These are rehabilitation guidelines for OSU Sports Medicine patients. Please contact us at 614.293.2385 if you have any questions.

INTRODUCTION

Target Population:

Inclusions
Individuals with primary, unilateral ACL reconstruction (ACLR) with the goal of returning to pre-injury activities
- Autograft or allograft
- Meniscus repair* or debridement
- Medial collateral ligament injury without surgical intervention

*Considerations for rehabilitation progression, see Overall Considerations/Rehabilitation Precautions

Exclusions
- Individuals with multi-ligament injury
- Individuals with revision ACLR
- Individuals who are skeletally immature (epiphyseal sparing procedure)

Overall Considerations/Rehabilitation Precautions:

Rehabilitation progression is criterion-based, with consideration for tissue healing times, patient history and attributes, and clinical examination findings
- Weight bearing as tolerated (WBAT) without antalgic gait (see Meniscal Repair, below)
- No resistive hamstring exercises for 8 weeks with hamstring autograft
- Isotonic strengthening
  - Perform open-chain exercises between 40°-90° to avoid patellofemoral irritation.
    - No open chain exercise <40° to avoid ACL graft strain
  - Perform closed-chain exercises at < 90° to avoid patellofemoral irritation

Meniscal repair
- No weight-bearing (WB) therapeutic exercise >90° x 8 WEEKS
- Restrictions on WB status and therapeutic exercise will vary slightly among surgeons
  - You MUST confirm this with the surgeon for each patient
- Delay this guideline by 2-4 weeks if meniscal repair performed, per physician instruction
In this protocol, you will find:

- “Key Principles in Clinical Decision-Making” – over-arching themes to be applied throughout rehabilitation
- Levels of Evidence – documenting the level of evidence (1-5) for the given citation.
- Each “Phase of Rehabilitation” (Early, Middle, Late) is based on five impairment areas:
  - Pain and effusion
  - Range of motion (ROM)
  - Strength and muscle performance
  - Weight bearing and joint Loading
  - Neuromuscular control (NMC)
- “Goals for Progression” to the next phase are criterion-, impairment- and time-oriented, dependent on soft tissue healing, patient demographics, and clinician evaluation
- Exercises listed within are suggestions and when available, are based on evidence and cited accordingly by author, date and level of evidence (Table 1)
- Exercises may be appropriate to address one or more impairments within and across phases of rehabilitation

### Table 1: Levels of Evidence#

<table>
<thead>
<tr>
<th>Quality Level</th>
<th>Definition</th>
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<tbody>
<tr>
<td>1a</td>
<td>Systematic Review (SR)<em>, meta-analysis</em></td>
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<tr>
<td>1b</td>
<td>Randomized Controlled Trial (RCT)</td>
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<tr>
<td>2a</td>
<td>SR of cohort studies</td>
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<td>2b</td>
<td>Single cohort study, poor quality RCT</td>
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<tr>
<td>3a</td>
<td>SR of case-control studies</td>
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<td>3b</td>
<td>Single case-control study</td>
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<tr>
<td>4</td>
<td>Case series; poor quality case-control or cohort studies</td>
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<tr>
<td>5</td>
<td>Expert Opinion</td>
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Adapted from Oxford Centre for Evidence-based Medicine

| a = good quality study |
| b = lesser quality study |
| * = quality level of these studies is dependent upon the studies included in the analysis/review. (e.g. Systematic review of Level 1 RCTs = Level 1a evidence) |

Development of this table based on:
- Oxford Centre for Evidence-based Medicine – Levels of Evidence (March 2009).
Key Principles in Clinical Decision-Making:

I. Principles of Healing (Table 2)

Table 2: Principles of Healing

<table>
<thead>
<tr>
<th></th>
<th>0-3 days</th>
<th>4-14 days</th>
<th>3-4 wks</th>
<th>5-7 wks</th>
<th>2-3 mo</th>
<th>3-6 mo</th>
<th>6-12 mo</th>
<th>Up to 2 yrs</th>
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<tr>
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<td>Tendinitis</td>
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<td>Grade II</td>
<td>Grade III</td>
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<tr>
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<td>Grade II</td>
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<td>Ligament Graft</td>
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Adapted from Snyder-Mackler and Axe 2005 (Axe and Snyder-Mackler 2005)

- Consideration of healing properties can promote long term joint integrity and help avoid delays in rehabilitation, and/or re-injury (Local Consensus)(5).
- Following these guidelines can promote tissue health by avoiding potentially detrimental stresses/strains placed on the lesion site (Reinold, Wilk et al. 2006)(5), (Local Consensus)(5).
- Examples of protecting healing tissues: bracing, use of crutches, etc.

II. Patient Considerations

This clinical care guideline is derived from current evidence and should be applied to each athlete with consideration for their unique characteristics and clinical presentation, within the context of their injury (Local Consensus)(5).

- Addressing athlete-specific, sport-specific, position-specific needs are important in determining late phase and sport-reintegration activities, and preparing the athlete to return to sport. For individuals not returning to sport, addressing individual needs are important in returning to pre-injury activities.
- Consider the influences of other patient conditions and medical history (i.e. clotting disorders, diabetes, concomitant injuries, laxity, malalignment) on rehabilitation interventions and progressions. Modifications to this standard post-ACLR protocol should be discussed and agreed upon by the medical and rehabilitation team.
- Other patient factors, including psychosocial impairments, may affect patient outcomes or the rehabilitation process. Referrals to other professionals (e.g. sport psychologist to address...
psychosocial components of impairments and functional disability) may be warranted and should be discussed and agreed upon by the medical and rehabilitation team.

III. Impairments

A. Pain and effusion
- Controlling pain and effusion are a primary focus of early phase rehabilitation
- Assessment and management of these impairments should continue throughout rehabilitation
- ***IMPORTANT***: Persistent pain and effusion contribute to elevated intra-articular joint temperature associated with stimulation of proteoglycic enzyme activity, which may have a detrimental effect on articular cartilage healing (English 1997)(5)

B. Range of Motion
- Loss of ROM after ACLR is associated with poorer self-reported outcomes (Shelbourne and Nitz 1992)(5) and increased incidence of OA (Shelbourne, Urch et al. 2012)(3)
- Controlled ROM can assist in the nourishment of healing tissues (Buckwalter 1998)(5) via synovial fluid flow and stimulation of cartilage matrix production.

C. Strength and Muscle Performance
- Exercises and other interventions that focus on restoration of quadriceps muscle strength should be emphasized due to its role in force production and attenuation around the knee (Mikesky, Meyer et al. 2000)(4), (Local consensus)(5), and relationship to functional outcomes in ACL-reconstructed individuals (de Jong, van Caspel et al. 2007)(4), (Eitzen, Holm et al. 2009)(3)
- Isokinetic strengthening can be used to augment quadriceps strength after ACLR (Hartigan, Axe et al. 2010)(1)
- High intensity neuromuscular electrical stimulation significantly augments quadriceps strength and functional recovery early after ACLR compared with low intensity stimulation or volitional exercise alone (Snyder-Mackler, Delitto et al. 1995)(2a)
- Measures of strength symmetry of the quadriceps and hamstrings are used to document criterion to progress through advancing rehabilitation phases (Myer, Paterno et al. 2006)(5) and to determine return to sport readiness (Myer, Paterno et al. 2006)(5) (Thomee, Kaplan et al. 2011)(3a)
- Strength deficits affect movement symmetry (Lewek, Rudolph et al. 2002)(3) and functional performance (de Jong, van Caspel et al. 2007)(4a), (Local consensus)(5).

