Knee Stability and Movement Coordination Impairments / Knee Ligament Sprain

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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Recommendations*

Pathoanatomical Features: Knee ligament strains can be the result of a contact or noncontact incidents, which can result in damage to one or more structures. Clinicians should assess for impairments in range of motion, motor control, strength, and endurance of the limb associated with the identified ligament pathology. (Recommendation based on strong evidence.)

Risk Factors: Clinicians should consider the shoe-surface interaction, increased body mass index, narrow femoral notch width, increased joint laxity, pre-ovulatory 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 non-contact ACL injury. (Recommendation based on moderate evidence.)

Diagnosis/Classification: Passive knee instability, joint pain, effusion, and movement coordination impairments are useful clinical findings for classifying a patient with knee instability into the following International Statistical Classification of Diseases and Related Health Problems (ICD) categories: Sprain and strain involving collateral ligament of knee, Sprain and strain involving cruciate ligament of knee, Injury to multiple structures of knee; and the associated International Classification of Functioning, Disability, and Health (ICF) impairment-based category of knee instability (b7150 Stability of a single joint) and movement coordination impairments (b7601 Control of complex voluntary movements). (Recommendation based on strong evidence.)

Differential Diagnosis: 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. (Recommendation based on moderate evidence.)

Examination – Outcome Measures: Clinicians should use a validated patient-reported outcome measure with a general health questionnaire, along with a validated activity scale for patients with knee insufficiency. These measures 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. (Recommendation based on strong evidence.)

Examination – Activity Limitation Measures: Clinicians should utilize easily reproducible physical performance measures, such as single limb hop tests, to assess activity limitation and participation restrictions associated with their patient’s knee stability and movement coordination impairments and to assess the changes in the patient’s level of function over the episode of care. (Recommendation based on weak evidence.)

Interventions – Continuous Passive Motion: Clinicians should not consider the use of continuous passive motion to increase knee range of motion. Clinicians can consider using
continuous passive motion to decrease post-operative pain. (Recommendation based on moderate evidence.)

**Interventions – Early Weight Bearing:** Early weight-bearing can be used for patients following ACL reconstruction without incurring detrimental effects on stability or function. (Recommendation based on weak evidence.)

**Interventions – Post Operative Bracing:** The use of post-operative or functional knee bracing is no more beneficial than not using a brace in patients following ACL injury or reconstruction. (Recommendation based on moderate evidence.) Knee bracing can be used for patients with severe MCL injuries. (Recommendation based on expert opinion.)

**Interventions – Immediate versus Delayed Mobilization:** Clinicians should consider the use of immediate mobilization following ACL reconstruction to increase ROM, reduce pain, and limit adverse changes to soft tissue structures. (Recommendation based on moderate evidence.)

**Interventions – Supervised Rehabilitation:** Clinicians should consider the use of exercises provided as a part of a supervised in-clinic rehabilitation program or as part of a supervised home-based rehabilitation program for patients following ACL injury or reconstruction. (Recommendation based on moderate evidence.)

**Interventions – Therapeutic Exercises:** Clinicians should consider the use of open kinetic chain exercises in conjunction with closed kinetic chain exercises in patients with knee stability and movement coordination impairments. (Recommendation based on strong evidence.)

**Interventions – Neuromuscular Electrical Stimulation:** Neuromuscular electrical stimulation can be used with patients following ACL reconstruction to increase quadriceps muscle strength. (Recommendation based on moderate evidence.)

**Interventions – Neuromuscular Reeducation:** Clinicians should consider the use of neuromuscular training as a supplementary program to strength training in patients with knee stability and movement coordination impairments. (Recommendation based on moderate evidence.)

**Interventions – Accelerated Rehabilitation:** Accelerated rehabilitation can be used for patients with ACL reconstruction. Accelerated rehabilitation may be appropriate in patients with ACL reconstruction and concomitant meniscal repair. (Recommendation based on moderate evidence.)

**Interventions – Eccentric Strengthening:** Clinicians should consider the use of eccentric strengthening in patients following ACL reconstruction or PCL injury to increase muscle strength and functional performance. (Recommendation based on moderate evidence.)

*These recommendations and clinical practice guidelines are based on the scientific literature published prior to January 2009.*
Introduction

AIM OF THE GUIDELINE

The Orthopaedic Section of the American Physical Therapy Association (APTA) has an ongoing effort to create evidence-based practice guidelines 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).°

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 physical therapists
- Classify and define common musculoskeletal conditions using the World Health Organization’s terminology related to impairments of body function and body structure, activity limitations, and participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, activity limitations, and participation restrictions associated with common musculoskeletal conditions
- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions
- Provide a description to policy makers, using internationally accepted terminology, of the practice of orthopaedic physical therapists
- Provide information for payors 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

This guideline is 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 in light of the clinical data presented by the patient, the diagnostic and treatment options available, and the patient’s values, expectations, and preferences. However, we suggest that the rationale for significant departures from accepted guidelines be documented in the patient’s medical records at the time the relevant clinical decision is made.
Methods

The Orthopaedic Section, APTA appointed content experts as developers and authors of clinical practice guidelines for musculoskeletal conditions of the knee which are commonly treated by physical therapists. These content experts were given the task to identify impairments of body function and structure, activity limitations, and participation restrictions, described using ICF terminology, that could 1) categorize patients into mutually exclusive impairment patterns upon which to base intervention strategies, and 2) serve as measures of changes in function over the course of an episode of care. The second task given to the content experts was to describe the supporting evidence for the identified impairment pattern classification as well as interventions for patients with activity limitations and impairments of body function and structure consistent with the identified impairment pattern classification. It was also acknowledged by the Orthopaedic Section, APTA content experts that a systematic search and review of the evidence solely related to diagnostic categories based on International Statistical Classification of Diseases and Health Related Problems (ICD) terminology would not be useful for these ICF-based clinical practice guidelines as most of the evidence associated with changes in levels of impairment or function in homogeneous populations is not readily searchable using the ICD terminology. For this reason, the content experts were directed to also search the scientific literature related to classification, outcome measures, and intervention strategies for musculoskeletal conditions commonly treated by physical therapists. Thus, the authors of this clinical practice guideline systematically searched MEDLINE, CINAHL, and the Cochrane Database of Systematic Reviews (1966 through January 2009) for any relevant articles related to classification, outcome measures, and intervention strategies for ligament injuries and instabilities of the knee. Additionally, when relevant articles were identified their reference lists were hand-searched in an attempt to identify other articles that might have contributed to the outcome of these clinical practice guidelines. This guideline was issued in 2009 based upon publications in the scientific literature prior to January 2009. This guideline will be considered for review in 2014, 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 will be graded according to criteria described by the Center for Evidence-Based Medicine, Oxford, United Kingdom. (Table 1)

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<th>Level</th>
<th>Description</th>
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<tr>
<td>I</td>
<td>Evidence obtained from high quality randomized controlled trials, prospective studies, or diagnostic studies</td>
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<tr>
<td>II</td>
<td>Evidence obtained from less equality randomized controlled trials, prospective studies or diagnostic studies (e.g., improper randomization, no blinding, &lt; 80% follow-up)</td>
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<td>III</td>
<td>Case controlled studies or retrospective studies</td>
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<td>IV</td>
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<td>Expert opinion</td>
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Grades of Evidence
The overall strength of the evidence supporting recommendations made in this guideline will be graded according to guidelines described by Guyatt 47 as modified by MacDermid and adopted by the coordinator and reviewers of this project. In this modified system, the typical A, B, C and D grades of evidence have been modified to include the role of consensus expert opinion and basic science research to demonstrate biological or biomechanical plausibility. (Table 2)

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<th>Grades of Recommendation</th>
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<tr>
<td>A</td>
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Review Process
The Orthopaedic Section, APTA also selected consultants from the following areas to serve as reviewers of the early drafts of this clinical practice guideline:
- Claims review
- Coding
- Epidemiology
- Orthopaedic Section of the APTA, Inc
- Medical practice guidelines
- Orthopaedic physical therapy residency education
- Orthopaedic surgery
- Physical therapy academic education
- Sports physical therapy residency education

Comments from these reviewers were utilized by the authors to edit this clinical practice guideline prior to submitting it for publication to the Journal of Orthopaedic & Sports Physical Therapy.
Classification
The primary 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 corresponding ICD-9 CM codes and conditions, which are used in the USA are 717.83 Old disruption of anterior cruciate ligament; 717.84 Old disruption of posterior cruciate ligament; 717.85 Old disruption of other ligaments of knee, 844.0 Sprain of lateral collateral ligament of knee, 844.1 Sprain of medial collateral ligament of knee, and 844.2 Sprain of cruciate ligament of knee,

The primary ICF body functions 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 structures 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 insufficiency are d2302 Completing the daily routine and d4558 Moving around, specified as direction changes while walking or running.

The ICD-10 and primary and secondary ICF codes associated with knee stability and movement coordination impairments are provided in Table 3 on the facing page.
ICD-10 and ICF Codes Associated with Knee Stability and Movement Coordination Impairments

INTERNATIONAL STATISTICAL CLASSIFICATION OF DISEASES AND RELATED HEALTH PROBLEMS

Primary ICD-10

S83.4 Sprain and strain involving collateral ligament of knee
S83.5 Sprain and strain involving cruciate ligament of knee
S83.7 Injury to multiple structures of knee

INTERNATIONAL CLASSIFICATION OF FUNCTIONING, DISABILITY, AND HEALTH

PRIMARY ICF CODES

Body function
- b7150 Stability of a single joint
- b7601 Control of complex voluntary movements

Body structure
- s75011 Knee joint
- s75002 Muscles of thigh
- s75012 Muscles of lower leg
- s75018 Structure of lower leg, specified as ligaments of the knee

Activities and participation
- d2302 Completing the daily routine
- d4558 Moving around, specified as direction changes while walking or running

SECONDARY ICF CODES

Body function
- b28016 Pain in joint
- b7100 Mobility of a single joint
- b7301 Power of muscles of one limb
- b7408 Muscle endurance functions, specified as endurance of muscles of one limb
- b770 Gait pattern functions (knee instability with walking and running)

Activities and participation
- d4101 Squatting
- d4102 Kneeling
- d4106 Shifting the body’s centre of gravity
- d4351 Kicking
- d4502 Walking on different surfaces
- d4503 Walking around obstacles
- d4551 Climbing
- d4552 Running
- d4553 Jumping
- d9201 Sports
Environmental factors e1408 Products and technology for culture, recreation, and sport, specified as shoe-surface interaction and knee bracing
CLINICAL GUIDELINES

Impairment/Function-based Diagnosis

INCIDENCE

Anterior Cruciate Ligament. It is estimated that 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 noncontact ACL injuries is greater in sports that require multidirectional activities, such as rapid deceleration, pivoting, cutting, and landing from jumps. The incidence of ACL injuries was 20.3% of all athletic knee injuries over a period of 10 years.

Female athletes sustain ACL injuries at a 2.4-9.7 times greater rate when compared to male athletes. Prodromos et al matched to gender and sport and using weighted means to calculate the female to male ratios. The results for female to male ACL injury ratios were: wrestling, 4.05; basketball, 3.5; indoor soccer, 2.77; soccer, 2.67; rugby, 1.94; lacrosse, 1.18; and alpine skiing, 1.00.

