrasonograph*) OR TI (ultrasonograph*) OR AB (ultrasonograph*)) OR (TI (ultrasound*) OR AB (ultrasound*) OR SU (ultrasound*)) OR (SU (acupunctur*) OR TI (acupunctur*) OR AB (acupunctur*)) OR (SU (laser*) OR TI (laser*) OR AB (laser*)) OR (SU (patient education*) OR TI (patient education*) OR AB (patient education*)) OR (SU (electrical stimulation) OR TI (electrical stimulation) OR AB (electrical stimulation)) OR (TI (electrical stimulation therap*) OR AB (electrical stimulation therap*) OR SU (electrical stimulation therap*)) OR (SU (Transcutaneous electric nerve stimulation) OR TI (Transcutaneous electric nerve stimulation) OR AB (Transcutaneous electric nerve stimulation)) OR (SU (tap*) OR TI (tap*) OR AB (tap*)) OR (TI (brac*) OR AB (brac*) OR SU (brac*)) OR (SU (orthotic*) OR TI (orthotic*) OR AB (orthotic*)) OR (SU (weight-bearing) OR TI (weight-bearing) OR AB (weight-bearing)) OR (SU (Range of Motion) OR TI (Range of motion) OR AB (Range of motion)) OR (SU (treatment outcome*) OR TI (treatment outcome*) OR AB (treatment outcome*)) OR (SU (exercise*) OR TI (exercise*) OR AB (exercise*)) OR (SU (training program*) OR TI (training program*) OR AB (training program*)))

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(((“patellofemoral pain*”) OR (“patellofemoral syndrom*”) OR (“patello-femoral pain*”) OR (“patello-femoral syndrom*”) OR (“anterior knee pain*”) OR (“patellofemoral disorder*”) OR (“patello-femoral disorder*”) OR (“chondromalacia patellae”) OR (“Sinding-Larsen-Johansson disease*”) OR (“Sinding Larsen Johansson disease*”) OR (“Sinding-Larsen-Johansson syndrom*”) OR (“Sinding Larsen Johansson syndrom*”) OR (“runner’s knee”) OR (PFPS) OR (“extensor mechanism disorder*”)) OR (((arthralg*) OR (pain*)) AND ((patell*) OR (femoropatell*) OR (“femoro-patell*”) OR (retropatell*) OR (“retro-patell*”) OR (“lateral facet*”) OR (“lateral compr*”) OR (“lateral press*”) OR (“odd facet*”)) AND ((syndrom*) OR (dysfunct*) OR (disorder*) OR (chondromal*) OR (chondropath*)))) AND (classif*)

(((“patellofemoral pain*”) OR (“patellofemoral syndrom*”) OR (“patello-femoral pain*”) OR (“patello-femoral syndrom*”) OR (“anterior knee pain*”) OR (“patellofemoral disorder*”) OR (“patello-femoral disorder*”) OR (“chondromalacia patellae”) OR (“Sinding-Larsen-Johansson disease*”) OR (“Sinding Larsen

## APPENDIX A

Johansson disease*") OR ("Sinding-Larsen-Johansson syndrom*") OR ("Sinding Larsen Johansson syndrom*") OR ("runner's knee") OR (PFPS) OR ("extensor mechanism disorder*")) OR (((arthralg*) OR (pain*)) AND ((patell*) OR (femoropatell*) OR ("femoro-patell*") OR (retropatell*) OR ("retro-patell*") OR ("lateral facet*") OR ("lateral compr*") OR ("lateral press*") OR ("odd facet*")) AND ((syndrom*) OR (dysfunct*) OR (disorder*) OR (chondromal*) OR (chondropath*))))) AND ((associat*) OR (risk*) OR (probabil*) OR (odds*) OR (relat*) OR (prevalen*) OR (predict*) OR (caus*) OR (etiol*) OR (interact*))

(((("patellofemoral pain*") OR ("patellofemoral syndrom*") OR ("patello-femoral pain*") OR ("patello-femoral syndrom*") OR ("anterior knee pain*") OR ("patellofemoral disorder*") OR ("patello-femoral disorder*") OR ("chondromalacia patellae") OR ("Sinding-Larsen-Johansson disease*") OR ("Sinding Larsen Johansson disease*") OR ("Sinding-Larsen-Johansson syndrom*") OR ("Sinding Larsen Johansson syndrom*") OR ("runner's knee") OR (PFPS) OR ("extensor mechanism disorder*")) OR (((arthralg*) OR (pain*)) AND ((patell*) OR (femoropatell*) OR ("femoro-patell*") OR (retropatell*) OR ("retro-patell*") OR ("lateral facet*") OR ("lateral compr*") OR ("lateral press*") OR ("odd facet*")) AND ((syndrom*) OR (dysfunct*) OR (disorder*) OR (chondromal*) OR (chondropath*))))) AND ((preval*) OR (inciden*) OR (epidemiolog*))

(((("patellofemoral pain*") OR ("patellofemoral syndrom*") OR ("patello-femoral pain*") OR ("patello-femoral syndrom*") OR ("anterior knee pain*") OR ("patellofemoral disorder*") OR ("patello-femoral disorder*") OR ("chondromalacia patellae") OR ("Sinding-Larsen-Johansson disease*") OR ("Sinding Larsen Johansson disease*") OR ("Sinding-Larsen-Johansson syndrom*") OR ("Sinding Larsen Johansson syndrom*") OR ("runner's knee") OR (PFPS) OR ("extensor mechanism disorder*")) OR (((arthralg*) OR (pain*)) AND ((patell*) OR (femoropatell*) OR ("femoro-patell*") OR (retropatell*) OR ("retro-patell*") OR ("lateral facet*") OR ("lateral compr*") OR ("lateral press*") OR ("odd facet*")) AND ((syndrom*) OR (dysfunct*) OR (disorder*) OR (chondromal*) OR (chondropath*))))) AND ((sensitiv*) OR (specificity) OR (diagnos*) OR ("disability evaluation") OR (questionnaire) OR (questionnaires) OR (instrument) OR (instruments) OR (scale) OR (scales) OR (measurement) OR (measurements) OR (index) OR (indices) OR (score) OR (scores))

((("patellofemoral pain*") OR ("patellofemoral syndrom*") OR ("patello-femoral pain*") OR ("patello-femoral syndrom*") OR ("anterior knee pain*") OR ("patellofemoral disorder*") OR ("patello-femoral disorder*") OR ("chondromalacia patellae") OR ("Sinding-Larsen-Johansson disease*") OR ("Sinding Larsen Johansson disease*") OR ("Sinding-Larsen-Johansson syndrom*") OR ("Sinding Larsen Johansson syndrom*") OR ("runner's knee") OR (PFPS) OR ("extensor mechanism disorder*")) OR (((arthralg*) OR (pain*)) AND ((patell*) OR (femoropatell*) OR ("femoro-patell*") OR (retropatell*) OR ("retro-patell*") OR ("lateral facet*") OR ("lateral compr*") OR ("lateral press*") OR ("odd facet*")) AND ((syndrom*) OR (dysfunct*) OR (disorder*) OR (chondromal*) OR (chondropath*))))) AND ((prognos*) OR ("return to work") OR ("return to sport"))

