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# Knee Stability and Movement Coordination Impairments: Knee Ligament Sprain Revision 2017

## *Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Orthopaedic Section of the American Physical Therapy Association*

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# Summary of Recommendations*

## DIAGNOSIS/CLASSIFICATION

**A** Physical therapists should diagnose the International Classification of Diseases (ICD) categories of Sprain and strain involving collateral ligament of knee, Sprain and strain involving cruciate ligament of knee, and Injury to multiple structures of knee, and the associated International Classification of Functioning, Disability and Health (ICF) impairment-based categories of knee instability (**b7150 Stability of a single joint**) and movement coordination impairments (**b7601 Control of complex voluntary movements**), using the following history and physical examination findings: mechanism of injury, passive knee laxity, joint pain, joint effusion, and movement coordination impairments.

## DIFFERENTIAL DIAGNOSIS

**B** The clinician should suspect diagnostic classifications associated with serious pathological conditions when the individual's reported activity limitations and impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline, or when the individual's symptoms are not resolving with intervention aimed at normalization of the individual's impairments of body function.

## EXAMINATION – OUTCOME MEASURES: ACTIVITY LIMITATIONS AND SELF-REPORTED MEASURES

**B** Clinicians should use the International Knee Documentation Committee 2000 Subjective Knee Evaluation Form (IKDC 2000) or Knee injury and Osteoarthritis Outcome Score (KOOS), and may use the Lysholm scale, as validated patient-reported outcome measures to assess knee symptoms and function, and should use the Tegner activity scale or Marx Activity Rating Scale to assess activity level, before and after interventions intended to alleviate the physical impairments, activity limitations, and participation restrictions associated with knee ligament sprain. Clinicians may use the Anterior Cruciate Ligament-Return to Sport after Injury (ACL-RSI) instrument as a validated patient-reported outcome measure to assess psychological factors that may hinder return to sports before and after interventions intended to alleviate fear of reinjury associated with knee ligament sprain.

## EXAMINATION – PHYSICAL PERFORMANCE MEASURES

**B** Clinicians should administer appropriate clinical or field tests, such as single-legged hop tests (eg, single hop for distance, crossover hop for distance, triple hop for distance, and 6-meter timed hop), that can identify a patient's baseline status relative to pain, function, and disability; detect side-to-side asymmetries; assess global knee function; determine a patient's readiness to return to activities; and monitor changes in the patient's status throughout the course of treatment.

## EXAMINATION – PHYSICAL IMPAIRMENT MEASURES

**B** When evaluating a patient with ligament sprain over an episode of care, clinicians should use assessments of impairment of body structure and function, including measures of knee laxity/stability, lower-limb movement coordination, thigh muscle strength, knee effusion, and knee joint range of motion.

## INTERVENTIONS – CONTINUOUS PASSIVE MOTION

**C** Clinicians may use continuous passive motion in the immediate postoperative period to decrease postoperative pain after anterior cruciate ligament (ACL) reconstruction.

## INTERVENTIONS – EARLY WEIGHT BEARING

**C** Clinicians may implement early weight bearing as tolerated (within 1 week after surgery) for patients after ACL reconstruction.

## INTERVENTIONS – KNEE BRACING

**C** Clinicians may use functional knee bracing in patients with ACL deficiency.

**D** Clinicians should elicit and document patient preferences in the decision to use functional knee bracing following ACL reconstruction, as evidence exists for and against its use.

**F** Clinicians may use appropriate knee bracing for patients with acute posterior cruciate ligament (PCL) injuries, severe medial collateral ligament (MCL) injuries, or posterolateral corner (PLC) injuries.

## INTERVENTIONS – IMMEDIATE VERSUS DELAYED MOBILIZATION

**B** Clinicians should use immediate mobilization (within 1 week) after ACL reconstruction to increase joint range of motion, reduce joint pain, and reduce the risk of adverse responses of surrounding soft tissue structures, such as those associated with knee extension range-of-motion loss.

## INTERVENTIONS – CRYOTHERAPY

**B** Clinicians should use cryotherapy immediately after ACL reconstruction to reduce postoperative knee pain.

## INTERVENTIONS – SUPERVISED REHABILITATION

**B** Clinicians should use exercises as part of the in-clinic supervised rehabilitation program after ACL reconstruction and should provide and supervise the progression of a home-based exercise program, providing education to ensure independent performance.

## INTERVENTIONS – THERAPEUTIC EXERCISES

**A** Weight-bearing and non–weight-bearing concentric and eccentric exercises should be implemented within 4 to 6 weeks, 2 to 3 times per week for 6 to 10 months, to increase thigh muscle strength and functional performance after ACL reconstruction.

## Summary of Recommendations* *(continued)*

### INTERVENTIONS – NEUROMUSCULAR ELECTRICAL STIMULATION

**A** Neuromuscular electrical stimulation should be used for 6 to 8 weeks to augment muscle strengthening exercises in patients after ACL reconstruction to increase quadriceps muscle strength and enhance short-term functional outcomes.

### INTERVENTIONS – NEUROMUSCULAR RE-EDUCATION

**A** Neuromuscular re-education training should be incorporated with muscle strengthening exercises in patients with knee stability and movement coordination impairments.

*These recommendations and clinical practice guidelines are based on the scientific literature published prior to December 2016.

## List of Abbreviations

**ACL:** anterior cruciate ligament
**ACL-RSI:** Anterior Cruciate Ligament-Return to Sport after Injury
**ADLs:** activities of daily living
**APTA:** American Physical Therapy Association
**CI:** confidence interval
**CPG:** clinical practice guideline
**EQ-5D:** EuroQol-5 Dimensions
**HRQoL:** health-related quality of life
**ICC:** intraclass correlation coefficient
**ICD:** International Classification of Diseases
**ICF:** International Classification of Functioning, Disability and Health
**IKDC 2000:** International Knee Documentation Committee 2000 Subjective Knee Evaluation Form
***JOSPT*:** *Journal of Orthopaedic & Sports Physical Therapy*
**KOOS:** Knee injury and Osteoarthritis Outcome Score
**KQoL-26:** Knee Quality of Life 26-item questionnaire
**LCL:** lateral collateral ligament
**MCL:** medial collateral ligament
**MDC:** minimal detectable change
**MRI:** magnetic resonance imaging
**NLR:** negative likelihood ratio
**NMES:** neuromuscular electrical stimulation
**OR:** odds ratio
**PCL:** posterior cruciate ligament
**PLC:** posterolateral corner
**PLR:** positive likelihood ratio
**PROs:** patient-reported outcomes
**QoL:** quality of life
**RCTs:** randomized controlled trials
**SANE:** single assessment numeric evaluation
**SF-12:** Medical Outcomes Study 12-Item Short-Form Health Survey
**SF-36:** Medical Outcomes Study 36-Item Short-Form Health Survey
**TSK-11:** Tampa Scale of Kinesiophobia

## Introduction

### AIM OF THE GUIDELINES

The Orthopaedic Section of the American Physical Therapy Association (APTA) 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).[125]

The purposes of these clinical guidelines are to:

- Describe evidence-based physical therapy practice, including diagnosis, prognosis, intervention, and assessment of outcome for musculoskeletal disorders commonly managed by orthopaedic and sports 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

# Introduction *(continued)*

- 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.



# Methods

Content experts were appointed by the Orthopaedic Section of the APTA to conduct a review of the literature and to develop an updated "Knee Stability and Movement Coordination Impairments: Knee Ligament Sprain" CPG as indicated by the current state of the evidence in the field. The aims of the revision were to provide a concise summary of the evidence since publication of the original guideline and to develop new recommendations or revise previously published recommendations to support evidence-based practice. The authors of this guideline revision worked with research librarians with expertise in systematic reviews to perform a systematic search for concepts associated with ligament injuries and instabilities of the knee for articles published since 2008 related to classification, examination, and intervention strategies consistent with previous guideline development methods related to ICF classification.[70] Briefly, the following databases were searched from 2008 to December 2016: MEDLINE (PubMed; 2008 to date), Scopus (Elsevier; 2008 to date), CINAHL (EBSCO; 2008 to date), SPORTDiscus (EBSCO; 2008 to date), Cochrane Library (Wiley; 2008 to date). (See **APPENDIX A** for full search strategies and **APPENDIX B** for search dates and results, available at www.orthopt.org.)

The authors declared relationships and developed a conflict management plan, which included submitting a Conflict of Interest form to the Orthopaedic Section, 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 knee stability and movement coordination impairments/knee ligament sprain. 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.orthopt.org). Full-text review was then similarly conducted to obtain the final set of articles for contribution to the 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.orthopt.org). For selected relevant topics that were not appropriate for the development of recommendations, such as incidence and imaging, articles were not subject to systematic review and were not included in the flow chart. Evidence tables for this CPG are available on the Clinical Practice Guidelines page of the Orthopaedic Section of the APTA website (www.orthopt.org).

## Methods *(continued)*

This guideline was issued in 2017 based on the published literature up to December 2016. This guideline will be considered for review in 2021, or sooner if new evidence becomes available. Any updates to the guideline in the interim period will be noted on the Orthopaedic Section of the APTA 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.[91] 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** (available at www.orthopt.org) for the levels of evidence table and details on procedures used for assigning levels of evidence. The evidence update was organized from highest level of evidence to lowest level. An abbreviated version of the grading system is provided below.

| | |
|---|---|
| I | Evidence obtained from systematic reviews, high-quality diagnostic studies, prospective studies, or randomized controlled trials |
| II | Evidence obtained from systematic reviews, lesser-quality diagnostic studies, prospective studies, 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 |

### GRADES OF EVIDENCE

The strength of the evidence supporting the recommendations was graded according to the previously established methods for the original guideline and those provided below. Each team developed recommendations based on the strength of evidence, including how directly the studies addressed the question on knee stability and movement coordination impairments/knee ligament sprain 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 | BASED ON | 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 conclusion |
| F | Expert opinion | Best practice based on the clinical experience of the guidelines development team |

### GUIDELINE REVIEW PROCESS AND VALIDATION

Identified reviewers who are experts in knee ligament injury management and rehabilitation reviewed the content and methods of this CPG for integrity, accuracy, and to ensure that it fully represents the condition. Any comments, suggestions, or feedback from the expert reviewers were delivered to the authors and editors to consider and make appropriate revisions. These guidelines were also posted for public comment and review on the orthopt.org website, and a notification of this posting was sent to the members of the Orthopaedic Section, APTA, Inc. Any comments, suggestions, and feedback gathered from public commentary were sent to the 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 the 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 Orthopaedic Section, APTA's ICF-based Clinical Practice Guideline Policies and provide feedback and comments to the Clinical Practice Guideline 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 Orthopaedic Section, APTA websites for free access, and will

## Methods *(continued)*

be submitted for posting on the Agency for Healthcare Research and Quality website (www.guideline.gov). The implementation tools planned to be available for patients, clinicians, educators, payers, policy makers, and researchers, and the associated implementation strategies, are listed in the **TABLE**.

### CLASSIFICATION

The primary International Classification of Diseases 10th revision (ICD-10) codes and conditions associated with knee stability and movement coordination impairments are **S83.4 Sprain and strain involving (fibular)(tibial) collateral ligament of knee, S83.5 Sprain and strain involving (anterior)(posterior) cruciate ligament of knee**, and **S83.7 Injury to multiple structures of knee, Injury to (lateral) (medial) meniscus in combination with (collateral)(cruciate) ligaments**.

The primary ICF body function codes associated with the above-noted ICD-10 conditions are **b7150 Stability of a single joint** and **b7601 Control of complex voluntary movements**.

The primary ICF body structure codes associated with knee stability and movement coordination impairments are **s75011 Knee joint**, **s75002 Muscles of thigh**, **s75012 Muscles of lower leg**, and **s75018 Structure of lower leg**, specified as ligaments of the knee.

The primary ICF activities and participation codes associated with knee stability and movement coordination impairments are **d2302 Completing the daily routine** and **d4558 Moving around**, specified as direction changes while walking or running.

A comprehensive list of codes was published in the previous guideline.[70]

### ORGANIZATION OF THE GUIDELINE

For each topic, the summary recommendation and grade of evidence from the 2010 guideline are presented, followed by a synthesis of the recent literature with the corresponding evidence levels. Each topic concludes with the 2017 summary recommendation and its updated grade of evidence.

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

| Tool | Strategy |
|---|---|
| "Perspectives for Patients" | Patient-oriented guideline summary available on www.jospt.org and www.orthopt.org |
| Mobile app of guideline-based exercises for patients/clients and health care practitioners | Marketing and distribution of app using www.orthopt.org and www.jospt.org |
| Clinician's quick-reference guide | Summary of guideline recommendations available on www.orthopt.org |
| Read-for-credit continuing education units | Continuing education units available for physical therapists and athletic trainers through *JOSPT* |
| Educational webinars 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 and www.jospt.org |
| Physical Therapy National Outcomes Data Registry | Support the ongoing usage of data registry for common musculoskeletal conditions of the head and neck region |
| Logical Observation Identifiers Names and Codes mapping | Publication of minimal data sets and their corresponding Logical Observation Identifiers Names and Codes for the head and neck 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 via www.jospt.org |

CLINICAL GUIDELINES

# Impairment/Function-Based Diagnosis

## INCIDENCE

### 2010 Summary

Approximately 80 000 to 250 000 injuries occur to the anterior cruciate ligament (ACL) per year in the United States, with about 100 000 ACL reconstructions performed annually, the sixth most common orthopaedic procedure in the United States. Approximately 70% of all ACL injuries are noncontact in nature and 30% are contact injuries. The incidence of posterior cruciate ligament (PCL) injury is 0.65% to 44% of all ligamentous knee injuries. The most common causes for PCL injury are motor vehicle accidents and athletics. The incidence of medial (tibial) collateral ligament (MCL) lesions is 7.9% of all athletic injuries. Injury to the lateral (fibular) collateral ligament (LCL) is the least common of all knee ligament injuries, with an incidence of 4%. Two of the most common multiligament knee injuries involve the MCL and the ACL, and the posterolateral corner (PLC) and the ACL or the PCL. A comprehensive description of the incidence of ligamentous injuries of the knee was published in the 2010 guidelines.[70]

## EVIDENCE UPDATE

I — A systematic review of ACL injuries and/or surgery reported that the annual incidence rates of national populations in different countries ranged from 0.01% to 0.05% (median, 0.03%), or 8 to 52 per 100 000 person-years (median, 32 per 100 000 person-years).[78] Incidence rates for military groups and professional athletes are substantially higher, and rates for amateur athletes are moderately higher than national-population incidence rates.[78]

I — Of increasing interest is the rate of second ACL injury. A systematic review with meta-analysis by Wiggins et al[123] reported the overall second ACL injury rate to be 15% (8% to the ipsilateral ACL graft, 7% to the contralateral ACL). Patients younger than 25 years had a second ACL injury rate of 21%. Athletes younger than 25 years who returned to sports had a second ACL injury rate of 23%.

II — A systematic review and meta-analysis by Gornitzky et al[39] reported the overall ACL injury incidence rate to be 0.062 injuries per 1000 exposures in US high school athletes. Compared to boys, girls had a relative risk rate of 1.57 injuries per exposure, despite a greater number of ACL injuries in boys. In girls, the highest per-season injury risk levels (incidence rate by number of exposures per season) were seen in soccer (1.11%), basketball (0.88%), and lacrosse (0.53%). In boys, the highest injury risk levels per season were seen in American football (0.80%), lacrosse (0.44%), and soccer (0.30%).

II — In intermediate follow-up studies, the incidence rate of ipsilateral ACL graft rupture ranged from 3% to 9%, and that of contralateral ACL injury ranged from 3% to 20.5%.[88,126] Female athletes after ACL reconstruction and returning to sport are 4.5 times more likely to sustain an ACL injury within 24 months compared to female controls.[87,88] A systematic review of studies with a minimum of 5 years of follow-up after ACL reconstruction reported an ipsilateral ACL graft rupture rate ranging from 1.8% to 10.4% (pooled, 5.8%) and a contralateral ACL injury rate ranging from 8.2% to 16.0% (pooled, 11.8%).[127]

III — In a case-control study by Webster et al,[122] the incidence of second ACL injury was 4.5% to the ACL graft (ipsilateral) and 7.5% to the contralateral ACL. The incidence of second ACL injury was highest in patients who were under 20 years of age at primary surgery (29% to either knee), with an odds ratio (OR) of 6.3 for ipsilateral graft rupture and an OR of 3.1 for contralateral ACL injury. Returning to high-risk sports involving cutting and pivoting increased the odds of ipsilateral graft rupture by 3.9-fold and of contralateral ACL rupture by 4.9-fold.