A comprehensive review by Beynnon et al report that the natural history of patients with an ACL-deficient knee may experience giving-way episodes and are more likely to develop meniscal tears and knee osteoarthritis. One study reports the incidence of meniscal tears in ACL-deficient patients is 40% at year 1, 60% at year 5, and 80% 10 years after the index injury.

Posterior Cruciate Ligament. Depending on the clinical setting, 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. It has been reported that trauma patients have a higher incidence of PCL injuries than athletes. Motorcycle accidents and soccer-related injuries accounted for the main specific injury causes. In traffic accidents, 63.8% who were injured had a combined PCL insufficiency, whereas, in athletic injuries, combined injuries represented 47.5%. Ninety-five percent of PCL injuries have associated ligamentous injuries in the ipsilateral knee.

Collateral Ligaments. The incidence of medial (tibial) collateral ligament (MCL) lesions was 7.9% of all athletic injuries. An injury to the MCL was the most common knee injury reported at the 2005 National Football League Combine and in alpine skiing and second most in American collegiate men’s ice hockey and collegiate women’s rugby. Injury to the lateral (fibular) collateral ligament (LCL) is the least common of all knee ligament injuries with an incidence of 4%. Injury to the LCL usually occurs as a soft-tissue avulsion off the proximal attachment on the femur or as a bone avulsion associated with an arcuate fracture of the fibular head. LCL injuries usually are a part of more extensive injuries that involve the posterolateral corner (PLC).
Multiple ligaments. Two of the most common multi-ligament knee injuries involve the MCL and ACL, and the PLC with the ACL or the PCL. Halinen et al\textsuperscript{49} reported an incidence of multiple ligament knee injuries of approximately 0.8/100,000 persons per year. With continued displacement after MCL rupture, the ACL may also tear, producing a more extensive injury.\textsuperscript{111} Grade III MCL lesions have an almost 80% incidence of concomitant ligament damage, and 95% of the time, the torn ligament is the ACL.\textsuperscript{34,49} The incidence of ACL tears was 20% with no valgus laxity on clinical exam, 53% with laxity only in 30 degrees, and 78% with valgus laxity in full extension.\textsuperscript{111} Isolated PLC injuries account for only 1.6% of all knee ligament injuries with concomitant ligament damage ranging from 43% to 80%.\textsuperscript{8} Combined posterior instabilities were present in 53% of patients, with a significantly higher incidence after vehicular trauma (64%) compared to athletic injuries (46%).\textsuperscript{126}

PATHOANATOMICAL FEATURES AND CLINICAL COURSE

Anterior Cruciate Ligament Sprains

The ACL originates at the medial side of the lateral femoral condyle and runs an oblique course through the intercondylar fossa distoanteromedial to the insertion at the medial tibial eminence.\textsuperscript{110} Girgis et al\textsuperscript{42} divided the ACL into two functional bands, the anteromedial and posterolateral bundles. It is the primary restraint to anterior translation of the tibia relative to the femur\textsuperscript{20} and a major secondary restraint to internal rotation, particularly when the joint is near full extension.\textsuperscript{30} The most common region of an ACL tear occurs in the midsubstance of the ACL during low energy injuries as seen in sporting activities.\textsuperscript{74,105}

Shimokochi and Shultz\textsuperscript{132} performed a systematic review examining the mechanics of noncontact ACL injury, which included studies published through 2007. They concluded that noncontact ACL injuries are likely to happen during deceleration and acceleration motions with excessive quadriceps contraction and reduced hamstring co-contraction at or near full knee extension. ACL 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.
Outcomes. Noyes et al\textsuperscript{106} suggested that one-third of individuals with an ACL injury will compensate well and successfully return to unrestricted activities without surgery. Another third could return to recreational activities with knee bracing, a leg strengthening program, and activity modification. The final third would not be able to return to sports due to knee instability and would require surgical intervention. A meta-analysis by Muaidi et al\textsuperscript{103} examined the clinical course of function to identify prognostic factors in the conservative management of ACL-deficient subjects. Self-reported measures of knee function utilizing the Lysholm or modified Lysholm knee score ranged from 75/100 at 60 months to 94/100 at 66 months. Activity level was measured using the Tegner scale with pre-injury activity level of 7.1/10 and at follow-up between 12 and 66 months later it had decreased to 5.6/10.

Mosksnes and Risberg\textsuperscript{101} found at 1 year follow-up in non-operated patients, Knee Outcome Scale (KOS) scores were 94/100, global rating scale of knee function (GRS) was 85.3/100, and International Knee Documentation Committee Subjective Knee Form (IKDC-2000) was 86/100. Functional performance was measured using the one-leg single-hop-for-distance. One-leg single-hop-for distance is usually expressing as the limb symmetry index. Limb symmetry index (LSI) is calculated by dividing the result of the involved limb by that of the uninvolved limb and multiplying by 100%. LSI was 87-93% pre-operatively.\textsuperscript{28, 101} Others reported LSI was $>95\%$ (normal values $>85\%$ \textsuperscript{10}) at a follow-up of between 12 and 55 months.\textsuperscript{101, 103} Kostogiannis et al\textsuperscript{77} found that only 42% of the patients were able to resume their pre-injury activity within 3 years. The mean Lysholm knee score was 96, 95, and 86 at 1, 3, and 15 years after index injury, respectively. The mean Tegner activity scale decreased from 7 to 4 15 years after the injury. 73% of patients reported good/excellent results and 17% reported fair/poor function at 15 years.

Activity level. Multiple case series reveal that conservative management patients with ACL-deficient knees can be effective for patients who are willing to avoid high-risk activities.\textsuperscript{13} Non-operative return to high-level activities based on patient self-selected basis has ranged from 23\% to 42\%.\textsuperscript{56, 77} A decision making scheme developed by Fitzgerald et al\textsuperscript{35} screened 93 consecutive patients with acute unilateral ACL ruptures, classifying them as either rehabilitation candidate ($n=39$) or noncandidate ($n=54$). The screening examination is detailed in the Diagnosis/Classification section. Twenty-eight of the 39 rehabilitation candidates attempted rehabilitation without surgery. Rehabilitation consisted of lower extremity strengthening, agility skill training, and sport-specific skill training. Subjects returned to full activity on average 4 weeks following the screening exam. Seventy-nine percent of the rehabilitation candidates who choose nonoperative care were able to return to their previous level of activity without experiencing an episode of their knee giving-way.
Fitzgerald et al.\textsuperscript{36} examined the efficacy of augmenting standard nonoperative ACL care with a specialized perturbation training program. Using the same screening exam as previously stated, 26 subjects qualified and completed training. 14 subjects were randomized to the standard treatment group and 12 subjects were randomized to the perturbation group. Standard rehabilitation consisted of lower extremity strengthening, cardiovascular endurance training, agility and sport-specific skill training. Perturbation training is a specialized neuromuscular training program designed to aid in the development of dynamic knee stability among individuals with complete ACL rupture.\textsuperscript{36, 58} Perturbation training involves maintaining lower extremity balance during the disruption of support surfaces consisting of three techniques: rockerboard, rollerboard, and rollerboard with stationary platform.\textsuperscript{36, 58} All subjects underwent 10 treatment sessions. Subjects who received perturbation training were 4.88 times more likely to have a successful outcome than whose receiving standard rehabilitation. Subjects in both groups showed an increase in their outcomes scores from pre- to post-training. However, only the subjects in the perturbation training group were able to maintain their score at follow-up.

In a 10-year prospective study published by Hurd et al.,\textsuperscript{56} 345 patients with acute unilateral ACL injuries were screened as described by Fitzgerald et al.\textsuperscript{35} Fifty-eight percent of the patients were classified as non-copers and 42\% were classified as potential copers. Seventy-two percent of patients who were classified as potential copers and received specialized neuromuscular training successfully returned to high-level sports activities, and none sustained additional chondral or meniscal lesions.

Moksnes et al.\textsuperscript{102} investigated the predictive value at 1-year follow-up of the screening examination proposed by Fitzgerald et al.\textsuperscript{35} on subjects who underwent non-operative ACL treatment. One hundred twenty-five consecutive subjects were screened as either potential non-copers (n=79) and potential copers (n=46) with 102 subjects available for 1-year follow-up. The sensitivity of the screening examination was 44.1\%, specificity was 44.4\%, positive predictive value was 60\%, and negative predictive value was 29.8\%.

**Range of motion.** Patients who follow a pre-operative exercise program can achieve range of motion (ROM) close to full before surgery.\textsuperscript{72}

**Muscle strength.** Knee extension strength deficits have been reported between 6 months and 15 years post injury in the involved limb of patients with have ACL deficient knees who have not undergone reconstructive surgery.\textsuperscript{62} Tsepis et al.\textsuperscript{145} examined quadriceps and hamstrings strength in amateur athletes divided into 3 separate groups with an ACL-deficient knee without structured rehabilitation at a mean time of 4, 12, and 56 months. Strength was tested isokinetically at 60 degrees per second. They found both groups of muscles to be substantially weaker at all time periods when compared to controls, ranging from 32\% to 21\% weaker. The quadriceps showed greater side-to-side asymmetry, whereas,
hamstrings symmetry could be achieved by 1 year after injury.

Hurd et al\textsuperscript{57} examined 349 patients with acute, completed unilateral ACL ruptures who were classified as either non-coper or potential coper using an established screening examination. Quadriceps strength was measured during a maximum voluntary isometric contraction using a burst superimposition technique. They found 12.1% side-to-side asymmetry for potential copers and 14.6% asymmetry for non-copers.

Chmielewski et al\textsuperscript{23} examined 100 consecutive patients with complete acute ACL ruptures. She found that the average voluntary activation for the involved side quadriceps was 7.4% and for the uninvolved side quadriceps was 7.2%. Ageberg et al\textsuperscript{1} performed a long-term (1, 3 and 15 years) follow-up in patients with unilateral ACL injuries. They measured peak isometric flexion and extension torque and peak isokinetic flexion and extension torque. LSI values for the various torque measurements ranged from 88.2\% to 100.6\% at the 1 year follow-up, 94.6\% to 103.0\% for the 3 year follow-up, and 96.5\% to 102.2\% at the 5 year follow-up.

Ageberg et al\textsuperscript{1} performed a long-term (1, 3 and 15 years) follow-up in patients with unilateral ACL injuries. They measured peak isometric flexion and extension torque and peak isokinetic flexion and extension torque. LSI values for the various torque measurements ranged from 88.2\% to 100.6\% at the 1 year follow-up, 94.6\% to 103.0\% for the 3 year follow-up, and 96.5\% to 102.2\% at the 5 year follow-up.

\textit{Surgical outcomes.} The most recent Cochrane Collaboration Review \textsuperscript{85} of surgical versus conservative interventions for anterior cruciate ligament ruptures in adults included 2 randomized and quasi-randomized trials. Both trials were considered poor quality. Both studies were conducted in the early 1980s. Conservative treatments and surgical interventions have changed since then. No randomized trials have been conducted using current method of treatments. A recent published clinical practice guideline concluded that ACL reconstruction has the most to offer those people with recurrent instability who must perform multidirectional activity as part of their occupation or sports.\textsuperscript{4} The standard of care by the majority of surgeons for ACL injury is early ACL reconstruction\textsuperscript{29}.

