Version 5.0

NEVADA PHYSICAL THERAPY

REHAB/STRENGTH/PERFORMANCE

THE ACL PROJECT

An Updated Anterior Cruciate Ligament Reconstruction Protocol

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ANTERIOR CRUCIATE LIGAMENT REHAB PROTOCOL

Nevada Physical Therapy

Phase 1

Weeks 0-2

Precautions/Common Pitfalls (0-4 weeks):

- **Excessive Weight-Bearing**
- **Pushing through pain during mobility and stability progressions**
- **Rapid progression of exercise volume and intensity**
- **Persistent lack of passive knee extension**

CRUTCH DISCHARGE CRITERIA

- **Symmetrical Passive Knee Extension**
- **Normalized quad contraction with quad setting, ie. "Heel Pop" with quad set.**
- **Able to perform a straight leg raise without an extensor lag**
- **Able to demonstrate normal heel-to-toe mechanics in strike phase of gait without knee flexion "break"**
- **Minimal to no increase in swelling with mobility work and early phase strength training.**

Mobility/Range of Motion:

- Heel Slides
- Assisted Knee Flexion EOT
- Strap Calf Stretch
- Heel Prop Knee Extension

Therapeutic Exercise:

- Quad Isometrics
- Straight Leg Bridge
- TA Pullovers w/ quad set
- Mini Crunches w/ quad set
- Ankle Pumps
- Standing SLR w/ quad set
- Hip ABD w/ quad set (on UNINV)
- Prone Hip Extensions w/ Ball Rollout

Phase 1b

Weeks 3-5

Mobility/Range of Motion (including above)

- Wall Slides
- Bike Rockbacks
- Seated Hamstring Stretch
- Prone Quad Stretch

Therapeutic Exercise (including above)

- Weight Shifts/Wobble Board
- Long Arc Quads/Knee Extensions
- ECC 1L Leg Press
- Mini Squats
- Hip Hinge/RDLs
- Split Squat (INV in front)
- 1L Leg Press
- Low Step Up

Phase 1 Progression Criteria:

- **Equal, normal knee extension compared to non-surgical side**
- **110 degrees of flexion by PO Day 21**
- **Post-operative trauma resolution (decreased swelling week over week)**
- **Ambulate independently without AD with normal knee mechanics**

Phase 2a

Weeks 6-10

Mobility/Range of Motion

- Heel Slides
- Wall Slides
- Strap Calf Stretch
- Heel Prop Extension
- Prone Knee Hang
- Strap HS Stretch
- Prone Quad Stretch

Common Pitfalls

- **Pain with daily activity**
- **Persistent swelling**
- **Subjective complaint of active knee hyperextension moments**
- **Rapid progression of exercise volume and intensity**
- **Decreasing mobility emphasis too soon**

Phase 2 Progression Criteria:

- **Demonstrate ability to reproduce program outside of clinic, consistently and as prescribed.**
- **Normalized passive range of motion in all planes (extension/flexion)**
- **50% Limb Symmetry or greater with hip ABD, Knee Extension testing**
- **Able to complete training session with less than 2 pt increase in pain**

ANTERIOR CRUCIATE LIGAMENT REHAB PROTOCOL

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Phase 2

Weeks 5-8

Therapeutic Exercise

- Lateral Agility/Monster Walks
- 2 Step Drill
- Wall Squats
- KB Front Squats to Box
- KB RDLs
- BB RDLs
- KB Bridge
- Barbell Bridge
- Lunges (INV in front)
- Lateral Step Down
- Low Step Up
- 1L RDLs
- 1L Hip Thruster
- Hip Thrusters
- 2L ABD Bridge
- ECC 1L Squat
- 1L Leg Press
- Calf Raises
- 1L Calf Raises
- ECC 1L Calf Raise
- Soleus Bridge
- Banded HS Curls
- Machine HS Curls
- 90-60 deg Knee Extensions
- 1L Knee Extension (Partials)
- Knee Ext ISOM
- 1L Knee Extensions
- Bent Knee Side Plank
- TA OH Pullovers
- Partial Crunch w/ QS
- Front Plank w/ LE Lift
- Front Planks
- Modified Side Plank
- Pallof Press

General Milestones

- ◊ Normalize Knee EXT PROM: Equal to UNINV limb by 2 weeks
- ◊ Knee FLEX PROM: 90 deg by 2 weeks
- ◊ Knee FLEX PROM: 105-110 deg by 3-4 weeks
- ◊ Knee FLEX PROM: 120 deg by week 5
- ◊ Crutch Discharge Criteria Met by 4-5 weeks
- ◊ Normalize Quad Contraction: “Heel Pop” by 4 weeks
- ◊ Normalize Quad Contraction: SLR with no extensor lag by 4 weeks
- ◊ Peripatellar Swelling: Resolution of post-op trauma by 4 weeks (<+1 edema)
- ◊ Knee PROM >90% flexion, normal symmetrical extension by 8 weeks/End of Phase

Phase 3a

Weeks 9-14

Common Pitfalls

- **Initiating Return to Run protocol prior to skill work**
- **Introducing skill work prior to meeting strength milestones**
- **Failure to use autoregulation/subjective measurements of intensity or similar anchoring**
- **Progressing intensity too quickly**
- **Failure to manage swelling or harvest site pain**
- **Reducing mobility focus too soon**

Therapeutic Exercise (including above)

- Trap bar Deadlifts
- Elevated Deadlifts
- Barbell Back Squats (earlier if well tolerated)
- KB Step Up
- Cossack Lunge
- Bilateral Split Squats
- ECC Hamstring Sliders
- Glute Med Side Plank
- Side Plank Progressions

Phase 3 Progression Criteria:

- **No Subjective Complaints of Instability or Buckling**
- **3 mm or less PA laxity compared to UNINV side**
- **Minimal to No Joint Effusion**
- **>70% Limb Symmetry Knee Extension Isometric Testing**
- **>70% Limb Symmetry with Side Plank Hip ABD Testing**
- **>70% Limb Symmetry with Single Leg Squat Testing**

Mobility/Range of Motion:

- Wall Slides
- Prone Knee Hangs
- Strap Calf Stretch
- Standing Quad Stretch
- ADD/ITB/Quad Foam Roll
- Piriformis/FABER as tolerated
- Standing ITB Stretch
- Standing ADD Stretch

ANTERIOR CRUCIATE LIGAMENT REHAB PROTOCOL

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Phase 3b

Weeks 15-16

SAMPLE SKILL BLOCK 1

Level 1	Level 2
Pogos	1L Lateral Tape Hops
Snap Downs	DBL Wall Switches
Ball Slams	Bulgarian Split Squat Hops
Wall Marches	Decel Lunges
Single Wall Switches	Lean Starts
Bulgarian Split Squat Tempo	

General Milestones

- ◊ Normalize Quad Strength: 50% LSI with isometric testing by 12 weeks
- ◊ Normalize Quad Strength: > .4 ft lb/lb BW by 12 weeks
- ◊ Normalize Hip Strength: 50% LSI with isometric testing by 12 weeks
- ◊ Psychological Readiness: ACL-RSI >40 pts by 12 weeks

Phase 4

Weeks 16-20

Common Pitfalls

- ♦ **Failure to manage tendon/harvest site pain**
- ♦ **Excessive closed chain rotation/pivoting**
- ♦ **Progressing skill development too quickly**

Mobility/Range of Motion:

- ♦ Couch Stretch
- ♦ Standing Quad Stretch
- ♦ ADD/ITB/Quad Foam Roll
- ♦ Piriformis/FABER as tolerated
- ♦ Standing ITB Stretch

Therapeutic Exercise (including above)

- ♦ Deadlifts
- ♦ Reverse Nordics
- ♦ Copenhagen Variations
- ♦ Olympic Lifts
- ♦ Kettlebell Swings
- ♦ Barbell Rollouts
- ♦ Isokinetic/Power Knee Extensions
- ♦ Anterior Step Downs
- ♦ Rack Taps/Pistol Squats

Phase 4 Progression Criteria:

- ♦ **Successful Completion of Return to Running Protocol**
- ♦ **QUAD Torque >.7 ft lb/lb BW or 2.0 N m/kg BW**
- ♦ **HAM Torque >.4 ft lb/lb BW or 1.0 N m/kg BW**
- ♦ **IKDC >70%**
- ♦ **>70% Limb Symmetry Lateral Step Down testing (20% BW load, 12 in box)**
- ♦ **No increase in pain or swelling with current programming.**

General Milestones

- ◊ Knee Stability: 3 mm or less PA Laxity by 16 weeks
- ◊ Normalize Quad Strength: 70% LSI isometric testing by 16 weeks
- ◊ Normalize Quad Strength: >.5 ft lb/lb BW Knee EXT TTBW by 16 weeks
- ◊ Normalize Hip Strength: >70% LSI with Side Plank ABD Testing by 16 weeks
- ◊ Normalize Hip/Knee Strength: 70% LSI with SL Squat to 70 deg knee flexion by 16 weeks
- ◊ Normalize Hip/Knee Strength: <8 cm Ant. Y-Balance Test by 16 weeks

ANTERIOR CRUCIATE LIGAMENT REHAB PROTOCOL

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Phase 5

Weeks 25-36

Common Pitfalls

- **Failure to measure and program for hip and plantarflexion strength**
- **Random skill/plyo selection**
- **Decreasing strength emphasis too early**
- **Programming change of direction work prior to meeting strength criteria**

Therapeutic Exercise (including above)

- No restrictions on lifting

Phase 5 Progression Criteria:

- **QUAD Torque >.8 ft lb/lb BW or 2.4 N m/kg BW**
- **HAM Torque >.5 ft lb/lb BW or 1.5 N m/kg BW**
- **>80% LSI with Quad Power Testing (Isokinetic or RFD)**
- **Hip ABD Torque >.6 ft lb/lb BW, Hip ADD Torque >.7 ft lb/lb BW**
- **Plantarflexion Isometric Testing > 1.3x BW and >90% LSI**
- **IKDC >80%, ACL-RSI >65 pts**
- **>85% Limb Symmetry Lateral Step Down testing (20% BW load, 12 in box)**
- **>85% Limb Symmetry Side Plank Testing (AMRAP)**
- **Anterior Y-Balance <6cm Deficit**
- **Successful completion of Force Plate Battery**