III — In a population-based epidemiologic study in Sweden, young men aged 21 to 30 years had the highest incidence rate of ACL injuries at 225 per 100 000 inhabitants (95% confidence interval [CI]: 220, 229).[85] However, girls aged 11 to 20 years were injured at a higher rate (144 per 100 000 inhabitants; 95% CI: 140, 147) than boys of the same ages.[85]

III — In a US-based population epidemiologic study, the overall adjusted incidence rate for ACL ruptures was 68.6 per 100 000 person-years.[103] Men had a higher incidence rate (81.7 per 100 000) compared to women (55.3 per 100 000). Young men aged 19 to 25 years had the highest incidence rate at 241.0 per 100 000 person-years. The peak incidence rate for women was in the range of 14 to 18 years old (227.6 per 100 000 person-years).

III In an epidemiologic study among high school athletes across 9 different sports, the overall ACL injury rate was 6.5 per 100 000 athlete exposures.[57] The injury rate ratio for competition was 7.3 (95% CI: 6.1, 8.7) relative to practice. The injury rate ratio for girls was 3.4 (95% CI: 2.6, 4.5) relative to boys in sex-comparable sports. Girls and boys had an ACL injury rate ratio of 8.8 and 6.5, respectively, for competition relative to practice.

III In the National Collegiate Athletic Association Injury Surveillance System data update from 2004-2005 through 2012-2013, 60% of ACL injuries in women were noncontact in nature, as were 59% of ACL injuries in men.[2] In women, the injury rate per 1000 athlete-exposures ranged from 0.02 in ice hockey to 0.24 in gymnastics. In men, the injury rate per 1000 athlete-exposures ranged from 0.02 in baseball to 0.17 in football.

III In a descriptive epidemiological study, the incidence of ACL reconstructions increased from 86 687 (32.9 per 100 000 person-years) in 1994 to 129 836 (43.5 per 100 000 person-years) in 2006.[73] In women, the incidence increased from 10.36 to 18.06 per 100 000 person-years, and in men from 22.58 to 25.42 per 100 000 person-years. The number of reconstructions increased in patients younger than 20 (12.22 to 17.97 per 100 000 person-years) and in patients older than 40 (1.65 to 7.57 per 100 000 person-years).

III In a descriptive epidemiological study of military cadets, Roach et al[99] investigated the incidence of MCL injuries. Of the 128 injuries, 89% were sustained in men and 11% in women. The overall incidence rate was 7.27 per 1000 person-years. In collegiate athletes, the overall incidence rate was 10.14 per 1000 person-years and 0.11 per 1000 athlete-exposures. In intramural athletes, the incidence rate was 0.07 per 1000 athlete-exposures.

## 2017 SUMMARY

The incidence rates of ACL and MCL injuries are high in physically active individuals. The ACL injury rate remains high in young female athletes compared to male athletes of similar age in comparable sports, most injuries being noncontact injuries. The rate of second ACL injury, to the same and contralateral knee, progressively rises from time of surgery, and young female athletes who have returned to sports are particularly vulnerable. No new data exist on the incidence of PCL or PLC injuries.

## PATHOANATOMICAL FEATURES

### 2010 Summary

Noncontact ACL injuries are likely to happen during deceleration and acceleration motions with excessive quadriceps contraction and reduced hamstring cocontraction at or near full knee extension.[107] Anterior cruciate ligament loading was higher during the application of a quadriceps force when combined with knee internal rotation, a valgus load combined with knee internal rotation, or excessive valgus knee loads applied during weight-bearing decelerating activities.[107]

The most common injury mechanism for a PCL injury was a "dashboard/anterior tibial blow injury" (38.5%), followed by a fall on the flexed knee with the foot in plantar flexion (24.6%), and, last, a sudden violent hyperextension of the knee joint (11.9%).[105]

The vast majority of MCL injuries involve a sudden application of a valgus torque to the knee,[95] typically a direct hit to the lateral aspect of the knee with the foot in contact with the ground.[54] The LCL is the main structure responsible for resisting varus forces, particularly in the initial 0° to 30° of knee flexion, and has a role in limiting external rotation of a flexed knee.[43]

Isolated injury to the PLC can occur from a posterolateral-directed force to the proximal medial tibia with the knee at or near full extension, forcing the knee into hyperextension and varus. Combined PLC injuries can result from knee hyperextension, external rotation, and varus rotation; complete knee dislocation; or a flexed and externally rotated knee that receives a posteriorly directed force to the tibia.[11,74,98]

### Evidence Update and 2017 Summary

A review of 2 ACL reconstruction registries (Norwegian Knee Ligament Registry and the Kaiser Permanente ACLR Registry) identified sport-specific patterns to knee ligament injuries.[41] Soccer accounted for over a third of ACL reconstructions and was used as the reference sport for all other sports. Skiing injuries had 1.13 times (95% CI: 1.01, 1.27) the likelihood of isolated ACL injuries, 2 times the likelihood of PCL injuries, and nearly 2 times the likelihood of MCL and multiligament injuries.[41]

## CLINICAL COURSE

### 2010 Summary

The summary is new to 2017 guidelines.

### Evidence Update

*Outcomes*

I Smith et al[110] compared outcomes between early and delayed surgery after ACL injury. They reported no statistically significant differences between groups for knee laxity or instability, range of motion, muscle strength, patient-reported outcomes (PROs), clinician-reported outcomes, return-to-sport levels, or postoperative complications.

I Frobell and colleagues[30] conducted a randomized controlled trial (RCT) comparing patients with structured rehabilitation and early ACL reconstruction to those with structured rehabilitation with an option for later ACL reconstruction. They reported similar mean change scores in Knee injury and Osteoarthritis Outcome Score (KOOS) subscales, the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36), and Tegner activity scales from baseline to 2 years. In the 5-year follow-up study, they had similar results, with no differences between groups in PROs, activity level, or radiographic incidence of osteoarthritis in the surgical knee.

II In a systematic review assessing outcomes after quadriceps autograft ACL reconstruction, Mulford et al[81] reported in 4 comparative studies that ligament stability testing and PROs were similar among quadriceps tendon, hamstrings tendon, and bone-patellar tendon-bone autograft ACL reconstruction.

II A systematic review on the operative management of MCL repair and reconstruction in patients with multiligament knee injuries examined several outcome variables.[64] After MCL repair, the frequency of stable knees via valgus testing ranged from 70% to 100% of cases in 3 studies, the mean Lysholm score ranged from 79 to 90 (out of 100) in 5 studies, and the mean Tegner score ranged from 3.8 to 4.7 (out of 10) in 4 studies. After MCL reconstruction, the frequency of stable knees via valgus testing ranged from 67% to 100% of cases in 3 studies, the mean Lysholm score was 91 in 2 studies, and the mean Tegner score ranged from 5.3 to 5.7 in 2 studies.

III In their systematic review, Magnussen et al[72] reported on PROs at a minimum of 10 years after ACL reconstruction. They found that the mean ± SD scores were: Lysholm, 91.7 ± 11.2 (6 studies); International Knee Documentation Committee 2000 Subjective Knee Evaluation Form (IKDC 2000), 84.2% ± 15.5% (5 studies); Cincinnati Knee Rating System score, 87.4 ± 14.4 (out of 100) (3 studies); and Tegner score, 5.1 (8 studies).

III In their systematic review, Pujol et al[94] examined 12 studies on the natural history of partial ACL injuries. They found that the preoperative Lachman test was positive in 49.7% of cases, whereas the preoperative pivot shift test was negative in all cases. At the follow-up (mean, 5.2 years), the Lachman test was positive in 47.6% of cases and the pivot shift test was positive in more than a quarter (26.3%) of the cases. More than 50% of patients continued to report pain; however, 55% had returned to preinjury sport level and had satisfactory knee function scores (mean Lysholm score, 88.4/100).

III A systematic review on the operative management of combined ACL-PCL-PLC injuries examined several outcome variables.[16] All 95 patients had ACL reconstruction, 72 of those had PLC reconstruction, and 67 of the 72 patients had a PCL reconstruction as well. Fourteen patients with PLC injuries were treated nonoperatively and 9 had anatomical repair. Eighty-eight percent of patients with PLC reconstruction were graded as excellent/good on the objective IKDC (IKDC A/B). Only 33% of those with anatomical PLC repair were graded as excellent/good. For those with nonoperative PLC treatment, the mean IKDC 2000 score was 80.5%.

III Systematic reviews by Geeslin et al[34] and Moulton et al[79] reported outcomes of acute and chronic injuries to the PLC. In patients with early surgical intervention for acute PLC injuries, the mean postoperative Lysholm scores ranged from 87.5 to 90.3 (out of 100) and the mean IKDC 2000 scores ranged from 78.1% to 91.3%. In addition, the overall success rate was 81% based on varus stress examinations. In patients with surgical treatment for chronic PLC injuries, the mean postoperative Lysholm scores ranged from 65.5 to 91.8, and the mean IKDC 2000 scores ranged from 62.6% to 86.0%. Additionally, 90% were categorized as successful based on varus stress examinations.

III Rochecongar et al[100] performed a systematic review on combined ACL or PCL and PLC injuries. In patients with combined ACL and PLC surgery, the mean Lysholm scores improved from 77 (out of 100) preoperatively to 90 at the last follow-up, and 81.6% of patients were graded as having excellent/good (IKDC A/B) outcomes. In patients with combined PCL and PLC surgery, the mean Lysholm scores improved from 65 preoperatively to 89 at the last follow-up, and 81.0% were graded as excellent/good (IKDC A/B).

### *Laxity*

I Paterno et al,[89] in a systematic review, compared sex differences of knee laxity after ACL reconstruction based on autograft type. Women had greater anterior-to-posterior knee laxity after hamstrings autograft ACL reconstruction compared to women after bone-patellar tendon-bone autograft reconstruction and to men after ACL reconstruction with either autograft. However, the level of evidence for the included trials was low, and no RCTs were available for analysis.

### Muscle Function

II

Xergia et al[128] published a meta-analysis on the influence of graft choice on isokinetic muscle strength using peak torque (Newton meters) 4 to 24 months after ACL reconstruction. At a speed of 60°/s, patients with bone-patellar tendon-bone grafts had 9% weaker quadriceps and 8% stronger hamstrings compared to patients with hamstring grafts. At a speed of 180°/s, patients with bone-patellar tendon-bone grafts had 7% weaker quadriceps and 9% stronger hamstrings compared to patients with hamstring grafts.

II

Hart et al[47] published a systematic review on quadriceps activation (the ability to contract all motor units in the quadriceps muscles during a volitional contraction) after knee injuries. If an individual was unable to maximally contract motor units, the application of an external stimulation produced a contraction greater than the volitional contraction. The quotient between the volitional contraction and the externally produced contraction from the stimulation is referred to as the quadriceps activation ratio. Ten studies examined quadriceps activation in patients with ACL-deficient knees. The mean percent of quadriceps activation for the injured side was 87.3% (95% CI: 85.4%, 89.3%), and for the noninjured side was 91.0% (95% CI: 89.3%, 92.7%). The prevalence of poor quadriceps activation (criterion of 95% activation) was 57.1% on the injured side, 34.2% on the noninjured side, and 21% bilaterally. Four clinical trials examined quadriceps activation in patients after ACL reconstruction. The mean quadriceps activation for the injured side was 86.5% (95% CI: 78.1%, 94.9%), and for the noninjured side was 84.0% (95% CI: 74.8%, 93.2%).

III

A systematic review of 61 articles was performed on the utility of strength deficits as return-to-sport criteria.[90] Forty-nine articles reported strength deficits in quadriceps and hamstrings muscles and 6 articles reported strength deficits in hip muscles after ACL reconstruction. Quadriceps and hamstrings strength decreased from surgery to 6 months after surgery. Quadriceps strength deficits can persist up to 5 years after ACL reconstruction. Knee extensor strength deficits were associated with bone-patellar tendon-bone autografts and knee flexor strength deficits were associated with hamstrings autografts.

### Balance and Proprioception

I

A systematic review by Howells et al[50] examined 10 studies on postural control after ACL reconstruction. The participants were in their mid-to-late twenties and the testing was performed from 1 week to 96 months after ACL reconstruction. The majority of the studies were cross-sectional. The authors found that static postural control (single-leg stance on fixed platform with eyes open and closed) was moderately impaired after ACL reconstruction compared to healthy controls, and moderately magnified with dynamic postural control tasks (eyes open on unstable platforms or perturbations).

II

In a systematic review, Relph et al[97] examined 6 studies involving patients with ACL-injured knees (either ACL deficiency and/or with ACL reconstruction) and healthy controls. In studies comparing joint position sense, they reported lower mean angle errors (better joint position sense) in the uninvolved knee compared to the ACL-injured knee, in the healthy control knee compared to the ACL-injured knee, and in the ACL-reconstructed knee compared to the ACL-deficient knee. In studies comparing the threshold to detect passive motion, they reported similar mean angle errors in the uninvolved knee compared to the ACL-injured knee, but lower mean angle errors (better ability to detect passive motion) in the healthy control knee compared to the ACL-injured knee.

III

Gokeler et al[36] performed a systematic review examining 24 studies on the clinical relevance of proprioceptive-related deficits after ACL injury. They reported that the level of evidence for all the articles was low. They reported a wide range of associations between thigh muscle strength and proprioception in 5 studies ($r$ = 0.06 to −0.74). In 7 studies between knee joint laxity and proprioception, they reported no to low associations between the 2 variables ($r$ = −0.005 to 0.33). No correlation to moderate correlations were reported between hop performance and proprioception in 7 studies ($r$ = −0.11 to −0.56) and between balance and proprioception in 4 studies ($r$ = 0.00 to 0.58). In 15 studies looking at the association between PROs and proprioception, no to moderate correlations were reported ($r$ = 0.04 to 0.63). The authors concluded that there were weak to moderate associations between proprioceptive deficits and impairments, performance-based outcomes, and PROs. The evidence was limited in determining that proprioceptive deficits were clinically relevant in influencing function.

III

A systematic review of postural control during single-leg stance found moderately impaired postural control in both legs in patients after ACL injury compared to healthy controls.[83] Postural control deficits were minimally larger in the injured leg compared to the uninjured leg in patients after ACL injury.

### Functional Performance

I

In a systematic review that examined functional performance tests after ACL reconstruction, Narducci et al[82] reported that current performance-based tests or a test battery have not demonstrated construct or predictive validity for determining clearance for return to sports in athletes 1 year after ACL reconstruction. More research is needed to establish a battery of different performance-based tests to identify athletes' readiness to return to sport. Before athletes begin participating in high-demand activities, additional sessions of intensive rehabilitation may be recommended to improve knee function performance and movement symmetry.

### Psychological Factors

I A systematic review of 8 articles by Everhart et al[26] evaluated psychological predictors of outcomes after ACL reconstruction. They reported that fear of movement and pain catastrophizing were not associated with knee function in the early rehabilitation phase. Patients with higher motivation were more compliant with home exercises and demonstrated greater effort during rehabilitation. High optimism was associated with higher self-reported knee function. Confidence increased the likelihood of returning to preinjury activity levels and returning more quickly.

II te Wierike et al[114] performed a systematic review of 24 studies to evaluate psychological responses in the cognitive, affective, and behavioral domains on recovery among individuals after ACL reconstruction. They reported that a high internal health locus of control and higher self-efficacy prior to surgery resulted in better outcomes after ACL reconstruction. High internal locus of control and self-efficacy can facilitate recovery after ACL injury. During the rehabilitation process, athletes had fewer negative feelings, more positive emotions about returning to sport, and less pain. Fear of reinjury negatively influenced recovery. Athletes with positive coping strategies (ie, relaxation, imagery, self-efficacy training, modeling) and good adherence to rehabilitation also had better recovery. Athletes who returned to sports after ACL injury were more seasoned and had lower levels of fear of reinjury compared to those who did not return to sports. Furthermore, psychological interventions can facilitate an athlete's rehabilitation.

II A systematic review evaluated 11 studies and 15 psychological factors associated with returning to sport after a sports injury.[8] The review reported that athletes who returned to sport after ACL reconstruction had significantly higher preoperative motivation and more positive psychological response than those who did not return. In athletes who returned, those with more positive perception of their return had greater intrinsic motivation and a greater sense of autonomy, competence, and relatedness need satisfaction (supported and encouraged by team coach and team during the injury process). Positive emotions increased and negative emotions decreased as rehabilitation progressed and upon return to sport. Fear significantly increased when competition was resumed as compared to rehabilitation. Higher motivation and confidence and lower fear increased the likelihood of returning to preinjury activity levels and returning more quickly. However, the authors reported that all studies had a moderate to high risk of bias.

### Return to Sport

I A 2014 systematic review on return to sport after ACL reconstruction of 7556 participants by Ardern et al[7] found that 81% of athletes were able to return to some level of sport, 65% of athletes returned to their preinjury sport level, and 55% of athletes returned to competitive sport. Limb-to-limb symmetry with hop performance, younger age, male sex, and risk appraisal increased the odds of returning to preinjury sport. Interestingly, athletes with bone-patellar tendon-bone autografts had greater odds of returning to preinjury sports, whereas athletes with hamstrings autografts had greater odds of returning to competitive sports, although most of the studies included in this comparison were not randomized trials.