D. Weight Bearing and Joint Loading
- Altered joint loading profiles have been identified in both the injured and uninjured limbs following ACLR (Castanharo, da Luz et al. 2011)(3b), (Paterno, Ford et al. 2007)(3b), (Paterno, Schmitt et al. 2010)(3), (Gao and Zheng 2010)(3b), (Roewer, Di Stasi et al. 2011)(2b) (Webster, Feller et al. 2012)(2b)
- Altered joint loading, including that on the uninvolved limb is predictive of secondary ACL injury risk (Paterno, Schmitt et al. 2010)(3b) (Moraiti, Stergiou et al. 2010)(3b)
- Abnormal joint loads can be successfully addressed with neuromuscular training (Hewett, Lindenfeld et al. 1999)(1b), (Myer, Paterno et al. 2008)(5)
E. Neuromuscular Control
- Altered NMC is common after ACL injury and ACLR (Castanharo, da Luz et al. 2011)(3b), (Paterno, Ford et al. 2007)(3b), (Roewer, Di Stasi et al. 2011)(2b) and can be addressed with neuromuscular training (Di Stasi 2012)(4), (Myer, Paterno et al. 2008)(5)
- Altered NMC is predictive of secondary ACL injury risk and can be characterized by movement asymmetry and deficiencies of both the injured and uninjured limbs (Paterno, Schmitt et al. 2010)(3b)

Components of Evaluation and Re-assessment:

A. Pain and Effusion
   a. Modified Stroke Test (Sturgill, Snyder-Mackler et al. 2009)(3)

B. Range of Motion
   a. Extension equal to contralateral limb and inclusive of hyperextension (Shelbourne and Nitz 1992 (5)
   b. Flexion equal to contralateral limb (Local Consensus)(5)

C. Strength and Muscle Performance
   a. Isometric testing (Snyder-Mackler, Delitto et al. 1994)(2a)

D. Weight Bearing and Joint Loading
   a. Observe gait and functional movements for asymmetries and out-of-plane motion (e.g. restricted knee motion with gait, pelvic drop with step-down task, or knee valgus during running)
   b. Symmetrical landing strategies with dynamic double and single-leg jumping and landing tasks.

E. Neuromuscular Control
   b. Tuck jump assessment (Myer, Paterno et al. 2008)(5)
   c. Sport-specific functional testing (e.g. soccer vs. volleyball)
   d. Position-specific functional testing (e.g. football: lineman vs. wide receiver)

Criteria for Advancement to Sport-Specific/Return to Activity Training Phase:

1. Effusion: none
2. ROM: full, painfree knee ROM, symmetrical with the uninvolved limb
3. Strength and muscle performance:
   a. Quadriceps Index (QI) ≥ 85%
   b. MMT = 5/5 for other lower extremity and core musculature
4. WB and joint loading: normalized gait and jogging mechanics
5. Neuromuscular control: appropriate mechanics and force attenuation strategies with high-level agility, plyometrics, and high impact movements
6. Additional goal: single leg hop testing performance (at least 2) (van Grinsven 2010) (5) within 15% of the unininvolved limb(Myer, Schmitt et al. 2011)(5)
PHASES OF REHABILITATION

EARLY POST-OPERATIVE

Day 1 up to approximately 2 weeks

A. Pain and Effusion
- Ice/cryotherapy, compression, elevation to reduce post-operative effusion

B. Range of Motion
- Begin passive, active-assisted, and active ROM as tolerated
  - Biking: bike with ½ revolutions and progress to full revolutions per precautions
- No forced flexion beyond 90° with meniscal repairs
- Patellar mobilization
  - Emphasis on superior and inferior mobility
- Towel stretching, prone hangs, ‘bag hangs’ to achieve and maintain knee extension symmetrical to the contralateral limb (Adams, Logerstedt et al. 2012)(3b)
  - Symmetrical extension (including hyperextension) is a goal for all patients.
  - For individuals with excessive general joint laxity, modify or avoid aggressive stretching tactics early in the rehabilitation period. These patients will often regain symmetrical hyperextension as they perform functional activities (Local Consensus)(5).
  - Consideration of the individual’s overall joint laxity with range of motion considerations will mitigate risk of over-extension or damage to the graft (Local Consensus)(5).

C. Strength and Muscle Performance
- Quadriceps sets, gluteal sets
- Neuromuscular re-education with electrical stimulation (Snyder-Mackler, Delitto et al. 1994)(2b) at 60° of knee flexion (Table 4)
- Flexion and abduction straight leg raise (SLR), emphasis on reducing extensor lag
  - Relax quadriceps between repetitions to improve quality of quadriceps contraction

NMES pads are placed to the proximal and distal quadriceps as shown here.

The patient is to be secured in a seated position with the knee in about 60° of flexion. This may vary depending on pain and co-morbidities. The ankle pad should be two finger widths above the superior portion of the lateral malleoli.

The patient is instructed to relax while the e-stim generates at least 50% of their max volitional contraction against a fixed resistance.

D. Weight Bearing and Joint Loading
- WBAT: ***WB status will vary with meniscal repair***
  - You MUST confirm with surgeon if their WB status is not documented in the chart
  - Lower extremity (LE) weight shifts with crutches per tolerance, progressing to unsupported weight shifts
• Gait training: focus on equal weight distribution bilaterally
  - Begin ambulation with two crutches, then progress to one crutch and no support as able
  - Evaluate for symmetrical joint loading during stance phase, heel strike with full knee extension at initial contact, appropriate push-off at toe off

E. Neuromuscular Control
• Gait training: Level surface training to ensure proper propulsion and weight acceptance strategy; avoid hip circumduction strategy; avoid flexed-knee posturing and encourage normal use of available knee ROM including knee extension at initial contact
• Use of biofeedback for quadriceps activation

Goals to Progress to Next Phase

A. Pain and Effusion
  1. Effusion: ≤ 2+ (effusion can at least be swept out of medial sulcus)

B. Range of Motion
  1. ROM ≥ 0-90º - achieve and maintain knee extension symmetrical with other side

C. Strength and Muscle Performance
  1. Quadriceps setting with normal superior patellar glide
  2. SLR x 10 seconds without extensor lag

D. Weight Bearing and Joint Loading
  1. Patient is able to tolerate full WB without increased pain or 3+ effusion

E. Neuromuscular Control
  1. Patient able to walk with assistive device, without obvious deviations on observation

SUBACUTE PHASE OF REHABILITATION

Weeks 2-4

A. Pain and Effusion
• Ice/cryotherapy, compression, elevation to reduce post-operative effusion
• Patellar taping or strapping to reduce patellofemoral symptoms with increasing therapeutic exercise intensity

B. Range of Motion
• Continue passive, active-assisted, and active ROM as tolerated
  - Biking (no resistance): bike with full revolutions per precautions
    - Meniscal repairs: no forced flexion beyond 90º
  - Towel stretching, prone hangs, ‘bag hangs’ to achieve and maintain knee extension symmetrical to the contralateral limb (Adams, Logerstedt et al. 2012)(3b)
    - Symmetrical extension (including hyperextension) is a goal for all patients.
    - For individuals with excessive general joint laxity, modify or avoid aggressive stretching tactics early in the rehabilitation period. These patients will often regain symmetrical hyperextension as they perform functional activities (Local Consensus)(5).
• Consideration of the individual’s overall joint laxity with range of motion considerations will mitigate risk of over-extension or damage to the graft (Local Consensus)(5).