General Milestones

- ◊ Normalize Quad Strength: >.8 ft lb/lb BW Knee EXT TTBW by 6-7 months
- ◊ Normalize Quad Strength: Peak Power >80% LSI by 6-7 months
- ◊ Normalize HS Strength: >.5 ft lb/lb BW Knee FLEX TTBW by 6-7 months
- ◊ Normalize Hip/Knee Strength: <6 cm Ant. Y-Balance Test by 6-7 months
- ◊ Normalize Hip/Knee Strength: >85% LSI with Lateral Step Down Test by 6-7 months
- ◊ Normalize Hip Strength: >85% LSI with Side Plank Hip ABD Testing by 6-7 months
- ◊ Subjective Reporting: IKDC >80% by 6-7 months
- ◊ Psychological Readiness: >65 pts ACL-RSI by 6-7 months

SAMPLE SKILL BLOCK 2

Level 1	Level 2
2L Drop Landing	Skater Hops
Skater Hop ACCEL	Lateral Shuffle
Skater Hop DECEL	Lunge Switches
A Skips	Countermovement Jump
1L Drop Landing	Lateral Bench Overs
Bench Lateral Step Down	Sled Sprints

SAMPLE SKILL BLOCK 3

Level 1	Level 2
1L Assisted Vertical Jump	Reactive 1L Box Jump
2L to 2L Lateral Box Jump	2-1-2 Lateral Box Jump
FWD Sprint to DECEL	1L Vertical Jump
W Sprints	1l to 2L Horizontal Broad Jump
5-0-5 (Frontal Plane)	FWD Sprint to Backpedal to FWD
FWD Sprint to Backpedal	Sprint to Backpedal and Turn
Box Jumps	Sprint to 45 deg Cut

ANTERIOR CRUCIATE LIGAMENT REHAB PROTOCOL

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Phase 6

Month 7-RTS

Common Pitfalls

- **Failure to measure power/RFD**
- **Continuing to progress workload in the presence of knee or secondary symptoms**
- **Inadequate skill emphasis**
- **Arbitrary skill progressions**
- **Failure to meet RTS criteria prior to being cleared for contact**

SAMPLE SKILL BLOCK 4

Level 1		Level 2
Sprint to Lateral Shuffle	1L Broad Jump	Endurance Skill Block
VAIL Lateral Agility	5-10-5	Unanticipated Skill Block
DVJ to Sprint	5-0-5 COD (15 yard)	Sport Specific Block

RETURN TO SPORT BATTERY

Functional Outcome Reporting	>90% IKDC, >72 pts ACL-RSI
A-P Knee Laxity	<4 mm cut-off, goal is <3 mm
Isometric Quad Strength	>1.0 ft lb/lb BW and >90% LSI
Isometric Ham Strength	>.6 ft lb/lb BW and 90% LSI
Ham:Quad Isometric Ratio	>.6 once quad isometric goal met
Isokinetic Quad Strength	>90% LSI @ .25 m/s (Voltra I)
Isometric Hip ABD/ADD Strength	>.6 ft lb/lb BW ABD; >.7 ft lb/lb BW ADD
Isometric Plantarflexion Strength	>1.3x BW cutoff, goal >1.5x BW
Nordic Hamstring Curl	>70 deg break angle
1L Squat Test (10% BW to 70 deg knee flexion, max reps in 30 sec)	>90% LSI
Side Plank Hip ABD (max reps to failure)	>90% LSI
Anterior Y-Balance	<4cm deficit side to side
Lateral Step Down Test (12 in box, 20% BW, max reps in 30 sec)	>90% LSI
Countermovement Jump	♦ <10% concentric impulse asymmetry ♦ >90% BW unweighting with eccentric/braking phase ♦ > 1.2m/s eccentric velocity ♦ Reactive Sport Index (RSI) >.4 m/s
1L Vertical Jump Test	♦ <10% vertical jump height asymmetry ♦ <10% RSI asymmetry
Hop Test	No obvious lateralization with concentric impulse or landing force; goal > 4 “crossovers” with 10 rep test
5-0-5 COD	<10% asymmetry with COD time (entry to exit)
Vail Lateral Agility	4 out 5 or higher score for each 20 second block
Appropriate Workload Established	Athlete has established roughly 70% workload of total in-season demands without restriction
All RTS Criteria Met	Pass/Fail based on meeting goals above

ACL REHAB PROTOCOL

Nevada Physical Therapy

Introduction

Current Anterior Cruciate Ligament Reconstruction (ACLR) rehabilitation protocols often focus on three major tenets: protection of the repair, improving knee range of motion and strength to "within normal limits" and safely returning to sport. Despite hundreds of articles highlighting these points, incidence of re-injury continues to be high and further, it has been demonstrated that even if there is *no* re-injury, only 63% of athletes return to their pre-injury sport and only 55% returned to competitive athletic participation (Ardern et al 2011, Ardern & Fuller, 2014). This suggests that current rehabilitation models and return to sport parameters may be incomplete, may not be addressing the appropriate deficits, or both. At Nevada PT, we are committed to using the best available research in designing and implementing our rehabilitation protocols and the current evidence suggests that the key to successful rehab lies in appreciating the multi-factorial nature of ACL injury and re-injury. Components of the multi-pronged approach we use include:

- Maximum protection of the graft early with specific crutch discharge criteria to minimize potential for increased laxity secondary to suboptimal strength and gait mechanics.
- Objective strength testing for the knee joint utilizing a combination of isometric and isokinetic testing based on normative data when available.
- Progressive functional strength testing as strength and skill levels evolve.
- Frequent testing throughout the rehabilitation process with clear progression criteria between phases.
- Utilization of psychosocial readiness measures in addition to traditional subjective patient reported outcome measures.
- Structured and appropriate skill development in combination of a continuum-based approach to return to sport exposure.

Additionally, we hope to advance the discussion on *when* to clear an athlete to return to play; a complex decision that includes more than just clearing objective testing criteria or as commonly seen, time alone. Finally, an important but rarely explicitly stated component of this rehab is the establishment of an acceptable sport participation workload as an athlete or patient is resuming athletic participation. An athlete should be cleared for contact *prior* to completing the protocol as the final month is focused on establishing a progressive ramp back into full activity exposure. It is potentially counterintuitive that the athlete completes our program once they have actually returned to full athletic activity with both intensity and volume in mind. While the following protocol borrows many tried-and-true rehabilitation theories from the best in sports medicine, it also incorporates modern progressive models to address the above-mentioned goals.

84-91%

Percentage of athletes who believe they will return to their previous level of athletic participation prior to ACL reconstruction.
- Webster & Fuller, 2019

"Nearly 90% of those who met the criteria returned to pivoting sports and were almost six times more likely to do so compared with those who stopped rehabilitation early."
- Kotsifaki et al., 2025

ACL REHAB PROTOCOL

Nevada Physical Therapy

Introduction (cont'd))

One of the primary questions often asked in developing a loading protocol for a patient who has recently had anterior cruciate ligament reconstruction is: How *much* should we be protecting the repair versus loading it? There are multiple studies showing that mechanical loading is an important component to establishing tendon or ligament to bone homeostasis, restoring mineral density of the bone complex, stimulating healing, etc. (Wolff et al 1892; Bedi et al 2010). Bedi et al. investigated the effects of cyclical loading (2% strain x 50 repetitions daily) in surgically repaired ACLs in rats divided into three groups: immediately post-op, 4 days post-op, and 10 days post-op (2010). They found: "*At 4 weeks, the group in which delayed loading had been initiated on postoperative day 4 demonstrated a load to failure that was significantly greater than that in all other groups (13.5N +/- 4N vs 8N +/- 4N, p=0.01)*." It should be noted that conflicting findings have been found in early loading versus immobilization in other animal tendon studies (Sakai et al 2000; Kamps et al 1994) and, as always, further research is needed. Additionally, several studies have demonstrated that early failure of the graft is often from anchor failure as opposed to mid-substance as demonstrated in another rat study where investigators demonstrated the required force for failure doubled from 2 weeks to 4 weeks post-operatively (Brophy et al 2011). It seems that, overall, mechanical loading is an important component to stimulate healing of the repaired bone to tendon or ligament site but there is still much that is unknown on what constitutes optimal loading for healing.

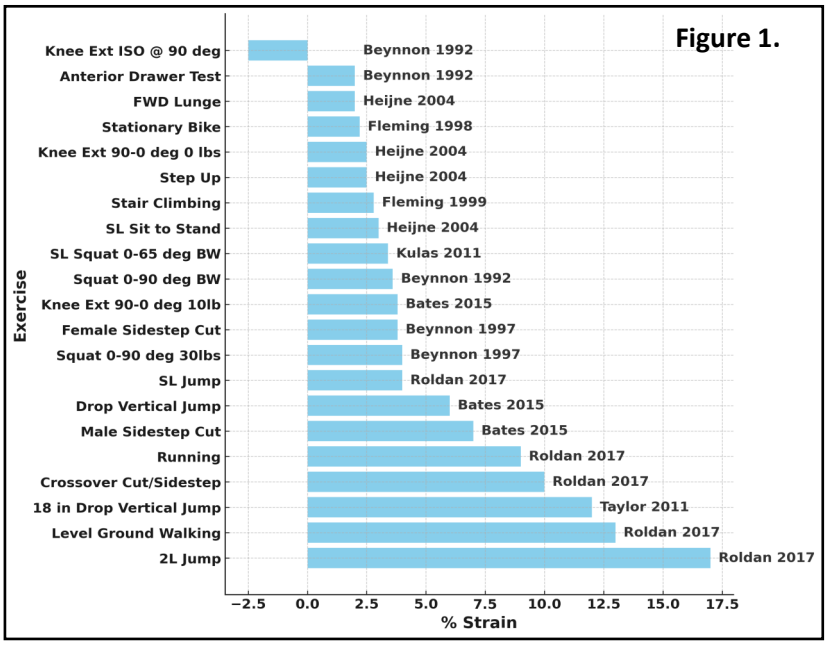
"most rehabilitation protocols do not expose patients to quadriceps strength until 6–12 weeks after ACLR, which has significant consequences for strength scores on RTS tests."