III Czuppon et al[21] examined individual factors related to return to sport after ACL reconstruction. Higher postoperative quadriceps strength, less knee effusion, lower pain, fewer episodes of knee instability, and greater tibial rotational range of motion were associated with return to sports. Additionally, lower kinesiophobia, higher athletic confidence, and higher preoperative knee self-efficacy and self-motivation were associated with return to sports. While the level of evidence was weak, fewer impairments and better psychological responses had an effect on the ability to return to sport.

III A systematic review of 15 articles by Undheim et al[117] reported on the muscle strength limb symmetry index as a return-to-sport criterion. Eight articles reported specific limb symmetry index scores ranging from 70% to 90%, as a return-to-sport criterion, while the other 7 reported either returning to "normal," "adequate," or "good" or to preoperative levels of strength. However, it is unclear whether deficits in quadriceps strength can be used to predict return to sport.

### 2017 Summary

The clinical course for most patients after ligament injury and surgery is satisfactory, with no differences between graft type or timing of surgery. Rates of return to any sport are good, but there are substantially lower rates for return to preinjury levels or competitive sports. Physical impairments, performance-based tests, PROs, and psychological responses may influence return-to-sport rates. Other important factors include psychological responses, including fear of movement/reinjury, athletic confidence, self-efficacy, and emotions, after ACL reconstruction.

## RISK FACTORS

### 2010 Recommendation

**B** Clinicians should consider the shoe-surface interaction, increased body mass index, narrow femoral notch width, increased joint laxity, preovulatory phase of the menstrual cycle in females, combined loading pattern, and strong quadriceps activation during eccentric contractions as predisposing factors for the risk of sustaining a noncontact ACL injury. The vast majority of PCL, collateral, and multiple ligament injuries are the result of contact injuries. Thus, a lack of evidence exists regarding risk factor stratification for these injuries.

### Evidence Update

**II** In a comprehensive systematic review of risk factors in male athletes, dry weather, artificial turf compared to natural grass, and a greater posterior slope of the lateral tibial plateau may increase the risk of noncontact ACL injuries.[3] Limited evidence exists on the neuromuscular and biomechanical variables as risk factors for noncontact ACL injuries in male athletes.[3]

**II** A systematic review and meta-analysis by Wordeman et al[124] examined the in vivo evidence of medial and lateral tibial plateau slopes as risk factors for ACL injury. While the current evidence suggests a potential association between greater posterior slope of either the lateral or medial tibial plateau in individuals with ACL-injured knees compared to healthy controls, inconsistencies exist on actual values that are considered "at risk," and the variability in tibial plateau slope values in controls is high.

**IV** Smith et al[108,109] performed 2 systematic reviews on risk factors for ACL injury. The first review focused on anatomic and neuromuscular risk. They reviewed 30 case-control and prospective cohort studies. They reported that an increased risk of sustaining an ACL injury was associated with female sex, narrow intercondylar femoral notch size, lesser concavity depth of the medial tibial plateau, greater posterior tibial plateau slope, and greater knee joint anterior/posterior laxity.[108] The second review focused on hormonal, genetic, cognitive function, previous injury, and extrinsic risk factors. They reviewed 21 studies and reported that prior ACL reconstruction and familial predisposition were associated with ACL injury risk.[109]

### 2017 Summary

Dry weather conditions and artificial turf surface are potential risk factors for noncontact ACL injuries. Female sex, narrow intercondylar femoral notch size, lesser concavity depth of the medial tibial plateau, greater anterior/posterior tibiofemoral joint laxity, prior ACL reconstruction, and familial predisposition are associated with ACL injury risk. Conflicting evidence exists regarding the magnitude of the posterior slope of the tibial plateau as an ACL injury factor. A lack of evidence exists regarding biomechanical and neuromuscular risk factors for noncontact ACL injuries in male athletes.

## DIAGNOSIS/CLASSIFICATION

### 2010 Summary

The ICD diagnosis of a sprain of the ACL and the associated ICF diagnosis of knee stability and movement coordination impairments are made with a reasonable level of certainty when the patient presents with the following clinical findings[12,52,55,71,104]:

- Mechanism of injury consisting of deceleration and acceleration motions with noncontact valgus load at or near full knee extension
- Hearing or feeling a "pop" at time of injury
- Hemarthrosis within 0 to 12 hours following injury
- History of giving way
- Positive Lachman test with "soft" end feel or increased anterior tibial translation (sensitivity, 85%; 95% CI: 83%, 87% and specificity, 94%; 95% CI: 92%, 95%)
- Positive pivot shift test (sensitivity, 24%; 95% CI: 21%, 27% and specificity, 98%; 95% CI: 96%, 99%)

Anterior cruciate ligament sprain–associated ICF diagnosis of knee stability and movement coordination impairments:

- 6-meter single-limb timed hop test result that is less than 80% of the uninvolved limb
- Maximum voluntary isometric quadriceps strength index that is less than 80% using the burst superimposition technique
- Reported history of giving-way episodes with 2 or more activities of daily living (ADLs)

The ICD diagnosis of a sprain of the PCL and the associated ICF diagnosis of knee stability and movement coordination impairments are made with a reasonable level of certainty when the patient presents with the following clinical findings[55,56,74,111]:

- Posterior-directed force on the proximal tibia (dashboard/anterior tibial blow injury), a fall on the flexed knee, or a sudden violent hyperextension of the knee joint
- Localized posterior knee pain with kneeling or decelerating
- Positive posterior drawer test at 90° with a nondiscrete end feel or an increased posterior tibial translation (sensitivity, 90%; 95% CI not available and specificity, 99%; 95% CI not available)
- Posterior sag (subluxation) of the proximal tibia posteriorly relative to the anterior aspect of the femoral condyles (sensitivity, 79%; 95% CI: 57%, 91% and specificity, 100%; 95% CI: 85%, 100%)

The ICD diagnosis of a sprain of the MCL and the associated ICF diagnosis of knee stability and movement coordination impairments are made with a reasonable level of certainty when the patient presents with the following clinical findings[58,92,95]:

- Trauma by a force applied to the lateral aspect of the lower extremity
- Rotational trauma
- Medial knee pain with valgus stress test performed at 30° of knee flexion (sensitivity, 78%; 95% CI: 64%, 92% and specificity, 67%; 95% CI: 57%, 76%)
- Increased separation between the femur and tibia (laxity) with a valgus stress test performed at 30° of knee flexion (sensitivity, 91%; 95% CI: 81%, 100% and specificity, 49%; 95% CI: 39%, 59%)
- Tenderness over the MCL and its attachments reproduces familiar pain

The ICD diagnosis of a sprain of the LCL and the associated ICF diagnosis of knee stability and movement coordination impairments are made with a reasonable level of certainty when the patient presents with the following clinical findings[18]:

- Varus trauma
- Localized swelling over the LCL
- Tenderness over the LCL and its attachments reproduces familiar pain
- Lateral knee pain with varus stress test performed at 0° and 30° of knee flexion
- Increased separation between the femur and tibia (laxity) with varus stress test applied at 0° and 30° of knee flexion

## Evidence Update

None.

## 2017 Recommendation

**A** Physical therapists should diagnose the ICD categories of Sprain and strain involving collateral ligament of knee, Sprain and strain involving cruciate ligament of knee, and Injury to multiple structures of knee, and the associated ICF impairment-based categories of knee instability (**b7150 Stability of a single joint**) and movement coordination impairments (**b7601 Control of complex voluntary movements**), using the following history and physical examination findings: mechanism of injury, passive knee laxity, joint pain, joint effusion, and movement coordination impairments.

## Decision Tree Model

A pathoanatomical/medical diagnosis of ligament sprain can provide valuable information in describing tissue pathology and may assist in preoperative planning and predicting prognosis. The proposed model for examination, diagnosis, and treatment planning for patients with knee stability and movement coordination impairments associated with knee ligament sprain uses the following components: (1) medical screening, (2) classification of 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, (4) determination of evaluative outcome measure instruments, and (5) intervention strategies for patients with ligament sprain. 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. The Ottawa knee rules, discussed earlier, are an example of tools that may be helpful in this decision-making process. In addition to these conditions, clinicians should screen for the presence of psychosocial issues that may affect prognostication and treatment decision making for rehabilitation. Psychological stress negatively influences recovery. Fear of reinjury is a frequently cited reason why athletes do not return to sport or reduce their level of physical activity.[5,6] Low internal health locus of control (the belief in one's ability to control one's life), lower self-efficacy, and depressive symptoms prior to surgery result in worse outcomes after ACL reconstruction.[32,114] Athletes who did not return to sport after ACL reconstruction had significantly lower preoperative motivation and more negative psychological response than those who did return.[9] Accordingly, identifying cognitive behavioral tendencies during the patient's evaluation can direct the therapist to employ specific patient education strategies to optimize patient outcomes after physical therapy interventions and potentially provide indications for referring the patient for consultation with another medical or mental health practitioner.[13]

### *Component 2*

Differential evaluation of musculoskeletal clinical findings is used to determine the most relevant physical impairments associated with the patient's reported activity limitations and medical diagnosis.[59] 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 ICD-10 and primary and secondary ICF codes associated with ligament sprain are provided in the 2010 ICF-based ligament sprain CPG.[70] These impairment patterns are useful in driving the interventions, which focus on normalizing the key impairments of body function, which in turn improves the movement and function of the patient and lessens or alleviates the activity limitations commonly reported by the patients who meet the diagnostic criteria of that specific pattern. Key clini-

**Component 1: Medical Screening**

Appropriate for physical therapy evaluation and intervention

Versus

Appropriate for physical therapy evaluation and intervention along with consultation with another health care provider

Versus

Not appropriate for physical therapy evaluation and intervention

Consultation with appropriate health care provider

**Component 2: Classify Condition**

Differential evaluation of clinical findings suggestive of musculoskeletal impairments of body functioning (ICF) and the associated tissue pathology/disease (ICD)

Diagnostic Classification Criteria

**Knee Ligament Sprain**

Knee Instability/Movement Coordination Deficits

**Clinical findings**

- Symptom onset linked to precipitating trauma
- Deceleration, cutting, or valgus motion associated with injury
- "Pop" heard or felt at time of injury
- Hemarthrosis within 0 to 12 hours following injury
- Knee effusion present
- Sense of knee instability reported
- Excessive tibiofemoral laxity with (cruciate/collateral) ligament integrity tests
- Pain/symptoms with (cruciate/collateral) ligament integrity tests
- Lower-limb strength and coordination deficits
- Impaired single-leg proprioception/balance
- Abnormal compensatory strategies observed during deceleration or cutting movements

**Component 3: Determination of Irritability Stage**

Diagnosis of tissue irritability is important for guiding the 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. There are cases where the alignment of irritability and the duration of symptoms does not match, requiring clinicians to make judgments when applying time-based research results on a patient-by-patient basis.

**Component 4: Measures**

**Knee Ligament Sprain**

Knee Instability/Movement Coordination Deficits

**Impairment measures[B]**

- Pain at rest (current level of pain)
- Pain at best (lowest level of pain in recent 24 hours)
- Pain at worst (highest level of pain in recent 24 hours)
- Pain frequency (percent of time in pain in recent 24 hours)
- Level of pain while performing most aggravating movement
- Modified stroke test for knee effusion
- Star Excursion Balance Test, anterior direction
- Star Excursion Balance Test, posterolateral direction
- Star Excursion Balance Test, posteromedial direction
- Single hop test for distance
- Crossover hop test for distance
- Triple hop test for distance
- 6-meter hop test for time

**Activity limitations, self-reported measures[B]**

- IKDC 2000
- KOOS pain subscale
- KOOS symptom subscale
- KOOS activities of daily living subscale
- KOOS sport/recreation subscale
- KOOS quality of life subscale
- Lysholm Knee Scoring Scale
- Tegner Activity Scale
- Marx Activity Rating Scale
- Capacity to walk (without knee symptoms)
- Capacity to run (without knee symptoms)
- Capacity to perform light household or work tasks (without knee symptoms)
- Capacity to participate in recreational or athletic activities (without knee symptoms)

*Figure continues on page A15.*

**FIGURE.** Model of diagnosis, examination, and treatment. [A]Guidelines based on strong evidence. [B]Guidelines based on moderate evidence. [C]Guidelines based on weak evidence.

**Component 5: Intervention Strategies**

**Knee Ligament Sprain**
Knee Instability/Movement Coordination Deficits

**Early rehabilitation strategies**
- Immediate mobilization[B]
- Cryotherapy[B]
- Early weight bearing[C]
- Continuous passive motion[C]
- Neuromuscular electrical stimulation[A]

**Early to late rehabilitation strategies**
- Therapeutic exercises[A]
  - Optimal range of motion, strength, and flexibility training progression specifically addressing the knee but also potentially the ankle/foot, hip, and trunk regions
- Neuromuscular re-education[A]
  - Optimal neuromuscular training progression
  - Field/court sports performance
- Supervised rehabilitation[B]
  - Optimal range of motion, strength, and flexibility training progression specifically addressing the knee but also potentially the ankle/foot, hip, and trunk regions
  - Optimal neuromuscular training progression
  - Field/court sports performance
- Education/counseling strategies
  - Indications for surgical interventions
  - Athletic or occupational activity modification
  - Return-to-sport readiness/risk appraisal

**FIGURE (CONTINUED).** Model of diagnosis, examination, and treatment.



cal findings to rule in and rule out the common impairment patterns, and their associated medical conditions, are shown in the **FIGURE**. 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.[59] However, it is important for clinicians to understand that the impairment pattern and 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 the optimal interventions throughout the patient's episode of care.[14]

### Component 3

*Irritability* is a term used by rehabilitation practitioners to reflect the tissue's ability to handle physical stress,[80] and is presumably related to physical status and the extent of inflammatory activity that is present. There are cases where the alignment of irritability and the duration of symptoms does not match, requiring clinicians to make judgments when applying time-based research results on a patient-by-patient basis.[14] Diagnosis of tissue irritability is important for guiding the 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.[14,59] There are other biopsychosocial elements that may relate to staging of the condition, including, but not limited to, the level of disability reported by the patient and activity avoidance.[20]

### Component 4

Outcome measure instruments are standardized instruments for measuring a specific end point, whether it is a body structure or function, activity limitation, or participation restriction. They are important in direct management of individual patient care and because they can collectively compare care and determine effectiveness through the repeated application of 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 upon the health of the patient and society. Outcome measurement 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 measure instruments can be classified as PRO measures, physical performance measures, and physical impairment measures.

### Component 5

Interventions are listed by phase of rehabilitation (early, early to late). 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.[14,59] Additionally, clinicians should attend to influences from psychosocial factors[5,6,9] in patients with conditions in all stages of recovery.

## DIFFERENTIAL DIAGNOSIS

### 2010 Recommendation

**B** Clinicians should consider diagnostic classifications associated with serious pathological 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/Classification section 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.

### Evidence Update

None.

### 2017 Recommendation

**B** Clinicians should suspect diagnostic classifications associated with serious pathological conditions when the individual's reported activity limitations and impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline, or when the individual's symptoms are not resolving with intervention aimed at normalization of the individual's impairments of body function.

## IMAGING STUDIES

### 2010 and 2017 Summary

When a patient reports a history of knee trauma, the therapist needs to be alert for the presence of knee fracture. The Ottawa knee rule has been developed and validated to assist clinicians in determining when to order radiographs in individuals with acute knee injury, which recommends knee radiographs for patients with any of the following criteria: age 55 or older, isolated tenderness of patella (no bone tenderness of knee other than patella), tenderness of head of the fibula, inability to flex the knee to 90°, inability to bear weight both immediately and in the emergency department for 4 steps regardless of limping.[10,112] Clinical examination by well-trained clinicians appears to be as accurate as magnetic resonance imaging (MRI) in regard to the diagnosis of cruciate or meniscal lesions.[62,71] A lower threshold of suspicion of a meniscal tear is warranted in middle-aged and elderly patients.[44,71] Magnetic resonance imaging may be reserved for more complicated or confusing cases[62] and may assist an orthopaedic surgeon in aiding in preoperative planning and predicting the prognosis.[62,71]

CLINICAL GUIDELINES

# Examination

## OUTCOME MEASURES – ACTIVITY LIMITATIONS: SELF-REPORTED MEASURES

### 2010 Recommendation

**A** Clinicians should use a validated PRO measure with a general health questionnaire, along with a validated activity scale, for patients with knee stability and movement coordination impairments. These tools are useful for identifying a patient's baseline status relative to pain, function, and disability and for monitoring changes in the patient's status throughout the course of treatment.

### Evidence Update

#### *General Health Questionnaires*

**I** Webster and Feller[121] reported on a large patient cohort comparing results on the SF-36 to those from the Medical Outcomes Study 12-Item Short-Form Health Survey (SF-12). A cohort of 1474 patients after ACL reconstruction completed the SF-36 and the SF-12 from the subscales of the SF-36. The authors reported small but statistically significant mean differences between subscales of the SF-36 and SF-12, except for the bodily pain subscale. They reported that a large majority of patients after ACL reconstruction have average to above-average scores compared to the US general population. For the physical component summary score, the authors reported moderate correlations between the SF-36 and SF-12 with self-reported outcome measures ($r$ = 0.47-0.62).