(((("patellofemoral pain*") OR ("patellofemoral syndrom*") OR ("patello-femoral pain*") OR ("patello-femoral syndrom*") OR ("anterior knee pain*") OR ("patellofemoral disorder*") OR ("patello-femoral disorder*") OR ("chondromalacia patellae") OR ("Sinding-Larsen-Johansson disease*") OR ("Sinding Larsen Johansson disease*") OR ("Sinding-Larsen-Johansson syndrom*") OR ("Sinding Larsen Johansson syndrom*") OR ("runner's knee") OR (PFPS) OR ("extensor mechanism disorder*")) OR (((arthralg*) OR (pain*)) AND ((patell*) OR (femoropatell*) OR ("femoro-patell*") OR (retropatell*) OR ("retro-patell*") OR ("lateral facet*") OR ("lateral compr*") OR ("lateral press*") OR ("odd facet*")) AND ((syndrom*) OR (dysfunct*) OR (disorder*) OR (chondromal*) OR (chondropath*))))) AND (("physical therapy modalit*") OR ("recovery of function") OR (rehab*) OR (therapeutic*) OR ("physical therap*") OR (physiother*) OR (recover*) OR (restor*) OR ("re-education*") OR ("early ambulation") OR (strengthen*) OR ("resistance training") OR ("resistance method*") OR ("exercise therap*") OR (stretch*) OR (biofeedback) OR ("neuromuscular electrical stimulation*") OR ("pain management") OR ("pain measurement*") OR (mobiliz*) OR ("muscle stretching exercise*") OR ("spinal manipulation*") OR (ultrasonograph*) OR (ultrasound*) OR (acupunctur*) OR (laser*) OR ("patient education*") OR ("electrical stimulation") OR ("electrical stimulation therap*") OR ("Transcutaneous electric nerve stimulation") OR (tap*) OR (brac*) OR (orthotic*) OR ("weight-bearing") OR ("range of motion") OR ("treatment outcome*") OR (exercise*) OR ("training program*"))

## APPENDIX B

### SEARCH RESULTS

| Database | Date Conducted | Results, n |
|---|---|---|
| MEDLINE/PubMed | May 2018 | 4604 |
| Scopus | May 2018 | 8814 |
| CINAHL | May 2018 | 2656 |
| SPORTDiscus | May 2018 | 2730 |
| Cochrane Library | May 2018 | 1230 |
| Cochrane reviews | | 38 |
| Other reviews | | 28 |
| Trials | | 1161 |
| Technology assessments | | 1 |
| Economic evaluations | | 2 |
| Total | | 20034 |
| Total with duplicates removed | | 4691 |
| Total with hand search | | 12 |

## APPENDIX C

# CRITERIA FOR INCLUSION AND EXCLUSION OF STUDIES FOR REVIEW

### Criteria for Considering Studies for Review

Inclusions: articles published in peer-reviewed journals that include studies of the following types: systematic reviews, meta-analyses, experimental and quasi-experimental, cohort, case series, and cross-sectional studies.

### Inclusion Criteria

Articles reporting on

- The functional anatomy of the patellofemoral joint

OR

- Tests and measures for diagnosis and/or differential diagnosis of patellofemoral pain within the scope of physical therapist practice, including but not limited to "specific tests and measures"

OR

- Measurement properties of instruments and tests specific to measuring patellofemoral pain, or patellofemoral pain–related outcomes (including but not limited to symptoms, functions, activity, and participation)

OR

- Measurement properties of instruments that are specific to patellofemoral pain or lower extremity outcomes tested in patients with patellofemoral pain

OR

- Measurement properties of instruments using data from a sample of patients with patellofemoral pain

OR

- Primarily adolescents (12 years of age or older) and adults with patellofemoral pain
  - Studies reporting on persons younger than 12 years of age IF the proportion in the sample is small (less than 5%) OR separate data are available for adults

AND

Patellofemoral pain, including the following topics:

- Risk of patellofemoral pain, including but not limited to range of motion and body mass
- Diagnostic characteristics of patellofemoral pain, including but not limited to pain location, duration, and quality and related impairments and functional limitations
- Interventions within the scope of practice of physical therapists, including but not limited to manual therapy, stretching exercises, taping, orthotic devices, splints, neuromuscular re-education, muscle strengthening, modalities, etc)

All outcomes were included.

### Exclusion Criteria

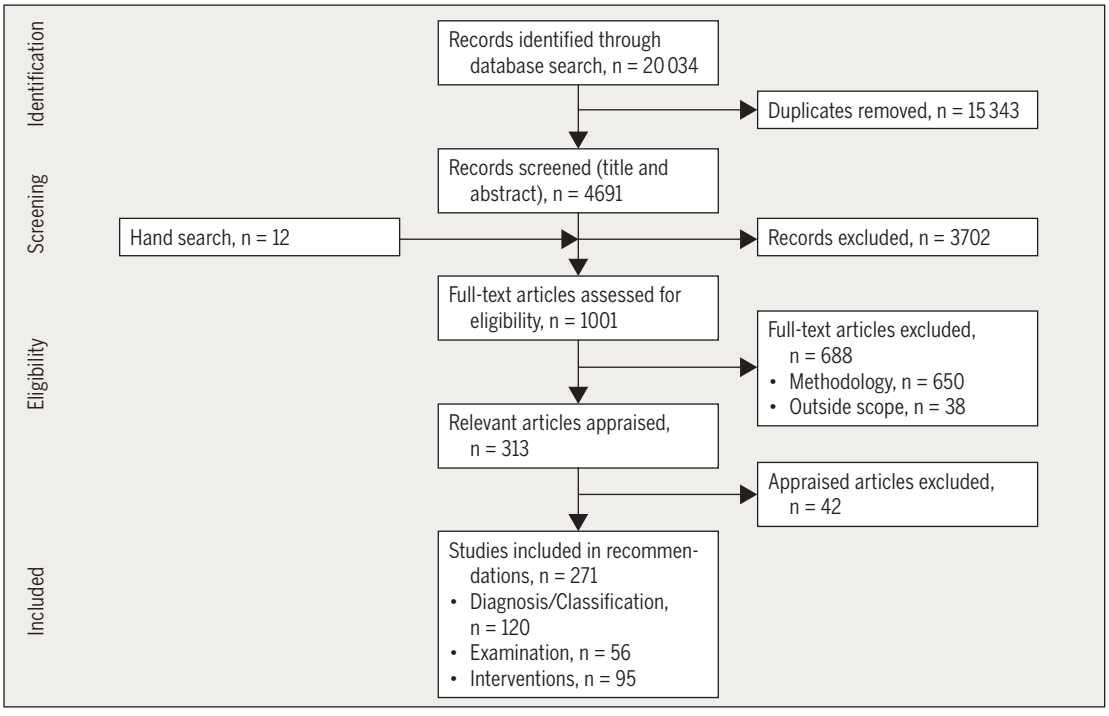
Exclusions: meeting abstracts/conference proceedings, press releases, theses, letters to the editor, authors' responses, nonsystematic review articles, case reports, and articles that cannot be retrieved in English.