Recently, there have been several systematic reviews investigating the outcomes of ACL reconstruction comparing hamstring (HS) autograft with bone-patella tendon-bone (BPTB) autograft. Subjective knee function, as measured by knee outcome scores and GRS, are lowest early after surgery and improve to up to 6 years post surgery\textsuperscript{54, 72, 101}. Using the Cincinnati Knee Rating System, scores improved from 60.5/100 at 12 weeks post reconstruction to 85.9/100 at 1 year follow-up.\textsuperscript{54} Using the GRS, scores improved from 63.1/100 taken at week 12 to 83.3/100 at week 52.
Moksness and Risberg\textsuperscript{101} reported similar post-surgical GRS results of 86.0/100 at 1 year follow-up. Functional performance post-ACL reconstruction also improved over time. As measured by the one-leg single-hop-for-distance, LSI improved from 85% at 6 months to 91.8-95% 12 months\textsuperscript{28,101}. Using the one-leg triple crossover and 6-m timed hop test, scores improved from 76.8% and 79.1%, respectively, at 12 weeks\textsuperscript{54} to 91.9-93.5% and 94.2-94.7%, respectively, at 1 year follow-up\textsuperscript{54,101}. At a 2 to 5 year follow-up, LSI improved to 99.5% in the one-leg single-hop-for-distance and to 96.4% in the one-leg vertical jump.\textsuperscript{2} Most postsurgical rehabilitation protocols enable individuals to return to sports-specific activities from 4-6 months post-ACL reconstruction with a full return to sports from 6-12 months.

At a 5 year follow-up, Lee et al\textsuperscript{82} reviewed 45 individuals regarding their return to sport. Sixty-two percent of individuals return to their previous level of sports and maintained their Tegner activity level of 6. Twenty percent did not return to their previous level of activity due to fear of injury and 18% because of persistent instability and pain.

Post-surgical range of motion. The loss of knee ROM can have a disabling effect on an individual’s gait.\textsuperscript{99} The incidence of ROM loss following ACL reconstruction has been reported from 2-11%.\textsuperscript{99} A recent long-term study by Shelbourne and Gray\textsuperscript{129} reports that 73% of patients had normal knee extension and flexion, 10% had normal extension but less than normal flexion, 10% had less than normal extension but normal flexion, and 6% had less than normal knee extension and flexion. Mauro et al\textsuperscript{94} found that 25.3% of patients had a loss of knee extension 4 weeks after ACL surgery. Loss of extension was associated with preoperative extension, time from injury to surgery, and use of autograft.\textsuperscript{94}

Post-surgical strength. Deficits in quadriceps strength following ACL reconstruction have been reported at various speeds and years post-reconstruction.\textsuperscript{62} The largest degree of quadriceps weakness occurs in the first months after reconstruction.\textsuperscript{28,62,72} Deficits in the uninvolved limb have also been reported several years following surgery.\textsuperscript{62} Some evidence exists that strength deficits in the hamstrings may be more associated with the hamstring graft choice.\textsuperscript{62}

Ageberg et al\textsuperscript{2} investigated muscle strength in patients who had received conservative, non-surgical treatment as compared to patients who had undergone surgical reconstruction and post-surgical rehabilitation under the guidance of a physical therapist. At two to five year follow-up, 44% of the surgically treated patients and 44% of the non-surgically treated patients had normal limb symmetry values (> 90%) for the muscle power test battery. Moisala et al\textsuperscript{100} analyzed the quadriceps and hamstrings isokinetically in 16 patients with BPTB graft ACL reconstruction and 32 patients with HS graft ACL reconstruction between 4 to 7 years follow-up. He found that no
significant strength deficits between patient groups. Muscle strengths were better in patients with a longer follow-up.

**Posterior Cruciate Ligament Sprains**

**PCL.** The PCL proximally attaches to the roof and medial aspect of the femoral intercondylar notch and distally attaches onto the superior aspect of the posterior tibial ‘shelf’. It is divided into two main fiber bundles, anterolateral and posteromedial bundles. The PCL is the primary restraint to posterior tibial translation, contributing about 90% of the resistance across the knee flexion arc and the secondary restraint to external rotation.

In a retrospective study by Schulz, 587 patients with acute and chronic PCL-deficient knees were evaluated. Almost half of the patients were able to give a detailed history of the mechanism of injury. The most common injury mechanism 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 lastly, a sudden violent hyperextension of the knee joint (11.9%).

**Outcomes.** A systematic review by Grassmayr et al evaluated the biomechanical and biological consequences of PCL deficiency. They reviewed 47 articles up to 2006. The majority of studies found no correlation between laxity and functional or subjective outcomes. Shelbourne and Muthukaruppan reported that the mean score on the modified Noyes subjective questionnaires was 85.6 and no significant difference in modified Noyes scores based on PCL laxity grade. At follow-up >5 years, the mean Tegner score was 5.7-6.6. The majority of subjects treated non-operatively can expect to return to activity at the same or similar level. Fifty to 76% of patients with isolated PCL injuries were able to return to sports or activity at a similar level, 33% returned at a lower level, and 17% did not return to the same sport, however, high speed running may be most affected. Keller et al reported that a majority were limited in activity with 90% reporting activity-dependent knee pain and almost half (43%) complaining of problems during ambulation.

**Range of motion.** No significant differences have been noted in ROM following PCL injury with 4 degrees of hyperextension and 141 degrees of flexion in the PCL-injured knee and 4 degrees of hyperextension and 140 degrees of flexion in the uninvolved knee.

**Muscle strength.** Inconclusive results were found on muscle strength following PCL injury. Six studies found no differences in muscle strength, while five studies found either eccentric or concentric weakness in the quadriceps in the PCL limb. One study found hamstring strength deficits within 6 months of the index injury. However, a number of factors may confound the results on the effect of strength, such as time after injury, the laxity grade, severity and mechanism of injury, assessment protocol and the treatment modality.
Collateral Ligaments Sprains

The MCL originates on the medial aspect of the femur, proximal and posterior to
the medial femoral epicondyle. It can be divided into three tissue layers
(superficial medial collateral ligament, deep medial collateral ligament, and
posterior oblique ligament) and multiple interconnections to the joint capsule,
the muscle-tendon units, and the medial meniscus. In cadaver knee studies,
the superficial MCL provided 57% of the restraining knee valgus moment at 5
degrees of knee flexion, and provided 78% of the restraining moment at 25
degrees of knee flexion, due to decreased contribution from the posterior
capsule. The vast majority of MCL injuries involve a sudden application of a
valgus torque to the knee, typically a direct hit to the lateral aspect of the knee
with the foot in contact with the ground. Clinical and laboratory findings are in
conflict whether the femoral insertion or tibial insertion as the most common site
of MCL injury.

The LCL attaches to the femur approximately equidistant from the posterior and distal
borders of the lateral femoral condyle and distally to a superior and laterally facing V-
shaped plateau on the head of the fibula. It is the main structure responsible for resisting
varus forces, particularly in the initial 0 degrees to 30 degrees of knee flexion and having a
role in limiting external rotation of a flexed knee.

Outcomes. The long-term outcomes for non-operative treatment of MCL
injuries may depend upon the grade of injury. Kannus showed that isolated
grade III sprains of the MCL long-term results were much worse than grade I/II
sprains, with a higher rate of medial instability, muscle weakness, and poor
function outcomes. However, others have shown that individuals with higher
graded MCL injuries can have successful outcomes and return to sports.

Posterolateral Corner Injuries

The PLC consists of several structures, including the lateral head of the gastrocnemius, the
popliteus tendon, the popliteofibular ligament, the LCL, and the arcuate ligament-
fabellousfibular ligament. The PLC serves as the primary restraint to both varus and
external rotation forces and the secondary restraint to posterior translation of the tibia on
the femur. Isolated injury 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.

Treatment of PLC injuries is dependent upon the severity and timing of the injury.
Good results have documented in Grade I and moderate Grade II injuries with non-
operative treatment. Conservative management of more severe PLC injuries leads to
poor functional outcomes, advocating the surgical management of these injuries.
Surgical intervention of acute PLC injuries has resulted in more success than operative management of chronic PLC injuries.\textsuperscript{118}

**Multiple Ligament Sprains**

*Outcomes.* The outcomes of combined ACL-Grade III MCL treatment management is varied.\textsuperscript{49} Individuals who undergo ACL reconstruction and non-operated treatment of the MCL resulted in good to excellent results. Greater and more rapid strength gains were seen in these patients. Higher incidences of ROM problems were present in patients with surgical interventions to both ligaments. Others have showed excellent functional results and the vast majority of individuals returning to pre-injury level of sports following MCL repair and conservative management of the ACL. Varied results were seen in the non-operative treatment of combined ACL and MCL lesions. Tzurbakis and colleagues\textsuperscript{146} compared the results of surgical treatment of individuals with multiple knee ligament injuries. Forty-eight patients were classified based on specific anatomical structures injured: ACL/MCL involvement (Group A), ACL or PCL ruptures combined with PLC injuries (Group B), and knee dislocations (Group C). Forty-four patients were followed up at a mean of 51.3 months. No differences were noted between groups in Lysholm scores. Tegner scores were lower in Group A and B, with no differences in Group C. Seventy-seven percent of the patients considered their knee to be normal or nearly normal. No differences were noted in ROM, loss of extension and loss of flexion among groups.

Knee ligament strains can be the result of a contact or noncontact incidents, which can result in damage to one or more structures. Clinicians should assess for impairments in range of motion, motor control, strength, and endurance of the limb associated with the identified ligament pathology.
RISK FACTORS

ACL. There are multiple risk factors associated with noncontact ACL injuries. The risk factors can be divided into 4 categories: environmental, anatomical, hormonal, and neuromuscular. Evidence regarding environmental risk factors suggests that increasing the shoe-surface interaction from higher traction may increase the risk of injury to the ACL. The evidence on knee brace use is inconsistent and equivocal.

There is evidence regarding anatomical factors, in a select, athletic, college-aged population, that a combination of increased body mass index, narrow femoral notch width, and increased joint laxity (defined by KT-2000 arthrometer or hyperlaxity measures), is directly associated and predictive of ACL injury (relative risk = 21.3). Anatomical risk factors may be more difficult to modify than other risk factors.

In regards to hormonal risk factors, evidence supports that most ACL injuries in female athletes occur during the early and late follicular phases of the menstrual cycle. In a systematic review by Hewett et al, which included studies published through 2005, female athletes may be more predisposed to ACL injuries during the pre-ovulatory phase of the menstrual cycle. Hormonal intervention for ACL injury prevention is not warranted, and evidence is lacking for activity modification or sports participation restriction for women at any time during their menstrual cycles.

Significant knowledge in ACL risk factors stems from the clarification of risk factors attributed to neuromuscular components. Current research suggests that a combined loading pattern as being most detrimental with respect to ACL injury. Movement patterns that appear to increase ACL injury risk points to valgus and varus or extension moments, especially during slight knee flexion (‘dynamic’ knee valgus). Each segment of the lower extremity kinetic chain may play a role in injury of the ACL. Strong quadriceps activation during eccentric contractions may be a main factor in the injury risk to the ACL. Neuromuscular control may be important to injury risk and the most modifiable risk factor.

PCL, collateral, multi-ligament. 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.