- Welling et al. 2019

"With every step, strain on the ACL is 2 to 3 times the strain of open-chain knee extension with 30 Nm of extension torque at 15° of knee flexion."

-Noehren & Snyder-Mackler, 2020

ACL % Strain with Exercise



While there is very little literature establishing how much (or how little) stress is ideal to stimulate healing in a reconstructed anterior cruciate ligament, we do have a few dozen studies that have investigated the various forces that occur in the ACL during many rehabilitation tasks. Strain, or the lengthening of the ligament while under load, has been organized per the literature in Figures 1 & 2. What is interesting is that almost all non-plyometric movements (i.e. running, jumping, etc.) show a lower strain than seen with level ground walking (Shelbourne et al. 2005, Roldan et al., 2017). It is noteworthy that many of these studies utilized different techniques for establishing strain and stress forces such as 3-D mathematical models, cadaver modeling, motion camera analysis and surgically implanted force transducers which may limit clinical application.

Introduction (cont'd)

In specific reference to this protocol, we maintain limited weight bearing for the first two to 4 weeks to minimize strain on the repair while the acute inflammatory process associated with surgery resolves. You can read more about phase 1 expectations and crutch discharge criteria later in this narrative. At Nevada Physical Therapy, we begin knee extension isometric training early in the process, often before patients are even off their crutches. Early open-kinetic chain training has shown superior knee extension torque strength at both 3 and 6 months compared to classic closed-kinetic chain programming without increase in joint laxity (Forelli et al. 2023) and we test it often throughout the rehab process. As supported by figure 1, we may start OKC exercises such as 90 deg isometrics, various range isotonics, etc. within the first two weeks as these appear to create minimal strain on the repair but may be helpful in restoring quad function early on. Once early phase progression criteria are met, we begin loading the knee in closed-chain progressions consistent with the current evidence regarding strain profiles.

Expectation setting is critical in the early phases as well as throughout the course of rehab. This means explicitly discussing the goals of the first phase, crutch discharge criteria, the therapist's role in the rehab process, etc. As seen in papers published in the hip arthroscopy space (Jones, 2020), a mismatch in the patient's expectations and reality can, and often does, increase the emotional and mental stress in an already stressful experience.

> ***"Quadriceps muscle recovery can only occur if the quadriceps are directly targeted during rehabilitation"***
> **-Noehren & Snyder-Mackler, 2020**

ACL % Strain with Athletic Tasks

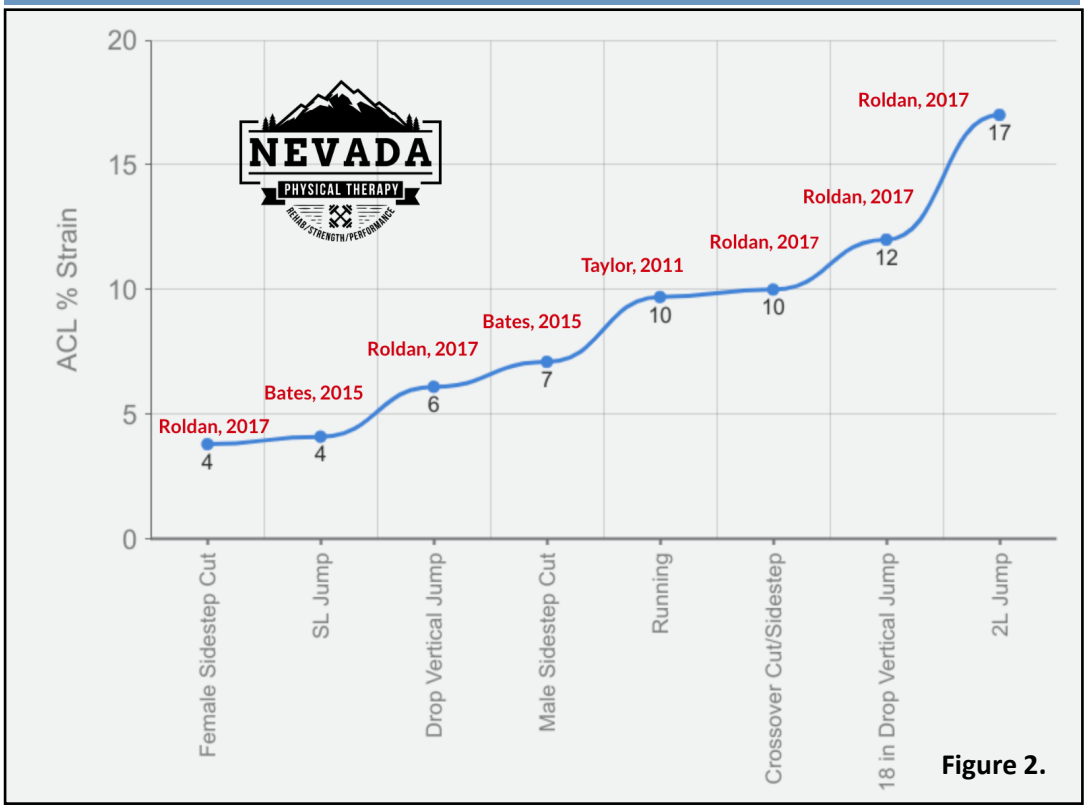


Figure 2.

Note: While these studies are limited by methodological constraints in a similar fashion to the previously mentioned studies on ACL strain, they do allow clinicians to establish an evidence-based protocol when establishing jump skill protocols and progressions. It should be noted, however, that there is limited research from which to draw from and clinical judgment should be exercised.

Introduction (continued)

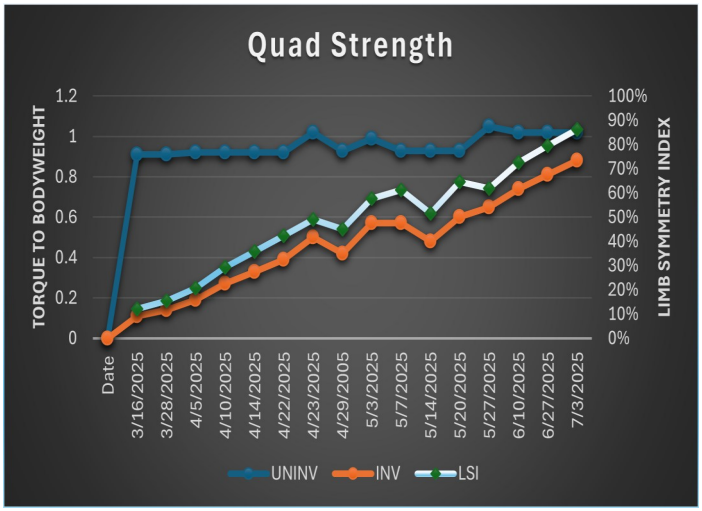
The phases are broken down in more detail below, but the main takeaway from Nevada Physical Therapy's protocol is that there are objective criteria that guide the progressions, not just time and anecdote as seen in nearly half of all currently utilized rehab programs (Burgi et al. 2019). From restoring the quadriceps to lifting to jumping and ultimately to competing, we measure and track objective criteria the entire time an athlete is with us. Once the criteria are met for jump testing, we utilize state-of-the-art force plates to give us the ability to measure thousands of metrics on jump performance (for more detail on our force plate testing, see Appendix B) and we test consistently throughout the rehab program to ensure appropriate skills and capacity are restored. Quality of jumping in a sterile, i.e. controlled, environment is important, but the nature of athletics is anything but controlled. We not only measure and restore normal jumping mechanics but also create an entire skill progression based around the athlete's unique sport demands. This includes unanticipated skill development, fatigue training protocols, and dual task or neurocognitive exposures. Jumping and landing strategies are influenced by the obvious (strength) as well as the less obvious (fear, predictive processing, cognitive load) and more.

Strength Testing– A Side Quest

Torque is defined as "a measure of force causing rotation around an axis" and more specifically, "the rate of change of angular momentum that would be imparted to an isolated body". For the small percentage of clinicians that actually use objective measures for testing, the vast majority use limb symmetry as their primary metric for measuring strength. Limb symmetry is, briefly, comparing the performance of one limb compared to the other (non-involved) limb with the goal of becoming symmetrical over time. Clinicians should be using not only limb symmetry but also aiming for strength standards based on bodyweight ratios as limb symmetry itself may "overestimate knee function" (Wellsandt et al., 2017).

***Percentage of clinicians that use manual muscle testing to assess strength after ACLR.* - Greenberg et al. 2019**

While the early phases may prioritize symmetry, this is defined as "relative strength" (i.e. how strong they are compared to their uninvolved side), this metric should evolve thereafter into "absolute strength" or how strong they *should* be. In a recent study by Van Wyngaarden et al., they found that a 1.0 N·m/kg improvement in torque to bodyweight improved subjective knee reporting indexes by an average of 17 points (2021). This is in support of additional research showing athletes who demonstrated ≥3.10 N·m·kg−1 torque to bodyweight ratio had "over eight times higher odds of reporting an IKDC score ≥90%" (Pietrosimone et al. 2016).



Strength Testing– A Side Quest (cont'd)

Aiming for a standard torque to body weight goal of 2.5-3.0 N·m/kg (converted to roughly 1.0 lb-ft/lb) for knee extension strength has not only been established to improve subjective knee reporting but we also see athletic performance reflect this measure. For example, knee extension weakness has been demonstrated to show poor single leg vertical jump height (Fischer et al. 2017) as well as altered joint force contributions with jump tasks for those athletes who did not meet strength criteria (Graham et al. 2023). Specifically, the surgical knee contributed, on average, 21% less joint power across all jumping tasks compared to the uninvolved knee and compared to controls. Graham et al. found the surgical knee was consistently weaker (1.85 ± 0.53 N·m/kg) than both the uninvolved limb (2.95 ± 0.54 N·m/kg) and when compared to controls (2.49-2.55 ± 0.75-.77 N·m/kg for left and right limbs) in athletes at 6 months post-ACL reconstruction. In fact, over 60% of their participants did not meet minimum torque ratios of 2.1N·m/kg a time of testing.