**I** A longitudinal analysis of a multicenter cohort of 1411 patients who completed the SF-36 preoperatively and at 2 years and/or 6 years after ACL reconstruction[24] found that higher physical component summary scores were predicted by higher preoperative physical component summary scores, younger age, lower preoperative body mass index, having greater than 50% lateral meniscus excision, and no treatment to the lateral meniscus tear. Lower physical component summary scores were predicted by shorter follow-up, ACL revision reconstruction, preoperative smoking, less education, and degenerative changes of the lateral tibial plateau.

**II** Månsson et al[76] examined the predictability of preoperative factors on SF-36 and KOOS questionnaires. They reported that sex, preoperative Tegner level, knee flexion deficit, and age explained 29% of the variance in SF-36 general health, while Tegner level, single-legged hop performance, and knee flexion range-of-motion deficit explained 21% of the variance in SF-36 role-emotional. Similarly, preoperative Tegner level explained 14% of the variance in KOOS sport and recreation, and preoperative Tegner level and knee flexion range-of-motion deficit explained 18% of the variance in KOOS quality of life (QoL). Preoperative Tegner level and knee flexion range-of-motion deficit are good predictors of health-related quality of life (HRQoL) after ACL reconstruction.

**II** Thomeé et al[115] examined preoperative self-efficacy of knee function as a predictor of activity level and knee symptoms and function 1 year after ACL reconstruction. Preoperative knee self-efficacy was a significant predictor of Tegner activity level and physical activity scale scores. Preoperative future knee self-efficacy was a significant predictor of KOOS sport and recreation and KOOS QoL.

**II** This study reported on the development and validation of a new self-report questionnaire, the Knee Quality of Life 26-item (KQoL-26) questionnaire, for patients with a suspected ligamentous or meniscal injury.[33] The questionnaire contains 26 items with 3 subscales of knee-related QoL: physical functioning, activity limitations, and emotional functioning. The KQoL-26 was found to have good evidence for internal reliability (Cronbach $\alpha$ = .91-.94), test-retest reliability (estimates of 0.80 to 0.93), construct validity (correlations with other knee scales, including the Lysholm knee scoring scale, EuroQol-5 Dimensions [EQ-5D] questionnaire, SF-36, and knee symptom questions), and responsiveness (higher effect sizes and responsiveness statistics than the EQ-5D and SF-36).

**III** Månsson et al[75] compared the results of the SF-36 in patients 2 to 7 years after ACL reconstruction with a sex- and age-matched control group and compared the results between sex and graft type. They reported that patients in the long term after ACL reconstruction have good health relative to the general population. Additionally, there were no differences between men and women in HRQoL.

#### *Knee Injury and Osteoarthritis Outcome Score*

**II** Salavati and colleagues[101] reported on the reliability and validity of the KOOS in competitive athletes after ACL reconstruction. In this population, the KOOS was found to have good internal reliability (Cronbach $\alpha$ = .74-.96), test-retest reliability (intraclass correlation coefficient [ICC]>0.75), and construct validity (correlations with SF-36 ranging from $r$ = 0.72 to 0.79).

II A systematic review by Filbay et al[27] reported on HRQoL after ACL reconstruction. They included 14 studies on various HRQoL measures. Pooled KOOS QoL subscores of 74.5 (95% CI: 68.3, 80.7) were lower than previously reported healthy population norms with no knee symptoms (90; 95% CI: 83.7, 96.3) and general population norms (82.4; 95% CI: 79.9, 84.9). The authors reported that meniscus injuries, revision surgery, and severe radiographic osteoarthritis were factors associated with poor KOOS QoL subscores.

II A systematic review by Filbay et al[28] reported on HRQoL in patients with ACL-deficient knees greater than 5 years after the index injury. They included 11 studies on various HRQoL measures. The KOOS-QoL subscores ranged from a mean ± SD of 54 ± 17 to 77 ± 22 and were lower than previously reported general population norms (81 ± 24). No differences were reported between pooled KOOS QoL subscores for groups with ACL-deficient compared to ACL-reconstructed (2.9; 95% CI: –3.3, 9.1) knees.

II Granan et al[40] reported that from the Norwegian Knee Ligament Registry, patients who had an ACL reconstruction revision surgery had clinically significantly lower scores on the KOOS sport and recreation and QoL subscales compared to those who did not have revision surgery. When adjusted for age, sex, and preoperative KOOS scores, the risk of a subsequent revision surgery was 3.7 (95% CI: 2.2, 6.0) times higher in patients with a 2-year postsurgery KOOS QoL score less than 44, compared to those with a score greater than or equal to 44. Additionally, for every 10-point drop in KOOS QoL subscore, there was a 33.6% (95% CI: 21.2%, 47.55%) higher risk for ACL reconstruction revision surgery.

III A Rasch model was used to assess the internal construct validity of the KOOS in 200 consecutive questionnaires from patients 20 weeks after ACL reconstruction.[19] Fit to the Rasch model was achieved only for the sport and recreation subscale and the QoL subscale. The KOOS was found to have fair to good evidence for internal consistency (Cronbach $\alpha$ = .59 for knee symptoms to .91 for function in ADLs). The subdomains for pain, symptoms, and ADLs do not adequately assess patients 20 weeks after ACL reconstruction, whereas the sport and recreation and QoL subdomains can be used to assess change in these constructs.

III The KOOS has been cross-culturally adapted for use in both the Persian and Arabic languages. In Iranian patients with ACL, meniscus, and combined meniscus and ACL injuries, the Persian version showed acceptable test-retest reliability on all subscales (ICC>0.70) except the sport and recreation subscale (ICC = 0.61), and adequate construct validity against the SF-36.[102] The Arabic version showed acceptable test-retest reliability (ICC>0.7) for all subscales, as well as good construct validity against subscales of the RAND-36 (Arabic version of the SF-36) and visual analog scale scores of pain in Egyptian patients with ACL, meniscus, and combined knee injuries.[4]

### *IKDC 2000 Subjective Knee Evaluation Form*

II Shelbourne and colleagues[106] evaluated the relationship between the single assessment numeric evaluation (SANE) rating score and the IKDC 2000 and the modified Cincinnati Knee Rating System yearly in patients after ACL reconstruction or knee arthroscopy. In patients after ACL reconstruction, the correlation between the SANE rating score was 0.66 with the IKDC 2000 and the modified Cincinnati Knee Rating System, and 0.74 for both scales in patients after knee arthroscopy.

III van Meer et al[118] evaluated the IKDC 2000 and the KOOS to determine which questionnaire may be more useful early and within 1 year after ACL reconstruction. Both questionnaires were found to have good evidence for test-retest reliability (ICC>0.81 for both scales; the minimal detectable change [MDC] for KOOS subscales ranged from 18.3 to 35.2 and was 12.2 for the IKDC 2000), content validity (high percentage of relevant items), and no floor effects. The KOOS pain and ADL subscales had high ceiling effects, whereas the IKDC 2000 scores did not exhibit a ceiling effect. The authors concluded that the IKDC 2000 questionnaire was more useful for young, active individuals early and within 1 year after ACL reconstruction.

III Hambly and Griva[45] identified that after ACL reconstruction, the IKDC 2000 outperformed the KOOS for the whole cohort and for sex subgroups. For the IKDC 2000 in patients less than 12 months after ACL reconstruction, 15 of the 18 items and 10 of the 18 items were deemed important by more than half and by more than 75% of the patients, respectively. For the KOOS in patients less than 12 months after ACL reconstruction, 33 of the 42 items and 14 of the 42 items were deemed important by more than half and by more than 75% of the patients, respectively. However, the KOOS sport and recreation and QoL subscales had significantly higher mean importance rankings than the IKDC 2000 for the whole cohort and for sex subgroups.

III Della Villa et al[23] reported that higher knee function (IKDC 2000) scores 12 months after ACL reconstruction and quicker recovery were associated with younger patients with higher preinjury Tegner levels or those at the professional sports level without concomitant capsular injuries and without postoperative knee bracing. Higher knee function was also related to more on-field training sessions and better muscle strength recovery.

### Lysholm and Tegner Scales

I

Briggs et al[17] reported the reliability, validity, and responsiveness of the Lysholm score and Tegner scale for patients with ACL injury. The Lysholm score was found to have acceptable evidence for test-retest reliability (ICC = 0.9 and MDC of 8.9), construct validity (correlations with other knee scales, including the IKDC 2000 and SF-12), and responsiveness (moderate to large effect sizes and standardized response means on all domains, except for locking). The Tegner scale was found to have acceptable evidence for test-retest reliability (ICC = 0.8 and MDC of 1), low construct validity (low correlations with the IKDC 2000 and SF-12), and responsiveness (large effect sizes and standardized response means).

III

The Tegner scale and the Marx Activity Rating Scale have been cross-culturally adapted for use in the Persian language.[84] In Iranian patients with ACL injury, the Persian version showed acceptable test-retest reliability on the Tegner scale (ICC = 0.81) and on the Marx Activity Rating Scale (ICC = 0.78), and acceptable evidence for internal reliability on the Marx Activity Rating Scale (Cronbach $\alpha$ = .87). The MDC for the Tegner scale was 0.75 and for the Marx Activity Rating Scale was 1.70. There was low construct validity of both the Tegner scale and Marx Activity Rating Scale (low correlations with the KOOS and SF-12), likely because the Tegner scale and Marx Activity Rating Scale measure activity level, whereas the SF-12 measures general health and the KOOS measures knee-specific symptoms and function.

III

The Tegner rating scale has been cross-culturally adapted for use in the Chinese language.[51] In Chinese patients with ACL injury, the simplified Chinese version showed high test-retest reliability for healthy controls (ICC = 0.97) and for patients post–ACL reconstruction (ICC = 0.95-0.99), and acceptable reliability for patients pre–ACL reconstruction (ICC = 0.71). The MDC for the Tegner scale was 0.43 for healthy controls, 2.12 for preoperative patients, 0.89 for patients 2 to 3 months post–ACL reconstruction, and 0.44 for patients 3 to 12 months post–ACL reconstruction. No ceiling or floor effects were seen for any group.

III

The Lysholm scale has been cross-culturally adapted for use in the Chinese language.[119] In Chinese patients with ACL injury, the Chinese version showed high test-retest reliability for patients with ACL injury (ICC = 0.94) and acceptable internal reliability (Cronbach $\alpha$ = .73). There was good construct validity of the Chinese Lysholm scale, with high correlations with the IKDC 2000 ($r$ = 0.73-0.81) and moderate correlations with the physical component summary score of the SF-36 ($r$ = 0.51-0.71). The responsiveness of the Chinese Lysholm scale was good, with a standard response mean of 1.26. No ceiling (1.6%) or floor (0.8%) effects were seen.

### Psychological Questionnaires

II

In a systematic review, Ardern et al[8] evaluated 11 studies and 15 psychological factors associated with returning to sport after a sports injury. They reported that athletes who returned to sport after ACL reconstruction had significantly higher preoperative motivation and more positive psychological response than those who did not return. In those who returned, those with a more positive perception of their return had greater intrinsic motivation and a greater sense of autonomy, competence, and relatedness need satisfaction. Positive emotions increased and negative emotions decreased as rehabilitation progressed and upon return to sport. Fear significantly increased when competition was resumed, as compared to rehabilitation. However, the authors reported that all studies had a moderate to high risk of bias.

III

The Anterior Cruciate Ligament-Return to Sport after Injury (ACL-RSI) scale has been cross-culturally adapted for use in the Swedish, French, and Turkish languages. In Swedish patients after ACL reconstruction, the Swedish ACL-RSI (scored on a scale from 1 to 10) showed good face validity (relevant and easy to understand for the patient population), good evidence for internal consistency (Cronbach $\alpha$ = .95) and construct validity (relationships between returning to sport and previous activity levels, and with other knee scales including the Tampa Scale of Kinesiophobia-11 [TSK-11], Knee Self-Efficacy Scale, KOOS, Anterior Cruciate Ligament-Quality of Life, and the Multidimensional Health Locus of Control, C-form), acceptable floor and ceiling effects, and good reproducibility ($ICC_{2,1}$ = 0.89; standard error of the measurement, 0.7; and MDC for individual score of 1.9 and MDC for the group score of 0.3).[65] In French-speaking patients after ACL reconstruction, the French version of the ACL-RSI showed good evidence for internal consistency (Cronbach $\alpha$ = .96), good discriminant validity, good construct validity (correlations against the IKDC 2000, KOOS subscales, and Lysholm scale), acceptable floor and ceiling effects, and good reproducibility (ICC = 0.90).[15] In patients after ACL reconstruction, the Turkish translation of the ACL-RSI showed evidence for good internal consistency (Cronbach $\alpha$ = .88), fair construct validity ($r$ = 0.36-0.58 against the IKDC 2000, KOOS subscales, Lysholm scale, and TSK-11), good discriminant validity, acceptable floor and ceiling effects, and excellent test-retest reliability (ICC = 0.92).[46]

III

Flanigan et al[29] evaluated the factors for not returning to sport after primary or revision ACL reconstruction. They reported that 46% of patients had returned to preinjury activity levels, whereas 54% did not return. In those who did not return, 68% reported persistent knee symptoms and 52% reported fear of reinjury as factors for not returning to sport. Additionally, 29% reported non–knee-related life events, such as children, occupation, education, or other health issues, as other factors for not returning to sport.

III George et al[35] investigated whether shortened versions of the TSK-11 and Pain Catastrophizing Scale may be used with patients after ACL reconstruction. They reported that the TSK-11 could be shortened to a 3-item fear-of-injury scale (items 1, 2, and 10) in the early postoperative phase (less than 12 weeks after surgery), but the TSK-11 is not recommended in the late postoperative phase (greater than 6 months after surgery). The shortened version of the Pain Catastrophizing Scale is not recommended in the early postoperative phase, but may be shortened to a 7-item helplessness-and-magnification scale (items 1, 3, 4, 5, 6, 7, and 13) in the late postoperative phase.

### 2017 Recommendations

B Clinicians should use the IKDC 2000 or KOOS and may use the Lysholm scale as validated PRO measures to assess knee symptoms and function, and should use the Tegner scale or Marx Activity Rating Scale to assess activity level, before and after interventions intended to alleviate the physical impairments, activity limitations, and participation restrictions associated with knee ligament sprain. Clinicians may use the ACL-RSI as a validated PRO measure to assess psychological factors that may hinder return to sports before and after interventions intended to alleviate fear of reinjury associated with knee ligament sprain.

## PHYSICAL PERFORMANCE MEASURES

Refer to the 2010 knee stability and movement coordination impairment CPG for a list of activity limitation measures and their measurement properties.[70]

### 2010 Recommendation

C Clinicians should utilize easily reproducible physical performance measures, such as single-limb hop tests, to assess activity limitations and participation restrictions associated with their patients' knee stability and movement coordination impairments to assess the changes in the patient's level of function over the episode of care and to classify and screen knee stability and movement coordination.

### Evidence Update

II A systematic review by Abrams et al[1] examined performance-based tests after ACL reconstruction. They reported that limb symmetry indexes for hop tests ranged from 76% to 90% 6 months after ACL reconstruction, 88% to 95% 12 months after ACL reconstruction, and 92% to 99% 24 months after ACL reconstruction. Limb symmetry indexes for isokinetic knee extensor strength tests (depending on graft type and isokinetic speed) ranged from 65% to 86% 6 months after ACL reconstruction, 84% to 91% 12 months after ACL reconstruction, and 91% to 100% 24 months after ACL reconstruction. Limb symmetry indexes for isokinetic knee flexor strength tests (depending on graft type and isokinetic speed) ranged from 84% to 96% 6 months after ACL reconstruction, 87% to 99% 12 months after ACL reconstruction, and 88% to 100% 24 months after ACL reconstruction.

II Hegedus et al[48] performed a systematic review of 29 articles examining the measurement properties of performance-based tests for the knee. They reported poor to fair methodological quality of studies examining reliability, poor to good quality of studies examining hypothesis testing and construct validity, and primarily good quality of studies examining criterion validity. Methodological quality examining responsiveness was poor to good, while no studies examined measurement error.

II After an ACL injury and nonoperative rehabilitation, a cutoff score greater than 88% on the single-leg single hop for distance test can be used to identify with high probability that the patient will have normal knee function based on the 15th percentile from the age- and sex-matched IKDC 2000 normative data 1 year later.[42] Single-leg hop tests conducted 6 months after ACL reconstruction can predict the likelihood of successful and unsuccessful outcome 1 year after ACL reconstruction.[68] Athletes demonstrating less than the 88% cutoff score on the 6-meter timed hop test at 6 months may benefit from targeted training to improve limb symmetry in an attempt to normalize function. Athletes with minimal side-to-side differences on the crossover hop test at 6 months will likely have normal knee function 1 year after reconstruction if they continue with their current training regimen. Preoperative single-leg hop tests are not able to predict postoperative outcomes.[68] Single-leg hop tests can identify important limb asymmetries and predict self-reported knee function in patients with knee stability and movement coordination impairments.