Clinicians should consider the shoe-surface interaction, increased body mass index, narrow femoral notch width, increased joint laxity, pre-ovulatory 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 non-contact ACL injury.
DIAGNOSIS/CLASSIFICATION

Classification of knee stability and movement coordination impairments can be defined by passive knee stability and dynamic knee stability. However, a poor relationship exists between the amount of anterior knee joint laxity and functional abilities among patients with ACL deficient knees\(^\text{57}\) and a high percentage of patients with ACL rupture could successfully return to sport without ACL surgery.\(^\text{106}\) Therefore, a classification system was developed to determine which active individuals with an ACL sprain have a good probability of returning to a high level of functioning without surgical intervention, classifying these individuals as a potential coper or non-coper.\(^\text{35}\) Assessing movement coordination impairments are a major component of this classification, which has been used to help decision making regarding rehabilitation activities for patients not receiving an ACL reconstructive surgery or regarding rehabilitative activities while awaiting ACL surgery.\(^\text{57}\) Seventy-two to 92\% of patients who are classified as potential copers and undergo specialized neuromuscular training (perturbation training) were able to successfully return to all pre-injury activities at the pre-injury level.\(^\text{35, 56}\) The classification system described by Fitzgerald et al\(^\text{35}\) is based on:

- Number of giving way episodes less than or equal to 1 episode
- 6-m one-leg timed hop greater than or equal to 80\% involved limb as compared to the uninvolved limb
- Knee Outcome Survey-Activities of Daily Living Scale (KOS-ADLS) greater than or equal to 80\%
- Global rating scale of perceived knee function greater than or equal to 60\%

Individuals must meet all the above criteria to be classified as a potential coper. If an individual does not pass any one criterion, he/she is classified as a non-coper.

The ICD diagnosis of a sprain of the anterior cruciate ligament and the associated ICF diagnosis of knee stability and movement coordination impairments is made with a reasonable level of certainty when the patient presents with the following clinical findings:\(^\text{11, 57, 68, 88, 125}\)

- 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 0-2 hours follow injury
- History of giving way
- Loss of end range knee extension
- Positive Lachman test with nondiscrete endfeel or increased anterior tibial translation
- Positive pivot shift test with a nearly normal (“glide”), abnormal (“clunk”), or severely abnormal (“gross”) at 10-20 degrees of knee flexion
- 6-m one-leg timed hop test result that is within 80\% of the uninvolved
• Maximum voluntary isometric quadriceps strength index that is within 80% using burst superimposition technique.

The ICD diagnosis of a sprain of the 

**posterior cruciate ligament**

and the associated ICF diagnosis of knee stability and movement coordination impairments is made with a reasonable level of certainty when the patient presents with the following clinical findings:

- Posterior directed force on the proximal tibia (dashboard/anterior tibial blow injury), a fall on the flexed knee with the foot in plantar flexion or a sudden violent hyperextension of the knee joint
- Abrasions or ecchymosis on the anterior aspect of the proximal tibia
- Localized posterior knee pain with kneeling or decelerating
- Positive posterior drawer test at 90 degrees with a nondiscrete endfeel or an increased posterior tibial translation
- Posterior sag test with a subluxation or ‘sag’ of the proximal tibia posterior relative to anterior aspect of the femoral condyles
- A positive Modified stroke test or Bulge sign
- Loss of knee extension during gait observation or ROM testing

The ICD diagnosis of a sprain of the 

**tibial (medial) collateral ligament**

and the associated ICF diagnosis of knee stability and movement coordination impairments is made with a reasonable level of certainty when the patient presents with the following clinical findings:

- Trauma by a force lateral to the leg
- Rotational trauma
- Pain with valgus stress test at 30 degrees
- Increased separation between femur and tibia (laxity) with valgus stress test at 30 degrees
- Normal knee range of motion
- Palpatory provocation of MCL reproduces familiar pain
- Modified stroke test or Bulge sign

The ICD diagnosis of a sprain of the 

**fibular (lateral) collateral ligament**

and the associated ICF diagnosis of knee stability and movement coordination impairments is made with a reasonable level of certainty when the patient presents with the following clinical findings:

- Excessive varus trauma
- Localized effusion over LCL
- Palpatory provocation of LCL reproduces familiar pain
- Pain with varus stress test at 0 and 30 degrees
- Increased separation between femur and tibia (laxity) with valgus stress test at 0 and 30 degrees
- Positive modified stroke test or Bulge sign
Passive knee instability, joint pain, effusion, and movement coordination impairments are useful clinical findings for classifying a patient with knee instability into the following International Statistical Classification of Diseases and Related Health Problems (ICD) categories: Sprain and strain involving collateral ligament of knee, Sprain and strain involving cruciate ligament of knee, Injury to multiple structures of knee; and the associated International Classification of Functioning, Disability, and Health (ICF) impairment-based category of knee instability (b7150 Stability of a single joint) and movement coordination impairments (b7601 Control of complex voluntary movements).
DIFFERENTIAL DIAGNOSIS

A primary goal of diagnosis is to match the patient’s clinical presentation with the most efficacious treatment approach. A component is to determine the appropriateness of physical therapy management. However, in a much smaller percentage of patients, trauma to the knee may be something more severe, such as fracture, knee dislocation, or neurovascular compromise. Following surgical intervention, serious conditions may develop, such as arthrofibrosis, postoperative infection and septic arthritis, deep vein thrombosis, anterior knee pain, and patella fractures. Vigilance is warranted of the critical signs and symptoms associated with serious knee conditions, continually screen for the presence of these conditions, and initiate referral to the appropriate medical practitioner when a potentially serious medical condition is suspected.

Psychosocial factors may partially attribute to an inability to return to pre-injury activity levels. Fear of movement/re-injury decreases as a patient is farther removed from surgery and is inversely related to function as a function of time. Patients that did not return to their pre-injury activity level had more fear of re-injury, which was correlated with low knee-related quality of life. Elevated pain-related fear of movement/re-injury may place a patient at risk for chronic disability and reducing this fear can be accomplished through patient education and graded exercise prescription. Thomee et al found that patients’ perceived self-efficacy of knee function using the knee self-efficacy scale (K-SES) prior to ACL reconstruction is predictive of return to acceptable levels of physical activity, symptoms and muscle function 1 year following ACL reconstruction.

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.
Acute knee injury is one of the most common orthopaedic conditions. When a patient reports a history of knee trauma, the therapist needs to be alert for the presence of knee fracture. Being able to properly identify a fracture at the knee can eliminate needless radiographs and be cost-effective.\(^7\) The Ottawa Knee rule has been developed and validated to assist clinicians in determining when to order radiographs in individuals with acute knee injury.\(^7,135\) A knee radiograph series are required in 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 knee to 90 degrees
- Inability to bear weight both immediately and in the emergency department for 4 steps regardless of limping

Clinical examination by well-trained clinicians appears to be as accurate as magnetic resonance imaging (MRI) in regards to the diagnosis of cruciate or meniscal lesions.\(^75,88\) A lower threshold of suspicion of a meniscal tear is warranted in middle aged and elderly patients.\(^48,88\) MRI may be reserved for more complicated or confusing cases.\(^75\) MRI may assist an orthopaedic surgeon in aiding in pre-operative planning and predicting the prognosis.\(^75,88\)
CLINICAL GUIDELINES

Examination

OUTCOME MEASURES

A vast number of knee injury outcomes scales have been developed and used over the years to evaluate a patient’s disability. Recently, two reviews have been completed on knee outcome scales.\textsuperscript{86, 151}

The Medical Outcomes Study 36-item Short Form (SF-36) is currently the most popular general health outcome measure.\textsuperscript{151} The measure was designed to improve on the ability to measure general health outcomes without significantly lengthening the questionnaire and could be completed in less than 10 minutes. The SF-36 consists of 35 questions in eight subscale domains and one general overall health status question. Each subscale score is totaled, weighted, and transformed to fall between 0 (worst possible health, severe disability) and 100 (best possible health, no disability).\textsuperscript{107} The SF-36 form has been validated for a variety of ages and languages.\textsuperscript{151} It has demonstrated effectiveness in a vast number of conditions pertaining to orthopaedic and sports injuries.

The Knee Outcome Survey - Activities of Daily Living Scale (KOS-ADLs) is a patient-reported measure of functional limitations and impairments of the knee during activities of daily living.\textsuperscript{66} The KOS-ADLs contains items, 7 related to symptoms, and 10 related to functional disability during ADLs. Each item is scored 0-5 and the total score is expressed as a percentage, with lower scores corresponding to greater disability. Irgang et al\textsuperscript{66} identified a higher internal consistency of the KOS-ADLs than that of the Lysholm Knee Scale. They also indentified that validity has demonstrated by moderately strong correlation with the Lysholm Knee Scale and global assessment of function. They found that the KOS-ADLs is responsive for the assessment of functional limitations of the knee.

The Knee Injury and Osteoarthritis Outcome Score (KOOS) is designed as a patient-reported assessment for evaluating sports injuries and outcomes in the young and middle-aged athlete.\textsuperscript{122, 151} The KOOS consists of items in 5 domains, 9 items related to pain, 7 items related to symptoms, 17 items related to ADLs, 5 items related to sport and recreation function, and 4 items related to knee-related quality of life. Each item is graded fro 0-4. Each subscale is summed and transformed to a score of 0 (worst) to 100 (best). Roos and colleagues\textsuperscript{122, 151} identified a fair to modest relationship between the physical and mental health components of the SF-36. The pain, sport and recreation, and quality of life subdomains have been determined to be the most sensitive, with the largest effect size for active, young patients.\textsuperscript{151} The KOOS has been demonstrated to contain items regarding symptoms and disabilities important to patients with an ACL tear, isolated meniscal tears or knee osteoarthritis.\textsuperscript{138}
The International Knee Documentation Committee Subjective Knee Evaluation Form (IKDC) is a joint-specific outcome measure for assessing symptoms, function, and sports activity pertinent to a variety of knee conditions. The form contains 18 questions, in which the total scores is expressed as a percentage. The IKDC has been demonstrated to contain items regarding symptoms and disabilities important to patients with an ACL tear, isolated meniscal tears or knee osteoarthritis.

Irrgang et al was able to demonstrate the responsiveness of the IKDC Subjective Knee Form. 207 patients with a variety of knee patients who had scores at baseline and final follow-up participated in this study. They were able to identify a change score of 11.5 had a sensitivity of 0.82 and a specificity of 0.64, and a change score of 20.5 had a sensitivity of 0.64 and a specificity of 0.84 for detecting a patient who perceives improvement. The minimal detectable change (MDC) for the IKDC was a score of ± 12.8. Based on the close agreement of the cutoff score and MDC, a score of 11.5 is necessary to distinguish between those who have improved and those who have not improved.

The Lysholm Knee Scale was originally designed for follow-up evaluation of knee ligament surgery. The scale contains 8 items of symptoms and function. It is scored from 0-100 points. Instability and pain are weighted the most heavily. The Lysholm scale is arbitrarily graded with 95-100 as excellent, 84-94 as good, 65-83 as fair, and < 65 as poor. Research has demonstrated its validity in a number of knee injuries and associated with patient satisfaction, whereas others have questioned its validity, sensitivity, and reliability. The Lysholm scale may prove to be more meaningful when combined with an activity rating scale.