- Patellar mobilization, especially superior and inferior
- Stretching program
  - Gentle quadriceps stretching and hamstring stretching
  - Gastrocnemius/soleus stretching

C. Strength and Muscle Performance
• Quadriceps sets, gluteal sets
• Neuromuscular re-education with electrical stimulation (Snyder-Mackler, Delitto et al. 1994)(2b) and/or biofeedback
• Flexion and abduction SLR, emphasis on reducing extensor lag
  - Relax quadriceps between repetitions to improve quality of quadriceps contraction
• Step-ups (2” starting height) progressed without increased pain and with good technique
• Partial ROM wall sits
• Begin trunk and lumbo-pelvic strengthening
  - E.g. bridging, planks, pelvic tilts, teach abdominal bracing

D. Weight Bearing and Joint Loading
• Gait training – focus on equal weight distribution and transfer between limbs
• Exercises emphasizing reconstructed-limb loading
  - Single leg balance: progress to eyes closed
  - Single leg balance with contralateral leg multidirectional hip (Steamboats)
  - SLR (multi-directional) without extensor lag
  - Mini-squats emphasizing equal WB between limbs
  - Heel/toe raises
  - Shuttle (90° – 0°)
    - Bilateral to single-leg presses per patient tolerance and good mechanics/control
    - Increase resistance per patient tolerance (pain and reactive joint effusion)

E. Neuromuscular Control
• Terminal knee extension exercise with theraband and/or electrical stimulation to activate quadriceps
• Mini-squats
• Gait training emphasizing avoidance of flexed or stiff-knee gait and normal push-off with gastrocnemius/soleus complex to restore normal gait speed and cadence.

Goals to Progress to Next Phase

A. Pain and Effusion
  1. Effusion: ≤ 2+ (effusion can at least be swept out of medial sulcus)

B. Range of Motion
  1. AROM ≥ 0-120° - achieve and maintain knee extension symmetrical with other side

C. Strength and Muscle Performance
  1. Weighted SLR x 10 seconds without extensor lag
  2. Isometric quadriceps strength ≥ 40% contralateral limb
D. Weight Bearing and Joint Loading
1. Patient is able to tolerate current closed kinetic chain (CKC) therapeutic exercise program without increased pain and ≤ 2+ effusion

E. Neuromuscular Control
1. Patient able to walk on level surfaces without assistive device and without obvious deviations on observation
2. Patient able to stand on single-leg at least 30 seconds without loss of balance

Weeks 4-6
A. Pain and Effusion
- Ice/cryotherapy, compression, elevation to reduce post-operative effusion
  - McConnell taping or strapping to reduce patellofemoral symptoms with increasing therapeutic exercise intensity

B. Range of Motion
- Continue passive, active-assisted, and active ROM as tolerated
  - Biking: bike with full revolutions per precautions
    - Meniscal repairs: no forced flexion beyond 90º
    - ***Concerns with limited ROM need to be addressed directly with surgeon***
- Maintain full knee extension symmetrical to contralateral limb
  - Begin more aggressive extension ROM stretching techniques (i.e. weighted bag hang) as needed in younger patients with >10º of recurvatum in the uninvolved limb
- Patellar mobilizations continued as needed

C. Strength and Muscle Performance
- Neuromuscular re-education with electrical stimulation (Snyder-Mackler, Delitto et al. 1994) (2b) and/or biofeedback for emphasis on regaining quadriceps strength
- Multi-angle weighted SLR
- Resistance exercises for gluteal strengthening
  - Resisted side stepping, and backward walking
  - Clamshells, reverse clamshells
- Flexion and abduction SLR, emphasis on reducing extensor lag
  - Relax quadriceps between repetitions to improve quality of quadriceps contraction
- Progressive resistance quadriceps and hamstring exercises
  - Lunges in protected range
  - Progress WB/CKC (shuttle, aquatics, Total Gym, etc.) strengthening
    - NO JOGGING OR SINGLE-LEG PLYOMETRICS
  - Mini squats on BOSU with upper extremity (UE) assist as needed
- Progress gait training if abnormal (unlevel surfaces)
- Continue trunk and lumbosacral strengthening

D. Weight Bearing and Joint Loading
- Gait training – focus on equal weight distribution and transfer between limbs
- Exercises emphasizing reconstructed-limb loading
  - Single leg balance: progress to eyes closed
  - Single leg balance with contralateral leg multidirectional hip (Steamboats)
  - Heel/toe raises
  - Shuttle (90º – 0º)
    - Bilateral to single-leg presses per tolerance and good mechanics/control
    - Increase resistance per tolerance (pain and reactive joint effusion)
E. Neuromuscular Control

- Continue to emphasize strong quadriceps contraction with all activities
  - Single limb terminal knee extension with theraband and/or electrical stimulation to activate quadriceps
- Step-ups progressed to step downs (heel touch), beginning with 2” step
  - May vary dependent on patellofemoral complaints.
  - Progress height as tolerated (no reactive effusion, good technique, no pain)
- Treadmill walking to emphasize normal gait at controlled speed.

Goals to Progress to Next Phase

A. Pain and Effusion
1. Effusion: ≤ 2+ (effusion can be swept out of medial sulcus)
2. Patient is able to perform therapeutic exercise program and ADLs without patellofemoral pain symptoms

B. Range of Motion
1. Full, pain-free AROM is equal to contralateral limb (CONTACT SURGEON IF ABNORMAL)
2. Normal patellofemoral mobility
3. LE flexibility is equal bilaterally

C. Strength and Muscle Performance
1. Isometric quadriceps strength ≥ 60% contralateral limb

D. Weight Bearing and Joint Loading
1. Patient is able to tolerate therapeutic exercise program without increased pain or effusion grade

E. Neuromuscular Control
1. Patient demonstrates normal mechanics without pain during reciprocal stair climbing and descent.