II The triple hop for distance limb symmetry index was a significant predictor of the IKDC 2000 jump-related question (14h) and KOOS jump-related question (sport and recreation item 3) 2 years after ACL reconstruction.[96]

### 2017 Recommendation

B Clinicians should administer appropriate clinical or field tests, such as single-leg hop tests (eg, single hop for distance, crossover hop for distance, triple hop for distance, and 6-meter timed hop), that can identify a patient's baseline status relative to pain, function, and disability; detect side-to-side asymmetries; assess global knee function; determine a patient's readiness to return to activities; and monitor changes in the patient's status throughout the course of treatment.

## PHYSICAL IMPAIRMENT MEASURES

Refer to the 2010 knee stability and movement coordination impairment CPG for a list of physical impairment measures and their measurement properties.[70]

### Evidence Update

I A systematic review by Swain et al[113] reported small to large likelihood ratios for the Lachman test (positive likelihood ratio [PLR] = 1.39-40.81, negative likelihood ratio [NLR] = 0.02-0.52), anterior drawer test (PLR = 1.94-87.88, NLR = 0.23-0.74), and the pivot shift test (PLR = 4.37-16.42, NLR = 0.38-0.84) across studies. A PLR is the likelihood that a given positive clinical test result would be expected in a patient with an ACL tear, compared to the likelihood that the same positive test result would be expected in a patient without an ACL tear, whereas an NLR is the likelihood that a given negative clinical test result would be expected in a patient without an ACL tear, compared to the likelihood that the same negative result would be expected in a patient with an ACL tear. Likelihood threshold values can be categorized as low (PLR>2, NLR<0.2), moderate (PLR = 2-5, NLR = 0.1-0.2), or high (PLR>5, NLR<0.1).

II Preoperative quadriceps strength deficits are predictive of impaired self-reported knee function 6 months and 2 years after ACL reconstruction.[25,69]

II Greater than 6 months after ACL reconstruction, a cutoff score greater than 3.10 $Nm \cdot kg^{-1}$ on quadriceps peak torque per body mass can be used to identify with high probability (8.15 times higher odds) that the patient will have high self-reported knee function (IKDC 2000 greater than 90%) at the same time point.[93] A cutoff score greater than 96.5% on the quadriceps limb symmetry index can be used to identify with moderate probability (2.78 times higher odds) that the patient will have high self-reported knee function.

II Athletes with no knee effusion, no knee instability, and who reported over 93% on the IKDC 2000 1 year after ACL reconstruction were more than 14 times more likely to return to sports 1 year after ACL reconstruction (PLR = 14.54).[67] Athletes meeting only 1 criterion (no knee effusion, no knee instability, or greater than 93% on the IKDC 2000) 1 year after ACL reconstruction were more than 6 times more likely to not return to sports 1 year after ACL reconstruction (NLR = 0.16).[67]

II A test battery of performance-based measures and PROs was developed to enhance decision making regarding clearance for return to sports.[38] Return-to-sport criteria were defined as isokinetic and hop test symmetry indexes greater than 90%, Landing Error Scoring System score less than 5, ACL-RSI score greater than 56, and IKDC 2000 scores at or above the 15th percentile of age- and sex-matched normative data. Six months after ACL reconstruction, only 7.1% of patients passed all criteria. This study was a preliminary study to develop a test battery on return-to-sport criteria.

II A systematic review of 9 studies evaluated the reliability of diagnostic clinical tests for ACL injury.[22] The anterior drawer test had moderate to excellent interrater reliability ($\kappa$ = 0.96) in low-quality studies. The Lachman test had poor to excellent interrater reliability ($\kappa$ = 0.19-0.93) and poor to moderate intrarater reliability ($\kappa$ = 0.29-0.51).

II A systematic review by Kopkow et al[63] reported that the quadriceps active test was the most specific test for diagnosing a PCL tear (sensitivity, 0.53-0.98; specificity, 0.96-1.00; PLR = 11.97-98.44; NLR = 0.04-0.50) and that the posterior sag sign was the most sensitive (sensitivity, 0.46-1.00; specificity, 1.00; PLR = 88.35; NLR = 0.28). However, the methodological quality of the studies reviewed was insufficient and the studies had a high risk of bias.

II Leblanc et al[66] performed a systematic review of 8 studies examining the diagnostic accuracy of the Lachman test. Pooled analysis for sensitivity during awake evaluations of the Lachman test for complete tear of the ACL was 96%, whereas nonpooled analysis for specificity was 78.1%.

III Higher preoperative quadriceps strength index (OR = 1.02), young age (OR = 0.92), and male sex (OR = 2.45) were associated with higher quadriceps strength 6 months after ACL reconstruction.[116] Higher knee pain (OR = 0.17) was associated with lower odds of higher quadriceps strength 6 months after ACL reconstruction. A cutoff score greater than 70.2% on the preoperative quadriceps strength index can be used to identify with moderate probability (PLR = 2) that the patient will have a quadriceps strength index of at least 85% 6 months after ACL reconstruction.

### 2017 Recommendation

B When evaluating a patient with ligament sprain over an episode of care, clinicians should use assessments of impairment of body structure and function, including measures of knee laxity/stability, lower-limb movement coordination, thigh muscle strength, knee effusion, and knee joint range of motion.

CLINICAL GUIDELINES

# Interventions

A systematic search of the literature did not reveal high-quality reviews or articles to alter the 2010 recommendations for continuous passive motion, early weight bearing, knee bracing, or immediate versus delayed mobilization. However, edits were made to these 2010 recommendations to improve the clarity of the recommendations. Additionally, in the 2010 guidelines, "accelerated" rehabilitation was a separate category. Early restoration of knee extension range of motion and early weight-bearing activity have now been in practice for over 20 years and are the current standard of care after isolated ACL reconstruction, thus "accelerated" rehabilitation is included in the Immediate Versus Delayed Mobilization section in these 2017 guidelines. Likewise, in the 2010 guidelines, eccentric strengthening was a separate category. However, eccentric strengthening, a form of therapeutic exercise, is now placed under the Therapeutic Exercise section.

## CONTINUOUS PASSIVE MOTION

### 2010 and 2017 Recommendation

**C** Clinicians may use continuous passive motion in the immediate postoperative period to decrease postoperative pain after ACL reconstruction.

## EARLY WEIGHT BEARING

### 2010 Recommendation

**C** Early weight bearing can be used for patients following ACL reconstruction without incurring detrimental effects on stability or function.

### Evidence Update

None.

### 2017 Recommendation

**C** Clinicians may implement early weight bearing as tolerated (within 1 week after surgery) for patients after ACL reconstruction.

## KNEE BRACING

### 2010 Recommendation

**C** The use of functional knee bracing appears to be more beneficial than not using a brace in patients with ACL deficiency.

**B** The use of immediate postoperative knee bracing appears to be no more beneficial than not using a brace in patients following ACL reconstruction.

**D** Conflicting evidence exists for the use of functional knee bracing in patients following ACL reconstruction.

**F** Knee bracing can be used for patients with acute PCL injuries, severe MCL injuries, or PLC injuries.

### Evidence Update

**II** A systematic review by Kinikli et al[61] included 11 studies on the effectiveness of knee bracing after ACL reconstruction. They evaluated 7 RCTs, 2 prospective controlled trials, 1 clinic trial, and 1 crossover study. For knee laxity between braced and nonbraced groups, the braced group had statistically significant but not clinically significantly less knee laxity after ACL reconstruction. For muscle strength, no differences were found between the braced and nonbraced groups. For knee joint range of motion, knee pain, and self-reported knee function, the braced and the nonbraced groups were similar in outcomes at the majority of follow-up periods and in the majority of studies.

### 2017 Recommendation

**C** Clinicians may use functional knee bracing in patients with ACL deficiency.

**D** Clinicians should elicit and document patient preferences in the decision to use functional knee bracing after ACL reconstruction, as evidence exists for and against its use.

**F** Clinicians may use appropriate knee bracing for patients with acute PCL injuries, severe MCL injuries, or PLC injuries.

## IMMEDIATE VERSUS DELAYED MOBILIZATION

### 2010 Recommendation

**B** Clinicians should consider the use of immediate mobilization following ACL reconstruction to increase range of motion, reduce pain, and limit adverse changes to soft tissue structures.

### Evidence Update

None.

### 2017 Recommendation

**B** Clinicians should use immediate mobilization (within 1 week) after ACL reconstruction to increase joint range of motion, reduce joint pain, and reduce the risk of adverse responses of surrounding soft tissue structures, such as those associated with knee extension range-of-motion loss.

## CRYOTHERAPY

### 2010 Recommendation

**C** Clinicians should consider the use of cryotherapy to reduce postoperative knee pain immediately post–ACL reconstruction.

### Evidence Update

**II** A systematic review by Martimbianco et al[77] concluded that cryotherapy after arthroscopic ACL reconstruction significantly reduced immediate postsurgery pain and did not increase the risk of adverse events in the short term (up to 48 hours after surgery). The limited evidence currently available from RCTs is insufficient to draw definitive conclusions on the effectiveness of cryotherapy for other outcomes such as edema, knee function, postoperative blood loss, duration of hospital stay, range of motion, postoperative analgesic medication use, patient satisfaction, or QoL.

### 2017 Recommendation

**B** Clinicians should use cryotherapy immediately after ACL reconstruction to reduce postoperative knee pain.

## SUPERVISED REHABILITATION

### 2010 Recommendation

**B** Clinicians should use exercises as part of the in-clinic program, supplemented by a prescribed home-based program supervised by a physical therapist, in patients with knee stability and movement coordination impairments.

### Evidence Update

**II** Papalia and colleagues,[86] in a systematic review, evaluated 10 studies comparing outcomes between home-based and supervised outpatient rehabilitation after ACL reconstruction. The systematic review included 7 RCTs that evaluated range of motion and PROs (Lysholm scale, Tegner scale, or modified Cincinnati Knee Rating System) as their primary outcome variables. In intermediate follow-ups, PRO scores were high. However, activity level (Tegner) scores ranged from 4 to 5. Only Hohmann et al,[49] in this systematic review, reported on performance-based outcomes, on which both groups demonstrated limb asymmetries. Therefore, caution is warranted in interpreting the results of this systematic review. Mid-range Tegner scores suggest that patients were not competitive or pivoting-type athletes, and limb asymmetries on performance-based tests suggest that patients were not fully rehabilitated at last follow-up.

### 2017 Recommendation

**B** Clinicians should use exercises as part of the in-clinic supervised rehabilitation program after ACL reconstruction and should provide and supervise the progression of a home-based exercise program, providing education to ensure independent performance.

## THERAPEUTIC EXERCISES

### 2010 Recommendation

**A** Clinicians should consider the use of non–weight-bearing (open-chain) exercises in conjunction with weight-bearing (closed-chain) exercises in patients with knee stability and movement coordination impairments.

### Evidence Update

**II** One moderate-quality systematic review by Gokeler et al[37] included 8 RCTs and 2 prospective cohort studies on the effect of various rehabilitation strategies on quadriceps function after ACL reconstruction. Seven studies reported an increase in quadriceps strength when tested isokinetically. Five studies reported an increase in activity level based on Tegner scores throughout rehabilitation. Cincinnati Knee Rating System scores were increased after neuromuscular training and strength training.

### 2017 Recommendation

**A** Weight-bearing and non–weight-bearing concentric and eccentric exercises should be implemented within 4 to 6 weeks, 2 to 3 times per week for 6 to 10 months, to increase thigh muscle strength and functional performance after ACL reconstruction.

## NEUROMUSCULAR ELECTRICAL STIMULATION

### 2010 Recommendation

**B** Neuromuscular electrical stimulation (NMES) can be used with patients following ACL reconstruction to increase quadriceps muscle strength.

### Evidence Update

I In a high-quality systematic review, Kim et al[60] investigated the effects of NMES on quadriceps muscle strength, performance-based measures, and patient-reported measures after ACL reconstruction. The NMES was administered within the first 3 weeks after ACL reconstruction and for a duration of 3 to 11 weeks. They found that, in 10 of 11 comparisons of quadriceps strength outcomes, the effect sizes were small to very large (0.08-3.81), favoring NMES combined with exercise when compared to exercise only or another comparable treatment. In 3 comparisons of performance-based measures, the effects were small to moderate (0.07-0.64, with 95% CIs crossing zero), favoring NMES combined with exercise when compared to exercise only. In 2 comparisons of patient-reported measures, the effects were moderate (0.66-0.72), favoring NMES compared to another comparable treatment. They concluded from 8 RCTs that NMES combined with exercise may be more effective in improving quadriceps strength than exercise alone after ACL reconstruction, whereas its effect on functional performance and patient-oriented outcomes is inconclusive. A variety of NMES parameters and applications of NMES were used in the reviewed studies.

II Imoto et al[53] conducted a systematic review of 17 RCTs on the effectiveness of NMES after ACL injuries. In 3 studies, the mean difference of isometric quadriceps strength 6 to 8 weeks after ACL reconstruction was 32.7 Nm, favoring NMES compared to other treatments (95% CI: 25.48, 39.92). The evidence in this moderate-quality review concluded that conventional rehabilitation augmented with NMES can improve quadriceps muscle strength 6 to 8 weeks after ACL reconstruction.

### 2017 Recommendation

A Neuromuscular electrical stimulation should be used for 6 to 8 weeks to augment muscle strengthening exercises in patients after ACL reconstruction to increase quadriceps muscle strength and enhance short-term functional outcomes.

## NEUROMUSCULAR RE-EDUCATION

### 2010 Recommendation

B Clinicians should consider the use of neuromuscular re-education as a supplementary program to strength training in patients with knee stability and movement coordination impairments.

### Evidence Update

I One moderate-quality systematic review by Gokeler et al[37] included 8 RCTs and 2 prospective cohort studies on the effect of rehabilitation on quadriceps muscle strength and patient-reported measures after ACL reconstruction. Seven studies reported an increase in quadriceps strength, and 2 studies reported that training on an eccentric ergometer significantly improved quadriceps strength more than concentric training. Five studies reported an increase in Tegner activity score throughout rehabilitation, but 4 of 5 studies found no differences between groups at the final follow-up time point. Four studies reported that neuromuscular training and strength training can increase patient-reported measures 6 months to 2 years after ACL reconstruction. The evidence from this review indicates that neuromuscular training incorporating motor learning principles should be added to strength training to optimize patient outcomes.

II A moderate-quality systematic review conducted by Zech and colleagues[129] included 13 RCTs and 2 controlled clinical trials, with 3 studies focused on ACL injuries. They concluded that neuromuscular interventions after ACL injuries can be effective for the nonoperative management of ACL injuries, in terms of function and joint stability.

III The results of a systematic review looked at the effectiveness of electromyographic biofeedback on the quadriceps after ACL reconstruction.[120] In 1 study, biofeedback appeared to benefit short-term postsurgical quadriceps strength. However, this review is very limited, as only 2 studies evaluated biofeedback after ACL reconstruction, and only 1 provided analysis on current surgical techniques.

### 2017 Recommendation

A Neuromuscular re-education training should be incorporated with muscle strengthening exercises in patients with knee stability and movement coordination impairments.