Two studies have examined the test re-test reliability of the Lysholm Knee Scale. These have demonstrated the overall ICC for test re-test reliability of >0.70 to 0.93.

The Cincinnati Knee Rating Scale is a clinician-based and patient-reported outcome measure. It was developed to assess subjective symptoms and functional activities. It has been modified over the years. It has now designed as a 6 dimension scale based on a total of 100 points: symptoms (20 points), daily and sports activities (15 points), physical examination (25 points), knee stability testing (20 points), radiographic findings (10 points), and functional testing (10 points). Portions of the rating scale have been validated. The ICC value of test re-test reliability in patients with ACLR was greater than 0.75.

The Tegner Activity Level Scale was developed as a score of activity level from 0 to 10 points. The scale grades a person’s activity level where 0 is ‘on sick leave/disability’ and 10 is ‘participation in competitive sports at the national elite level’. It is commonly used in combination with the Lysholm score.
The Marx Activity Level Scale is a patient-reported activity assessment. It contains 4 questions evaluating high-level functional activities. Each question is scored 0-4, based on the frequency per week performed at each item. It is designed to assess the patient’s highest peak activity over the past year. The scale has been validated but responsiveness has not been determined.

Clinicians should use a validated patient-reported outcome measure with a general health questionnaire, along with a validated activity scale for patients with knee insufficiency. These measures 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.
ACTIVITY LIMITATION AND PARTICIPATION RESTRICTION MEASURES

A variety of activity limitation and participation restriction measures have been described in the literature. The most common method used to quantify lower extremity function is through functional performance tests. Hop testing has frequently been proposed as a practical, performance-based outcome measure that reflects the integrated effect of neuromuscular control, strength, and confidence in the limb.116

The single limb hop tests are the most common hop tests utilized to capture limb asymmetries in patients with lower extremity dysfunction. The following four hop tests are primarily used in patients with knee lesions: single hop for distance, triple crossover hop for distance, triple hop for distance, and 6-m timed hop. These hop tests have demonstrated high test re-test reliability in normal, young adults.16, 123 For single hop for distance, ICC ranged from 0.92-0.96, the triple crossover hop for distance ranged from 0.93-0.96, triple hop for distance ranged from 0.95-0.97, and 6-m timed hop ranged from 0.66-0.92.

Noyes and colleagues104 regard a LSI of less than 85% as abnormal. Following ACL rupture, 50% of the patients exhibited abnormal LSI on a sole hop test. If the results of two tests were calculated, 62% of the patients were identified as having abnormal scores.

In patients following ACL reconstruction, patients performed hop tests at 16 weeks postoperatively (day 1), plus 24-48 hours (day 2 and 3) and 22 weeks postoperatively (day 4).116 Hop test LSI test re-test reliability was assessed using values from day 2 and 3. ICC ranged from 0.82 to 0.88 with overall combination of hop tests was 0.93.

Other activity limitation and participation restriction measures may be as a part of the patient-reported outcome measure noted in this guideline’s section on Outcome Measures.

Clinicians should utilize easily reproducible physical performance measures, such as single limb hop tests, to assess activity limitation and participation restrictions associated with their patient’s knee stability and movement coordination impairments and to assess the changes in the patient’s level of function over the episode of care.
### ACTIVITY LIMITATION AND PARTICIPATIONRESTRICTION MEASURES

## SINGLE LIMB SINGLE HOP TEST FOR DISTANCE

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measurement of activity limitation – jumping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The amount of distance a patient performs a single hop on one limb. The subject stands on the uninvolved leg, with his toe on the starting line. The subject hops as far as possible forward and lands on the same leg. The distance hopped is measured from the starting line to the point where the patient’s heel landed. The patient is given 2 practice trials and 2 recorded trials. Testing is repeated on the involved limb while wearing a functional knee brace.</td>
</tr>
<tr>
<td>Nature of variable</td>
<td>Continuous</td>
</tr>
<tr>
<td>Units of measurement</td>
<td>Centimeters</td>
</tr>
</tbody>
</table>
| Measurement properties | Test-retest reliability  
  - Healthy individuals: ICC=0.92, SEM=4.61 cm<sup>123</sup>  
  - Mean distance: 208.08-208.24 cm  
  LSI reliability in patients with ACL reconstruction<sup>116</sup>  
  - ICC=0.92  
  - Minimal Detectable Change = 8.09%  
  - Mean LSI at 16 weeks post ACLR = 81.0-82.9%  
  - Mean LSI at 22 weeks post ACLR = 88.2% |
### SINGLE LIMB TRIPLE HOP TEST FOR DISTANCE

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measurement of activity limitation – jumping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The distance a patient performs three maximal forward hops as far as possible.</td>
</tr>
<tr>
<td>Measurement method</td>
<td>The subject stands on the uninvolved leg, with his toe on the starting line. The subject performs 3 consecutive maximal hops far as possible forward and lands on the same leg. The distance hopped is measured from the starting line to the point where the patient’s heel landed. The patient is given two practice trials and two recorded trials. The test is repeated on the involved limb.</td>
</tr>
<tr>
<td>Nature of variable</td>
<td>Continuous</td>
</tr>
<tr>
<td>Units of measurement</td>
<td>Centimeters</td>
</tr>
<tr>
<td>Measurement properties</td>
<td>Test-retest reliability</td>
</tr>
<tr>
<td></td>
<td>• Healthy individuals: ICC=0.97, SEM=11.17 cm^{123}</td>
</tr>
<tr>
<td></td>
<td>• Mean distance: 670.12-673.35 cm</td>
</tr>
<tr>
<td></td>
<td>LSI reliability in patients with ACL reconstruction^{116}</td>
</tr>
<tr>
<td></td>
<td>• ICC=0.88</td>
</tr>
<tr>
<td></td>
<td>• Minimal Detectable Change = 10.02%</td>
</tr>
<tr>
<td></td>
<td>• Mean LSI at 16 weeks post ACLR = 82.4-82.6%</td>
</tr>
<tr>
<td></td>
<td>• Mean LSI at 22 weeks post ACLR = 87.7%</td>
</tr>
</tbody>
</table>
**SINGLE LIMB CROSSOVER HOP TEST FOR DISTANCE**

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measurement of activity limitation – jumping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The distance a patient performs three maximal crossover forward hops as far as possible</td>
</tr>
<tr>
<td>Measurement method</td>
<td>The subject stands on the uninvolved leg, with his toe on the starting line. The subject performs 3 consecutive maximal hops as far as possible forward and lands on the same leg while alternately crossing over a 15-cm strip on the floor. The distance hopped is measured from the starting line to the point where the patient’s heel landed. The patient is given two practice trials and two recorded trials. The test is repeated on the involved limb.</td>
</tr>
<tr>
<td>Nature of variable</td>
<td>Continuous</td>
</tr>
<tr>
<td>Units of measurement</td>
<td>Centimeters</td>
</tr>
<tr>
<td>Measurement properties</td>
<td>Test-retest reliability</td>
</tr>
<tr>
<td></td>
<td>• Healthy individuals: ICC=0.93, SEM=17.74 cm^{123}</td>
</tr>
<tr>
<td></td>
<td>• Mean distance: 637.40-649.19 cm</td>
</tr>
<tr>
<td></td>
<td>LSI reliability in patients with ACL reconstruction^{116}</td>
</tr>
<tr>
<td></td>
<td>• ICC=0.84</td>
</tr>
<tr>
<td></td>
<td>• Minimal Detectable Change = 12.25%</td>
</tr>
<tr>
<td></td>
<td>• Mean LSI at 16 weeks post ACLR = 82.2-83.1%</td>
</tr>
<tr>
<td></td>
<td>• Mean LSI at 22 weeks post ACLR = 88.3%</td>
</tr>
</tbody>
</table>
**SINGLE LIMB 6-M HOP TEST FOR TIME**

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measurement of activity limitation – jumping</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>The amount of time a subject hops on one leg a distance of 6-m as quickly as possible.</td>
</tr>
<tr>
<td><strong>Measurement method</strong></td>
<td>The subject stands on the uninvolved leg, with his toe on the starting line. After the examiner’s command of “Ready, set, go”, timing begins with a stopwatch accurate to 0.01 seconds. The subject hops the 6-m distance as quickly as possible with the test leg. The testing stops when the subject crosses the 6-m finish line. The subject performs two practice hops and performs 2 recordable hops. Testing is repeated on the involved limb while wearing a functional knee brace.</td>
</tr>
<tr>
<td><strong>Nature of variable</strong></td>
<td>Continuous</td>
</tr>
<tr>
<td><strong>Units of measurement</strong></td>
<td>Seconds</td>
</tr>
<tr>
<td><strong>Measurement properties</strong></td>
<td>Test-retest reliability</td>
</tr>
<tr>
<td></td>
<td>• Healthy individuals: ICC=0.93, SEM=0.06 sec$^{123}$</td>
</tr>
<tr>
<td></td>
<td>• Mean time: 1.82-1.86 sec</td>
</tr>
<tr>
<td><strong>LSI reliability in patients with ACL reconstruction$^{116}$</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• ICC=0.82</td>
</tr>
<tr>
<td></td>
<td>• Minimal Detectable Change = 12.96%</td>
</tr>
<tr>
<td></td>
<td>• Mean LSI at 16 weeks post ACLR = 81.7-83.2%</td>
</tr>
<tr>
<td></td>
<td>• Mean LSI at 22 weeks post ACLR = 89.6%</td>
</tr>
</tbody>
</table>
## MODIFIED STROKE TEST

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measurement of impairment of body structure – Knee joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The amount of fluid in the knee joint measured by visual inspection by clinician</td>
</tr>
<tr>
<td>Measurement method</td>
<td>A stroke test is performed with the patient in supine and with the knee in full extension and relaxed. Starting at the medial joint line the examiner strokes upward two or three times toward the suprapatellar pouch in an attempt to move effusion from the knee. The examiner then strokes downward on the distal lateral thigh just superior to the suprapatellar pouch toward the lateral joint line. A wave of fluid may be observed within seconds on the medial side of the knee.</td>
</tr>
<tr>
<td>Nature of variable</td>
<td>Ordinal</td>
</tr>
<tr>
<td>Units of measurement</td>
<td>Grading</td>
</tr>
<tr>
<td></td>
<td>Zero = no wave produced with downward stroke</td>
</tr>
<tr>
<td></td>
<td>Trace = small wave of fluid on the medial side of the knee</td>
</tr>
<tr>
<td></td>
<td>1+ = Larger bulge of fluid on the medial side of the knee</td>
</tr>
<tr>
<td></td>
<td>2+ = Effusion completely fills the medial knee sulcus with downward stroke or returns to the medial side of the knee without downward stroke</td>
</tr>
<tr>
<td></td>
<td>3+ = Inability to move the effusion out of the medial aspect of the knee</td>
</tr>
<tr>
<td>Measurement properties</td>
<td>The modified stroke test has a Kappa value of 0.61. 72% of testing pairs had perfect agreement. 8% had a disagreement of 2 grades.</td>
</tr>
<tr>
<td>Instrument variations</td>
<td>Bulge sign and minor effusion test can be used to assess knee effusion. In addition to visual inspection, knee effusion can be measured using a tape measure or Perometer for knee circumference.</td>
</tr>
</tbody>
</table>
BULGE SIGN

ICF category Measurement of impairment of body structure – Knee joint
Description The amount of fluid in the knee joint measured by visual inspection by clinician
Measurement method The examiner, with one hand superior to the patella, pushes the tissues (and possible fluid) inferiorly towards the patella. Keeping this hand in this position while holding pressure on these tissues, press the medial aspect of the knee just posterior to the patellar edge to force any fluid within the joint laterally. Now, as you watch this medial joint area, take your hand and press quickly along the lateral (i.e., opposite) aspect of the knee, looking for a fluid wave to present medially.
Nature of variable Nominal
Units of measurement • Absent
• Present
Measurement properties The bulge exhibited reliability coefficient of 0.9724 in patients with knee osteoarthritis.
Instrument variations Minor effusion test can be used to assess knee effusion.71 In addition to visual inspection, knee effusion can be measured using a tape measure or Perometer for knee circumference.92,140
# KNEE PASSIVE RANGE OF MOTION

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Description</th>
<th>Measurement method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The amount of passive knee extension and flexion measured using a goniometer.</td>
<td>For measurement using the goniometer, 1 arm of the goniometer was placed parallel to the shaft of the femur lining up with the greater trochanter, and the other arm was placed parallel to the shaft of the lower leg lining up with the lateral malleolus of the fibula. The axis of the goniometer was placed over the lateral femoral epicondyle.</td>
</tr>
</tbody>
</table>

Knee extension: The patient is supine. The heel of the limb of interest is propped on a bolster, assuring the back of the knee and calf are not touched the support surface. The amount of knee extension is recorded with the goniometer.