F. Other
1. Knee Outcome Survey Activities of Daily Living Scale (KOS-ADLS) and Global Rating score (GRS) ≥ 50% (Appendix B)

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MIDDLE PHASE OF REHABILITATION

Weeks 6-8

A. Pain and Effusion
- Ice/cryotherapy, compression, elevation to reduce reactive effusion following exercise
- Patellar taping or strapping to reduce patellofemoral symptoms with increasing therapeutic exercise intensity

B. Range of Motion
- Continue biking as warm-up activity
- Maintain normal knee AROM and patellofemoral mobility
- Continue flexibility program of the LE (see Weeks 2-4)
C. Strength and Muscle Performance
- Neuromuscular re-education with electrical stimulation (Snyder-Mackler, Delitto et al. 1994) (2b) and/or biofeedback
- Progress weightbearing strengthening exercises
  - Lunges, shuttle, steamboats, sidestepping, leg press, squats, etc.
- Step-ups and step downs (heel touch)
  - Height of step, number of repetitions/steps may vary dependent on patellofemoral complaints.
  - Progress height as tolerated (no reactive effusion, good technique, no pain)
- Continue trunk and lumbosacral strengthening
- Begin sub-maximal leg extensions, 90° - 45° only
- Begin bilateral shuttle jumping ≤ 50% body weight (shuttle, Total Gym, etc.)
- Work on endurance with low impact activities
  - Treadmill walking, stepper, elliptical

D. Weight Bearing and Joint Loading
- Gait training – focus on normal weight transfer between limbs
- Exercises emphasizing reconstructed-limb loading
  - Single leg balance (progress difficulty with change in support surface, e.g. Airex pad)
  - Single leg balance with contralateral leg multidirectional hip (Steamboats)
  - Single leg heel raises
  - Shuttle (90° – 0°)
    - Single-leg presses per tolerance and good mechanics/control
    - Increase resistance per tolerance (pain and reactive joint effusion)

E. Neuromuscular Control
- Progress single leg balance activities
  - With distraction (ball toss)
  - On dynamic surfaces (airex, dyna disc, BOSU, etc.)
  - Eyes closed
- Walking lunges, single leg sit → stand with focus on avoiding out-of-plane motions of the hip, knee, and ankle
- Begin bilateral shuttle jumping ≤ 50% body weight (shuttle, Total Gym, etc) emphasizing symmetry in landing and take-off phases

Goals to Progress to Next Phase

A. Pain and Effusion
1. Effusion: ≤ 1+ (effusion can be swept out of medial sulcus and returns only with lateral sweep)

B. Range of Motion
1. Maintain full, pain-free AROM equal to contralateral limb
2. Maintain normal patellofemoral mobility
3. Maintain LE flexibility = bilaterally

C. Strength and Muscle Performance
1. Isometric quadriceps strength ≥ 70% contralateral limb
D. Weight Bearing and Joint Loading
1. Patient is able to tolerate therapeutic exercise program without increased pain or 2+ effusion

E. Neuromuscular Control
1. Patient demonstrates control of out-of-plane hip, knee, and ankle motion with all CKC exercise and early jumping activities

Weeks 8-10

A. Pain and Effusion
- Continue with ice, compression, taping as needed to control reactive effusion or pain

B. Range of Motion
- Continue with exercise bike and stretching

C. Strength and Muscle Performance
- Initiate isolated hamstring strengthening per tolerance.
  - Leg curl
  - Stool scoots
  - Deadlifts
- Initiate partial weight bearing (PWB) jogging on shuttle
- Progress LE and trunk strength and stability exercises
  - Progress step downs from 2-4” height
  - Emphasis on appropriate mechanics, avoid dynamic valgus

D. Weight Bearing and Joint Loading
- Emphasize normal motion and weight transfer between limbs during all activities
- Emphasize reconstructed-limb loading
  - Single leg balance (progress difficulty with change in support surface, e.g. Airex pad)
  - Single leg balance with contralateral leg multidirectional hip (Steamboats)
  - Single leg heel raises
  - Shuttle (90° – 0°)
    - Single-leg presses per tolerance and good mechanics/control
    - Increase resistance per tolerance (pain and reactive joint effusion)

E. Neuromuscular Control
- Progress single leg balance activities
  - With distraction (ball toss)
  - On dynamic surfaces (airex, dyna disc, BOSU, etc.)
  - Eyes closed
- Walking lunges, single leg sit → stand with focus on avoiding out-of-plane motions of the hip, knee, and ankle
- Begin bilateral shuttle jumping ≤ 50% body weight (shuttle, Total Gym, etc) emphasizing symmetry in landing and take-off phases

Goals to Progress to Next Phase

A. Pain and Effusion:
\[ \leq 1+ \] (effusion can be swept out of medial sulcus and returns only with lateral sweep)
B. Range of Motion
   1. Maintain full, painfree AROM is symmetrical to contralateral limb
   2. Maintain normal patellofemoral mobility
   3. Maintain LE flexibility equal bilaterally

C. Strength and Muscle Performance
   1. Isometric quadriceps strength ≥ 80% contralateral limb

D. Weight Bearing and Joint Loading
   1. Patient is able to tolerate full WB without increased pain or 2+ effusion

E. Neuromuscular Control
   1. Patient demonstrates control of out-of-plane hip, knee, and ankle motion with all CKC exercise and early jumping activities

Weeks 10-12

A. Pain and Effusion
   - Continue with ice, compression, taping as needed to control reactive effusion or pain

B. Range of Motion
   - Maintain ROM symmetrical to contralateral limb

C. Strength and Muscle Performance
   - Full weight bearing (FWB) plyometrics
     - Progress from straight-plane to diagonal/rotation exercise
   - Strength progression stable to unstable surface
     - Emphasis on quadriceps, hamstring and trunk dynamic stability
   - Challenge PWB plyometrics via shuttle
     - Progress rotational and single leg jumping activities
   - Initiate walk-jog progression
     - Criteria to initiate jogging
       - ≥ 7/10 on #10 IKDC Questionnaire (Appendix A)
       - 20 heel touches with good alignment
       - Hop downs with appropriate landing mechanics
       - Normalized ROM
       - Audible rhythmic strike patterns and no gross visual antalgia
   - Begin agility exercises between 50-75% (utilize visual feedback to improve mechanics)
     - Side shuffling
     - Hopping
     - Carioca
     - Figure 8
     - Zig-zags
     - Resisted jogging (Sports Cord) in straight planes, etc
     - Back pedaling

Goals to Progress to Next Phase

A. Pain and Effusion
   1. Effusion: ≤ 1+ (effusion can be swept out of medial sulcus and returns only with lateral sweep)
B. Range of Motion
1. Maintain full, pain-free AROM symmetrical to contralateral limb
2. Maintain normal patellofemoral mobility
3. Maintain LE flexibility to symmetrical bilaterally

C. Strength and Muscle Performance
1. Isometric quadriceps strength ≥ 80% contralateral limb

D. Weight Bearing and Joint Loading
1. Patient is able to tolerate therapeutic exercise program, including jogging progression, without increased pain or 2+ effusion

E. Neuromuscular Control
1. Patient able to demonstrate control of (lack of) out-of-plane hip, knee, and ankle motion with all therapeutic exercise activities, bilaterally (i.e. good dynamic limb stability)

G. Other
1. ≥ 7/10 on #10 IKDC Questionnaire (Appendix A)
2. KOS-ADLS and GRF scores ≥ 80% (Appendix B)

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**LATE PHASE OF REHABILITATION**

Weeks 12-16

A. Pain and Effusion
- Patient should not have pain during activities in physical therapy, may have reactive pain from increased activity