Articles reporting on

- Primarily infants and children (younger than 12 years of age)
- Pain related primarily to conditions such as
  - Patellar tendinopathy/tendon pain
  - Iliotibial band syndrome
  - Patellofemoral instability/subluxation/dislocation
  - Knee and/or patellofemoral osteoarthritis
  - Osteochondritis dissecans
  - Knee plica/fat-pad syndrome (Hoffa's syndrome)
  - Bipartite patella
  - Fractures (including stress fractures)
  - Compartment syndrome
  - Tumors
  - Postoperative patellofemoral pain, patellar tendinopathy/tendon pain, or iliotibial band pain from knee surgery or arthroplasty
    - Anterior cruciate ligament surgery, reconstruction
    - Total knee arthroplasty
    - Lateral release of patella
    - Proximal and/or distal realignment of patella
  - Pain secondary to systemic conditions or nerve compression
    - Diabetes
    - Ulcers
    - Primary peripheral nerve entrapment
- Topics outside the scope of physical therapist practice
  - Decisions to order radiologic tests (magnetic resonance imaging, etc)

## APPENDIX D

### FLOW CHART OF ARTICLES



## APPENDIX E

## ARTICLES INCLUDED IN RECOMMENDATIONS, BY TOPIC

### Impairment/Function-Based Diagnosis

#### *Prevalence/Incidence*


Boling M, Padua D, Marshall S, Guskiewicz K, Pyne S, Beutler A. Gender differences in the incidence and prevalence of patellofemoral pain syndrome. *Scand J Med Sci Sports*. 2010;20:725-730. https://doi.org/10.1111/j.1600-0838.2009.00996.x

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Lakstein D, Fridman T, Ziv YB, Kosashvili Y. Prevalence of anterior knee pain and pes planus in Israel Defense Force recruits. *Mil Med*. 2010;175:855-857. https://doi.org/10.7205/milmed-d-09-00145

Lankhorst NE, van Middelkoop M, Crossley KM, et al. Factors that predict a poor outcome 5–8 years after the diagnosis of patellofemoral pain: a multicentre observational analysis. *Br J Sports Med*. 2016;50:881-886. https://doi.org/10.1136/bjsports-2015-094664

Myer GD, Ford KR, Barber Foss KD, et al. The incidence and potential pathomechanics of patellofemoral pain in female athletes. *Clin Biomech (Bristol, Avon)*. 2010;25:700-707. https://doi.org/10.1016/j.clinbiomech.2010.04.001

Neal BS, Griffiths IB, Dowling GJ, et al. Foot posture as a risk factor for lower limb overuse injury: a systematic review and meta-analysis. *J Foot Ankle Res*. 2014;7:55. https://doi.org/10.1186/s13047-014-0055-4

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Patel DR, Nelson TL. Sports injuries in adolescents. *Med Clin North Am*. 2000;84:983-1007. https://doi.org/10.1016/S0025-7125(05)70270-4

Rathleff CR, Olesen JL, Roos EM, Rasmussen S, Rathleff MS. Half of 12-15-year-olds with knee pain still have pain after one year. *Dan Med J*. 2013;60:A4725.

Rathleff MS, Rathleff CR, Olesen JL, Rasmussen S, Roos EM. Is knee pain during adolescence a self-limiting condition? Prognosis of patellofemoral pain and other types of knee pain. *Am J Sports Med*. 2016;44:1165-1171. https://doi.org/10.1177/0363546515622456

Sandow MJ, Goodfellow JW. The natural history of anterior knee pain in adolescents. *J Bone Joint Surg Br*. 1985;67:36-38.

Smith BE, Moffatt F, Hendrick P, et al. The experience of living with patellofemoral pain—loss, confusion and fear-avoidance: a UK qualitative study. *BMJ Open*. 2018;8:e018624. https://doi.org/10.1136/bmjopen-2017-018624

Stathopulu E, Baildam E. Anterior knee pain: a long-term follow-up. *Rheumatology (Oxford)*. 2003;42:380-382. https://doi.org/10.1093/rheumatology/keg093

Tenforde AS, Sayres LC, McCurdy ML, Collado H, Sainani KL, Fredericson M. Overuse injuries in high school runners: lifetime prevalence and prevention strategies. *PM R*. 2011;3:125-131; quiz 131. https://doi.org/10.1016/j.pmrj.2010.09.009

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#### *Clinical Course*


Blond L, Hansen L. Patellofemoral pain syndrome in athletes: a 5.7-year retrospective follow-up study of 250 athletes. *Acta Orthop Belg*. 1998;64:393-400.

Boling MC, Padua DA, Marshall SW, Guskiewicz K, Pyne S, Beutler A. A prospective investigation of biomechanical risk factors for patellofemoral pain syndrome: the Joint Undertaking to Monitor and Prevent ACL Injury (JUMP-ACL) cohort. *Am J Sports Med*. 2009;37:2108-2116. https://doi.org/10.1177/0363546509337934

Collins NJ, Vicenzino B, van der Heijden RA, van Middelkoop M. Pain during prolonged sitting is a common problem in persons with patellofemoral pain. *J Orthop Sports Phys Ther*. 2016;46:658-663. https://doi.org/10.2519/jospt.2016.6470

Conchie H, Clark D, Metcalfe A, Eldridge J, Whitehouse M. Adolescent knee pain and patellar dislocations are associated with patellofemoral osteoarthritis in adulthood: a case control study. *Knee*. 2016;23:708-711. https://doi.org/10.1016/j.knee.2016.04.009

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Crossley KM, Stefanik JJ, Selfe J, et al. 2016 patellofemoral pain consensus statement from the 4th International Patellofemoral Pain Research Retreat, Manchester. Part 1: terminology, definitions, clinical examination, natural history, patellofemoral osteoarthritis and patient-reported outcome measures. *Br J Sports Med*. 2016;50:839-843. https://doi.org/10.1136/bjsports-2016-096384

de Oliveira Silva D, Briani RV, Pazzinatto MF, Ferrari D, Aragão FA, de Azevedo FM. Reduced knee flexion is a possible cause of increased loading rates in individuals with patellofemoral pain. *Clin Biomech (Bristol, Avon)*. 2015;30:971-975. https://doi.org/10.1016/j.clinbiomech.2015.06.021