Knee flexion: The patient is supine. The patient flexes the knee as far as possible. The therapist then passively flexes the knee to the point of tissue resistance. The amount of knee flexion is recorded with the goniometer.

<table>
<thead>
<tr>
<th>Nature of variable</th>
<th>Units of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>Degrees</td>
</tr>
</tbody>
</table>

Measurement properties:
- Passive ROM measurements for flexion and extension\(^{112}\)
  - Validity: ICC=0.98-0.99
  - Intra-examiner reliability coefficients ranging from ICC=0.85-0.99
  - Inter-examiner reliability coefficients ranging from ICC=0.62 to 0.99
**KNEE ACTIVE RANGE OF MOTION**

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measure of impairment of body function – mobility of a single joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The amount of active knee extension and flexion measured using a goniometer</td>
</tr>
<tr>
<td>Measurement method</td>
<td>For measurement using the goniometer, 1 arm of the goniometer was placed parallel to the shaft of the femur lining up with the greater trochanter, and the other arm was placed parallel to the shaft of the lower leg lining up with the lateral malleolus of the fibula. The axis of the goniometer was placed over the lateral femoral epicondyle.</td>
</tr>
</tbody>
</table>

Knee extension: The patient is supine. The heel of the limb of interest is propped on a bolster, assuring the back of the knee and calf are not touched the support surface. The patient is asked to actively contract the quadriceps. The amount of knee extension is recorded with the goniometer.

Knee flexion: The patient is prone. The patient flexes the knee as far as possible. The amount of knee flexion is recorded with the goniometer.

<table>
<thead>
<tr>
<th>Nature of variable</th>
<th>Continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units of measurement</td>
<td>Degrees</td>
</tr>
<tr>
<td>Measurement properties</td>
<td>Intra-examiner ICC for active extension and flexion was 0.85 and 0.95, respectively.</td>
</tr>
</tbody>
</table>

25
## LACHMAN TEST

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measure of impairment of body function – stability of a single joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The amount of anterior tibial translation in respect to the femur</td>
</tr>
<tr>
<td>Measurement</td>
<td>The Lachman test is performed with the patient lying supine and with</td>
</tr>
<tr>
<td>method 11</td>
<td>the involved extremity on the side of the examiner. The femur is</td>
</tr>
<tr>
<td></td>
<td>stabilized with 1 hand, with the patient’s knee joint in 20° to 30° of</td>
</tr>
<tr>
<td></td>
<td>flexion. The examiner’s other hand is applied to the posterior aspect</td>
</tr>
<tr>
<td></td>
<td>of the proximal tibia. An anteriorly directed force is applied to</td>
</tr>
<tr>
<td></td>
<td>displace the tibia. Increased anterior tibial translation with a soft end</td>
</tr>
<tr>
<td></td>
<td>point compared to the contralateral side constitutes a positive test,</td>
</tr>
<tr>
<td></td>
<td>indicating disruption of the ACL.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nature of variable</th>
<th>Ordinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units of measurement</td>
<td>As described by the IKDC 2000, severity is graded as normal (-1 to 2 mm), nearly normal (3 to 5 mm), abnormal (6 to 10 mm), and severely abnormal (&gt; 10 mm)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measurement properties</th>
<th>Diagnostic Accuracy$^{11}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% Confidence Interval</td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>85%</td>
</tr>
<tr>
<td>Specificity</td>
<td>94%</td>
</tr>
<tr>
<td>Negative Likelihood ratio</td>
<td>0.2</td>
</tr>
<tr>
<td>Positive Likelihood ratio</td>
<td>10.2</td>
</tr>
<tr>
<td>Diagnostic Odds ratio</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>83-87%</td>
</tr>
<tr>
<td></td>
<td>92-95%</td>
</tr>
<tr>
<td></td>
<td>0.1-0.3</td>
</tr>
<tr>
<td></td>
<td>4.6-22.7</td>
</tr>
<tr>
<td></td>
<td>23-206</td>
</tr>
</tbody>
</table>

Reliability for Lachman test$^{27}$
- Intra-examiner judgments of positive or negative findings $\kappa=0.51$
- Intra-examiner judgments for grading based on excursion $\kappa=0.44-0.60$
- Inter-examiner judgments of positive or negative findings $\kappa=0.19$
- Inter-examiner judgments for grading based on excursion $\kappa=0.02-0.61$

| Instrument variations | The anterior tibial translation can be measured with the KT-1000 and Rolimeter$^{114}$ |
PIVOT SHIFT TEST

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measure of impairment of body function – stability of a single joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The amount of anterior tibial translation in respect to the femur</td>
</tr>
<tr>
<td>Measurement method</td>
<td>The pivot shift test is performed with the patient in supine. The involved leg is in an extended position. The leg is picked up at the ankle with the examiner’s ipsilateral hand. This hand internally rotates the knee and flexes the knee from full extension, while applying a valgus stress with contralateral hand on the lateral aspect of the proximal tibia. As the knee is moved into flexion, a sudden reduction of the anteriorly subluxed lateral tibial plateau indicates a positive shift test. This sudden reduction occurs at about 20 degrees of knee flexion.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nature of variable</th>
<th>Ordinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units of measurement</td>
<td>As described by the IKDC 2000, grades as normal (equal, none), nearly normal (glide, +), abnormal (clunk, ++), or severely abnormal (gross, +++).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measurement properties</th>
<th>Diagnostic Accuracy(^{11})</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Diagnostic Accuracy(^{11})</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>24%</td>
</tr>
<tr>
<td>Specificity</td>
<td>98%</td>
</tr>
<tr>
<td>Negative Likelihood ratio</td>
<td>0.9</td>
</tr>
<tr>
<td>Positive Likelihood ratio</td>
<td>8.5</td>
</tr>
<tr>
<td>Diagnostic Odds ratio</td>
<td>12</td>
</tr>
</tbody>
</table>
**MAXIMUM VOLUNTARY ISOMETRIC QUADRICEPS STRENGTH**

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measure of impairment of body function – power of isolated muscles and muscle groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The amount of quadriceps strength and activation of the involved limb relative to the noninvolved limb</td>
</tr>
<tr>
<td>Measurement method(^{23, 57})</td>
<td>Subjects were seated on a dynamometer with their hips and knees positioned in 90 degrees of flexion. The distal tibia was secured to the dynamometer force arm, and Velcro straps are used to stabilize the thigh and pelvis. After cleansing the area with alcohol, 7.6 cm by 12.7 cm self adhesive electrodes, used to deliver the electrical stimulus during testing, were placed over the proximal vastus lateralis and the distal vastus medialis muscle bellies. To ensure that the patients were exerting a maximal effort, patients were familiarized with the procedure, received verbal encouragement from the tester and visual feedback from the dynamometer's realtime force display. Patients performed 3 practice trials, and testing was initiated after 5 minutes of rest. For the test, patients were instructed to maximally contract their quadriceps for 5 seconds during which a supramaximal burst of electrical stimulation (amplitude, 135 V; pulse duration, 600 microseconds; pulse interval, 10 milliseconds; train duration, 100 milliseconds) was applied to the quadriceps to ensure complete muscle activation. If the force produced by the subject was &lt;95% of the electrically elicited force, the test was repeated, with a maximum of 3 trials per limb. To avoid the influence of fatigue, patients were given 2-3 minutes of rest between trials. If full activation was not achieved (voluntary torque &lt;95% of the electrically elicited force) during any of the trials, the highest voluntary force output from the 3 trials was used for analysis. Custom software was used to identify the maximum voluntary force produced by both the uninvolved and involved limbs during testing. A quadriceps index was calculated as a strength test score after testing was completed by calculated by ((involved side maximum force/uninvolved side maximum force) x 100).</td>
</tr>
<tr>
<td>Nature of variable</td>
<td>Continuous</td>
</tr>
<tr>
<td>Units of measurement</td>
<td>Newtons</td>
</tr>
<tr>
<td>Measurement properties</td>
<td>Interrater reliability ICC: 0.97-0.98</td>
</tr>
</tbody>
</table>
**POSTERIOR DRAWER TEST**

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measure of impairment of body function – stability of a single joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The position and amount of posterior tibial excursion in respect to the femur</td>
</tr>
<tr>
<td>Measurement method</td>
<td>The patient is supine with involved knee flexed to 90 degrees. The examiner is seated on the foot of the involved limb and applies the thenar eminence of both hands on the anterior aspect of the proximal tibia. A posteriorly directed force is applied to displace the tibia. Increased posterior tibial translation with a soft end point compared to the contralateral side constitutes a positive test, indicating disruption of the PCL.</td>
</tr>
<tr>
<td>Nature of variable</td>
<td>Ordinal</td>
</tr>
<tr>
<td>Units of measurement</td>
<td>As described by the IKDC 2000, severity is graded as normal (0 to 2 mm), nearly normal (3 to 5 mm), abnormal (6 to 10 mm), and severely abnormal (&gt; 10 mm).</td>
</tr>
<tr>
<td>Measurement properties</td>
<td>Diagnostic Accuracy[^124]</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>90%</td>
</tr>
<tr>
<td>Specificity</td>
<td>99%</td>
</tr>
<tr>
<td>Negative Likelihood ratio</td>
<td>0.1</td>
</tr>
<tr>
<td>Positive Likelihood ratio</td>
<td>90</td>
</tr>
</tbody>
</table>

The posterior tibial translation can be measured with the KT-1000[^31]
**POSTERIOR SAG TEST**