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# APPENDIX A

## SEARCH STRATEGIES FOR ALL DATABASES SEARCHED

### MEDLINE

((“Anterior cruciate ligament” [TW] OR “posterior cruciate ligament” [TW] OR “medial collateral ligament” [TW] OR “lateral collateral ligament” [TW] OR “tibial collateral ligament” [TW] OR “fibular collateral ligament” [TW] OR “posterolateral corner” [TW] OR “arcuate complex” [TW] OR “posteromedial corner” [TW]) OR ((knee joint [MH]) AND (ligaments, articular [MH] OR ACL [TW] OR PCL [TW] OR MCL [TW] OR LCL [TW] OR TCL [TW] OR FCL [TW]))) AND (preval* [tw] OR incidenc* [tw] OR epidem* [tw])

((“Anterior cruciate ligament” [TW] OR “posterior cruciate ligament” [TW] OR “medial collateral ligament” [TW] OR “lateral collateral ligament” [TW] OR “tibial collateral ligament” [TW] OR “fibular collateral ligament” [TW] OR “posterolateral corner” [TW] OR “arcuate complex” [TW] OR “posteromedial corner” [TW]) OR ((knee joint [MH]) AND (ligaments, articular [MH] OR ACL [TW] OR PCL [TW] OR MCL [TW] OR LCL [TW] OR TCL [TW] OR FCL [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])

((“Anterior cruciate ligament” [TW] OR “posterior cruciate ligament” [TW] OR “medial collateral ligament” [TW] OR “lateral collateral ligament” [TW] OR “tibial collateral ligament” [TW] OR “fibular collateral ligament” [TW] OR “posterolateral corner” [TW] OR “arcuate complex” [TW] OR “posteromedial corner” [TW]) OR ((knee joint [MH]) AND (ligaments, articular [MH] OR ACL [TW] OR PCL [TW] OR MCL [TW] OR LCL [TW] OR TCL [TW] OR FCL [TW]))) AND (prognos* [tw] OR return to work [tw] OR return to work [MH] OR return to sport [tw])

((“Anterior cruciate ligament” [TW] OR “posterior cruciate ligament” [TW] OR “medial collateral ligament” [TW] OR “lateral collateral ligament” [TW] OR “tibial collateral ligament” [TW] OR “fibular collateral ligament” [TW] OR “posterolateral corner” [TW] OR “arcuate complex” [TW] OR “posteromedial corner” [TW]) OR ((knee joint [MH]) AND (ligaments, articular [MH] OR ACL [TW] OR PCL [TW] OR MCL [TW] OR LCL [TW] OR TCL [TW] OR FCL [TW]))) AND (classif* [TW])

((“Anterior cruciate ligament” [TW] OR “posterior cruciate ligament” [TW] OR “medial collateral ligament” [TW] OR “lateral collateral ligament” [TW] OR “tibial collateral ligament” [TW] OR “fibular collateral ligament” [TW] OR “posterolateral corner” [TW] OR “arcuate complex” [TW] OR “posteromedial corner” [TW]) OR ((knee joint [MH]) AND (ligaments, articular [MH] OR ACL [TW] OR PCL [TW] OR MCL [TW] OR LCL [TW] OR TCL [TW] OR FCL [TW]))) AND (sensitiv* [Title/Abstract] OR sensitivity and specificity [MeSH Terms] OR diagnos* [Title/Abstract] OR diagnosis [MeSH:noexp] OR diagnostic [MeSH:noexp] OR diagnosis, differential [MeSH:noexp] OR diagnosis [Subheading:noexp])

((“Anterior cruciate ligament” [TW] OR “posterior cruciate ligament” [TW] OR “medial collateral ligament” [TW] OR “lateral collateral ligament” [TW] OR “tibial collateral ligament” [TW] OR “fibular collateral ligament” [TW] OR “posterolateral corner” [TW] OR “arcuate complex” [TW] OR “posteromedial corner” [TW]) OR ((knee joint [MH]) AND (ligaments, articular [MH] OR ACL [TW] OR PCL [TW] OR MCL [TW] OR LCL [TW] OR TCL [TW] OR FCL [TW]))) AND (physical therapy modalities [MH] OR recovery of function [MH] OR rehabilitation [MH] OR therapeutics [MH] OR “physical therapy” [TW] OR physiother* [TW] OR recovery [TW] OR restoration [TW] OR re-education [TW] OR early ambulation [MH] OR strengthening [TW] OR resistance training [MH] OR “resistance methods” [TW] OR exercise therapy [MH] OR biofeedback, psychology [MH] OR “neuromuscular electrical stimulation” [TW] OR pain management [MH] OR pain measurement [MH] OR mobilization* [TW] OR “continuous passive motion” [TW] OR manipulation, spinal [MH] OR ultrasonography [TW] OR ultrasound [TW] OR acupuncture [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 taping [TW] OR bracing [TW] OR orthotic* [TW] OR weight-bearing [MH] OR Range of motion [MH] OR Treatment Outcome [MH] OR Exercise [MH] OR “physical therapy treatments” [TW] OR “training program” [TW])

### Scopus

(((TITLE-ABS-KEY (“articular ligament”) OR TITLE-ABS-KEY (ACL) OR TITLE-ABS-KEY (PCL) OR TITLE-ABS-KEY (MCL) OR TITLE-ABS-KEY (LCL) OR TITLE-ABS-KEY (TCL) OR TITLE-ABS-KEY (FCL)) AND (TITLE-ABS-KEY (knee joint))) OR (TITLE-ABS-KEY (“Anterior cruciate ligament”) OR TITLE-ABS-KEY (“posterior cruciate ligament”) OR TITLE-ABS-KEY (“medial collateral ligament”) OR TITLE-ABS-KEY (“lateral collateral ligament”) OR TITLE-ABS-KEY (“tibial collateral ligament”) OR TITLE-ABS-KEY (“fibular collateral ligament”) OR TITLE-ABS-KEY (“posterolateral corner”) OR TITLE-ABS-KEY (“arcuate complex”) OR TITLE-ABS-KEY (“posteromedial corner”))) AND ((TITLE (prevalence) OR KEY (prevalence)) OR (TITLE (incidence) OR KEY (incidence)) OR (TITLE (epidemiology) OR KEY (epidemiology)))

(((TITLE-ABS-KEY (“articular ligament”) OR TITLE-ABS-KEY (ACL) OR TITLE-ABS-KEY (PCL) OR TITLE-ABS-KEY (MCL) OR TITLE-ABS-KEY (LCL) OR TITLE-ABS-KEY (TCL) OR TITLE-ABS-KEY (FCL)) AND (TITLE-ABS-KEY (knee joint))) OR (TITLE-ABS-KEY (“Anterior cruciate ligament”) OR TITLE-ABS-KEY (“posterior cruciate ligament”) OR TITLE-ABS-KEY (“medial collateral ligament”) OR TITLE-ABS-KEY (“lateral collateral ligament”) OR TITLE-ABS-KEY (“tibial collateral ligament”) OR TITLE-ABS-KEY (“fibular collateral ligament”) OR TITLE-ABS-KEY (“posterolateral corner”) OR TITLE-ABS-KEY (“arcuate complex”) OR TITLE-ABS-KEY (“posteromedial corner”))) AND (TITLE-ABS-KEY (associat*) OR TITLE-ABS-KEY (risk*) OR TITLE-ABS-KEY (probabil*) OR TITLE-ABS-KEY (odds*) OR TITLE-ABS-KEY (relat*) OR TITLE-ABS-KEY (prevalen*) OR TITLE-ABS-KEY (predict*) OR TITLE-ABS-KEY (caus*) OR TITLE-ABS-KEY (etiol*) OR TITLE-ABS-KEY (interact*))

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(((TITLE-ABS-KEY ("articular ligament") OR TITLE-ABS-KEY (ACL) OR TITLE-ABS-KEY (PCL) OR TITLE-ABS-KEY (MCL) OR TITLE-ABS-KEY (LCL) OR TITLE-ABS-KEY (TCL) OR TITLE-ABS-KEY (FCL)) AND (TITLE-ABS-KEY (knee joint))) OR (TITLE-ABS-KEY ("Anterior cruciate ligament") OR TITLE-ABS-KEY ("posterior cruciate ligament") OR TITLE-ABS-KEY ("medial collateral ligament") OR TITLE-ABS-KEY ("lateral collateral ligament") OR TITLE-ABS-KEY ("tibial collateral ligament") OR TITLE-ABS-KEY ("fibular collateral ligament") OR TITLE-ABS-KEY ("posterolateral corner") OR TITLE-ABS-KEY ("arcuate complex") OR TITLE-ABS-KEY ("posteromedial corner"))) AND (TITLE-ABS-KEY (prognos*) OR TITLE-ABS-KEY (return to work) OR TITLE-ABS-KEY (return to sport))

(((TITLE-ABS-KEY ("articular ligament") OR TITLE-ABS-KEY (ACL) OR TITLE-ABS-KEY (PCL) OR TITLE-ABS-KEY (MCL) OR TITLE-ABS-KEY (LCL) OR TITLE-ABS-KEY (TCL) OR TITLE-ABS-KEY (FCL)) AND (TITLE-ABS-KEY (knee joint))) OR (TITLE-ABS-KEY ("Anterior cruciate ligament") OR TITLE-ABS-KEY ("posterior cruciate ligament") OR TITLE-ABS-KEY ("medial collateral ligament") OR TITLE-ABS-KEY ("lateral collateral ligament") OR TITLE-ABS-KEY ("tibial collateral ligament") OR TITLE-ABS-KEY ("fibular collateral ligament") OR TITLE-ABS-KEY ("posterolateral corner") OR TITLE-ABS-KEY ("arcuate complex") OR TITLE-ABS-KEY ("posteromedial corner"))) AND (TITLE-ABS-KEY (classif*))

(((TITLE-ABS-KEY ("articular ligament") OR TITLE-ABS-KEY (ACL) OR TITLE-ABS-KEY (PCL) OR TITLE-ABS-KEY (MCL) OR TITLE-ABS-KEY (LCL) OR TITLE-ABS-KEY (TCL) OR TITLE-ABS-KEY (FCL)) AND (TITLE-ABS-KEY (knee joint))) OR (TITLE-ABS-KEY ("Anterior cruciate ligament") OR TITLE-ABS-KEY ("posterior cruciate ligament") OR TITLE-ABS-KEY ("medial collateral ligament") OR TITLE-ABS-KEY ("lateral collateral ligament") OR TITLE-ABS-KEY ("tibial collateral ligament") OR TITLE-ABS-KEY ("fibular collateral ligament") OR TITLE-ABS-KEY ("posterolateral corner") OR TITLE-ABS-KEY ("arcuate complex") OR TITLE-ABS-KEY ("posteromedial corner"))) AND (TITLE-ABS-KEY (sensitiv*) OR TITLE-ABS-KEY (sensitivity and specificity) OR TITLE-ABS-KEY (diagnos*))

(((TITLE-ABS-KEY ("articular ligament") OR TITLE-ABS-KEY (ACL) OR TITLE-ABS-KEY (PCL) OR TITLE-ABS-KEY (MCL) OR TITLE-ABS-KEY (LCL) OR TITLE-ABS-KEY (TCL) OR TITLE-ABS-KEY (FCL)) AND TITLE-ABS-KEY (knee joint)) OR TITLE-ABS-KEY ("Anterior cruciate ligament") OR TITLE-ABS-KEY ("posterior cruciate ligament") OR TITLE-ABS-KEY ("medial collateral ligament") OR TITLE-ABS-KEY ("lateral collateral ligament") OR TITLE-ABS-KEY ("tibial collateral ligament") OR TITLE-ABS-KEY ("fibular collateral ligament") OR TITLE-ABS-KEY ("posterolateral corner") OR TITLE-ABS-KEY ("arcuate complex") OR TITLE-ABS-KEY ("posteromedial corner")) AND (TITLE-ABS-KEY ("physical therapy modalities") OR TITLE-ABS-KEY ("recovery of function") OR TITLE-ABS-KEY (rehabilitation) OR TITLE-ABS-KEY (therapeutics) OR TITLE-ABS-KEY ("physical therapy") OR TITLE-ABS-KEY (physiother*) OR TITLE-ABS-KEY (recovery) OR TITLE-ABS-KEY (restoration) OR TITLE-ABS-KEY (re-education) OR TITLE-ABS-KEY ("early ambulation") OR TITLE-ABS-KEY (strengthening) OR TITLE-ABS-KEY ("resistance training") OR TITLE-ABS-KEY ("resistance methods") OR TITLE-ABS-KEY ("exercise therapy") 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 (mobilization*) OR TITLE-ABS-KEY ("continuous passive motion") OR TITLE-ABS-KEY ("spinal manipulation") OR TITLE-ABS-KEY (ultrasonography) OR TITLE-ABS-KEY (ultrasound) OR TITLE-ABS-KEY (acupuncture) OR TITLE-ABS-KEY (laser*) OR TITLE-ABS-KEY ("patient education") OR TITLE-ABS-KEY ("electrical stimulation") OR TITLE-ABS-KEY ("electrical stimulation therapy") OR TITLE-ABS-KEY ("Transcutaneous electric nerve stimulation") OR TITLE-ABS-KEY (taping) OR TITLE-ABS-KEY (bracing) 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 ("physical therapy treatments") OR TITLE-ABS-KEY ("training program"))

### *CINAHL*

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR (TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner"))) AND ((TI (prevalence) OR SU (prevalence)) OR (TI (incidence) OR SU (incidence)) OR (TI (epidemiology) OR SU (epidemiology)))

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR (TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner"))) AND (TX (associat*) OR TX (risk*) OR TX (probabil*) OR TX (odds*) OR TX (relat*) OR TX (prevalen*) OR TX (predict*) OR TX (caus*) OR TX (etiol* ) OR TX (interact*))

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR (TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner"))) AND (TX (prognos*) OR TX (return to work) OR TX (return to sport))

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR (TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament")

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OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner"))) AND (TX (classif*))

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR (TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner"))) AND (TX (sensitiv*) OR TX (sensitivity and specificity) OR TX (diagnos*))

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner")) AND (TX ("physical therapy modalities") OR TX ("recovery of function") OR TX (rehabilitation) OR TX (therapeutics) OR TX ("physical therapy") OR TX (physiother*) OR TX (recovery) OR TX (restoration) OR TX (re-education) OR TX ("early ambulation") OR TX (strengthening) OR TX ("resistance training") OR TX ("resistance methods") OR TX ("exercise therapy") OR TX (biofeedback) OR TX ("neuromuscular electrical stimulation") OR TX ("pain management") OR TX ("pain measurement") OR TX (mobilization*) OR TX ("continuous passive motion") OR TX ("spinal manipulation") OR TX (ultrasonography) OR TX (ultrasound) OR TX (acupuncture) OR TX (laser*) OR TX ("patient education") OR TX ("electrical stimulation") OR TX ("electrical stimulation therapy") OR TX ("Transcutaneous electric nerve stimulation") OR TX (taping) OR TX (bracing) OR TX (orthotic*) OR TX (weight-bearing) OR TX ("Range of motion") OR TX ("Treatment Outcome") OR TX (Exercise) OR TX ("physical therapy treatments") OR TX ("training program"))

### *SPORTDiscus*

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR (TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner"))) AND ((TI (prevalence) OR SU (prevalence)) OR (TI (incidence) OR SU (incidence)) OR (TI (epidemiology) OR SU (epidemiology)))

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR (TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner"))) AND (TX (associat*) OR TX (risk*) OR TX (probabil*) OR TX (odds*) OR TX (relat*) OR TX (prevalen*) OR TX (predict*) OR TX (caus*) OR TX (etiol* ) OR TX (interact*))

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR (TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner"))) AND (TX (prognos*) OR TX (return to work) OR TX (return to sport))

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR (TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner"))) AND (TX (classif*))

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR (TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner"))) AND (TX (sensitiv*) OR TX (sensitivity and specificity) OR TX (diagnos*))

(((TX ("articular ligament") OR TX (ACL) OR TX (PCL) OR TX (MCL) OR TX (LCL) OR TX (TCL) OR TX (FCL)) AND TX (knee joint)) OR TX ("Anterior cruciate ligament") OR TX ("posterior cruciate ligament") OR TX ("medial collateral ligament") OR TX ("lateral collateral ligament") OR TX ("tibial collateral ligament") OR TX ("fibular collateral ligament") OR TX ("posterolateral corner") OR TX ("arcuate complex") OR TX ("posteromedial corner")) AND (TX ("physical therapy modalities") OR TX ("recovery of function") OR TX (rehabilitation) OR TX (therapeutics) OR TX ("physical therapy") OR TX (physiother*) OR TX (recovery) OR TX (restoration) OR TX (re-education) OR TX ("early ambulation") OR TX (strengthening) OR TX ("resistance training") OR TX ("resistance methods") OR TX ("exercise therapy") OR TX (biofeedback) OR TX ("neuromuscular electrical stimulation") OR TX ("pain management") OR TX ("pain measurement") OR TX (mobilization*) OR TX ("continuous passive motion") OR TX ("spinal manipulation") OR TX (ultrasonography) OR TX (ultrasound) OR TX (acupuncture) OR TX (laser*) OR TX ("patient education") OR TX ("electrical stimulation") OR TX ("electrical stimulation therapy") OR TX ("Transcutaneous electric nerve stimulation") OR TX (taping) OR TX (bracing) OR TX (orthotic*) OR TX (weight-bearing) OR TX

## APPENDIX A

("Range of motion") OR TX ("Treatment Outcome") OR TX (Exercise) OR TX ("physical therapy treatments") OR TX ("training program"))

### *Cochrane Library*

(((("articular ligament") OR (ACL) OR (PCL) OR (MCL) OR (LCL) OR (TCL) OR (FCL)) AND (knee joint)) OR (("Anterior cruciate ligament") OR ("posterior cruciate ligament") OR ("medial collateral ligament") OR ("lateral collateral ligament") OR ("tibial collateral ligament") OR ("fibular collateral ligament") OR ("posterolateral corner") OR ("arcuate complex") OR ("posteromedial corner"))) AND ((prevalence) OR (incidence) OR (epidemiology))

(((("articular ligament") OR (ACL) OR (PCL) OR (MCL) OR (LCL) OR (TCL) OR (FCL)) AND (knee joint)) OR (("Anterior cruciate ligament") OR ("posterior cruciate ligament") OR ("medial collateral ligament") OR ("lateral collateral ligament") OR ("tibial collateral ligament") OR ("fibular collateral ligament") OR ("posterolateral corner") OR ("arcuate complex") OR ("posteromedial corner"))) AND ((associat*) OR (risk*) OR (probabil*) OR (odds*) OR (relat*) OR (prevalen*) OR (predict*) OR (caus*) OR (etiol* ) OR (interact*))