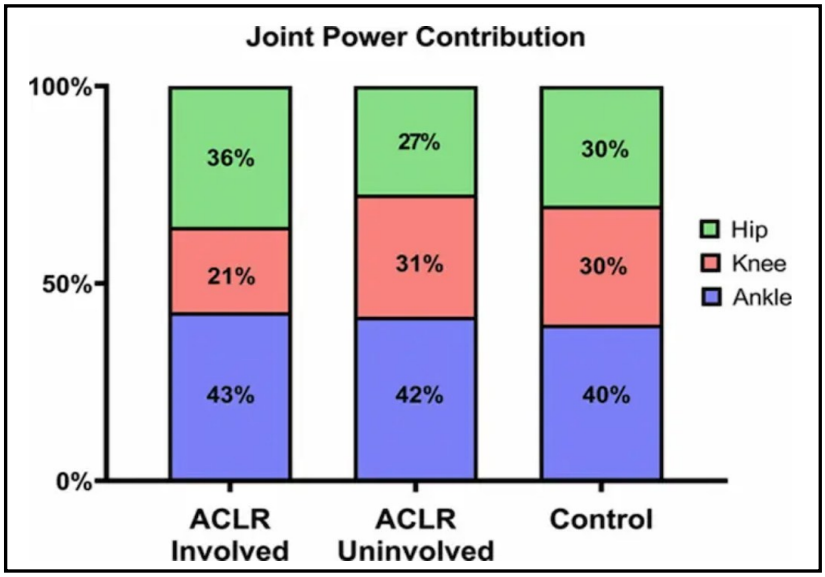


Image source: Graham et al. 2023

How to test knee extension isometric strength.

Knee extension torque is one of the simplest metrics a clinician can measure as in-line dynamometers (such as the Tindeq) cost less than $200. Making the technological jump to force plates, however, may be a reach for many clinicians but it warrants discussion here. Jump testing has become a foundation assessment in RTS testing and while we use a 90% cutoff criteria for our force plate metrics as noted later, this is not without its criticism. Agel et al. report "*this 90% rule is highly questionable because performance tests may be neither demanding nor sensitive enough to accurately identify differences between the injured and non-injured sides*" (2016). Despite this, recent publications continue to support jump testing as a key metric for RTS considerations. For example, single leg vertical jump testing has been shown to be a superior metric for measuring knee function in ACLr patients compared to horizontal hop testing (Kotsifaki et al., 2021) and its relationship to knee torque is, at least in part, explained previously. If our goal is to restore knee function, athletic performance and athlete confidence after ACL reconstruction, knee extension torque to body weight is an essential (and easy) metric that should be included in all evidence-based ACL rehab and with low-cost apps like MyJumpLab, building a robust RTS testing battery has never been more accessible (or essential).

ACL REHAB PROTOCOL

Nevada Physical Therapy

Psychological Readiness

The ACL-Return to Sport after Injury Scale or ACL-RSI is a questionnaire developed by Webster et al. in 2008 to assess an athlete's psychological readiness to return to sport. It consists of 3 metrics: emotion, confidence in exercise, and risk assessment and is typically scored from 0-100. For decades, we have known that fear of re-injury continues to be one of the primary limitations when it comes to getting an athlete back to their pre-injury competitive activities (Alswat et al., 2022). Recent research has expanded dramatically to investigate many other psychological considerations and their consideration in RTS decision making (Du et al, 2022). In several studies comparing various measures and their predictive power for RTS, the ACL-RSI was consistently shown to be one of the most robust predictors (Mueller et al, 2015, Ardern et al., 2013). This psychological readiness scale is a key component in the Nevada Physical Therapy Return to Sport testing battery and how it relates to predicting outcomes with individuals who have recently undergone ACL reconstruction.

In a study completed by Langold et al. (2019) not long after the creation of the ACL-RSI, researchers assessed ACL-RSI scores at the 3, 6 and 9 month marks after ACL reconstruction and were one of the first to begin identifying thresholds separating those who returned to pre-injury levels and those that did not. Those that had a successful outcome, i.e. returned to competitive sports, scored higher than those that did not at all measurable points.

Table 2 Mean scores and standard deviations on the ACL-RSI* scale at each time point

	Whole sample (n = 87)	Returned to competition (n = 44)	Not returned to competition (n = 43)
3 months	55.73 (16.87)	60.05 (16.53)	51.32 (16.23)
6 months	57.56 (17.83)	63.18 (17.20)	51.80 (16.78)
12 months	65.40 (18.50)	72.05 (16.25)	58.61 (18.34)

*The minimum score is 0 and a maximum score is 100. A higher score indicates more positive feelings associated with returning to sport.

Image source: Langold et al, 2019

Mueller et al. reported those that returned to level 1 sports scored on average 71 +/- 15 pts compared to those that did not had scored 48 +/- 27 pts at the time of follow up (2015). Similarly, in a more recent publication, Ohji et el. (2019) showed nearly identical scores between similarly described groups.

Table 3
Group differences in ACL-RSI score.

ACL-RSI score		All[a]	ACL-RSI[a]		*P* value	Effect size
		n = 50	Low (n = 17)	High (n = 33)		
Preoperative	Total score	54.8 ± 18.0	43.2 ± 7.5	60.8 ± 18.9	<0.001	1.10
	Confidence in performance	57.6 ± 21.6	43.5 ± 9.1	64.9 ± 22.6	<0.001	1.12
	Emotions	49.0 ± 19.4	36.7 ± 11.6	55.3 ± 19.7	<0.001	1.07
	Risk appraisal	63.3 ± 19.9	55.9 ± 17.9	67.1 ± 20.0	0.059	0.58
6 months post-ACLR	Total score	63.7 ± 19.2	42.0 ± 9.4	74.9 ± 11.9	<0.001	2.96
	Confidence in performance	65.9 ± 21.1	43.8 ± 14.1	77.3 ± 13.6	<0.001	2.43
	Emotions	59.1 ± 22.0	36.8 ± 11.6	70.6 ± 16.5	<0.001	2.25
	Risk appraisal	65.7 ± 22.0	49.1 ± 22.7	74.2 ± 16.2	<0.001	1.35
Changes preoperatively to 6 months post-ACLR	Total score	8.9 ± 17.4	−1.1 ± 12.7	14.1 ± 17.4	0.003	0.95
	Confidence in performance	8.3 ± 19.6	0.2 ± 16.4	12.4 ± 20.1	0.036	0.64
	Emotions	10.1 ± 18.8	0.1 ± 12.4	15.2 ± 19.6	0.006	0.86
	Risk appraisal	2.4 ± 22.6	−6.8 ± 27.9	7.1 ± 18.1	0.038	0.64

ACL-RSI, anterior cruciate ligament-return to sport after injury scale; ACLR, anterior cruciate ligament reconstruction.
[a] Mean ± standard deviation.

Image source: Ohji et al, 2019

Psychological Readiness (cont'd)

On the other end, there has yet to be a clear lower cutoff although most research uses >56 points as a minimum threshold (Ardern et al. 2013) and identifying athletes scoring below this metric during their rehab process may inform clinicians on potential risk factors affecting their athletes' ability to return to sport as well as potential re-injury. Similarly, Mcpherson et al. published an article in 2019 showing a statistically significant correlation between ACL-RSI scores and younger athletes who went on to re-injure (60.8 +/- 19.1 for the re-injury group vs 71.5 +/- 19.3 pts in those that did not).

Image source: McPherson et al, 2019

TABLE 2
Anterior Cruciate Ligament–Return to Sport after Injury (ACL-RSI) Scores for Combined Group, Younger Patients (≤20 years), and Older Patients (>20 years), Between Injured and Noninjured Patients[a]

Variable		All	Injured	Noninjured
Preoperative score	Combined group	49.5 ± 21.8	53.4 ± 24.5	48.8 ± 21.2
	≤20 y	51.9 ± 21.2	54.6 ± 24.7	51.2 ± 20.1
	>20 y	47.9 ± 22.1	51.9 ± 24.6	47.4 ± 21.7
12-month score	Combined group	66.4 ± 22.4	60.9 ± 23.4	67.2 ± 22.2
	≤20 y	68.7 ± 20.5	60.8 ± 19.1	71.5 ± 19.3[b]
	>20 y	64.1 ± 23.9	60.9 ± 29.1	64.6 ± 23.4

[a]Values are expressed as mean ± SD.
[b]Significant difference between injured and noninjured patients ($P < .05$).

As briefly described above, the ACL-RSI has consistently been shown to predict those that may fail to return to pre-injury activity levels although it should be noted that the mechanisms of this relationship are still poorly understood. From an intervention standpoint, knee extension strength appears to be related to an athlete's confidence when it comes to returning to high level sport. Lepley et al. demonstrated an athlete's knee extension isometric performance predicted 39% of the ACL-RSI score variance (2018).

Return to Sport Timing after ACL Reconstruction

Anterior Cruciate Ligament injuries are one of the most commonly repaired ligaments in the body with an estimated 100,000-200,000 reconstructions performed each year in the United States. Having surgery does not guarantee a return to prior level of function and those who have suffered an ACL injury, unfortunately also become higher risk for a second injury with 30% of those individuals suffering a contralateral (opposite knee) ACL injury in the first few years post-reconstruction (Grindem et al. 2016; Paterno et al. 2014) and further, elite athletes can have as high as 50% risk of reinjury in the first postoperative year (Kaeding et al. 2017). Understanding the potential contributors to re-injury risk is vital to the rehabilitation process as our goal is to get the individual or athlete back to doing what they love AND mitigating modifiable risk factors for re-injury.