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measure of impairment of body function – stability of a single joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The amount of posterior tibial translation in respect to the femur</td>
</tr>
<tr>
<td>Measurement method</td>
<td>The patient is supine. The examiner holds the heels of both legs, and</td>
</tr>
<tr>
<td></td>
<td>flexes the knees to 90 degrees and the hips to 90 degrees. The</td>
</tr>
<tr>
<td></td>
<td>position of the proximal tibia of the involved limb is compared to</td>
</tr>
<tr>
<td></td>
<td>contralateral side. If the position of the proximal tibia of the</td>
</tr>
<tr>
<td></td>
<td>involved limb is set more posterior or “sags” relative to the femoral</td>
</tr>
<tr>
<td></td>
<td>condyles as compared to the opposite side, the test is present for a</td>
</tr>
<tr>
<td></td>
<td>posterior sag.</td>
</tr>
<tr>
<td>Nature of variable</td>
<td>Nominal</td>
</tr>
<tr>
<td>Units of measurement</td>
<td>Absent</td>
</tr>
<tr>
<td>Measurement properties</td>
<td>Present</td>
</tr>
<tr>
<td>Diagnostic Accuracy</td>
<td>124</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>79%</td>
</tr>
<tr>
<td>Specificity</td>
<td>100%</td>
</tr>
<tr>
<td>Negative Likelihood ratio</td>
<td>.21</td>
</tr>
<tr>
<td>Positive Likelihood ratio</td>
<td>NA</td>
</tr>
</tbody>
</table>
**PAIN WITH VALGUS STRESS TEST AT 30 DEGREES**

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measure of impairment of body function – pain in joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The amount of pain at the MCL during a valgus stress test at 30 degrees</td>
</tr>
<tr>
<td>Measurement method</td>
<td>The patient is supine. While facing toward the feet of the patient, the examiner holds the ankle of the index limb with outside hand. The limb is extended over the edge of the testing table. The examiner places his inside thigh against the thigh of the index limb. The knee is flexed to 30 degrees. The opposite hand of the examiner is placed over the medial joint line of the involved limb. The examiner applies a valgus force by abducting the ankle and stabilizing the thigh. The amount of pain using the Numeric Pain Rating Scale at the medial collateral ligament is recorded.</td>
</tr>
<tr>
<td>Nature of variable</td>
<td>Ordinal</td>
</tr>
<tr>
<td>Units of measurement</td>
<td>Integers</td>
</tr>
<tr>
<td>Measurement properties</td>
<td>Diagnostic Accuracy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measurement properties</th>
<th>95% Confidence Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity 78%</td>
<td>64-92%</td>
</tr>
<tr>
<td>Specificity 67%</td>
<td>57-76%</td>
</tr>
<tr>
<td>Negative Likelihood ratio 0.3</td>
<td>0.2-.0.6</td>
</tr>
<tr>
<td>Positive Likelihood ratio 2.3</td>
<td>1.7-3.3</td>
</tr>
</tbody>
</table>
**LAXITY WITH VALGUS STRESS TEST AT 30 DEGREES**

<table>
<thead>
<tr>
<th>ICF category</th>
<th>Measure of impairment of body function – stability of a single joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The amount of separation between the tibia and femur at the MCL during a valgus stress test at 30 degrees</td>
</tr>
<tr>
<td>Measurement method</td>
<td>The patient is supine. While facing toward the feet of the patient, the examiner holds the ankle of the index limb with outside hand. The limb is extended over the edge of the testing table. The examiner places his inside thigh against the thigh of the index limb. The knee is flexed to 30 degrees. The opposite hand of the examiner is placed over the medial joint line of the involved limb. The examiner applies a valgus force by abducting the ankle and stabilizing the thigh. The amount of separation between the femur and tibia is recorded.</td>
</tr>
<tr>
<td>Nature of variable</td>
<td>Ordinal</td>
</tr>
<tr>
<td>Units of measurement</td>
<td>As described by the IKDC 2000, severity is graded as normal (-1 to 2 mm), nearly normal (3 to 5 mm), abnormal (6 to 10 mm), and severely abnormal (&gt; 10 mm).</td>
</tr>
<tr>
<td>Measurement properties</td>
<td>Diagnostic Accuracy?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>95% Confidence Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity 91% 81-100%</td>
</tr>
<tr>
<td>Specificity 49% 39-59%</td>
</tr>
<tr>
<td>Negative Likelihood ratio 0.2 0.1-.06</td>
</tr>
<tr>
<td>Positive Likelihood ratio 1.8 1.4-2.2</td>
</tr>
<tr>
<td>ICF category</td>
</tr>
<tr>
<td>------------------------------</td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Measurement method</td>
</tr>
<tr>
<td>Nature of variable</td>
</tr>
<tr>
<td>Units of measurement</td>
</tr>
<tr>
<td>Measurement properties</td>
</tr>
</tbody>
</table>
CLINICAL GUIDELINES

Interventions

A plethora of interventions have been depicted for the treatment of knee insufficiency. A preponderance of evidence for high-quality randomized, controlled trials and systematic reviews exists to support the benefits of physical therapy interventions in these patients.

CONTINUOUS PASSIVE MOTION

A systematic review by Wright et al\textsuperscript{153}, which included 6 randomized controlled trials published through 2005, concluded there is no substantial advantage for the use of continuous passive motion except for a possible decrease in pain in patients following ACL reconstruction. However, these studies included a small sample of patients and blinding of the examiners was not addressed.

A separate systematic review by Smith and Davies\textsuperscript{133}, which included 8 papers published between 1992 and 2006, concluded that no evidence exists between those who received continuous passive motion and those who did not with regard to joint laxity, functional outcomes, post-operative complications, radiological changes, ecchymoses and muscle atrophy. Insufficient evidence exists in regards to ROM, pain, swelling, blood loss, patient satisfaction, or duration of hospital stay. Many methodological issues exist, such as poor documentation of post-operative management, randomization, recruitment, short follow-ups, and small sample sizes.

Clinicians should not consider the use of continuous passive motion to increase knee range of motion. Clinicians can consider using continuous passive motion to decrease post-operative pain.
EARLY WEIGHT BEARING

Wright et al.\textsuperscript{153} conducted a systemic review and found 1 randomized trial that investigated the efficacy of immediate weight bearing versus delayed weight bearing following ACL reconstruction. No deleterious effects of early weight bearing on stability or function and anterior knee pain may be decreased when weight bearing.

As the forces transmitted to the MCL is very low (< 20 Newtons) during normal gait\textsuperscript{131}, the current standard of care for patients with isolated MCL injuries is to allow to weight bear to tolerance\textsuperscript{111,117}. Following repair to the MCL ligaments, non-weight bearing is recommended for the initial 3 weeks with weight-bearing as tolerated at 3 weeks\textsuperscript{111}.

Little evidence exists regarding weight bearing status following PCL injuries, but in order to protect the healing structures, partial weight bearing status is recommended for 2-4 weeks following PCL surgery.\textsuperscript{69}

The initial fixation may be tenuous and vulnerable to failure if stressed too early following multi-ligament knee surgery. Following multi-ligament knee surgeries, no weight bearing for the first week and limited weight bearing for the first 6 weeks is recommended.\textsuperscript{96,119}

In summary, the effects of early weight bearing are unknown in MCL or PCL knee ligament injuries or reconstructive surgeries.

Early weight-bearing can be used for patients following ACL reconstruction without incurring detrimental effects on stability or function.
POST-OPERATIVE BRACING

Birmingham et al\textsuperscript{15} conducted a randomized controlled clinical trial to compare post-operative outcomes in patients using a functional knee brace and patients using a neoprene sleeve. No significant differences were found between groups for quality of life, knee laxity, hop LSI and activity level.

Eleven articles were included in a recent systematic review\textsuperscript{152}, published through 2005. No evidence supported the routine use of functional or rehabilitative bracing following ACL reconstruction. No increase in post-operative injuries, increased pain, decreased ROM, or increased knee laxity was found in the control groups that were not bracing following surgery.\textsuperscript{153} Recent surveys show that approximately 50\% of surgeons still use bracing in the early post-operative period following ACL surgery\textsuperscript{5}.

The use of post-operative or functional knee bracing is no more beneficial than not using a brace in patients following ACL injury or reconstruction.

Knee bracing is not recommended following non-operative PCL injuries.\textsuperscript{69} Others recommend initial protective bracing with progression to full extension when posterior knee pain resolves.\textsuperscript{150} In regards to postoperative care, a hinged brace is locked in full knee extension for 2 to 4 weeks to avoid the effects of gravity and the forces applied by the hamstrings.\textsuperscript{69, 150} No current evidence exists that bracing prevents posterior tibial translation.

Consensus exists that bracing is beneficial for severe Grade II and Grade III ruptures of the MCL for the first 4-6 weeks to stabilize the knee to allow ligament healing to occur.\textsuperscript{5} Following surgery to the MCL, a long hinged brace allowing 30 to 90 degrees of knee motion for the first 3 weeks with progressive weaning off the brace starting at week 6.\textsuperscript{111}

For the first 4 weeks following multi-ligament surgery, patients are required to wear a post-operative knee brace locked in full knee extension with progressive flexion thereafter.\textsuperscript{96} A medial unloader functional brace is recommended for patients with PLC injuries during light and full activity.\textsuperscript{96}

Knee bracing can be used for patients with severe MCL injuries.
IMMEDIATE VERSUS DELAYED MOBILIZATION

In a prospective study, Ito and colleagues evaluated the results of 3-day immobilization as compared to 2-week immobilization following ACL hamstring graft reconstruction. Thirty consecutive patients underwent multistranded hamstring graft ACL reconstruction and were equally randomized to one of two groups: 3-day immobilization and 2-week immobilization. Anterior laxity, joint position sense, and thigh muscle strength were measured at 3, 6, and 12 months post surgery. No significant differences were noted between groups at all time periods.

Beynnon et al evaluated 5 randomized controlled trials on the effects of immediate knee motion as compared to delayed knee motion following ACL reconstruction. Although, the method of randomization was described in only one study, patients’ loss to follow up was minimal in 2 trials and no study stated if the investigators were blinded, they concluded that extended immobilization or limited motion without muscle activity is detrimental to the structures surrounding the knee and early mobilization is beneficial. Early joint motion after reconstruction of the ACL appears to be beneficial with reduction in pain, lessens adverse changes to articular cartilage, and helps prevent the formation of scar and capsular contractions that have the potential to limit joint motion.

Harner and Hoher discussed the current concepts on the evaluation and treatment of posterior cruciate ligament injuries. They recommend a 2- to 4-week period of immobilization in full extension following a Grade III PCL injury to maintain reduction of the tibia and minimize posterior sag to limit forces on the damaged PCL and posterolateral structures. The same recommendations apply following surgery to repair the PCL.

Clinicians should consider the use of immediate mobilization following ACL reconstruction to increase ROM, reduce pain, and limit adverse changes to soft tissue structures.
SUPERVISED REHABILITATION

The Cochrane collaboration on exercises for treating anterior cruciate ligament injuries in combination with collateral ligament and meniscal damage of the knee in adults\textsuperscript{144} included only one trial comparing supervised training group and home exercise group in patients with ACL deficiency. They concluded that there were no significant differences between groups in the outcome measures. Significant higher strength measures were found in isometric knee flexion and isokinetic knee flexion and extension in the supervised group.

The Cochrane collaboration on exercises for treating isolated anterior cruciate ligament injuries in adults\textsuperscript{143} that included 2 randomized controlled studies concluded that was no differences between home-based rehabilitation group and supervised rehabilitation group following ACL surgery in Lysholm scores at twelve weeks or Tegner scores (percent change) at six months.