## APPENDIX E


Dierks TA, Manal KT, Hamill J, Davis I. Lower extremity kinematics in runners with patellofemoral pain during a prolonged run. *Med Sci Sports Exerc*. 2011;43:693-700. https://doi.org/10.1249/MSS.0b013e3181f744f5

Gerbino PG, 2nd, Griffin ED, d'Hemecourt PA, et al. Patellofemoral pain syndrome: evaluation of location and intensity of pain. *Clin J Pain*. 2006;22:154-159. https://doi.org/10.1097/01.ajp.0000159583.31912.1d

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Herrington L. Knee valgus angle during single leg squat and landing in patellofemoral pain patients and controls. *Knee*. 2014;21:514-517. https://doi.org/10.1016/j.knee.2013.11.011

Hinman RS, Lentzos J, Vicenzino B, Crossley KM. Is patellofemoral osteoarthritis common in middle-aged people with chronic patellofemoral pain? *Arthritis Care Res (Hoboken)*. 2014;66:1252-1257. https://doi.org/10.1002/acr.22274

Hoglund LT, Hillstrom HJ, Barr-Gillespie AE, Lockard MA, Barbe MF, Song J. Frontal plane knee and hip kinematics during sit-to-stand and proximal lower extremity strength in persons with patellofemoral osteoarthritis: a pilot study. *J Appl Biomech*. 2014;30:82-94. https://doi.org/10.1123/jab.2012-0244

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### Examination

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## APPENDIX F

### LEVELS OF EVIDENCE TABLE*

| Level | Intervention/Prevention | Pathoanatomic/Risk/ Clinical Course/Prognosis/ Differential Diagnosis | Diagnosis/Diagnostic Accuracy | Prevalence of Condition/ Disorder | Exam/Outcomes |
|---|---|---|---|---|---|
| I | Systematic review of high-quality RCTs<br>High-quality RCT† | Systematic review of prospective cohort studies<br>High-quality prospective cohort study‡ | Systematic review of high-quality diagnostic studies<br>High-quality diagnostic study§ with validation | Systematic review, high-quality cross-sectional studies<br>High-quality cross-sectional study‖ | Systematic review of prospective cohort studies<br>High-quality prospective cohort study |
| II | Systematic review of high-quality cohort studies<br>High-quality cohort study‡<br>Outcomes study or ecological study<br>Lower-quality RCT¶ | Systematic review of retrospective cohort study<br>Lower-quality prospective cohort study<br>High-quality retrospective cohort study<br>Consecutive cohort<br>Outcomes study or ecological study | Systematic review of exploratory diagnostic studies or consecutive cohort studies<br>High-quality exploratory diagnostic studies<br>Consecutive retrospective cohort | Systematic review of studies that allows relevant estimate<br>Lower-quality cross-sectional study | Systematic review of lower-quality prospective cohort studies<br>Lower-quality prospective cohort study |
| III | Systematic reviews of case-control studies<br>High-quality case-control study<br>Lower-quality cohort study | Lower-quality retrospective cohort study<br>High-quality cross-sectional study<br>Case-control study | Lower-quality exploratory diagnostic studies<br>Nonconsecutive retrospective cohort | Local nonrandom study | High-quality cross-sectional study |
| IV | Case series | Case series | Case-control study | | Lower-quality cross-sectional study |
| V | Expert opinion | Expert opinion | Expert opinion | Expert opinion | Expert opinion |

*Abbreviation: RCT, randomized clinical trial.*

**Adapted from Phillips et al[228] (http://www.cebm.net/index.aspx?o=1025). See also* **APPENDIX G.**

†*High quality includes RCTs with greater than 80% follow-up, blinding, and appropriate randomization procedures.*

‡*High-quality cohort study includes greater than 80% follow-up.*

§*High-quality diagnostic study includes consistently applied reference standard and blinding.*

‖*High-quality prevalence study is a cross-sectional study that uses a local and current random sample or censuses.*

¶*Weaker diagnostic criteria and reference standards, improper randomization, no blinding, and less than 80% follow-up may add bias and threats to validity.*

## APPENDIX G

### PROCEDURES FOR ASSIGNING LEVELS OF EVIDENCE

- Level of evidence is assigned based on the study design using the Levels of Evidence table (**APPENDIX F**), assuming high quality (eg, for intervention, randomized clinical trial starts at level I)
- Study quality is assessed using the critical appraisal tool, and the study is assigned 1 of 4 overall quality ratings based on the critical appraisal results
- Level of evidence assignment is adjusted based on the overall quality rating:
  - High quality (high confidence in the estimate/results): study remains at assigned level of evidence (eg, if the randomized clinical trial is rated high quality, its final assignment is level I). High quality should include:
    - Randomized clinical trial with greater than 80% follow-up, blinding, and appropriate randomization procedures
    - Cohort study includes greater than 80% follow-up
    - Diagnostic study includes consistently applied reference standard and blinding
    - Prevalence study is a cross-sectional study that uses a local and current random sample or censuses
  - Acceptable quality (the study does not meet requirements for high quality and weaknesses limit the confidence in the accuracy of the estimate): downgrade 1 level
    - Based on critical appraisal results
  - Low quality: the study has significant limitations that substantially limit confidence in the estimate: downgrade 2 levels
    - Based on critical appraisal results
  - Unacceptable quality: serious limitations—exclude from consideration in the guideline
    - Based on critical appraisal results

## APPENDIX H

# PATELLOFEMORAL PAIN CLINICAL PRACTICE GUIDELINE CRITICAL APPRAISAL SCORES

### Risk Factors: Level of Evidence*

| Study | I | II | III | IV | V |
|---|---|---|---|---|---|
| Apibantaweesakul 2017 | | | X | | |
| Aysin et al 2018 | | | X | | |
| Barton et al 2009 | | X | | | |
| Barton et al 2010 | | X | | | |
| Bolgla et al 2015 | | | X | | |
| Bolgla et al 2016 | | | X | | |
| Boling et al 2009 | | X | | | |
| Boling et al 2010 | | X | | | |
| Carlson et al 2017 | | | X | | |
| Collins et al 2013 | | | X | | |
| Collins et al 2008 | X | | | | |
| Collins et al 2009 | X | | | | |
| de Moura Campos Carvalho-e-Silva et al 2016 | | | X | | |
| De Oliveira Silva et al 2019 | X | | | | |
| Dowling et al 2015 | | X | | | |
| Giles et al 2013 | X | | | | |
| Giles et al 2017 | X | | | | |
| Guney et al 2016 | | | X | | |
| Hall et al 2015 | | X | | | |
| Hoglund et al 2018 | | | X | | |
| Lankhorst et al 2013 | X | | | | |
| Lankhorst et al 2016 | X | | | | |
| Luedke et al 2015 | | X | | | |
| Maclachlan et al 2017 | X | | | | |
| Matthews et al 2017 | | X | | | |
| McMoreland et al 2011 | | | X | | |
| McPoil et al 2011 | | X | | | |
| Mucha et al 2017 | | X | | | |
| Neal et al 2016 | | X | | | |
| Nunes et al 2018 | | | X | | |
| Panken et al 2015 | X | | | | |
| Pappas and Wong-Tom 2012 | X | | | | |
| Park et al 2011 | | | X | | |
| Ramskov et al 2015 | | X | | | |
| Rathleff et al 2014 | X | | | | |
| Semciw et al 2016 | | X | | | |
| Steinberg et al 2017 | | | X | | |
| Tan et al 2018 | | | X | | |
| Van Cant et al 2014 | | X | | | |
| Van Cant et al 2017 | | | X | | |
| Van Middelkoop et al 2017 | | | | X | |
| Van Tiggelen et al 2004 | | X | | | |
| Vicenzino et al 2008 | X | | | | |
| Waryasz and McDermott 2008 | | X | | | |
| Witvrouw et al 2000 | | X | | | |