NON-MODIFIABLE

- **History of Previous Injury**
- **Gender**
- **Age: e.g., being < 25 years old may increase risk of re-injury up to 23% as found by Wiggins et al. (2016).**

"When comparing the current results to the ACL reinjury rates from the same institution during the period 2008–2015, using identical methods and inclusion criteria, we observed a significant reduction in reinjury rates—by half. The primary difference...is the implementation of mandatory regular testing and progress monitoring during rehabilitation" **—Kotsifaki et al., 2025**

ACL REHAB PROTOCOL

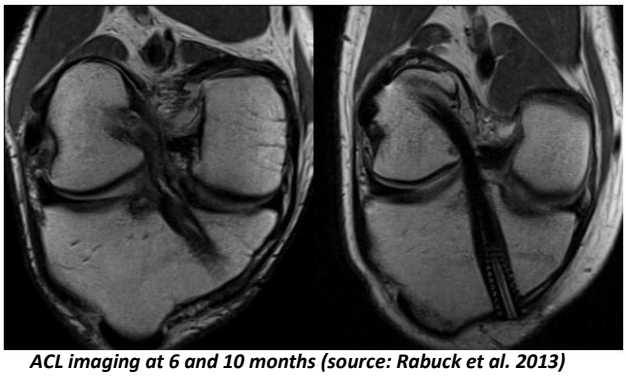
Nevada Physical Therapy

Return to Sport Timing after Anterior Cruciate Ligament Reconstruction

While we cannot change the non-modifiable, we *can* focus our efforts how to best address the modifiable contributions to an athlete suffering a second injury. To facilitate our decision-making process with clearing an athlete to return to play beyond just time (42% of medical providers used time ONLY as their criteria and only 13% used an objective criteria-based assessment as described by Burgi et al, 2019 and Barber-Westin and Noyes, 2011), we have developed an extensive RTS battery detailed in this protocol.

Return to Sport Testing (RTS) has become an area of research emphasis recently. This is not meant to address all the known risk factors but instead to add more depth to the Return to Sport conversation for clinicians specifically. An important note before discussing RTS testing: there is no gold standard in place and while we have many promising studies, there are still limitations in study design, populations, etc. and the research must be interpreted both individually and as a cumulative body of knowledge. For example, in this protocol we often reference the Kyritsis et al. (2016) study, which found a 4x higher rate of reinjury for those athletes that did not clear RTS criteria, however the sensitivity (the ability of a test to correctly identify those with the ailment) and specificity (the ability of the test to correctly identify those without the ailment) was only 54% and 79% respectively. Despite these limitations, recent publications support meeting RTS criteria as one of the most influential contributors to reducing risk of re-injury. In 2025, the ASPETAR group published a paper led by Dr. Kotsifaki reporting that athletes not meeting RTS criteria was a stronger predictor of reinjury than time from surgery and the athletes who met these criteria and subsequently were cleared for sport *earlier* than 9 months did not have higher risk of re-injury. However, it is worth noting, they reported most athletes needed 9 months or more to meet these criteria. They go on to encourage rigid, mandatory testing throughout the rehab process as a crucial component to success.

Nagelli and Hewett (2017) published an article stating that athletes "*require a longer postoperative recovery period than the typically advocated 6 to 12 months to facilitate the biological recovery of the joint*" with specific attention to bone-bruising which "*may be recovering up to one year following ACLR and require a longer recovery period than the standard timeline according to which athletes are returning to activity*".



ACL imaging at 6 and 10 months (source: Rabuck et al. 2013)

Finally, while MRI findings are not well correlated to outcomes when assessing sport readiness, Rabuck et al. showed marked changes in ACL revascularization between 6 and 10 months. Zaffagnini et al. (2007) similarly demonstrated the ACL is continuing to remodel up until 24 months after reconstruction with hamstring grafts showing a delayed remodeling phase occurring between 12-24 months in comparison to the 6–12-month timeline seen in patellar tendon autografts (Pauzenberger et al. 2013). While it is unlikely that this 24-month timeline argued for by Nagelli and Hewett will be adopted in NCAA and professional athletics until additional research is done on reinjury rates with those delayed to RTS to 24 months, and considering the recent ASPETAR paper on time being *less* of a factor than the ability of the athlete to clear objective criteria, the decision on when to clear an athlete for sport continues to be complex.

ACL REHAB PROTOCOL

Nevada Physical Therapy

The Protocol

Phase 1 (weeks 0-4)

The primary goal for the first phase is to allow the post-surgical trauma to resolve. Specifically, the sooner we can decrease swelling, the sooner we are able to normalize quad recruitment (a prerequisite for getting off crutches). While we appreciate that every patient wants to be off their crutches as soon as possible, it is imperative that the crutch discharge criteria is met prior to weaning off of assistive devices. These criteria are in place to ensure appropriate knee and quad function to begin walking on the newly reconstructed ligament and rushing this process will likely (and often does) lead to unnecessary increased strain on the ACL. These first several weeks typically set the tone for the entire rehab process and those that prioritize modifying activity to allow swelling to resolve, consistently follow their program, and are patient with the process often do much better than those that begin walking on the new ACL before they are ready.

Phase 1 Progression Criteria:

- **Equal, normal knee extension compared to non-surgical side**
- **110 degrees of flexion by PO Day 21**
- **Post-operative trauma resolution (decreased swelling week over week)**
- **Ambulate independently without AD with normal knee mechanics**

Precautions/Common Pitfalls (0-4 weeks):

- **Excessive Weight-Bearing**
- **Pushing through pain during mobility and stability progressions**
- **Rapid progression of exercise volume and intensity**
- **Persistent lack of passive knee extension**

SAMPLE PHASE 1 PROGRAM

Phase 1 (wks 0-2 post op)

First Week	Sets and Reps	Notes
Quad Sets	10x10 sec	
Ankle Pumps/Banded Plantarflexion	x30	Squeeze the calf, flex the quad!
Strap Calf Stretch	3x30 sec	
Heel Slides	x20	4-5/10 pain at most
Glute Squeezes	10x10 sec	

Second Week	Sets and Reps	Notes
Quad Sets	10x10 @ 80% effort	Gene Hackman voice "With some effort!!!"
Knee Extension ISOM	10x10 sec @ 50% effort	Begin once you comfortably have 90 deg knee flexion
Weight Shifts	x 2 min	Nice and easy, just getting comfortable putting weight through the leg.
Standing Hip ABD	2x10-12	Standing on NON-surgical Leg
TA Dumbbell Pullovers	2x10-12	Surgical leg straight, quad squeeze!
Partial Sit-Ups	2x10-12	Surgical leg straight, quad squeeze!

Days 14-21	Sets and Reps	Notes
Bike Rockbacks	8 minutes	Unresisted cycling once able
Quad Sets	10x10 @ 80% effort	With some effort!
Knee Extension ISOM	10 x 10 seconds at 50% effort	@ 70 deg knee bend or more
Hip Hinge Holds	10x10 seconds	Equal weight through feet, slight knee bend, goal is to maintain spine position and FEEL the hammies! No weight, just sliding hands down legs.
Standing Hip SLR	2x12-15	Strong Quad!
Standing Hip ABD	2x12-15	Strong Quad!
TA Dumbbell Pullovers	3x10-15	Surgical leg straight, quad squeeze!
Partial Sit-Ups	3x10-15	Surgical leg straight, quad squeeze!

Daily Mobility
Heel Slides
Wall Slides
LLLD Knee Extension
Strap Calf Stretch
Prone Hip Stretch
Please Review "appendix"
Phase 1.1 Goals
Equal, normal knee extension compared to non-surgical side
110 degrees of flexion by PO Day 21
Post-operative trauma resolution (decreased swelling week over week)
Beginning day 14 add:
Knee Flexion with Assist to daily mobility program
NOTE: Supine SLR should not be used as an exercise but rather as an occasional assessment for crutch criteria (see appendix)

ACL REHAB PROTOCOL

Nevada Physical Therapy

The Protocol

Phase 1 (weeks 0-4) cont'd.

This is likely the most important block of the protocol, specifically as it relates to expectation setting. Particular attention should be given to explaining the "why" the crutch discharge criteria are in place. We will make sure the patient clearly understands the criteria and how to optimize meeting them with minimal delays. The goals of reducing post-operative trauma by not exceeding weight bearing or activity tolerances is essential for normalization of the quad contraction and restoring passive knee hyperextension is a prerequisite for being able to get a heel "pop". Ensuring the patient understands that all decision making that happens in these early phases should prioritize these early goals can improve their own hierarchy of needs as many patients have a misconception on what the early phase looks like. Additional expectation setting will include establishing why appropriate gait mechanics are critical as patients will often be told they can wean off their crutches "when they feel like they are ready" which leads to downstream issues they may not be aware of like persistent loss of passive hyperextension or increased graft laxity.