B. Range of Motion
- Maintain ROM symmetrical to contralateral limb, and continue pre-exercise warm up

C. Strength and Muscle Performance
- Emphasize performance of the quadriceps, hamstrings and trunk dynamic stability
- Emphasize muscle power generation and absorption
- Focus on activities that challenge muscle demand in intensity, frequency, and duration of activity
- Emphasize sport- and position-specific activities
- Consider
  - Double leg and single leg activities and transitions
  - Vary planes of movement and change of direction
  - Perturbations and alter support surface (indoor and outdoor)
  - Challenge multiple muscle groups (lower extremity and core) simultaneously
- Examples:
  - Weight lifting: squats, leg extension, leg curl, leg press, deadlifts
  - Lunges-forward, backward, rotational
  - Crunches, rotational trunk exercises on static and dynamic surfaces
  - Monster walks with theraband resistance
  - Walking lunges with theraband resistance
  - Unilateral shuttle jumping with increasing resistance and mid-air rotations
D. Weight Bearing and Joint Loading

- Continue jogging progression
  - Vary distance, speed, distance, surface as needed for sport-specific return
- Emphasize appropriate symmetry in weight-bearing, joint loading and technique during performance of all therapeutic activities and plyometrics.
- Emphasize sport- and position-specific activities
- Consider
  - Impact loading and appropriate attenuation strategy, cue regarding “hard” landings
  - Double leg and single leg activities and transitions
  - Vary planes of movement and change of direction
- Examples
  - Single-leg hop downs from increasing height (up to 12” box)
  - Single-leg hop-holds (stable surface → Airex pad)
  - Double and single-leg hopping onto unstable surface (i.e. Airex pad)
  - Tuck jumps (focus on increasing multi-joint flexion during landing and holding stable position)

E. Neuromuscular Control

- Advance plyometrics, focus on high-level, sport- and position-specific tasks
- Challenge intensity, frequency and duration of activities
- Challenge power generation and impact attenuation
  - Cue patient regarding “hard landings”, focus on appropriate muscle activation without compensation and without co-contraction
- Consider
  - Double leg and single leg activities and transitions
  - Vary planes of movement and change of direction
  - Perturbations and alter support surface (indoor and outdoor)
  - Challenge multiple muscle groups (lower extremity and core) simultaneously
  - Add sequential and simultaneous activities
  - Focus on sport-specific activities by adding ball, racquet, stick, etc to drills and activities
- Examples
  - Double and single-leg jump-turns, progressing from 90° → 180°, clockwise and counterclockwise
  - Repeated tuck jumps (focus on increasing multi-joint flexion during landing and holding stable position)
  - Single-leg squats on BOSU, with manual perturbation to trunk or legs
  - Single-leg BOSU, balance progress to single-leg BOSU, Romanian deadlift

Goals to Progress to Next Phase
1. Functional Test

- Single –leg and 3 cross-over hop test for distance (within 15% of uninvolved limb) (Appendix B)
2. Isokinetic Testing*

Position the patient as follows:

The patient is to be secured in a seated position with the knee in 90 degrees of flexion. This may vary depending on pain and co-morbidities. The ankle pad should be two finger widths above the superior portion of the lateral malleoli. Trunk and pelvic straps should be secured prior to practice attempts.

The patient is given 2-3 practice attempts to ‘kick as hard as they can’ against the statically positioned arm of the dynamometer. Once they feel comfortable with the task, 2 trials of a 3 second isometric contraction will be documented and averaged, and compared between limbs.

- Side to side symmetry isokinetic peak torque with knee extension and knee flexion (within 15% at 60º/sec, 180º/sec and 300º/sec)
- Quadriceps to hamstring isokinetic strength ratio ≥ 60%

*Please contact OSUMC Sports Medicine to schedule test @ 4 months post-op if your clinic does not have isokinetic equipment or with any questions (614-293-2385)

3. Complete sport specific drills without exacerbation of symptoms or reactive effusion
RETURN TO ACTIVITY PHASE OF REHABILITATION
Activity Specific Training

Physical therapist / athletic trainer should educate the patient, coach, parents, etc on expectations for full return to activity on a PER PATIENT basis, dependent upon many factors, including objective measures of neuromuscular performance as detailed below.

In this sports specific phase, the physical therapist / athletic trainer should work with the patient and coaches, parents, etc to provide a criterion-based, goal-oriented and safe return to activity.

Months 4-9, or as objective criterion are met

Criterion for entry into Return to Sport Phase (Table 4) (Schmitt L 2010) (5)

<table>
<thead>
<tr>
<th>A. Successful completion of rehabilitation program based on clinical judgment or companion evidence-based care guidelines◊</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Results of functional evaluation</td>
</tr>
<tr>
<td>Pain</td>
</tr>
<tr>
<td>Effusion</td>
</tr>
<tr>
<td>ROM</td>
</tr>
<tr>
<td>Strength</td>
</tr>
<tr>
<td></td>
</tr>
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<td></td>
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<tr>
<td>Report-based Functional tests</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Performance-based Functional tests</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

◊ Based on evaluation findings and clinical judgment, some patients may directly enter this phase without prior participation in rehabilitation.

AROM = active range of motion; FAAM = Foot and Ankle Ability Measure; HOS = Hip Outcome Score; IKDC = International Knee Documentation Committee subjective knee function instrument; LSI = limb symmetry index; MMT = manual muscle test; ROM = range of motion; QF = quadriceps femoris; SL = single leg

General Considerations for Return to Sport (Schmitt L 2010)(5):

- Most patients do NOT return to previous levels of activity until 1 YEAR AFTER THEIR ACL RECONSTRUCTION!

- Risk of second ACL injury is highest in the first 7-8 months after surgery (Laboute, Savalli et al. 2010)(3) and higher in female athletes (Paterno, Rauh et al. 2012) (3).

- The expected outcome of this phase is successful transition of the patient from end stage rehabilitation to safe participation in sports with minimal risk of injury (Schmitt L 2010)(5).
• This phase is involves **collaboration between the rehabilitation specialist in the clinic and provider on the field** in an effort to transition from the clinic to field-specific training. The rehabilitation specialist in the clinic should work with other sports medicine professionals, the patient, coaches, and parents etc to provide a criterion-based, goal-oriented and safe return to activity.

• **Open communication** among the healthcare team (including therapist, athletic trainer, physician), coaches/trainers, and patient/family is critical. The rehabilitation specialist in the clinic should coordinate with the coaches, parents, and other sports medicine professionals to establish **expectations for full return to activity on a PER PATIENT basis** dependent upon many factors, including objective measures of neuromuscular performance as detailed below.

• Progression through this phase of rehabilitation should **rely on sound clinical judgment and achievement of criterion-based objective measures.**

A. Pain and Effusion
   • Resolved during all activities
   • Continue with ice, compression, taping as needed to control reactive effusion or pain

B. Range of Motion
   • Maintain ROM symmetrical to contralateral limb and continue pre-exercise warm up

C. Strength and Muscle Performance
   • Emphasis on quadriceps, hamstring and trunk dynamic stability and power generation
   • Focus on activities that challenge muscle demand in intensity, frequency and duration of activity
   • Emphasize sport- and position-specific activities
   • Emphasize neuromuscular symmetry (strength, landing mechanics, etc)
   • Progress to 100% effort per tolerance
   • Consider
     - Emphasize power and change of direction
     - Double leg and single leg activities and transitions
     - Vary planes of movement and change of direction
     - Perturbations and alter support surface (indoor and outdoor surfaces)
     - Challenge multiple muscle groups (lower extremity and core) simultaneously
   • Examples:
     - Weight lifting: squats, leg extension, leg curl, leg press, deadlifts
     - Lunges-forward, backward, rotational
     - Crunches, rotational trunk exercises on static and dynamic surfaces
     - Monster walks with theraband resistance
     - Walking lunges with theraband resistance
     - Unilateral shuttle jumping with increasing resistance and mid-air rotations