**Levels of evidence adapted from Phillips et al[228]: (I) Systematic review of prospective cohort studies; high-quality prospective cohort study; (II) Systematic review of retrospective cohort studies; lower-quality prospective cohort study; high-quality retrospective cohort study; consecutive cohort; outcomes study or ecological study; (III) Lower-quality retrospective cohort study; high-quality cross-sectional study; case-control study; (IV) Case series; (V) Expert opinion.*

## APPENDIX H

### Examination: Patient-Reported Outcome Measures, AMSTAR* Systematic Review

| Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Esculier et al 2013 | Y | Y | Y | Y | N | Y | Y | Y | CS | N | Y | High |
| Green et al 2014 | Y | Y | Y | Y | N | Y | Y | Y | CS | CS | N | Acceptable |
| Howe et al 2012 | N | Y | Y | N | N | Y | N | N | CS | N | N | Low |
| Papadopoulos et al 2015 | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | High |

*Abbreviations: AMSTAR, A MeaSurement Tool to Assess systematic Reviews; CS, can't say; N, no; Y, yes.*
**AMSTAR items: (1) Was an "a priori" design provided?; (2) Was there duplicate study selection and data extraction?; (3) Was a comprehensive literature search performed?; (4) Was the status of publication (ie, gray literature) used as an inclusion criterion?; (5) Was a list of studies (included and excluded) provided?; (6) Were the characteristics of the included studies provided?; (7) Was the scientific quality of the included studies assessed and documented?; (8) Was the scientific quality of the included studies used appropriately in formulating conclusions?; (9) Were the methods used to combine the findings of studies appropriate?; (10) Was the likelihood of publication bias assessed?; (11) Was the conflict of interest included?; (12) What is your overall assessment of the methodological quality of this review? (high, acceptable, low, unacceptable).*

### Examination: Patient-Reported Outcome Measures, CASP Systematic Review*

| Study | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Almeida et al 2017 | Y | Y | Y | Y | N | N |
| Bradbury et al 2013 | Y | Y | Y | Y | Y | Y |
| Chesworth et al 1989 | Y | Y | Y | N | Y | Y |
| Crossley et al 2004 | Y | NA | NA | Y | Y | Y |
| Crossley et al 2018 | Y | Y | Y | CS | Y | Y |
| Décary et al 2018 | Y | Y | Y | Y | Y | Y |
| Ittenbach et al 2016 | Y | CS | CS | CS | Y | Y |
| Laprade and Culham 2002 | Y | Y | Y | Y | Y | Y |
| Lee et al 2012 | Y | Y | Y | CS | Y | Y |
| Myer et al 2016 | Y | Y | Y | Y | Y | Y |
| Piva et al 2009 | Y | NA | NA | NA | Y | Y |
| Selfe et al 2001 (validity, reliability) | N | N | Y | CS | Y | Y |
| Siqueira et al 2012 | Y | CS | CS | Y | Y | Y |
| Watson et al 2005 | Y | Y | N | Y | Y | Y |

*Abbreviations: CASP, Critical Appraisal Skills Program; CS, can't say; N, no; NA, not applicable; Y, yes.*
**CASP items: (1) Was there a clear question for the study to address?; (2) Was there a comparison with an appropriate reference standard?; (3) Did all patients get the diagnostic test and reference standard?; (4) Could the results of the test have been influenced by the results of the reference standard?; (5) Is the disease status of the tested population clearly described?; (6) Were the methods for performing the test described in sufficient detail?*

## APPENDIX H

### Examination: Patient-Reported Outcome Measures, COSMIN Systematic Review*

| Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Overall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Almeida et al 2017 | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | NA | NA | NA | NA | NA | NA | Y | Y | Y | High |
| Bradbury et al 2013 | Y | Y | N | Y | Y | N | Y | Y | N | N | NA | NA | NA | NA | NA | NA | Y | Y | Y | Acceptable |
| Chesworth et al 1989 | Y | Y | N | Y | Y | Y | Y | Y | N | N | NA | NA | NA | NA | NA | NA | Y | Y | Y | High |
| Crossley et al 2004 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | NA | NA | NA | Y | Y | Y | Y | Y | High |
| Crossley et al 2018 | Y | Y | Y | Y | Y | CS | Y | Y | Y | Y | Y | CS | CS | CS | Y | Y | Y | Y | Y | High |
| Décary et al 2018 | Y | Y | Y | Y | Y | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | Y | Y | Y | High |
| Ittenbach et al 2016 | Y | Y | Y | Y | Y | CS | CS | CS | Y | Y | CS | CS | CS | CS | CS | CS | Y | Y | Y | High |
| Laprade and Culham 2002 | N | Y | N | Y | Y | N | Y | Y | N | N | NA | NA | NA | NA | NA | NA | Y | Y | Y | High |
| Lee et al 2012 | Y | Y | N | CS | Y | CS | Y | Y | Y | N | CS | CS | CS | CS | CS | CS | Y | Y | Y | High |
| Myer et al 2016 | Y | Y | Y | CS | CS | CS | N | N | Y | Y | CS | CS | CS | CS | CS | CS | Y | Y | Y | High |
| Piva et al 2009 | Y | Y | Y | Y | Y | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | Y | Y | Y | High |
| Selfe et al 2001 (validity, reliability) | Y | Y | Y | CS | CS | N | Y | Y | Y | N | Y | Y | Y | CS | CS | CS | Y | Y | Y | High |
| Siqueira et al 2012 | CS | CS | CS | CS | CS | NA | Y | Y | Y | CS | CS | CS | CS | CS | CS | CC | Y | Y | Y | High |
| Watson et al 2005 | Y | Y | N | Y | Y | N | Y | Y | Y | Y | Y | NA | NA | NA | Y | Y | Y | Y | Y | High |