CRUTCH DISCHARGE CRITERIA

- **Symmetrical Passive Knee Extension.**
- **Normalized quad contraction with quad setting, ie. "Heel Pop" with quad set.**
- **Able to perform a straight leg raise without an extensor lag.**
- **Able to demonstrate normal heel-to-toe mechanics in strike phase of gait without knee flexion "break".**
- **Minimal to no swelling with mobility work and early phase strength training.**

Tips

- **Patient should be seen in-clinic with 72 hours of surgery to mitigate bad habits that may develop if left to their own accord.**
- **Passive extension (heel prop) work is often programmed as a 10 minute long duration exposure (15 min max) with the goal to accumulate 60 minutes a day.**
- **If mobility is not improving, it almost always from the patient not doing them enough.**
- **If the knee is swelling after training, they are doing too much.**

SAMPLE PHASE 1 PROGRAM WKS 3-4

	Phase 1.2 (wks 3-5 post op)				
	Day 1	**Sets and Reps**	**Weight**	**Notes**	**Daily Mobility**
Warm Up	Bike Rockbacks	x8-10 min	None		Heel Slides
Warm Up	Standing Hip SLR	2x12-15		Strong Quad!	Wall Slides
Primary	Mini- Squats	2x10-12	Bodyweight	Equal Weight through the feet, minimize weight shift, to table or box as tolerated	LLLD Knee Extension
Secondary	RDLs	3x8-10	Light	Light Weight, smooth and pretty	Prone Knee Extension
Secondary	Eccentric Leg Press	24-30 total reps	Light to moderate	As tolerated, low RPE, just get comfortable	Strap Calf Stretch
Accessory	Standing Hip ABD	2x12-15 ea	Light band	Standing on both legs now, strong quad!	Prone Quad Stretch
Quad	Knee Ext ISOM	10x10 sec	@ 70-80% effort	<4/10 pain	Quad Foam Roll
Core	Mini-Sit Ups	3-4 x 10-12	Moderate	Surgical Leg Straight, strong quad!	Knee Flexion with Assist
	Day 2	**Sets and Reps**	**Weight**	**Notes**	Prone Hip Stretch
Warm Up	Bike Rockbacks	x8-10 min	None		
Warm Up	Standing Hip SLR	2x8-10		Strong Quad!	
Primary	Mini- Squats	3x8-10	Bodyweight	Equal weight through the feet, minimize weight shift, to table or box as tolerated	
Secondary	RDLs	3-4 x 8-10	Light	Light Weight, smooth and pretty	
Secondary	1L Leg Press	3x 10-15 reps	Light to moderate	As tolerated, low RPE, just get comfortable, try to get a stimulus	
Accessory	Standing Hip ABD	2x12-15 ea	Light band	Standing on both legs now, strong quad!	
Quad	Knee Extensions 90-60 deg	3x10	@ 3-4 RIR	Scale motion as need, 90-60 degrees is priority, top end range less so	
Core	Pallof Press	2x12-15 ea	Moderate	Slight knee bend, scale as needed	

ACL REHAB PROTOCOL

Nevada Physical Therapy

The Protocol

Phase 2 (weeks 5-8)

Phase 2 is focused primarily on establishing the training movements, specifically double leg squatting, split squats, and the hip hinge with skill and tolerance as the focus. Intensity is still low as we are continuing to facilitate post-surgical swelling resolution, protecting the reconstruction, and restoring quadriceps function. At this point, we should have been able to wean off crutches, normalize gait and establish reproducibility of the designed program outside of the clinic.

PHASE 2 PROGRESSION CRITERIA

- **Demonstrate ability to reproduce program outside of clinic, consistently and as prescribed.**
- **Normalized passive range of motion in all planes (extension/flexion)**
- **50% Limb Symmetry or greater with hip ABD, Knee Extension testing**
- **Able to complete training session with less than 2 pt increase in pain**

SAMPLE PHASE 2 PROGRAM

	Phase 2.1 (wks 6-7)				
	Day 1	**Sets and Reps**	**Weight**	**Notes**	**Mobility**
Warm Up	Stationary Bike				
Warm Up	Lateral Crab Walk...	3x60 sec	Moderate Band around knees		Heel Slides
Primary	KB RDLs	Ramp Sets of 8-10 until moderate intensity, 2 sets at top weight. Record weight.	3-4 RIR	See Appendix for Ramp Set Explanation	Wall Slides
Secondary	Lateral step Down	2-3 sets of 5-8 reps	Low volume, skill emphasis	Anterior Step Down once able	LLLD Knee Extension
Hypertrophy	Prone Hamstring Curls	3x10	Moderate band	Avoid hyperextrension	Prone Knee Extension
Hypertrophy	Knee Extension ISOM	10x10 sec @ 70% intensity			Strap Calf Stretch
Core	Front Planks	3 x 20-45 sec			Prone Quad Stretch
	Day 2	**Sets and Reps**	**Weight**		Quad Foam Roll
Warm Up	Monster Walk FW...	3x60 sec			
Primary	KB Front Squat	Ramp Sets of 8-10 until moderate intensity, 2 sets total at top weight. Record weight.		Skill emphasis	
Secondary	1L RDL	2x6		Skill emphasis	
Secondary	Ecc 1L Leg Press	3-4 sets of 8-12 reps		If available	
Hypertrophy	2L Bridge	3-4x10-15		Ok to progress to 1L once able	
Core	Side Planks	3 x 20-40 sec		See Progression, modifiy to tolerances	
	Day 3	**Sets and Reps**	**Weight**		
Warm Up	Lateral Crab Walk...	3x60 sec			
Primary	KB Box Step Up	Ramp Sets of 8-10 until moderate intensity, 2 sets at top weight. Record weight.	3 RIR	Start at 6in, work up to 12 in box over several weeks THEN add weight	
Secondary	Lunges (Surgical Leg in Front)	2x6			
Secondary	Calf Raises	3x10-15	3 RIR		
Hypertrophy	Knee Extensions 90-60 deg	3x12-15	4 RIR		
Core	Partial Sit Up	3x12	2-3 RIR	Surgical leg straight	

ACL REHAB PROTOCOL

Nevada Physical Therapy

The Protocol

Phase 3 (weeks 9-16)

Phase 3 should begin to look like a true strength program with specific subjective intensity goals with anywhere from two to four training days depending on the case. We are focusing on hypertrophy, volume and strength during this phase and will begin introducing early phase plyometric skills in preparation of returning to running (see Return to Running criteria and protocol here). Around the 16 week mark we will complete our first testing session as detailed in the protocol and programming moving forward will reflect adjustments to address any suboptimal testing results.

PHASE 3 PROGRESSION CRITERIA

- **No Subjective Complaints of Instability or Buckling**
- **3 mm or less PA laxity compared to UNINV side**
- **Minimal to No Joint Effusion**
- **>70% Limb Symmetry Knee Extension Isometric Testing**
- **>70% Limb Symmetry with Side Plank Hip ABD Testing**
- **>70% Limb Symmetry with Single Leg Squat Testing**

Sample Program at Week 10-11

	Day 1	Sets and Reps	Weight	Notes	Daily Mobility
Warm Up	Lateral Crab Walk...	3x60 sec			Heel Slides
Primary	Barbell RDLs	4 sets of 6-8 reps	@ 2-4 RIR	Progress to Deadlift when able	Wall Slides
Secondary	Lunges	2-3 sets of 5-8 reps	@ 2-4 RIR	BILATERAL >wk 10	LLLD Knee Extension
Hypertrophy	Prone Hamstring Curls	3-4 sets of 8-12	@ 2-3 RIR	Avoid hyper extension	Prone Knee Extension
Hypertrophy	Knee Extensions	3x8-12	@1-2 RIR	Nice and easy, see RIR	Strap Calf Stretch
Core	Front Planks	3 x 20-45 sec	2 RIR		Prone Quad Stretch
	Day 2	**Sets and Reps**	**Weight**		Quad Foam Roll
Warm Up	Monster Walk FW...	3x60 sec			
Primary	KB Front Squat	3-4 sets of 8-10 reps	@ 2-4 RIR	Note change in ramp set volume	
Secondary	1L RDL	3x6-10 reps	@ 2-3 RIR	Adjust weight for RIR	
Secondary	ECC 1L Squat	3-4 sets of 8-12 reps	@ 2-3 RIR	Progress to 1L Squat once able	
Hypertrophy	1L Bridge	3-4x10-15	@1-2 RIR	Volume emphasis	
Core	Side Planks	3 x 20-40 sec	2 RIR	Progress as able	
	Day 3	**Sets and Reps**	**Weight**		
Warm Up	Monster Walk FW...	3x60 sec			
Primary	Barbell Bridge	3-4 sets of 8-10 reps	@ 2-3 RIR		
Secondary	KB Box Step Up	3-4 sets of 8-10	@ 2-3 RIR	12 in box if able	
Secondary	Calf Raises	3x10-15	@1-2 RIR		
Hypertrophy	Knee Extension ISOM	10x10 sec @ 80% intensity	see %		
Core	Glute Med Side Plank	3x20-30 sec	@1-2 RIR	banded	

SAMPLE SKILL BLOCK 1

Level 1	Level 2
Pogos	1L Lateral Tape Hops
Snap Downs	DBL Wall Switches
Ball Slams	Bulgarian Split Squat Hops
Wall Marches	Decel Lunges
Single Wall Switches	Lean Starts
Bulgarian Split Squat Tempo	

Running is, by definition, a series of consecutive jumps so we have all of our athletes complete the first skill block prior to initiating the Return to Run Protocol. We typically program 2-3 movements per training day and run a skill "block" for two weeks at a time to allow athletes to get repeat exposures and build proficiency.

ACL REHAB PROTOCOL

Nevada Physical Therapy

The Protocol

Phase 4 (Months 4-5 Post-op)

Assuming progression criteria has been met, this is the first block where skill work begins building in total training volume as well as intensity. Our skill progressions will typically build off already established positions and movements (e.g. Static lunge > Rear Foot Elevated Split Squats > Bulgarian Split Squats > Bulgarian Split Squat Tempo Drill/Hops). The focus on skill development at this point is to begin moving quicker after several months of primarily lifting slow (*note: speed and skill work can and should be completed throughout the rehab process although may be heavily modified to avoid overstressing the recent ACL reconstruction)*. Return to Running typically begins in this phase once criteria have been met although we will spend a few weeks re-establishing running mechanics and skills before actually running. Strength work continues to focus on building overall capacity (traditional strength programming) with an increased emphasis on more explosive lifts.