D. Weight Bearing and Joint Loading
   • Continue jogging progression - vary distance, speed, distance, surface, as needed for sport-specific return
   • Emphasize appropriate symmetry in weight-bearing and technique during performance of all therapeutic activities and plyometrics.
   • Emphasize sport- and position-specific activities
   • Progress to 100% effort per tolerance
• Consider
  - Impact loading and appropriate attenuation strategy, cue regarding “hard” landings
  - Double leg and single leg activities and transitions
  - Vary planes of movement and change of direction

• Examples
  - Single-leg hop downs from increasing height (up to 12” box)
  - Single-leg hop-holds (stable surface $\rightarrow$ Airex pad)
  - Double and single-leg hopping onto unstable surface (i.e. Airex pad)

E. Neuromuscular Control

• Advance plyometrics, focus on high-level, sport- and position-specific tasks
• Challenge intensity, frequency and duration of activities
• Challenge power generation and impact attenuation
  - Cue patient regarding “hard landings”, focus on appropriate muscle activation without compensation and without co-contraction
• Advance to 100% effort, per tolerance
• Consider
  - Double leg and single leg activities and transitions
  - Vary planes of movement and change of direction
  - Perturbations and alter support surface (indoor and outdoor)
  - Challenge multiple muscle groups (lower extremity and core) simultaneously
  - Add sequential and simultaneous activities
  - Focus on sport-specific activities by adding ball, racquet, stick, etc to drills and activities
• Examples
  - Double and single-leg jump-turns, progressing from 90° $\rightarrow$ 180°, clockwise and counterclockwise
  - Repeated tuck jumps (focus on increasing multi-joint flexion during landing and holding stable position)
  - Single-leg squats on BOSU with manual perturbation to trunk or legs
  - Single-leg BOSU balance progress to single-leg BOSU Romanian deadlift
Goals to Return to Sport (Table 5)

1. Full pain-free ROM equal to contralateral limb
2. No reactive effusion or instability with sport-specific activity
3. Functional Test
   a. ≥ 90% symmetry with hop testing (Appendix D)
   b. ≥ 90% on KOS-ADLS and GRS self-report measures testing (Appendix B)
   c. ≥ age- and sex-matched norms on IKDC (Appendix C)
4. Isokinetic Testing*
   a. Side to side symmetry isokinetic peak torque with knee extension and knee flexion (within 10% at 60º/sec, 180º/sec and 300º/sec)
   b. Quadricep to hamstring isokinetic strength ratio ≥ 60% (bilaterally)
5. Physician Clearance

Table 5: Criteria for Unrestricted Activity Participation

<table>
<thead>
<tr>
<th>A. Successful reintegration into desired activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Results of functional evaluation</td>
</tr>
<tr>
<td>Pain</td>
</tr>
<tr>
<td>• Resolved during all activities</td>
</tr>
<tr>
<td>Effusion Strength</td>
</tr>
<tr>
<td>• Resolved during all activities</td>
</tr>
<tr>
<td>• QF and HS ≥ 90% of the uninvolved (measured with dynamometer)</td>
</tr>
<tr>
<td>• For hip/ankle injuries, relevant musculature ≥ 90% of the uninvolved (measured with dynamometer)</td>
</tr>
<tr>
<td>• MMT: 5/5 for relevant musculature</td>
</tr>
<tr>
<td>Report-based Functional tests</td>
</tr>
<tr>
<td>• For knee involvement, IKDC score ≥ 85</td>
</tr>
<tr>
<td>• For hip involvement, HOS score ≥ 85</td>
</tr>
<tr>
<td>• For ankle involvement, FAAM score ≥ 85</td>
</tr>
<tr>
<td>Performance-based Functional tests</td>
</tr>
<tr>
<td>• SL hop tests, LSI ≥ 90</td>
</tr>
<tr>
<td>• One or more of the following criteria◊◊</td>
</tr>
<tr>
<td>1. Drop vertical jump, demonstrate appropriate mechanics</td>
</tr>
<tr>
<td>2. Tuck Jump Assessment, less than 6 flaws</td>
</tr>
<tr>
<td>3. Start Excursion Balance Test, composite reach distance ≥ 94</td>
</tr>
<tr>
<td>• Demonstrate appropriate mechanics during activity-specific maneuvers and drills</td>
</tr>
<tr>
<td>- Limb symmetry</td>
</tr>
<tr>
<td>- Symmetrical and adequate power generation to meet task demands</td>
</tr>
<tr>
<td>- Symmetrical and adequate power absorption to meet task demands</td>
</tr>
<tr>
<td>- Integration of multiple and unanticipated movement patterns</td>
</tr>
</tbody>
</table>

◊◊ Assessment tool chosen depends on clinical judgment with consideration for type of injury and demands of desired activity. FAAM = Foot and Ankle Ability Measure; HOS = Hip Outcome Score; HS = hamstring muscles; IKDC = International Knee Documentation Committee subjective knee function instrument; LSI = limb symmetry index; QF = quadriceps femoris muscles; SL = single limb

*Please contact OSUMC Sports Medicine to schedule test @ 4 months post-op if your clinic does not have isokinetic equipment or with any questions (614-293-2385)
Appendix A

IKDC #10 Question of Function

“How would you rank the function of your knee on the scale of 0 to 10 with 10 being normal, excellent function and 0 being the inability to perform any of your usual daily activities which may include sports?”

FUNCTION PRIOR TO YOUR KNEE INJURY:

<table>
<thead>
<tr>
<th>Couldn’t perform daily activities</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>No limitation in daily activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>□</td>
<td>□</td>
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<td></td>
</tr>
</tbody>
</table>

CURRENT FUNCTION YOUR KNEE:

<table>
<thead>
<tr>
<th>Couldn’t perform daily activities</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>No limitation in daily activities</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>
Appendix B. (Irrgang, Snyder-Mackler et al. 1998)

Knee Outcome Survey
Activities of Daily Living Scale

Patient name: ______________________ KOS: ______________
Today’s Date: ______________________ Global rating: ______
DOB: ______________________

Instructions:

The following questionnaire is designed to determine the symptoms and limitations that you experience because of your knee while you perform your usual daily activities. Please answer each question by checking the one statement that best describes you over the last 1 to 2 days. For a given question, more than one of the statements may describe you, but please mark only the statement which best describes you during your usual daily activities.