*Abbreviations: COSMIN, COnsensus-based Standards for the selection of health status Measurement INstruments; CS, can't say; N, no; NA, not applicable; Y, yes. *COSMIN items: (1) Was there an assessment of whether all items refer to relevant aspects of the construct to be measured?; (2) Was there an assessment of whether all items are relevant for the study population? (eg, age, gender, disease characteristics, country, setting); (3) Was there an assessment of whether all items are relevant for the purpose of the measurement instrument? (discriminative, evaluative, and/or predictive); (4) Can the criterion used or employed be considered as a reasonable "gold standard"?; (5) For continuous scores: Were correlations or the area under the receiver operating curve (ROC) calculated? For dichotomous scores: Were sensitivity and specificity determined?; (6) Was the percentage of missing items given?; (7) Were at least 2 measurements available?; (8) Was the time interval appropriate?; (9) For continuous scores: Was an intraclass correlation coefficient (ICC) calculated? For dichotomous/nominal/ordinal scores: Was kappa calculated?; (10) For CTT: Was the standard error of measurement (SEM), smallest detectable change (SDC), or limits of agreement (LoA) calculated?; (11) Was a longitudinal design with at least 2 measurements used?; (12) Were hypotheses about changes in scores formulated a priori (ie, before data collection)?; (13) Was the expected direction of correlations or mean differences of the change scores of HR-PRO instruments included in these hypotheses?; (14) Were the expected absolute or relative magnitude of correlations or mean differences of the change scores of HR-PRO instruments included in these hypotheses?; (15) Can the criterion for change be considered as a reasonable gold standard?; (16) For continuous scores: Were correlations between change scores, or the area under the ROC calculated? For dichotomous scales: Were sensitivity and specificity (changed versus not changed) determined?; (17) Can the results be applied to your patients/the population of interest?; (18) Can the test be applied to your patient or population of interest?; (19) Were all outcomes important to the individual or population considered?*

## APPENDIX H

### Examination: Patient-Reported Outcome Measures, Cross-cultural, COSMIN Systematic Review*

| Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Overall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alshehri et al 2017 | CS | Y | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | N | High |
| Apivatgaroon et al 2016 | N | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | High |
| Buckinx et al 2019 | N | N | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | N | Y | High |
| Buckinx 2017b | N | N | Y | Y | Y | Y | Y | Y | Y | Y | N | N | N | N | Acceptable |
| Celik et al 2013 | Y | Y | N | Y | Y | Y | Y | Y | Y | Y | N | N | N | N | Acceptable |
| Cheung et al 2012 | Y | Y | Y | N | N | N | N | N | N | N | N | Y | CS | N | Acceptable |
| Cheung et al 2013 | N | N | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | N | N | Acceptable |
| da Cunha et al 2013 | N | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | N | High |
| Evcik et al 2009 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | N | Y | N | High |
| Gil-Gámez et al 2016 | N | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | N | High |
| Kuru et al 2010 | Y | Y | N | Y | Y | Y | Y | N | CS | Y | N | Y | Y | N | High |
| Negahban et al 2012 | N | N | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | N | N | Acceptable |
| Negahban et al 2013 | N | N | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | N | Y | High |
| Papadopoulos et al 2017 | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | Y | Y | N | N | High |
| Sakunkaruna et al 2015 | N | N | Y | Y | N | N | Y | Y | Y | N | N | Y | Y | N | Acceptable |
| Ummels et al 2017 | N | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | N | High |

*Abbreviations: COSMIN, COnsensus-based Standards for the selection of health status Measurement INstruments; CS, can't say; N, no; Y, yes.*
**COSMIN items: (1) Was the percentage of missing items given?; (2) Was there a description of how missing items were handled?; (3) Was the sample size included in the analysis adequate?; (4) Were both the original language in which the HR-PRO instrument was developed, and the language in which the HR-PRO instrument was translated, described?; (5) Was the expertise of the people involved in the translation process adequately described? (eg, expertise in the disease(s) involved, expertise in the construct to be measured, expertise in both languages); (6) Did the translators work independently from each other?; (7) Were items translated forward and backward?; (8) Was there an adequate description of how differences between the original and translated versions were resolved?; (9) Was the translation reviewed by a committee (eg, original developers)?; (10) Was the HR-PRO instrument pretested (eg, cognitive interviews) to check interpretation, cultural relevance of the translation, and ease of comprehension?; (11) Was the sample used in the pretest adequately described?; (12) Were the samples similar for all characteristics except language and/or cultural background?; (13) Were there any important flaws in the design or methods of the study?; (14) For CTT: Was confirmatory factor analysis performed? For IRT: Was differential item function (DIF) between language groups assessed?*

### Examination: Physical Impairments/Activity Limitations, AMSTAR* Systematic Review

| Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chuter 2012 | Y | N | Y | Y | N | Y | N | Y | CS | N | Y | Acceptable |
| Cook et al 2012 | Y | Y | Y | Y | N | N | Y | Y | CS | N | Y | Acceptable |
| Décary et al 2016 | Y | Y | Y | N | N | Y | Y | Y | Y | N | Y | High |
| Fredericson and Yoon 2006 | Y | N | N | N | N | Y | N | N | CS | N | N | Low |
| Lankhorst et al 2013 | Y | Y | Y | Y | N | N | Y | Y | Y | N | Y | High |
| Nunes et al 2013 | Y | Y | Y | N | N | Y | Y | Y | CS | N | Y | Acceptable |
| Papadopoulos et al 2015 | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | High |

*Abbreviations: AMSTAR, A MeaSurement Tool to Assess systematic Reviews ; CS, can't say; N, no; Y, yes.*
**AMSTAR items: (1) Was an "a priori" design provided?; (2) Was there duplicate study selection and data extraction?; (3) Was a comprehensive literature search performed?; (4) Was the status of publication (ie, grayliterature) used as an inclusion criterion?; (5) Was a list of studies (included and excluded) provided?; (6) Were the characteristics of the included studies provided?; (7) Was the scientific quality of the included studies assessed and documented?; (8) Was the scientific quality of the included studies used appropriately in formulating conclusions?; (9) Were the methods used to combine the findings of studies appropriate?; (10) Was the likelihood of publication bias assessed?; (11) Was the conflict of interest included?; (12) What is your overall assessment of the methodological quality of this review? (high, acceptable, low, unacceptable).*

## APPENDIX H

### Examination: Physical Impairments/Activity Limitations, CASP Systematic Review*

| Study | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Nijs et al 2006 | Y | N | N | NA | N | Y |
| Piva et al 2006 | Y | NA | NA | NA | NA | NA |
| Piva et al 2009 | Y | NA | NA | NA | NA | NA |
| Scholtes and Salsich 2017 | Y | CS | CS | CS | Y | Y |
| Selfe et al 2001 (validity, reliability) | Y | N | N | N | Y | Y |
| van der Heijden 2015 | Y | NA | NA | NA | Y | Y |