(((("articular ligament") OR (ACL) OR (PCL) OR (MCL) OR (LCL) OR (TCL) OR (FCL)) AND (knee joint)) OR (("Anterior cruciate ligament") OR ("posterior cruciate ligament") OR ("medial collateral ligament") OR ("lateral collateral ligament") OR ("tibial collateral ligament") OR ("fibular collateral ligament") OR ("posterolateral corner") OR ("arcuate complex") OR ("posteromedial corner"))) AND ((prognos*) OR (return to work) OR (return to sport))

(((("articular ligament") OR (ACL) OR (PCL) OR (MCL) OR (LCL) OR (TCL) OR (FCL)) AND (knee joint)) OR (("Anterior cruciate ligament") OR ("posterior cruciate ligament") OR ("medial collateral ligament") OR ("lateral collateral ligament") OR ("tibial collateral ligament") OR ("fibular collateral ligament") OR ("posterolateral corner") OR ("arcuate complex") OR ("posteromedial corner"))) AND (classif*)

(((("articular ligament") OR (ACL) OR (PCL) OR (MCL) OR (LCL) OR (TCL) OR (FCL)) AND (knee joint)) OR (("Anterior cruciate ligament") OR ("posterior cruciate ligament") OR ("medial collateral ligament") OR ("lateral collateral ligament") OR ("tibial collateral ligament") OR ("fibular collateral ligament") OR ("posterolateral corner") OR ("arcuate complex") OR ("posteromedial corner"))) AND ((sensitiv*) OR (sensitivity and specificity) OR (diagnos*))

(((("articular ligament") OR (ACL) OR (PCL) OR (MCL) OR (LCL) OR (TCL) OR (FCL)) AND (knee joint)) OR ("Anterior cruciate ligament") OR ("posterior cruciate ligament") OR ("medial collateral ligament") OR ("lateral collateral ligament") OR ("tibial collateral ligament") OR ("fibular collateral ligament") OR ("posterolateral corner") OR ("arcuate complex") OR ("posteromedial corner")) AND (("physical therapy modalities") OR ("recovery of function") OR (rehabilitation) OR (therapeutics) OR ("physical therapy") OR (physiother*) OR (recovery) OR (restoration) OR (re-education) OR ("early ambulation") OR (strengthening) OR ("resistance training") OR ("resistance methods") OR ("exercise therapy") OR (biofeedback) OR ("neuromuscular electrical stimulation") OR ("pain management") OR ("pain measurement") OR (mobilization*) OR ("continuous passive motion") OR ("spinal manipulation") OR (ultrasonography) OR (ultrasound) OR (acupuncture) OR (laser*) OR ("patient education") OR ("electrical stimulation") OR ("electrical stimulation therapy") OR ("Transcutaneous electric nerve stimulation") OR (taping) OR (bracing) OR (orthotic*) OR (weight-bearing) OR ("Range of motion") OR ("Treatment Outcome") OR (Exercise) OR ("physical therapy treatments") OR ("training program"))

## APPENDIX B

### SEARCH RESULTS

| Database | Date Conducted | Results, n: January 2008 to September 2014 | Results, n: January 2014 to December 2016 |
|---|---|---|---|
| MEDLINE | September 2014 and December 2016 | 5884 | 3308 |
| Scopus | September 2014 and December 2016 | 10448 | 7378 |
| CINAHL | September 2014 and December 2016 | 4468 | 1631 |
| SPORTDiscus | September 2014 and December 2016 | 10745 | 6830 |
| Cochrane Library | September 2014 and December 2016 | 651 | 591 |
| Cochrane reviews | | 14 | 17 |
| Other reviews | | 56 | 17 |
| Trials | | 571 | 553 |
| Technology assessments | | 2 | 0 |
| Economic evaluations | | 8 | 4 |
| Total | | 32196 | 19738 |
| Total from 2014 and 2016 with duplicates removed | | 13774 | |

## APPENDIX C

## CRITERIA FOR INCLUSION AND EXCLUSION OF STUDIES FOR REVIEW

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 will be included.

Exclusions: meeting abstracts, press releases, theses, nonsystematic review articles, case reports, and articles that cannot be retrieved in English.

### Inclusion Criteria

We included articles reporting on:

- The functional anatomy (anterior cruciate ligament, posterior cruciate ligament, medial collateral ligament, lateral collateral ligament, posterolateral corner, and posteromedial corner, multiple or multiligamentous) of the tibiofemoral joint

OR

- Tests and measures for diagnosis and/or differential diagnosis of ligament sprain/tear/rupture 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 ligament sprain/tear/rupture–related outcomes (including but not limited to symptoms, functions, activity, and participation)

OR

- Measurement properties of instruments that are not specific to ligament sprain/tear/rupture BUT are specific to lower extremity outcomes

OR

- Measurement properties of instruments using data from a sample of patients with ligament sprain/tear/rupture

OR

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

AND

- Ligament sprain/tear/rupture, including the following topics:
  - Risk of ligament sprain/tear/rupture
  - Diagnostic characteristics of ligament sprain/tear/rupture, including but not limited to location, duration, and quality, and related impairments and functional limitations
  - Interventions within the scope of practice of physical therapists for ligament sprain/tear/rupture

We included all outcomes.

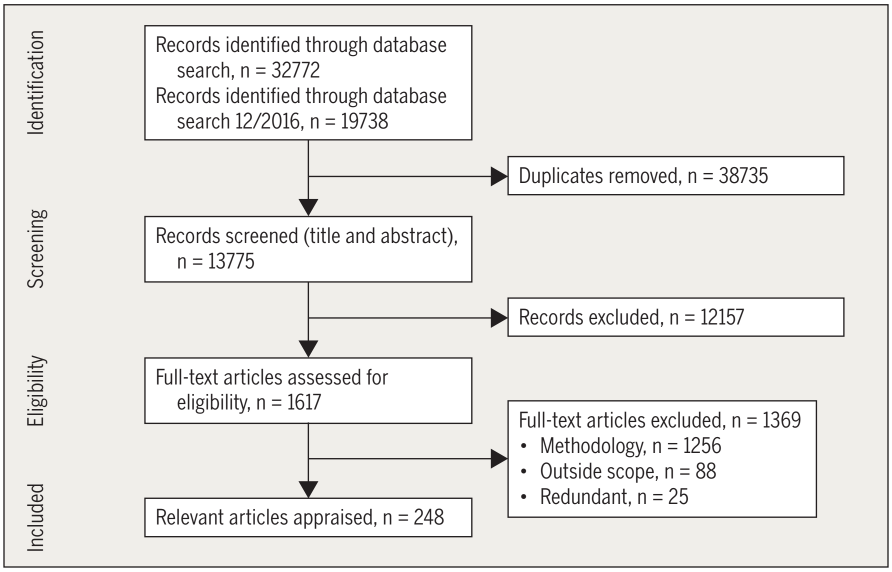
### Exclusion Criteria

We excluded articles reporting on:

- Primarily infants and children (younger than 12 years old)
- Meniscal injuries
- Articular cartilage injuries (chondral)
- Patellofemoral pain, patellar tendinopathy/tendon pain, or iliotibial band
- Nonmusculoskeletal tibiofemoral pain:
  - Diabetes
  - Ulcers
  - Primary peripheral nerve entrapment
- Topics outside the scope of physical therapist practice
  - Decisions to order radiologic tests
  - Pharmacological interventions

## APPENDIX D

### FLOW CHART OF ARTICLES



## APPENDIX E

## ARTICLES INCLUDED IN RECOMMENDATIONS

### DIAGNOSIS/CLASSIFICATION: DIFFERENTIAL DIAGNOSIS

#### Examination

*Outcome Measures – Activity Limitations: Self-Reported*


Almangoush A, Herrington L, Attia I, et al. Cross-cultural adaptation, reliability, internal consistency and validation of the Arabic version of the Knee injury and Osteoarthritis Outcome Score (KOOS) for Egyptian people with knee injuries. *Osteoarthritis Cartilage*. 2013;21:1855-1864. https://doi.org/10.1016/j.joca.2013.09.010

Ardern CL, Taylor NF, Feller JA, Webster KE. A systematic review of the psychological factors associated with returning to sport following injury. *Br J Sports Med*. 2013;47:1120-1126. https://doi.org/10.1136/bjsports-2012-091203

Bohu Y, Klouche S, Lefevre N, Webster K, Herman S. Translation, cross-cultural adaptation and validation of the French version of the Anterior Cruciate Ligament-Return to Sport after Injury (ACL-RSI) scale. *Knee Surg Sports Traumatol Arthrosc*. 2015;23:1192-1196. https://doi.org/10.1007/s00167-014-2942-4

Briggs KK, Lysholm J, Tegner Y, Rodkey WG, Kocher MS, Steadman JR. The reliability, validity, and responsiveness of the Lysholm score and Tegner activity scale for anterior cruciate ligament injuries of the knee: 25 years later. *Am J Sports Med*. 2009;37:890-897. https://doi.org/10.1177/0363546508330143

Comins J, Brodersen J, Krogsgaard M, Beyer N. Rasch analysis of the Knee injury and Osteoarthritis Outcome Score (KOOS): a statistical re-evaluation. *Scand J Med Sci Sports*. 2008;18:336-345. https://doi.org/10.1111/j.1600-0838.2007.00724.x

Della Villa F, Ricci M, Perdisa F, et al. Anterior cruciate ligament reconstruction and rehabilitation: predictors of functional outcome. *Joints*. 2015;3:179-185. https://doi.org/10.11138/jts/2015.3.4.179

Dunn WR, Wolf BR, Harrell FE, Jr., et al. Baseline predictors of health-related quality of life after anterior cruciate ligament reconstruction: a longitudinal analysis of a multicenter cohort at two and six years. *J Bone Joint Surg Am*. 2015;97:551-557. https://doi.org/10.2106/JBJS.N.00248

Filbay SR, Ackerman IN, Russell TG, Macri EM, Crossley KM. Health-related quality of life after anterior cruciate ligament reconstruction: a systematic review. *Am J Sports Med*. 2014;42:1247-1255. https://doi.org/10.1177/0363546513512774

Flanigan DC, Everhart JS, Pedroza A, Smith T, Kaeding CC. Fear of reinjury (kinesiophobia) and persistent knee symptoms are common factors for lack of return to sport after anterior cruciate ligament reconstruction. *Arthroscopy*. 2013;29:1322-1329. https://doi.org/10.1016/j.arthro.2013.05.015

Garratt AM, Brealey S, Robling M, et al. Development of the Knee Quality of Life (KQoL-26) 26-item questionnaire: data quality, reliability, validity and responsiveness. *Health Qual Life Outcomes*. 2008;6:48. https://doi.org/10.1186/1477-7525-6-48

George SZ, Lentz TA, Zeppieri G, Lee D, Chmielewski TL. Analysis of shortened versions of the Tampa Scale for Kinesiophobia and Pain Catastrophizing Scale for patients after anterior cruciate ligament reconstruction. *Clin J Pain*. 2012;28:73-80. https://doi.org/10.1097/AJP.0b013e31822363f4

Granan LP, Baste V, Engebretsen L, Inacio MC. Associations between inadequate knee function detected by KOOS and prospective graft failure in an anterior cruciate ligament-reconstructed knee. *Knee Surg Sports Traumatol Arthrosc*. 2015;23:1135-1140. https://doi.org/10.1007/s00167-014-2925-5

Hambly K, Griva K. IKDC or KOOS: which one captures symptoms and disabilities most important to patients who have undergone initial anterior cruciate ligament reconstruction? *Am J Sports Med*. 2010;38:1395-1404. https://doi.org/10.1177/0363546509359678

Harput G, Tok D, Ulusoy B, et al. Translation and cross-cultural adaptation of the anterior cruciate ligament-return to sport after injury (ACL-RSI) scale into Turkish. *Knee Surg Sports Traumatol Arthrosc*. 2017;25:159-164. https://doi.org/10.1007/s00167-016-4288-6

Huang H, Zhang D, Jiang Y, et al. Translation, validation and cross-cultural adaptation of a simplified-Chinese version of the Tegner Activity Score in Chinese patients with anterior cruciate ligament injury. *PLoS One*. 2016;11:e0155463. https://doi.org/10.1371/journal.pone.0155463

Kvist J, Österberg A, Gauffin H, Tagesson S, Webster K, Ardern C. Translation and measurement properties of the Swedish version of ACL-Return to Sports after Injury questionnaire. *Scand J Med Sci Sports*. 2013;23:568-575. https://doi.org/10.1111/j.1600-0838.2011.01438.x

Månsson O, Kartus J, Sernert N. Health-related quality of life after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2011;19:479-487. https://doi.org/10.1007/s00167-010-1303-1

Månsson O, Kartus J, Sernert N. Pre-operative factors predicting good outcome in terms of health-related quality of life after ACL reconstruction. *Scand J Med Sci Sports*. 2013;23:15-22. https://doi.org/10.1111/j.1600-0838.2011.01426.x

Negahban H, Mostafaee N, Sohani SM, et al. Reliability and validity of the Tegner and Marx activity rating scales in Iranian patients with anterior cruciate ligament injury. *Disabil Rehabil*. 2011;33:2305-2310. https://doi.org/10.3109/09638288.2011.570409

Salavati M, Akhbari B, Mohammadi F, Mazaheri M, Khorrami M. Knee injury and Osteoarthritis Outcome Score (KOOS); reliability and validity in competitive athletes after anterior cruciate ligament reconstruction. *Osteoarthritis Cartilage*. 2011;19:406-410. https://doi.org/10.1016/j.joca.2011.01.010

Shelbourne KD, Barnes AF, Gray T. Correlation of a single assessment numeric evaluation (SANE) rating with modified Cincinnati Knee Rating System and IKDC subjective total scores for patients after ACL reconstruction or knee arthroscopy. *Am J Sports Med*. 2012;40:2487-2491. https://doi.org/10.1177/0363546512458576

Thomeé P, Währborg P, Börjesson M, Thomeé R, Eriksson BI, Karls-

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son J. Self-efficacy of knee function as a pre-operative predictor of outcome 1 year after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2008;16:118-127. https://doi.org/10.1007/s00167-007-0433-6

van Meer BL, Meuffels DE, Vissers MM, et al. Knee injury and Osteoarthritis Outcome Score or International Knee Documentation Committee Subjective Knee Form: which questionnaire is most useful to monitor patients with an anterior cruciate ligament rupture in the short term? *Arthroscopy*. 2013;29:701-715. https://doi.org/10.1016/j.arthro.2012.12.015

Wang W, Liu L, Chang X, Jia ZY, Zhao JZ, Xu WD. Cross-cultural translation of the Lysholm knee score in Chinese and its validation in patients with anterior cruciate ligament injury. *BMC Musculoskelet Disord*. 2016;17:436. https://doi.org/10.1186/s12891-016-1283-5

Webster KE, Feller JA. Use of the short form health surveys as an outcome measure for anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2014;22:1142-1148. https://doi.org/10.1007/s00167-013-2520-1

### *Physical Performance Measures*

Abrams GD, Harris JD, Gupta AK, et al. Functional performance testing after anterior cruciate ligament reconstruction: a systematic review. *Orthop J Sports Med*. 2014;2:2325967113518305. https://doi.org/10.1177/2325967113518305

Grindem H, Logerstedt D, Eitzen I, et al. Single-legged hop tests as predictors of self-reported knee function in nonoperatively treated individuals with anterior cruciate ligament injury. *Am J Sports Med*. 2011;39:2347-2354. https://doi.org/10.1177/0363546511417085

Hegedus EJ, McDonough S, Bleakley C, Cook CE, Baxter GD. Clinician-friendly lower extremity physical performance measures in athletes: a systematic review of measurement properties and correlation with injury, part 1. The tests for knee function including the hop tests. *Br J Sports Med*. 2015;49:642-648. https://doi.org/10.1136/bjsports-2014-094094

Logerstedt D, Grindem H, Lynch A, et al. Single-legged hop tests as predictors of self-reported knee function after anterior cruciate ligament reconstruction: the Delaware-Oslo ACL Cohort study. *Am J Sports Med*. 2012;40:2348-2356. https://doi.org/10.1177/0363546512457551

Reinke EK, Spindler KP, Lorring D, et al. Hop tests correlate with IKDC and KOOS at minimum of 2 years after primary ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2011;19:1806-1816. https://doi.org/10.1007/s00167-011-1473-5

### *Physical Impairment Measures*

Abrams GD, Harris JD, Gupta AK, et al. Functional performance testing after anterior cruciate ligament reconstruction: a systematic review. *Orthop J Sports Med*. 2014;2:2325967113518305. https://doi.org/10.1177/2325967113518305

Décary S, Ouellet P, Vendittoli PA, Desmeules F. Reliability of physical examination tests for the diagnosis of knee disorders: evidence from a systematic review. *Man Ther*. 2016;26:172-182. https://doi.org/10.1016/j.math.2016.09.007