PHASE 4 PROGRESSION CRITERIA

- **Successful Completion of Return to Running Protocol**
- **QUAD Torque >.7 ft lb/lb BW or 2.0 N m/kg BW**
- **HAM Torque >.4 ft lb/lb BW or 1.0 N m/kg BW**
- **IKDC >70%**
- **>70% Limb Symmetry Lateral Step Down testing (20% BW load, 12 in box)**
- **No increase in pain or swelling with current programming.**

SAMPLE PROGRAM WEEK 16-17

Day 1		Sets and Reps
Warm Up	Monster Walks	3 rds x 60 sec
Skill	Skater Hops	3x 12 reps total, should have 40 deg knee flexion with landing
Skill	Lunge Switches	3x5 reps, snappy! (10 reps total)
Primary	Heel Elevated Squats	4x8 @ 2-3 RIR, 3 sec tempo (6 sec/rep)
Secondary	Copenhagens	3x5
Secondary	1L Leg Press	3x10, last set AMRAP
QUADS	1L Knee Extensions	3 sets, AMRAP, fail in <12
Core	Side Plank ABD Reps	2 sets, AMRAP, pretty reps!
Day 2		**Sets and Reps**
Warm Up	Lateral Agility	3 rds x 60 sec
Skill	1L Drop Landing	3x5 ea, 12 in box
Skill	CMJ	3x5, reset and hard effort!
Primary	Deadlifts	3x5 @ 3 RIR
Secondary	Anterior Step Down	4-6 in box, 4x8 @ 2 RIR
Secondary	ECC 1L Calf Raise	3 x 10 @ 1-2 RIR
QUADS	Nordic HS Curls	3x5
Core	Hanging Leg Raises	3x12 @ 2 RIR
Day 3		**Sets and Reps**
Warm Up	Monster Walks	3 rds x 60 sec
Skill	Lateral Shuffle	3 rds x 60 sec 10 yds @ 80% effort
Skill	Lateral Bench Overs	4x 20 sec
Primary	High Lateral Step Down	3x10 @ 2-3 RIR, 12 in box
Secondary	1L RDLs	3x8 @ 3 RIR
Secondary	Reverse Nordics	3x6
QUADS	1L Knee Extensions	5x5, hard AND fast
Core	Side Plank ABD Holds	2 sets, AMRAP, pretty reps!

All exercise videos can be seen on our youtube channel!

www.youtube.com/@nevpt

Many Return to Run protocols exist but we use the Delaware Protocol due to its simplicity, clear rules and easy to follow progressions. You can scan the QR code to view this protocol if interested.

ACL REHAB PROTOCOL

Nevada Physical Therapy

The Protocol

Phase 5 (Months 5-6 Post-op)

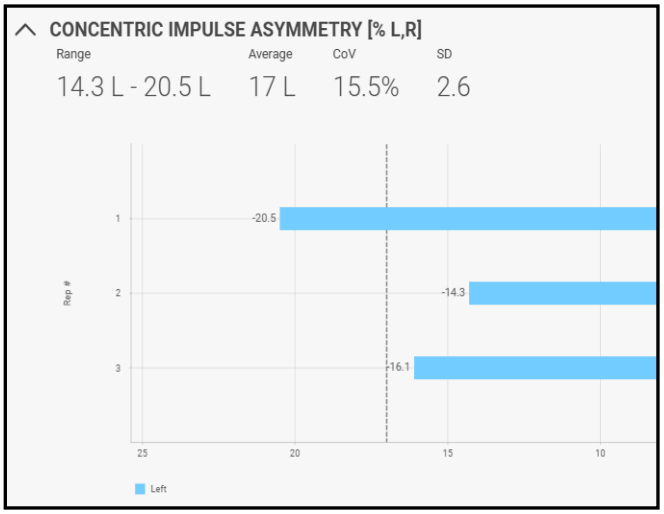
Phase 5 is a relatively seamless continuation of Phase 4 with the program progressing to increase speed development (acceleration, deceleration, forward sprinting) as well as conservatively introducing or progressing change of direction work. Intensity and effort emphasis on in-line speed work with skill and tolerance progressions for lower-level change of direction work. Force plate testing is usually completed at the end of this block (See Appendix) and programming becomes more case-specific compared to earlier phases. Common themes we see during force plate testing in this phase include slower eccentric velocity with both single leg and double leg jumping, decreased vertical jump height, increased ground contact time and asymmetrical concentric/landing strategies. It should be noted that the emphasis during this block continues to be on normalizing strength prior to normalizing jumping skills however these can, and often are, programmed simultaneously. For example, if jump height is asymmetrical in vertical jump testing and a double-digit limb symmetry strength deficit is observed, we will continue to build hip and knee strength as a priority but may also program for modified single leg jump skill development albeit with a lower time/intensity emphasis.

SAMPLE SKILL BLOCK 2

Level 1	Level 2
2L Drop Landing	Skater Hops
Skater Hop ACCEL	Lateral Shuffle
Skater Hop DECEL	Lunge Switches
A Skips	Countermovement Jump
1L Drop Landing	Lateral Bench Overs
Bench Lateral Step Down	Sled Sprints

SAMPLE SKILL BLOCK 3

Level 1	Level 2
1L Assisted Vertical Jump	Reactive 1L Box Jump
2L to 2L Lateral Box Jump	2-1-2 Lateral Box Jump
FWD Sprint to DECEL	1L Vertical Jump
W Sprints	1l to 2L Horizontal Broad Jump
5-0-5 (Frontal Plane)	FWD Sprint to Backpedal to FWD
FWD Sprint to Backpedal	Sprint to Backpedal and Turn
Box Jumps	Sprint to 45 deg Cut



While force plate data can help customize a program for that specific athlete's needs and deficits, if a notable strength asymmetry persists, the value of the force plate data is reduced. A significant side-to-side asymmetry will often, but not always, be the limiter for clearing these metrics. The athletes that can pass them with a <85% LSI are just...good athletes.

ACL REHAB PROTOCOL

Nevada Physical Therapy

The Protocol

Phase 5 (cont'd)

If strength has been normalized, we will increase efforts on developing the appropriate characteristics for jump performance based on testing results. From a readiness perspective, it has been noted in other sections of this protocol that an ACL-RSI score of below 55 pts at 6 months was a predictor of decreased likelihood of returning to pre-injury levels and while it is not a specific criteria at this point of the protocol, the ACL-RSI should be complete at the beginning and end of this phase to identify early risk factors of a suboptimal outcome.

PHASE 5 PROGRESSION CRITERIA

- **QUAD Torque >.8 ft lb/lb BW or 2.4 N m/kg BW**
- **HAM Torque >.5 ft lb/lb BW or 1.5 N m/kg BW**
- **>80% LSI with Quad Power Testing (Isokinetic or RFD)**
- **Hip ABD Torque >.6 ft lb/lb BW, Hip ADD Torque >.7 ft lb/lb BW**
- **Plantarflexion Isometric Testing > 1.3x BW and >90% LSI**
- **IKDC >80%, ACL-RSI >65 pts**
- **>85% Limb Symmetry Lateral Step Down testing (20% BW load, 12 in box)**
- **>85% Limb Symmetry Side Plank Testing (AMRAP)**
- **Anterior Y-Balance <6cm Deficit**
- **Successful completion of Force Plate Battery**

SAMPLE PROGRAM WEEK 22

Day 1		Sets and Reps
Warm Up	Monster Walks	3 rds x 60 sec
Warm Up	5-0-5 Frontal Plane	4 rds ea way @ 80-85% effort
Skill	Box Jumps	3x6 (12 reps total)
Skill	Sprint to Backpedal to Turn	4x8 @ 2-3 RIR, 3 sec tempo (6 sec/rep)
Primary	Barbell Front Squats	3x6 @ 2 RIR
Secondary	Copenhagens	2 sets, AMRAP, fail in <12
QUADS	1L Knee Extensions	3 sets, AMRAP, fail in <12
Core	Side Plank ABD Reps	2 sets, AMRAP, pretty reps!
Day 2		**Sets and Reps**
Warm Up	Lateral Agility	3 rds x 60 sec
Warm Up	CMJ	3x6, reset for each rep!
Skill	Reactive 1L Box Jump	3x5 ea, 12 in box
Skill	Sprint to Backpedal to Turn	3x5 @ 3 RIR
Primary	Deadlifts	4-6 in box, 4x8 @ 2 RIR
Secondary	Anterior Step Down	3x8 @ 1-2 RIR
QUADS	Nordic HS Curls	3x8
Core	Barbell Rollouts	3x6
Day 3		**Sets and Reps**
Warm Up	Monster Walks	3 rds x 60 sec
Warm Up	A Skips	3 rds x 60 sec
Skill	2-1-2 Lateral Box Jump	3x5 reps, snappy! (10 reps total)
Skill	FWD Sprint to Backpedal to FWD	15 yds @ 80-85% effort x 8 rds
Primary	FFESS	3x8 @ 3 RIR
Secondary	1L RDLs	3x6
QUADS	1L Knee Extensions	5x5, hard AND fast
Core	Side Plank ABD Holds	2rds 45 sec

Running is, by definition, a series of consecutive jumps so we have all of our athletes complete the first skill block prior to initiating the Return to Run Protocol. We typically program 2-3 movements per training day and run a skill "block" for two weeks at a time to allow athletes to get repeat exposures and build proficiency.

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The Protocol

Phase 6 (Months 7– RTS)

Phase Six is focused on primarily two things: addressing any suboptimal RTS testing results and restoring the capacities required for competitive athletics. Strength work is simplified during this phase to a primary movement, a secondary movement and one or two hypertrophy exercises with the remaining training volume dedicated towards energy system development and skill sharpening. Change of direction work, unanticipated reactive skills, and athleticism is emphasized. Towards the end of this block we should have met criteria for returning to contact although there are likely constraints in place to minimize exposures and risk. Athletes should be practicing with their team or trainers although with controls in place (i.e.. non-contact, training hours, etc.).

SAMPLE SKILL BLOCK 4

Level 1	Level 2
Sprint to Lateral Shuffle	Endurance Skill Block
VAIL Lateral Agility	Unanticipated Skill Block
DVJ to Sprint	Sport Specific Block
1L Broad Jump	
5-10-5	
5-0-5 COD (15 yard)	

There is no "right" way to program for skill development. This is a general idea of how we do it but rehabilitation will vary based on the athlete's needs and specific sport demands. The concept we try to convey here is that there should be a mental model to work from. Too many clinicians operate without one and it becomes a free-for-all of random movements that looked cool on social media.