*Abbreviations: CASP, Critical Appraisal Skills Program; CS, can't say; N, no; NA, not applicable; Y, yes.*
**CASP items: (1) Was there a clear question for the study to address? (2) Was there a comparison with an appropriate reference standard?; (3) Did all patients get the diagnostic test and reference standard?; (4) Could the results of the test have been influenced by the results of the reference standard?; (5) Is the disease status of the tested population clearly described?; (6) Were the methods for performing the test described in sufficient detail?*

### Examination: Physical Impairments/Activity Limitations, COSMIN Systematic Review*

| Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Overall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nijs et al 2006 | Y | Y | Y | N | N | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | Y | Y | Y | High |
| Piva et al 2006 | Y | Y | N | NA | NA | Y | Y | Y | Y | Y | NA | NA | NA | NA | NA | NA | Y | Y | Y | High |
| Piva et al 2009 | Y | Y | Y | CS | CS | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | Y | Y | Y | High |
| Scholtes and Salsich 2017 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | CS | CS | CS | CS | CS | CS | Y | Y | Y | High |
| Selfe et al 2001 (validity, reliability) | CS | CS | CS | CS | CS | N | Y | NA | N | NA | NA | NA | NA | NA | NA | NA | Y | N | N | Acceptable |
| van der Heijden et al 2015 | NA | NA | NA | NA | NA | Y | Y | CS | Y | N | CS | CS | CS | CS | CS | CS | Y | Y | Y | High |

*Abbreviations: COSMIN, COnsensus-based Standards for the selection of health status Measurement INstruments; CS, can't say; N, no; NA, not applicable; Y, yes.*
**COSMIN items: (1) Was there an assessment of whether all items refer to relevant aspects of the construct to be measured?; (2) Was there an assessment of whether all items are relevant for the study population? (eg, age, gender, disease characteristics, country, setting); (3) Was there an assessment of whether all items are relevant for the purpose of the measurement instrument? (discriminative, evaluative, and/or predictive); (4) Can the criterion used or employed be considered as a reasonable "gold standard"?; (5) For continuous scores: Were correlations or the area under the receiver operating curve (ROC) calculated? For dichotomous scores: Were sensitivity and specificity determined?; (6) Was the percentage of missing items given?; (7) Were at least 2 measurements available?; (8) Was the time interval appropriate?; (9) For continuous scores: Was an intraclass correlation coefficient (ICC) calculated? For dichotomous/nominal/ordinal scores: Was kappa calculated?; (10) For CTT: Was the standard error of measurement (SEM), smallest detectable change (SDC), or limits of agreement (LoA) calculated?; (11) Was a longitudinal design with at least 2 measurements used?; (12) Were hypotheses about changes in scores formulated a priori (ie, before data collection)?; (13) Was the expected direction of correlations or mean differences of the change scores of HR-PRO instruments included in these hypotheses?; (14) Were the expected absolute or relative magnitude of correlations or mean differences of the change scores of HR-PRO instruments included in these hypotheses?; (15) Can the criterion for change be considered as a reasonable gold standard?; (16) For continuous scores: Were correlations between change scores, or the area under the ROC calculated? For dichotomous scales: Were sensitivity and specificity (changed versus not changed) determined?; (17) Can the results be applied to your patients/the population of interest?; (18) Can the test be applied to your patient or population of interest?; (19) Were all outcomes important to the individual or population considered?*

### Examination: Physical Impairments/Activity Limitations, Level of Evidence*

| Study | I | II | III | IV | V |
|---|---|---|---|---|---|
| Chmielewski et al 2004 | | | X | | |
| Collins et al 2016 | | X | | | |
| Décary et al 2018 | | | X | | |
| Näslund et al 2006 | | | X | | |
| Watson et al 1999 | | | X | | |
| Watson et al 2001 | | | X | | |

**Levels of evidence adapted from Phillips et al[228]: (I) Systematic review of prospective cohort studies; high-quality prospective cohort study; (II) Systematic review of retrospective cohort studies; lower-quality prospective cohort study; high-quality retrospective cohort study; consecutive cohort; outcomes study or ecological study; (III) Lower-quality retrospective cohort study; high-quality cross-sectional study; case-control study; (IV) Case series; (V) Expert opinion.*

## APPENDIX H

### Interventions: SIGN Systematic Review*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Clijsen et al 2014 | N | CA | Y | N | N | N | Y | Y | Y | Y | N | Acceptable |
| Holden et al 2018 | Y | Y | Y | N | N | N | Y | Y | Y | N | Y | Acceptable |
| Kooiker et al 2014 | NA | CA | Y | CA | Y | Y | Y | Y | Y | N | N | Acceptable |
| Lack et al 2015 | N | CA | Y | CA | N | N | Y | Y | Y | N | N | Low |
| van der Heijden et al 2015 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | High |
| van der Heijden et al 2016 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | High |
| Harvie et al 2011 | N | CA | Y | N | N | N | Y | N | N | N | N | Low |
| Collins et al 2012 | N | N | Y | N | N | N | Y | Y | Y | N | N | Low |
| Lake and Wofford 2011 | N | CA | Y | N | N | N | Y | N | N | N | N | Low |
| Wasielewski et al 2011 | N | Y | N | N | Y | Y | Y | Y | Y | N | N | Acceptable |
| Barton et al 2010 | N | CA | Y | N | Y | Y | Y | Y | Y | N | N | Acceptable |
| Swart et al 2012 | N | Y | Y | N | N | Y | Y | Y | Y | N | N | Acceptable |
| Warden et al 2008 | Y | N | Y | Y | N | Y | Y | Y | Y | Y | N | High |
| Hossain et al 2011 | Y | Y | Y | CA | Y | N | Y | Y | Y | Y | N | High |
| Matthews et al 2017 | N | Y | Y | CA | Y | Y | N | Y | Y | N | Y | Acceptable |
| Neal et al 2016 | Y | Y | Y | N | N | Y | Y | N | Y | N | Y | Acceptable |
| Young et al 2018 | N | Y | Y | N | Y | Y | Y | Y | Y | N | Y | High |
| Callaghan and Selfe 2012 | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | N | High |
| Smith et al 2015 | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | N | High |

*Abbreviation: CA, can't answer; N, no; SIGN, Scottish Intercollegiate Guidelines Network; Y, yes.*
**SIGN items: (1) The study addresses a clearly defined research question; (2) At least 2 people should select studies and extract data; (3) A comprehensive literature search is carried out; (4) The authors clearly state if or how they limited their review by publication type; (5) The included and excluded studies are listed; (6) The characteristics of the included studies are provided; (7) The scientific quality of the included studies is assessed and documented; (8) The scientific quality of the included studies was assessed appropriately; (9) Appropriate methods are used to combine the individual study findings; (10) The likelihood of publication bias is assessed; (11) Conflicts of interest are declared; (12) What is your overall assessment of the methodological quality of this review? (high quality, 8 or greater; acceptable, 5 or greater; low, 4 or less).*