Eitzen I, Holm I, Risberg MA. Preoperative quadriceps strength is a significant predictor of knee function two years after anterior cruciate ligament reconstruction. *Br J Sports Med*. 2009;43:371-376. https://doi.org/10.1136/bjsm.2008.057059

Gokeler A, Welling W, Zaffagnini S, Seil R, Padua D. Development of a test battery to enhance safe return to sports after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2017;25:192-199. https://doi.org/10.1007/s00167-016-4246-3

Kopkow C, Freiberg A, Kirschner S, Seidler A, Schmitt J. Physical examination tests for the diagnosis of posterior cruciate ligament rupture: a systematic review. *J Orthop Sports Phys Ther*. 2013;43:804-813. https://doi.org/10.2519/jospt.2013.4906

Leblanc MC, Kowalczuk M, Andruszkiewicz N, et al. Diagnostic accuracy of physical examination for anterior knee instability: a systematic review. *Knee Surg Sports Traumatol Arthrosc*. 2015;23:2805-2813. https://doi.org/10.1007/s00167-015-3563-2

Lentz TA, Zeppieri G, Jr., Tillman SM, et al. Return to preinjury sports participation following anterior cruciate ligament reconstruction: contributions of demographic, knee impairment, and self-report measures. *J Orthop Sports Phys Ther*. 2012;42:893-901. https://doi.org/10.2519/jospt.2012.4077

Logerstedt D, Lynch A, Axe MJ, Snyder-Mackler L. Pre-operative quadriceps strength predicts IKDC2000 scores 6 months after anterior cruciate ligament reconstruction. *Knee*. 2013;20:208-212. https://doi.org/10.1016/j.knee.2012.07.011

Pietrosimone B, Lepley AS, Harkey MS, et al. Quadriceps strength predicts self-reported function post-ACL reconstruction. *Med Sci Sports Exerc*. 2016;48:1671-1677. https://doi.org/10.1249/MSS.0000000000000946

Swain MS, Henschke N, Kamper SJ, Downie AS, Koes BW, Maher CG. Accuracy of clinical tests in the diagnosis of anterior cruciate ligament injury: a systematic review. *Chiropr Man Therap*. 2014;22:25. https://doi.org/10.1186/s12998-014-0025-8

Ueda Y, Matsushita T, Araki D, et al. Factors affecting quadriceps strength recovery after anterior cruciate ligament reconstruction with hamstring autografts in athletes. *Knee Surg Sports Traumatol Arthrosc*. 2017;25:3213-3219. https://doi.org/10.1007/s00167-016-4296-6

## INTERVENTIONS

### Continuous Passive Motion

#### *Early Weight Bearing: Knee Bracing*

Kinikli Gİ, Callaghan MJ, Parkes MJ, Yüksel İ. Bracing after anterior cruciate ligament reconstruction: systematic review and meta-analysis. *Turkiye Klinikleri Spor Bilimleri*. 2014;6:28-38.

### Immediate Versus Delayed Mobilization

#### *Cryotherapy*

Martimbianco AL, da Silva BN, de Carvalho AP, Silva V, Torloni

## APPENDIX E

MR, Peccin MS. Effectiveness and safety of cryotherapy after arthroscopic anterior cruciate ligament reconstruction. A systematic review of the literature. *Phys Ther Sport*. 2014;15:261-268. https://doi.org/10.1016/j.ptsp.2014.02.008

### *Supervised Rehabilitation*

Hohmann E, Tetsworth K, Bryant A. Physiotherapy-guided versus home-based, unsupervised rehabilitation in isolated anterior cruciate injuries following surgical reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2011;19:1158-1167. https://doi.org/10.1007/s00167-010-1386-8

Papalia R, Vasta S, Tecame A, D'Adamio S, Maffulli N, Denaro V. Home-based vs supervised rehabilitation programs following knee surgery: a systematic review. *Br Med Bull*. 2013;108:55-72. https://doi.org/10.1093/bmb/ldt014

### *Therapeutic Exercises*

Gokeler A, Bisschop M, Benjaminse A, Myer GD, Eppinga P, Otten E. Quadriceps function following ACL reconstruction and rehabilitation: implications for optimisation of current practices. *Knee Surg Sports Traumatol Arthrosc*. 2014;22:1163-1174. https://doi.org/10.1007/s00167-013-2577-x

### *Neuromuscular Electrical Stimulation*

Imoto AM, Peccin S, Almeida GJ, Saconato H, Atallah AN. Effectiveness of electrical stimulation on rehabilitation after ligament and meniscal injuries: a systematic review. *São Paulo Med J*. 2011;129:414-423. https://doi.org/10.1590/S1516-31802011000600008

Kim KM, Croy T, Hertel J, Saliba S. Effects of neuromuscular electrical stimulation after anterior cruciate ligament reconstruction on quadriceps strength, function, and patient-oriented outcomes: a systematic review. *J Orthop Sports Phys Ther*. 2010;40:383-391. https://doi.org/10.2519/jospt.2010.3184

### *Neuromuscular Re-education*

Gokeler A, Bisschop M, Benjaminse A, Myer GD, Eppinga P, Otten E. Quadriceps function following ACL reconstruction and rehabilitation: implications for optimisation of current practices. *Knee Surg Sports Traumatol Arthrosc*. 2014;22:1163-1174. https://doi.org/10.1007/s00167-013-2577-x

Wasielewski NJ, Parker TM, Kotsko KM. Evaluation of electromyographic biofeedback for the quadriceps femoris: a systematic review. *J Athl Train*. 2011;46:543-554. https://doi.org/10.4085/1062-6050-46.5.543

Zech A, Hübscher M, Vogt L, Banzer W, Hänsel F, Pfeifer K. Neuromuscular training for rehabilitation of sports injuries: a systematic review. *Med Sci Sports Exerc*. 2009;41:1831-1841. https://doi.org/10.1249/MSS.0b013e3181a3cf0d

## APPENDIX F

### LEVELS OF EVIDENCE TABLE*

| Level | Intervention/Prevention | Pathoanatomic/Risk/Clinical Course/Prognosis/Differential Diagnosis | Diagnosis/Diagnostic Accuracy | Prevalence of Condition/Disorder | Examination/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[91] (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

# LIGAMENT SPRAIN CLINICAL PRACTICE GUIDELINES REVISION: CRITICAL APPRAISAL SCORES

**Clinical Course: SIGN Systematic Review***

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Quality† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ardern et al[8] | x | | x | x | x | x | x | x | | | x | H |
| Ardern et al[7] | x | x | x | x | x | | x | x | x | | x | H |
| Bonanzinga et al[16] | x | x | x | x | | x | x | | | | x | A |
| Czuppon et al[21] | x | x | x | x | | x | x | x | | | x | H |
| Everhart et al[26] | x | | x | x | | x | x | x | | | | A |
| Geeslin et al[34] | | x | x | x | | x | | | | | x | A |
| Gokeler et al[36] | x | x | x | x | x | x | x | x | | | x | H |
| Hart et al[47] | x | | x | x | | x | x | x | | | | A |
| Howells et al[50] | x | x | x | x | x | x | x | x | | | | H |
| Kovachevich et al[64] | x | x | x | x | | x | | | | | | A |
| Levy 2009 | x | x | x | x | | x | | | | | | A‡ |
| Magnussen et al[72] | x | x | | | | x | | | | | x | L |
| Mulford et al[81] | x | x | x | x | | x | | | | | x | A |
| Narducci et al[82] | x | x | x | x | x | x | x | x | | | | H |
| Negahban et al[83] | x | x | x | | | x | x | x | x | x | | H |
| Paterno et al[89] | x | x | x | x | | x | x | x | | | x | H |
| Petersen et al[90] | x | | | | | x | | | | | | L |
| Pujol et al[94] | x | | | | | x | | | | | x | L |
| Relph et al[97] | x | x | x | x | | x | x | x | x | | | H |
| Rochecongar et al[100] | x | x | x | | | x | x | | | | x | A |
| Smith et al[110] | x | x | x | x | x | x | x | x | x | x | x | H |
| Undheim et al[117] | x | x | x | | | | | | | | x | L |
| te Wierike et al[114] | x | | x | x | | x | x | x | | | | A |
| Xergia et al[128] | x | x | x | x | x | x | x | x | x | | x | H |

*Abbreviations: A, acceptable; H, high; L, low; SIGN, Scottish Intercollegiate Guidelines Network.*

**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.*

*†"What is your overall assessment of the methodological quality of this review?" High quality, 8 or higher; acceptable quality, 5 or higher; low quality, 4 or lower.*

*‡Not relevant to clinical outcomes.*

## APPENDIX H

**Clinical Course: SIGN Randomized Controlled Trial***

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Quality† |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Frobell et al[30] | x | x | x | | x | x | x | | x | NA | H |
| Frobell et al[31] | x | x | x | | x | x | x | | x | NA | H |

*Abbreviations: H, high; NA, not applicable; SIGN, Scottish Intercollegiate Guidelines Network.*
**Items: 1, The study addresses an appropriate and clearly focused question; 2, The assignment of subjects to treatment groups is randomized; 3, An adequate concealment method is used; 4, The design keeps subjects and investigators "blind" about treatment allocation; 5, The treatment and control groups are similar at the start of the trial; 6, The only difference between groups is the treatment under investigation; 7, All relevant outcomes are measured in a standard, valid, and reliable way; 8, What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed? 9, All the subjects are analyzed in the groups to which they were randomly allocated (often referred to as intention-to-treat analysis); 10, Where the study is carried out at more than 1 site, results are comparable for all sites.*
*†"What is your overall assessment of the methodological quality of this trial?" High quality, 7 or higher; acceptable quality, 4 or higher; low quality, 3 or lower.*

**Risk Factors: SIGN Systematic Review***

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Quality† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alentorn-Geli et al[3] | x | x | x | | | x | x | | | | | A |
| Smith et al[108] | x | | | x | | | | | | | | L |
| Smith et al[109] | x | | | x | | | | | | | | L |
| Wordeman et al[124] | x | | x | x | | | x | | | | x | A |

*Abbreviation: SIGN, Scottish Intercollegiate Guidelines Network.*
**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.*
*†"What is your overall assessment of the methodological quality of this review?" High quality, 8 or higher; acceptable quality, 5 or higher; low quality, 4 or lower.*

**Examination – Outcome Measures: Levels of Evidence Adapted From Phillips et al[91]**

| | SR of Prospective Cohort Studies* | SR of Lower-Quality Prospective Cohort Studies† | High-Quality Cross-sectional Study | Lower-Quality Cross-sectional Study | Expert Opinion | Quality‡ |
|---|---|---|---|---|---|---|
| Ardern et al[9] | | x | | | | A |
| Bohu et al[15] | | | x | | | A |
| Briggs et al[17] | x | | | | | H |
| Comins et al[19] | | | x | | | A |
| Dunn et al[24] | x | | | | | H |
| Filbay et al[27] | | x | | | | A |
| Flanigan et al[29] | | | x | | | A |
| Frobell et al[30] | x | | | | | H |
| Frobell et al[31] | x | | | | | H |
| Garratt et al[33] | | x | | | | A |
| George et al[35] | | x | | | | A |
| Gokeler et al[36] | | x | | | | A |
| Granan et al[40] | | x | | | | A |
| Hambly and Griva[45] | | x | | | | A |
| Harput et al[46] | | | x | | | A |

*Table continues on page A45.*

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| | SR of Prospective Cohort Studies* | SR of Lower-Quality Prospective Cohort Studies† | High-Quality Cross-sectional Study | Lower-Quality Cross-sectional Study | Expert Opinion | Quality‡ |
|---|---|---|---|---|---|---|
| Huang et al[51] | | | x | | | A |
| Kvist et al[65] | | | x | | | A |
| Månsson et al[75] | | | x | | | A |
| Månsson et al[76] | | x | | | | A |
| Negahban et al[84] | | | x | | | A |
| Salavati et al[101] | | x | | | | A |
| Shelbourne et al[106] | | x | | | | A |
| Thomeé et al[115] | | x | | | | A |
| van Meer et al[118] | | | x | | | A |
| Della Villa et al[23] | | | x | | | A |
| Wang et al[119] | | | x | | | A |
| Webster and Feller[121] | x | | | | | H |
| Almangoush et al[4] | | | x | | | U |
| Stratford 2014 | | | | Knee OA patients | | U |
| Hill 2013 | | | | x | | U |
| Kapreli 2011 | | | | x (multiple pathologies) | | U |
| Wera 2014 | | | | x (SR of levels I-IV) | | U |
| Ra 2014 | | | | x (retrospective) | | U |
| Celik 2013 | | | | x | | U |
| Hartigan 2013 | | x (outcome study) | | | | U |
| Chmielewski 2008 | | x (outcome study) | | | | U |
| Chmielewski 2013 | | x (outcome study) | | | | U |
| Langford 2009 | Included in Ardern SR | | | | | U |
| Webster 2009 | Included in Ardern SR | | | | | U |
| Fältström 2013 | | | | x | | U |
| McGuine 2012 | | | | x (multiple pathologies) | | U |
| Ochiai 2010 | | | | x | | U |
| Paradowski 2013 | | | | x | | U |

*Abbreviations: A, acceptable; H, high; OA, osteoarthritis; SR, systematic review; U, unacceptable.*
**High-quality prospective cohort study.*
*†Lower-quality prospective cohort study.*
*‡What is your overall assessment of the methodological quality of this review? (high, acceptable, low, unacceptable).*

## APPENDIX H

**Examination – Activity Limitations: Levels of Evidence Adapted From Phillips et al[91]**

| | SR of Prospective Cohort Studies* | SR of Lower-Quality Prospective Cohort Studies† | High-Quality Cross-sectional Study | Lower-Quality Cross-sectional Study | Expert Opinion | Quality‡ |
|---|---|---|---|---|---|---|
| Abrams et al[1] | | x | | | | A |
| Grindem et al[42] | | x | | | | A |
| Hegedus et al[48] | | x | | | | A |
| Logerstedt et al[68] | | x | | | | A |
| Reinke et al[96] | | | x | | | A |

*Abbreviation: A, acceptable.*
**High-quality prospective cohort study.*
*†Lower-quality prospective cohort study.*
*‡What is your overall assessment of the methodological quality of this review? (high, acceptable, low, unacceptable).*

**Examination – Physical Impairments: Levels of Evidence Adapted From Phillips et al[91]**

| | SR of Prospective Cohort Studies* | SR of Lower-Quality Prospective Cohort Studies† | High-Quality Cross-sectional Study | Lower-Quality Cross-sectional Study | Expert Opinion | Quality‡ |
|---|---|---|---|---|---|---|
| Décary et al[22] | | x | | | | A |
| Eitzen et al[25] | | x | | | | A |
| Gokeler et al[38] | | x | | | | A |
| Kopkow et al[63] | | x | | | | A |
| Leblanc et al[66] | | x | | | | A |
| Lentz et al[67] | | x | | | | A |
| Logerstedt et al[68] | | x | | | | A |
| Pietrosimone et al[93] | | x | | | | A |
| Swain et al[113] | x | | | | | H |
| Ueda et al[116] | | | x | | | A |

*Abbreviations: A, acceptable; H, high.*
**High-quality prospective cohort study.*
*†Lower-quality prospective cohort study.*
*‡What is your overall assessment of the methodological quality of this review? (high, acceptable, low, unacceptable).*

## APPENDIX H

**Interventions – SIGN Systematic Review***

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Quality† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Martimbianco et al[77] | x | x | x | x | x | x | x | x | x | x | x | H |
| Papalia et al[86] | | x | x | | | | x | x | | | | Low SR |
| Gokeler et al[37] | x | x | x | x | x | x | x | | | x | | H |
| Imoto et al[53] | x | x | x | x | x | x | x | | | x | | H |
| Kim et al[60] | x | x | x | x | x | | x | x | | | | A |
| Kinikli et al[61] | x | x | x | x | x | x | x | x | x | x | | H |
| Wasielewski et al[120] | x | | x | x | x | x | x | | | x | | A |
| Zech et al[129] | x | x | x | x | x | x | x | x | | | x | H |
| Smith SD 2014 | | | | | | | | | | | x | L |
| Salata 2010 | | | | | | | x | | | x | | L |
| Hohmann et al[49] | | | | | | | | | | | | Part of Papalia SR |
| Kruse 2012 | | | | | | | | | | | | Multiple intervention |
| Van Grinsven 2010 | | | | | | | | | | | | Multiple intervention |
| Trees 2011 | | | | | | | | | | | | Review withdrawn |
| Smith et al[110] | | | | | | | | | | | | Surgical intervention |

*Abbreviations: A, acceptable; H, high; L, low; SIGN, Scottish Intercollegiate Guidelines Network; SR, systematic review.*

**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.*

*†"What is your overall assessment of the methodological quality of this review?" High quality, 8 or higher; acceptable quality, 5 or higher; low quality, 4 or lower.*