Symptoms

To what degree does each of the following symptoms affect your level of daily activity? (check one answer on each line)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>I Do Not Have the Symptom</th>
<th>I Have the Symptom But It Does Not Affect My Activity</th>
<th>The Symptom Affects My Activity Slightly</th>
<th>The Symptom Affects My Activity Moderately</th>
<th>The Symptom Affects My Activity Severely</th>
<th>The Symptom Prevents Me From All Daily Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Stiffness</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Swelling</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Giving Way, Buckling or Shifting of Knee</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Weakness</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Limping</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
## Functional Limitations with Activities of Daily Living

How does your knee affect your ability to… (check one answer on each line)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Activity Is Not Difficult</th>
<th>Activity is Minimally Difficult</th>
<th>Activity is Somewhat Difficult</th>
<th>Activity is Fairly Difficult</th>
<th>Activity is Very Difficult</th>
<th>I am Unable to Do the Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Go up stairs?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Go down stairs?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stand?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kneel on the front of your knee?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squat?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit with your knee bent?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rise from a chair?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How would you rate the **overall function** of your knee during your usual daily activities? (please check the one response that best describes you)

- [ ] Normal
- [ ] Nearly normal
- [ ] Abnormal
- [ ] Severely abnormal

As a result of your knee injury, how would you rate your **current level of daily activity**? (please check the one response that best describes you)

- [ ] Normal
- [ ] Nearly normal
- [ ] Abnormal
- [ ] Severely abnormal

Global Rating:
How would you rate the current function of your knee on a scale from 0 to 100 with 0 being the inability to perform any activity and 100 being your level of knee function prior to your injury, including sports? ___________
Appendix C.

2000 IKDC SUBJECTIVE KNEE EVALUATION FORM

Your Full Name: ________________________________

Today's Date:    /   /    Date of Injury:   /   /    
Day   Month   Year               Day   Month   Year

SYMPTOMS*:
*Grade symptoms at the highest activity level at which you think you could function without significant symptoms, even if you are not actually performing activities at this level.

1. What is the highest level of activity that you can perform without significant knee pain?
   - Very strenuous activities like jumping or pivoting as in basketball or soccer
   - Strenuous activities like heavy physical work, skiing or tennis
   - Moderate activities like moderate physical work, running or jogging
   - Light activities like walking, housework or yard work
   - Unable to perform any of the above activities due to knee pain

2. During the past 4 weeks, or since your injury, how often have you had pain?
   - Never
   - 0 1 2 3 4 5 6 7 8 9 10 Constant
   - No pain
   - 0 1 2 3 4 5 6 7 8 9 10 Worst pain imaginable

3. If you have pain, how severe is it?
   - Not at all
   - Mildly
   - Moderately
   - Very
   - Extremely

4. During the past 4 weeks, or since your injury, how stiff or swollen was your knee?
   - Not at all
   - Mildly
   - Moderately
   - Very
   - Extremely

5. What is the highest level of activity you can perform without significant swelling in your knee?
   - Very strenuous activities like jumping or pivoting as in basketball or soccer
   - Strenuous activities like heavy physical work, skiing or tennis
   - Moderate activities like moderate physical work, running or jogging
   - Light activities like walking, housework, or yard work
   - Unable to perform any of the above activities due to knee swelling

6. During the past 4 weeks, or since your injury, did your knee lock or catch?
   - Yes
   - No

7. What is the highest level of activity you can perform without significant giving way in your knee?
   - Very strenuous activities like jumping or pivoting as in basketball or soccer
   - Strenuous activities like heavy physical work, skiing or tennis
   - Moderate activities like moderate physical work, running or jogging
   - Light activities like walking, housework, or yard work
   - Unable to perform any of the above activities due to giving way of the knee

(Irgang, Anderson et al. 2001)
SPORTS ACTIVITIES:

8. What is the highest level of activity you can participate in on a regular basis?
   - Very strenuous activities like jumping or pivoting as in basketball or soccer
   - Strenuous activities like heavy physical work, skiing or tennis
   - Moderate activities like moderate physical work, running or jogging
   - Light activities like walking, housework or yard work
   - Unable to perform any of the above activities due to knee

9. How does your knee affect your ability to:

<table>
<thead>
<tr>
<th></th>
<th>Not difficult at all</th>
<th>Minimally difficult</th>
<th>Moderately Difficult</th>
<th>Extremely difficult</th>
<th>Unable to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Go up stairs</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. Go down stairs</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>c. Kneel on the front of your knee</td>
<td>☐</td>
<td>☐</td>
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<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>d. Squat</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>e. Sit with your knee bent</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>f. Rise from a chair</td>
<td>☐</td>
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<tr>
<td>g. Run straight ahead</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>h. Jump and land on your involved leg</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>i. Stop and start quickly</td>
<td>☐</td>
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</tr>
</tbody>
</table>

FUNCTION:

10. How would you rate the function of your knee on a scale of 0 to 10 with 10 being normal, excellent function and 0 being the inability to perform any of your usual daily activities which may include sports?

FUNCTION PRIOR TO YOUR KNEE INJURY:

Cannot perform daily activities

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>No limitation in daily activities</th>
</tr>
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</tbody>
</table>

CURRENT FUNCTION OF YOUR KNEE:

Cannot perform daily activities

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>No limitation in daily activities</th>
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</tbody>
</table>
Appendix D.  

FUNCTIONAL TESTS

1.) Single hop for distance: Have the subject line their heel up with the zero mark of the tape measure, wearing athletic shoes. The subject then hops as far as he/she can, landing on the same push off leg, for at least 3 seconds. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trials, recording each distance from the starting point to the back of the heel. Average the distances hopped for each limb. The Limb Symmetry Index = Involved limb time/Uninvolved limb time x100%.

2.) Cross-over hop for distance: The subject lines his heel up at the zero mark of the tape measure and hops 3 times on one foot, crossing fully over the center line each time. Each subject should hop as far forward as he/she can on each hop, but only the total distance hopped is recorded. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trials, recording each distance from the starting point to the back of the heel. Average the distances hopped for each limb. The Limb Symmetry Index = Involved limb time/Uninvolved limb time x100%.

3.) Triple hop for distance: The subject lines his heel up at the zero mark of the tape measure and hops straight ahead 3 times on one foot. Each subject should hop as far forward as he/she can on each hop, but only the total distance hopped is recorded. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trials, recording each distance from the starting point to the back of the heel. Average the distances hopped for each limb. The Limb Symmetry Index = Involved limb time/Uninvolved limb time x100%.

4.) Timed 6-meter hop: The subject lines his heel up at the zero mark of the tape measure and hops, on cue with the tester, as fast as they can the length of the 6-meter tape. The arms are allowed to move freely during the testing, and the subject can continue past the 6-meter mark during testing. Testing time, however, will be recorded as soon as the patient begins the test and will end as soon as their foot crosses the 6-meter mark. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trials. Average the time (in seconds) for each limb. The Limb Symmetry Index = Uninvolved limb time/Involved limb time x100%.