## APPENDIX H

### Interventions: PEDro*

| Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abd Elhafz et al 2011 | Y | Y | N | Y | N | N | Y | Y | N | Y | Y | Acceptable |
| Bakhtiary and Fatemi 2008 | N | Y | Y | Y | N | N | N | N | Y | Y | Y | Acceptable |
| de Marche Baldon et al 2014 | Y | Y | Y | Y | N | N | N | Y | Y | Y | Y | High |
| Bily et al 2008 | Y | Y | Y | Y | N | N | N | N | N | Y | Y | Acceptable |
| Bolgla et al 2016 | Y | Y | N | Y | N | N | N | N | Y | N | Y | Acceptable |
| Bonacci et al 2018 | Y | Y | Y | Y | N | N | N | Y | N | Y | Y | Acceptable |
| Callaghan et al 2001 | Y | Y | Y | Y | Y | N | Y | Y | N | Y | Y | High |
| Callaghan and Oldham 2004 | Y | Y | N | Y | N | N | N | Y | N | Y | Y | Acceptable |
| Clark et al 2000 | Y | Y | N | Y | N | N | Y | Y | Y | Y | Y | High |
| Collins et al 2009 | Y | Y | Y | Y | N | N | Y | Y | Y | Y | Y | High |
| Crossley et al 2002 | Y | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | High |
| Demirci et al 2017 | N | Y | N | Y | N | N | N | Y | N | Y | Y | Acceptable |
| Dolak et al 2011 | Y | Y | N | Y | N | N | Y | N | Y | Y | Y | Acceptable |
| Dursun et al 2001 | Y | Y | N | Y | N | N | N | Y | N | Y | Y | Acceptable |
| Esculier et al 2016 | Y | Y | Y | N | N | N | N | Y | Y | Y | Y | Acceptable |
| Espí-López et al 2017 | Y | Y | Y | Y | N | N | Y | Y | Y | Y | Y | High |
| Ferber et al 2015 | Y | Y | Y | Y | N | N | N | N | Y | Y | Y | Acceptable |
| Fukuda et al 2010 | Y | Y | Y | Y | N | N | Y | Y | N | Y | Y | High |
| Fukuda et al 2012 | Y | Y | Y | N | N | Y | Y | Y | Y | Y | Y | High |
| Ghourbanpour et al 2018 | N | Y | N | Y | N | N | N | N | N | Y | Y | Low |
| Giles et al 2017 | Y | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | High |
| Günay et al 2017 | Y | Y | N | Y | N | N | N | N | N | Y | Y | Acceptable |
| Hains and Hains 2010 | Y | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | High |
| Ahmed Hamada et al 2017 | N | Y | Y | Y | N | N | Y | Y | N | Y | Y | Acceptable |
| Herrington and Al-Sherhi 2007 | Y | Y | Y | Y | N | N | Y | Y | N | Y | N | Acceptable |
| Khayambashi et al 2012 | Y | Y | N | Y | N | N | N | Y | N | Y | Y | Acceptable |
| Khayambashi et al 2014 | N | N | N | Y | N | N | N | Y | N | Y | Y | Low |
| Moyano et al 2013 | Y | Y | Y | Y | N | N | N | Y | N | Y | Y | Acceptable |
| Østerås et al 2013 | Y | Y | Y | Y | N | N | Y | N | N | Y | Y | Acceptable |
| Østerås et al 2013 | Y | Y | Y | Y | N | N | N | Y | N | Y | Y | Acceptable |
| Patle and Bhave 2015 | Y | Y | N | N | N | N | N | N | N | N | N | Low |
| dos Anjos Rabelo et al 2017 | Y | Y | Y | Y | N | N | Y | Y | Y | Y | Y | High |
| Rathleff et al 2015 | Y | Y | N | Y | N | N | Y | N | Y | Y | Y | Acceptable |
| Roper et al 2016 | N | Y | N | Y | N | N | N | Y | N | Y | Y | Acceptable |
| Song et al 2009 | Y | Y | Y | Y | N | N | Y | Y | Y | Y | Y | High |
| Stakes et al 2006 | Y | Y | Y | Y | N | N | N | Y | N | Y | Y | Acceptable |
| Sutlive et al 2004 | Y | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | High |
| Syme 2009 | Y | Y | Y | Y | N | N | Y | Y | Y | Y | Y | High |
| van Linschoten et al 2009 | Y | Y | N | Y | N | N | N | Y | Y | Y | Y | Acceptable |
| Whittingham et al 2004 | Y | Y | N | Y | Y | N | Y | Y | Y | Y | Y | High |
| Witvrouw et al 2004 | N | Y | Y | Y | N | N | Y | N | Y | Y | Y | Acceptable |
| Witvrouw et al 2000 | N | Y | Y | Y | N | N | N | Y | N | Y | Y | Acceptable |
| Yip and Ng 2006 | N | Y | N | Y | N | N | Y | Y | N | Y | Y | Acceptable |

*Abbreviations: N, no; PEDro, Physiotherapy Evidence Database; Y, yes.*

**(1) Eligibility criteria were specified; (2) Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated in the order in which treatments were received); (3) Allocation was concealed; (4) The groups were similar at baseline regarding the most important prognostic indicators; (5) There was blinding of all subjects; (6) There was blinding of all therapists who administered the therapy; (7) There was blinding of all assessors who measured at least 1 key outcome; (8) Measures of at least 1 key outcome were obtained from more than 85% of the subjects initially allocated to groups; (9) All subjects for whom outcome measures were available received the treatment or control condition as allocated, or, where this was not the case, data for at least 1 key outcome were analyzed by "intention to treat"; (10) The results of between-group statistical comparisons are reported for at least 1 key outcome; (11) The study provides both point measures and measures of variability for at least 1 key outcome; (12) What is your overall assessment of the methodological quality of this review? (high quality, 8 or greater; acceptable, 5 or greater; low, 4 or less).*

## APPENDIX H

### Interventions: Other, Level of Evidence*

| Study | I | II | III | IV | V |
|---|---|---|---|---|---|
| Crossley et al 2016 | | | | | X |
| Crossley et al 2016 | | | | | X |

**Levels of evidence adapted from Phillips et al[228]: (I) Systematic review of prospective cohort studies; high-quality prospective cohort study; (II) Systematic review of retrospective cohort studies; lower-quality prospective cohort study; high-quality retrospective cohort study; consecutive cohort; outcomes study or ecological study; (III) Lower-quality retrospective cohort study; high-quality cross-sectional study; case-control study; (IV) Case series; (V) Expert opinion.*