Four randomized controlled trial were included in a systematic review to evaluate standard clinic-based physical therapy rehabilitation as compared to minimally supervised home-based rehabilitation following ACL reconstruction.\textsuperscript{153} They concluded that a minimally supervised physical therapy regimen can be successful in restoring function in patients following ACL surgery.

Clinicians should consider the use of exercises provided as a part of a supervised in-clinic rehabilitation program or as part of a supervised home-based rehabilitation program for patients following ACL injury or reconstruction..
THERAPEUTIC EXERCISES

In a randomized controlled study, Tagesson and colleagues\textsuperscript{137} showed that open kinetic chain (OKC) exercise was more effective in increasing isokinetic knee extension force ($p < 0.009$) than closed kinetic chain exercise (CKC) in patients with ACL deficiency following 4 months of rehabilitation. The LSI for isokinetic knee extension in OKC was 96% (SD ± 14%) and CKC was 84% (SD ± 15%). No differences were demonstrated in isokinetic knee flexion, 1 repetition maximum squat, one-legged vertical jump, one-legged single hop for distance, or functional outcomes. This did not include long-term follow-up. Perry et al\textsuperscript{109}, in a randomized, single-blind clinical trial, investigated the effects between OKC and CKC exercises on function and laxity in patients with ACL deficiency. Patients underwent a 6-week training program. Results showed no differences between groups in knee joint laxity, outcome scores and functional performance.

In the Cochrane review by Trees et al\textsuperscript{143}, no differences were exhibited between OKC and CKC groups following ACL reconstruction in knee function, patellofemoral pain severe enough to restrict activity at one year, or knee laxity at one year. When CKC and OKC combined rehabilitation was compared to CKC rehabilitation only, return to sport at 2.5 years was significantly more common in the combined group compared to CKC only group but no differences were noted in knee laxity or isokinetic quadriceps strength at 6 months.

In a systematic review by Wright and colleagues\textsuperscript{154}, 5 prospectively randomized studies following ACL reconstruction have been conducted. Their findings at this time are inconclusive regarding the use and timing of OKC and CKC exercises following ACL reconstruction. The studies had a short follow-up period or lacked power in order for the reviewers to make reasonable conclusions.

In a current concepts commentary by Harner and Hoher\textsuperscript{50}, they recommend quadriceps muscle strengthening to counteract the posterior tibial subluxation and discourage hamstrings strengthening as the hamstring loading can increase forces on the PCL.

Clinicians should consider the use of open kinetic chain exercises in conjunction with closed kinetic chain exercises in patients with knee stability and movement coordination impairments.
NEUROMUSCULAR ELECTRICAL STIMULATION

Fourteen randomized controlled trials have evaluated the use of electrical stimulation during ACL rehabilitation. A variety of parameters were used, making generalized conclusions difficult. Improved isokinetic strength was noted in some studies with no correlation with patient outcomes or functional performance. However, neuromuscular stimulation may improve quadriceps strength if applied in a high-intensity setting early in the rehabilitation process.

Neuromuscular electrical stimulation can be used with patients following ACL reconstruction to increase quadriceps muscle strength.
NEUROMUSCULAR REEDUCATION

Cooper et al\textsuperscript{26} performed a systematic review that included 4 randomized clinical studies that investigated the use of proprioceptive and exercises in individuals with ACL deficiency. Improvements in joint position sense were inconclusive based on the variety of testing procedures used. Limited improvements were noted in muscle strength, subjective rating and hop testing following neuromuscular training when compared to traditional strengthening in patients with ACL deficiency.

Risberg et al\textsuperscript{120} conducted a single-blinded, randomized controlled trial (n=74) to determine the effect of a 6-month neuromuscular training program versus a traditional strength training program following ACL reconstruction. At 6 months, the neuromuscular training group had significantly higher scores in the Cincinnati Knee Score (P=.05) and visual analog scale for knee function as compared with the strength training group. No significant differences were exhibited in knee laxity, pain, functional performance, proprioception, and muscle strength. The authors concluded that neuromuscular exercises should be a part of ACL reconstruction rehabilitation. However, no long-term follow-up was a part of this study.

In the Cochrane collaboration by Trees et al\textsuperscript{144}, one study investigated supplementary proprioceptive and balance training as compared to traditional strength training in patients following ACL reconstruction. No differences were observed between groups in patient outcome measures or hop tests, with a significant difference in greater knee flexion ROM in the supplementary group versus the strengthening group.

Clinicians should consider the use of neuromuscular reeducation as a supplementary program to strength training in patients with knee stability and movement coordination impairments.
ACCELERATED REHABILITATION

Trees et al\textsuperscript{144}, in the Cochrane collaboration, found 1 study that investigated accelerated rehabilitation versus non-accelerated rehabilitation. No significant differences between groups were demonstrated in any KOOS domains. Interestingly, at six months, differences in the single limb hop test favored the accelerated group, at 12 months, it favored the non-accelerated group, and at 24 months, it favored the accelerated group.

In the systematic review by Wright and colleagues\textsuperscript{154}, two randomized controlled trials have been published to evaluate the effects of accelerated ACL reconstruction rehabilitation. The authors concluded that no significant conclusions could be made pertaining to the differences in a 6-month accelerated rehabilitation compared to an 8-month non-accelerated rehabilitation. Accelerated rehabilitation program for 19 weeks does not produce any deleterious effects compared with a non-accelerated 32-week program.

Recommendation: Accelerated rehabilitation can be used for patients with ACL reconstruction. Accelerated rehabilitation may be appropriate in patients with ACL reconstruction and concomitant meniscal repair.
ECCENTRIC STRENGTHENING

In a randomized, matched clinical trial (n=32), Gerber et al. investigated the safety, feasibility, and efficacy of 12-week negative work exercise via eccentric contractions at 26 weeks in patients following ACL reconstruction. Patients were randomly assigned to either a traditional or eccentric exercise program. Knee extension strength and functional performance in the involved limb were significantly improved in the eccentric group as compared to the traditional group. Activity level decreased to a greater extent in the traditional group versus the eccentric group. No significant differences were noted between groups in knee or thigh pain, knee effusion or knee joint laxity.

Gerber and colleagues evaluated the effectiveness of early progressive eccentric exercise at 1 year following ACL reconstruction. Patients were initially matched randomized into 2 groups: progressive eccentric exercise or standard rehabilitation. Training programs were conducted over a 12-week period. 32 patients (n=17 in progressive eccentric group and n=15 in standard rehabilitation) completed a 1-year follow-up. The results demonstrated greater muscle volume improvement in the quadriceps and gluteus maximus in the eccentric group as compared to the standard group (p < 0.05). Knee extension strength and functional performance improvements were noted in the involved limb in the eccentric group at 1-year follow-up compared to pre-training levels, whereas no improvements were noted in the standard group.

MacLean and associates evaluated the efficacy of a home eccentric exercise program in improving strength, knee function, and symptoms in athletes with PCL injury. Thirteen athletes with isolated PCL injury underwent 12 weeks of a home-based progressive and systematic eccentric squat program. Quadriceps and hamstrings eccentric and concentric torques at 60 and 120 degrees per second, single limb hop test, and Lysholm Knee scale scores were compared to 13 healthy sedentary subjects. In the treatment group, significant increases were noted in eccentric and concentric torques. Knee function and symptoms were improved over the 12-week period. The quadriceps in the involved limb showed significant greater improvement in eccentric torque than in concentric torque following eccentric training. Despite lower eccentric torque in the treatment group as compared to the control group prior to training, no differences existed post-training.

Recommendation: Clinicians should consider the use of eccentric strengthening in patients following ACL reconstruction or PCL injury to increase muscle strength and functional performance.
CLINICAL GUIDELINES

SUMMARY OF RECOMMENDATIONS

PATHOANATOMICAL FEATURES
Knee ligament strains can be the result of a contact or noncontact incidents, which can result in damage to one or more structures. Clinicians should assess for impairments in range of motion, motor control, strength, and endurance of the limb associated with the identified ligament pathology.

RISK FACTORS
Clinicians should consider the shoe-surface interaction, increased body mass index, narrow femoral notch width, increased joint laxity, pre-ovulatory 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 non-contact ACL injury.

DIAGNOSIS/classification
Passive knee instability, joint pain, effusion, and movement coordination impairments are useful clinical findings for classifying a patient with knee instability into the following International Statistical Classification of Diseases and Related Health Problems (ICD) categories: Sprain and strain involving collateral ligament of knee, Sprain and strain involving cruciate ligament of knee, Injury to multiple structures of knee; and the associated International Classification of Functioning, Disability, and Health (ICF) impairment-based category of knee instability (b7150 Stability of a single joint) and movement coordination impairments (b7601 Control of complex voluntary movements).

DIFFERENTIAL DIAGNOSIS
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.

EXAMINATION – OUTCOME MEASURES
Clinicians should use a validated patient-reported outcome measure with a general health questionnaire, along with a validated activity scale for patients with knee insufficiency. These measures 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.
EXAMINATION – ACTIVITY LIMITATION MEASURES
Clinicians should utilize easily reproducible physical performance measures, such as single limb hop tests, to assess activity limitation and participation restrictions associated with their patient’s knee stability and movement coordination impairments and to assess the changes in the patient’s level of function over the episode of care.

INTERVENTIONS – CONTINUOUS PASSIVE MOTION
Clinicians should not consider the use of continuous passive motion to increase knee range of motion. Clinicians can consider using continuous passive motion to decrease post-operative pain.

INTERVENTIONS – EARLY WEIGHT BEARING
Early weight-bearing can be used for patients following ACL reconstruction without incurring detrimental effects on stability or function.

INTERVENTIONS – POST OPERATIVE BRACING
The use of post-operative or functional knee bracing is no more beneficial than not using a brace in patients following ACL injury or reconstruction.

INTERVENTIONS – IMMEDIATE versus DELAYED MOBILIZATION
Clinicians should consider the use of immediate mobilization following ACL reconstruction to increase ROM, reduce pain, and limit adverse changes to soft tissue structures.

INTERVENTIONS – SUPERVISED REHABILITATION
Clinicians should consider the use of exercises provided as a part of a supervised in-clinic rehabilitation program or as part of a supervised home-based rehabilitation program for patients following ACL injury or reconstruction.

INTERVENTIONS – THERAPEUTIC EXERCISES
Clinicians should consider the use of open kinetic chain exercises in conjunction with closed kinetic chain exercises in patients with knee stability and movement coordination impairments

INTERVENTIONS – NEUROMUSCULAR ELECTRICAL STIMULATION
Neuromuscular electrical stimulation can be used with patients following ACL reconstruction to increase quadriceps muscle strength.

INTERVENTIONS – NEUROMUSCULAR REEDUCATION
Clinician should consider the use of neuromuscular reeducation as a supplementary program to strength training in patients with knee stability and movement coordination impairments.
INTERVENTIONS – ACCELERATED REHABILITATION
Accelerated rehabilitation can be used for patients with ACL reconstruction. Accelerated rehabilitation may be appropriate in patients with ACL reconstruction and concomitant meniscal repair.

INTERVENTIONS – ECCENTRIC STRENGTHENING
Clinicians should consider the use of eccentric strengthening in patients following ACL reconstruction or PCL injury to increase muscle strength and functional performance.
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