Scoring:
- Begin with the uninvolved leg. If using tape to mark distance, remove it before the next trial to minimize visual cues.
- If patient fails criteria to progress to next phase or return to sport, evaluate and implement appropriate strength/stability/balance exercise strategies. Re-test at 2-4 week intervals.
4.) **Tuck Jump Assessment** (Myer, Paterno et al. 2008)(5), (Klugman, Brent et al. 2011)(5)

<table>
<thead>
<tr>
<th>Date</th>
<th>PRE-TX</th>
<th>MID-TX</th>
<th>POST-TX</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knee and Thigh Motion</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1. Lower extremity valgus at landing</td>
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<tr>
<td>2. Thighs do not reach parallel (peak of jump)</td>
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<tr>
<td>3. Thighs not equal side-to-side (during flight)</td>
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<tr>
<td><strong>Foot Position During Landing</strong></td>
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<tr>
<td>4. Foot placement not shoulder width apart</td>
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<tr>
<td>5. Foot placement not parallel (front to back)</td>
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<tr>
<td>6. Foot contact timing not equal</td>
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<tr>
<td>7. Excessive landing contact noise</td>
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<tr>
<td><strong>Plyometric Technique</strong></td>
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<tr>
<td>8. Pause between jumps</td>
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<tr>
<td>9. Technique declines prior to 10 seconds</td>
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<tr>
<td>10. Does not land in same footprint</td>
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</table>

**TOTAL SCORE**

Instructions: The athlete performs repeated tuck jumps for 10 seconds, starting with the feet 35cm apart in an ‘athletic position.’ The athlete will begin the jump with a small counter movement (slight crouch downwards) as the arms move behind their body, then quickly swing their arms forward as they jump straight up pulling their knees up ‘as high as possible’ so they are parallel with the ground. There should be no pause between jumps and the athlete should use a toe to midfoot rocker landing, trying to land in the same ‘footprint’ they started in. **STOP** the athlete if there is a sharp decline in technique.

### Table 2: Levels of Evidence#

<table>
<thead>
<tr>
<th>Quality Level</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Systematic Review (SR)<em>, meta-analysis</em></td>
</tr>
<tr>
<td>1b</td>
<td>Randomized Controlled Trial (RCT)</td>
</tr>
<tr>
<td>2a</td>
<td>SR of cohort studies</td>
</tr>
<tr>
<td>2b</td>
<td>Single cohort study, poor quality RCT</td>
</tr>
<tr>
<td>3a</td>
<td>SR of case-control studies</td>
</tr>
<tr>
<td>3b</td>
<td>Single case-control study</td>
</tr>
<tr>
<td>4</td>
<td>Case series; poor quality case-control or cohort studies</td>
</tr>
<tr>
<td>5</td>
<td>Expert Opinion</td>
</tr>
</tbody>
</table>

*a* = good quality study  
*b* = lesser quality study  
* = quality level of these studies is dependent upon the studies included in the analysis/review. (e.g. Systematic review of Level 1 RCTs = Level 1a evidence)

# Development of this table based on:  
Oxford Centre for Evidence-based Medicine – Levels of Evidence (March 2009).  

### Table 2: Principles of Healing

<table>
<thead>
<tr>
<th>Tendon</th>
<th>0-3 days</th>
<th>4-14 days</th>
<th>3-4 wks</th>
<th>5-7 wks</th>
<th>2-3 mo</th>
<th>3-6 mo</th>
<th>6-12 mo</th>
<th>Up to 2 yrs</th>
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</thead>
<tbody>
<tr>
<td>Tendinitis Lacerations</td>
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</table>

<table>
<thead>
<tr>
<th>Muscle</th>
<th>0-3 days</th>
<th>4-14 days</th>
<th>3-4 wks</th>
<th>5-7 wks</th>
<th>2-3 mo</th>
<th>3-6 mo</th>
<th>6-12 mo</th>
<th>Up to 2 yrs</th>
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</thead>
<tbody>
<tr>
<td>Exercise-induced Grade I</td>
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<td></td>
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<tr>
<td>Grade II</td>
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<tr>
<td>Grade III</td>
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<table>
<thead>
<tr>
<th>Ligament</th>
<th>0-3 days</th>
<th>4-14 days</th>
<th>3-4 wks</th>
<th>5-7 wks</th>
<th>2-3 mo</th>
<th>3-6 mo</th>
<th>6-12 mo</th>
<th>Up to 2 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
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<tr>
<td>Grade II</td>
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<tr>
<td>Grade III</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Ligament Graft</th>
<th>0-3 days</th>
<th>4-14 days</th>
<th>3-4 wks</th>
<th>5-7 wks</th>
<th>2-3 mo</th>
<th>3-6 mo</th>
<th>6-12 mo</th>
<th>Up to 2 yrs</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Meniscus/Labrum</th>
<th>0-3 days</th>
<th>4-14 days</th>
<th>3-4 wks</th>
<th>5-7 wks</th>
<th>2-3 mo</th>
<th>3-6 mo</th>
<th>6-12 mo</th>
<th>Up to 2 yrs</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bone</th>
<th>0-3 days</th>
<th>4-14 days</th>
<th>3-4 wks</th>
<th>5-7 wks</th>
<th>2-3 mo</th>
<th>3-6 mo</th>
<th>6-12 mo</th>
<th>Up to 2 yrs</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Articular Cartilage Repair</th>
<th>0-3 days</th>
<th>4-14 days</th>
<th>3-4 wks</th>
<th>5-7 wks</th>
<th>2-3 mo</th>
<th>3-6 mo</th>
<th>6-12 mo</th>
<th>Up to 2 yrs</th>
</tr>
</thead>
</table>

Adapted from Snyder-Mackler and Axe 2005 (Axe and Snyder-Mackler 2005)
Table 3: Modified Stroke Test Grading Criteria (see also Figure 1)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero</td>
<td>No wave produced on downstroke</td>
</tr>
<tr>
<td>Trace</td>
<td>Small wave on medial side with downstroke</td>
</tr>
<tr>
<td>1+</td>
<td>Large bulge on medial side with downstroke</td>
</tr>
<tr>
<td>2+</td>
<td>Effusion spontaneously returns to medial side after upstroke (no downstroke necessary)</td>
</tr>
<tr>
<td>3+</td>
<td>So much fluid that it is not possible to move the effusion out of the medial aspect of the knee</td>
</tr>
</tbody>
</table>

Adapted from (Sturgill, Snyder-Mackler et al. 2009)

Table 4: Parameters for Neuromuscular Electrical Stimulation of the Quadriceps

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse duration/width (microseconds)</td>
<td>300</td>
</tr>
<tr>
<td>Frequency (Hz or pps)</td>
<td>55</td>
</tr>
<tr>
<td>On/off time (seconds)</td>
<td>12-15 on/50 off</td>
</tr>
<tr>
<td>Ramp time (seconds)</td>
<td>2-3</td>
</tr>
<tr>
<td>Treatment time (minutes)</td>
<td>15</td>
</tr>
</tbody>
</table>
FIGURES

Figure 1. Stroke test.

Black arrows represent (A) upstroke and (B) downstroke. Hashed red circle indicates location of effusion with downstroke.

Figure 2. Neuromuscular Electrical Stimulation (NMES) set-up. (Adams 2012)

NMES pads are placed to the proximal and distal quadriceps as shown here.

The patient is to be secured in a seated position with the knee in about 60 degrees of flexion. This may vary depending on pain and co-morbidities. The ankle pad should be two finger widths above the superior portion of the lateral malleoli.

The patient is instructed to relax while the e-stim generates at least 50% of their max volitional contraction against a fixed resistance.
Position the patient as follows:

The patient is to be secured in a seated position with the knee in 90 degrees of flexion. This may vary depending on pain and co-morbidities. The ankle pad should be two finger widths above the superior portion of the lateral malleoli. Trunk and pelvic straps should be secured prior to practice attempts.

The patient is given 2-3 practice attempts to ‘kick as hard as they can’ against the statically positioned arm of the dynamometer. Once they feel comfortable with the task, 2 trials of a 3 second isometric contraction will be documented and averaged, and compared between limbs.
References