Return to Sport

The final month is reserved for once all RTS criteria has been met with the possible exception of total workload requirements. Returning to Sport is not an inflection point but rather a spectrum where the athlete at this point should be practicing at anywhere from 50-75% of normal expectations. This last block is focused on conditioning, psychological readiness, and unanticipated reactive skills/capacity. This includes addressing any fear or confidence issues, typically through a combination of education and graded exposures. While many coaches talk about "sport-specific" training, we do not believe you can safely recreate the intensity and often chaotic nature of full intensity athletics within a clinic setting. Instead, skill work focused on improving the athlete's confidence in their ability to do the "hard things". Higher speed work, dual task movements, and creating a framework to improve their ability to respond to unanticipated movement is emphasized.

19% of those that failed to Return to Sport cited fear as primary reason.
—Ardern et al. 2011

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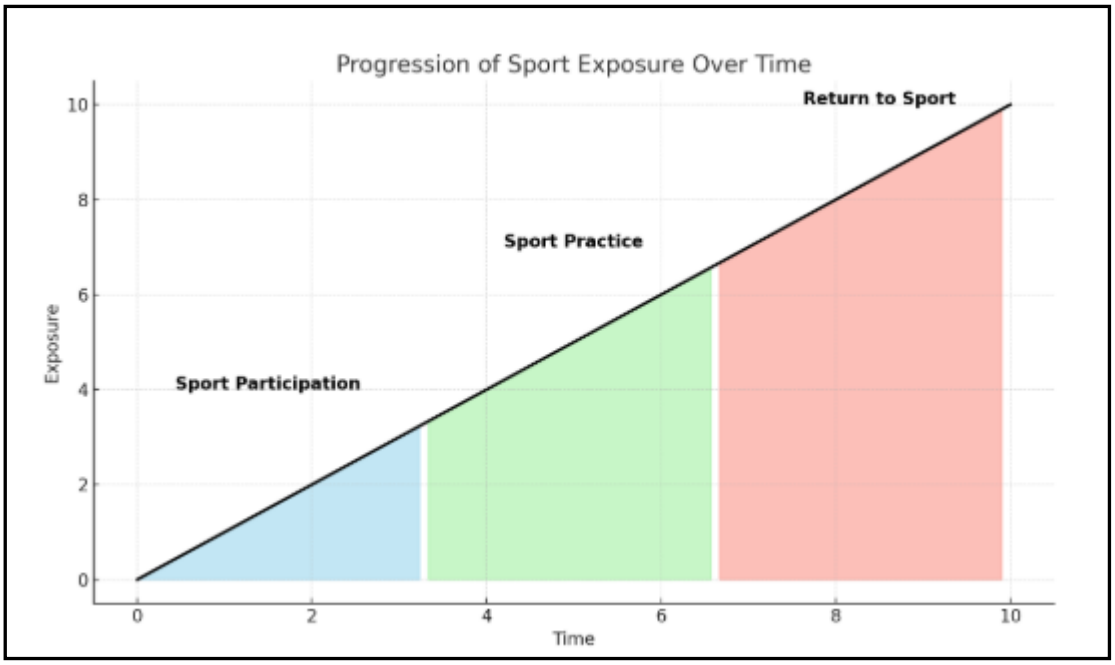
The Protocol

Return to Sport (cont'd)

As mentioned previously, a key factor in this phase is the establishment of an appropriate workload for returning to full in-season demands. Previous research shows a cumulative reduction in injury risk by delaying RTS from 6 months to 9 months by 84% (Grindem et al. 2016) and these months are focused on using that time to literally hit the ground running. This idea is in place to minimize an athlete spiking their workload when they are "cleared"; in other words, if they have only been training at 40-50% of their normal in-season demands, they run the risk of being undertrained and under-conditioned for a full return. Appropriate workload development and meeting all RTS testing criteria is our BEST way to minimize the modifiable risk factors for re-injury.



Return to Sport is *not* an inflection point in time but rather a *slow* shift in allowed risk exposure on a time **and** progression criterion-based continuum.

FINAL THOUGHTS

Considering the Grindem et al. paper above, which is frequently cited in the RTS conversations being had, in combination with the recent ASPETAR publications AND when taking biological healing into consideration, there is not one right answer. We focus on addressing our "knowns" which include absolute quad strength, psychological readiness, and preparing an athlete as best we can for returning to the field safely. This is a task best completed in appreciating the "unknowns" when it comes to clearing an athlete and having the conversation early on to set the expectation that we cannot guarantee they will not re-injure but using the current best evidence and our experience in this space, we can promise to do our very best to return them to their previous athletic level of competition as quickly and as safely as possible.

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Appendix A

Return to Sport Testing Battery

Functional Outcome Reporting	>90% IKDC, >72 pts ACL-RSI
A-P Knee Laxity	<4 mm cut-off, goal is <3 mm
Isometric Quad Strength	>1.0 ft lb/lb BW and >90% LSI
Isometric Ham Strength	>.6 ft lb/lb BW and 90% LSI
Ham:Quad Isometric Ratio	>.6 once quad isometric goal met
Isokinetic Quad Strength	>90% LSI @ .25 m/s (Voltra I)
Isometric Hip ABD/ADD Strength	>.6 ft lb/lb BW ABD; >.7 ft lb/lb BW ADD
Isometric Plantarflexion Strength	>1.3x BW cutoff, goal >1.5x BW
Nordic Hamstring Curl	>70 deg break angle
1L Squat Test (10% BW to 70 deg knee flexion, max reps in 30 sec)	>90% LSI
Side Plank Hip ABD (max reps to failure)	>90% LSI
Anterior Y-Balance	<4cm deficit side to side
Lateral Step Down Test (12 in box, 20% BW, max reps in 30 sec)	>90% LSI
Countermovement Jump	♦ <10% concentric impulse asymmetry ♦ >90% unweighting with eccentric/braking phase ♦ > 1.2m/s eccentric velocity ♦ Reactive Sport Index (RSI) >.4 m/s
1L Vertical Jump Test	♦ <10% vertical jump height asymmetry ♦ <10% RSI asymmetry
Hop Test	No obvious lateralization with concentric impulse or landing force; goal >4 “crossovers” with 10 rep test
5-0-5 COD	<10 asymmetry with change of direction time (entry to exit)
Vail Lateral Agility	4 out 5 or higher score for each 20 sec block
Appropriate Workload Established	Athlete has established roughly 70% workload of total in-season demands without restriction
All RTS Criteria Met	Pass/Fail based on meeting goals above

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Appendix A

Return to Sport Testing Battery

IKDC, ACL-RSI PASS/FAIL. Subjective measures, both knee function and readiness to play have been strongly associated with successful return to sport rates with Ardern et al. stating "psychological readiness to return to sport and recreation was the factor most strongly associated with returning to the pre-injury activity" in their 2014 publication. Specifically, scores below 47 points on the ACL-RSI "indicated that a patient was at risk of not returning to sport" (Faleide et al. 2021) and further, scores below 55 points at 6 months post-surgery "were associated with a greater risk of unsuccessful RTS at 1 year after surgery" (Kitaguchi et al., 2020). Nevada Physical Therapy requires 65 points or higher on the ACL-RSI as Ardern et al. state this was the threshold for a "satisfactory recovery" (2014). Additionally, aside from psychological readiness, "reduced IKDC score distinguish patients who are unable to return to preinjury sports participation because of fear of reinjury/lack of confidence" (Lentz et al., 2015)

A-P Knee Laxity: Successful return to sport has been associated with the amount of post-surgical ACL laxity with an increase of >3mm in AP laxity associated with increased risk of reinjury (J Orthop 2016). Additionally "...a 4-mm side-to-side difference was the prognostic threshold for failure to return to sports with a positive predictive value of 86% and specificity of 98%" and "a 1-mm increase in side-to-side difference was associated with a 50% higher probability of having a poor/fair ARPEGE score" (Jordan et al. 2022)

Knee Extension Strength (Isometric and Isokinetic) PASS/FAIL: Persistent quadriceps strength has been linked to poor Return to Sport testing; quadriceps strength collected at return to activity were associated with greater knee-joint function, greater readiness to return to functional activity, and more positive emotions connected to the injury process "*QF - quadricep femoris strength deficits predicted hop test performance beyond the influences of graft type, presence of meniscus injury, knee pain, and knee symptoms."* (Scmitt et al., 2012) (Knapik et al., 1991) In line with current research, Nevada Physical Therapy requires quad strength, when normalized to body mass, to be 1.0 ft·lb/ lb BW as individuals testing at or above this threshold "had over eight times higher odds of reporting an IKDC score ≥90%." (Pietrosimone et al. 2016). In other words, athletes demonstrating a quadriceps peak torque of 3.0 N·m/kg (converted to 1.0 1.0 ft·lb/ lb BW) would be "*expected to have KOOS Sport, KOOS QoL, and IKDC scores that were approximately 17 points higher than an individual with quadriceps peak torque of 2.0 N·m/kg*" (Van Wyngaarden et al. 2021)

Nordic Hamstring Proficiency (>70 deg), PASS/FAIL: Performance of the Nordic Hamstring Exercise is correlated with eccentric hamstring strength with lower (more open) knee flexion angles demonstrative of higher eccentric strength. Nordic Hamstring Exercise performance has been suggested to reduce ACL risk by improving eccentric hamstring strength (Monajati et al. 2016), a risk factor associated with ligament injury (Myer 2009) as well as increased ACL loading with sidestep cutting (Wienhandl et al. 2014)

Functional Strength, PASS/FAIL Decreased Single Leg Squat and/or Decreased Side Plank/Lateral Chain Strength may be predictive of ACL re-injury (Hegedus et al. 2016, Kyritsis et al., 2016)

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Appendix A

Return to Sport Testing Battery (cont'd)

Quad:Hamstring Ratio, PASS/FAIL Research suggests decreased quadriceps to hamstring strength may be a predictor for ACL re-injury (Knapik et al., 1991) and "for every 10% decrease in the hamstring to quadriceps strength ratio there was a 10.6 times higher risk of sustaining an ACL graft rupture (Kyritsis et al., 2016)

Jump Testing (Force Plate Testing; Countermovement Jump, Single Leg Vertical, Double Leg Repeated Hop Test) - Vertical jump testing is superior to horizontal hop testing in identifying knee function deficits in patients undergoing ACL reconstruction; (Kotsifaki et al. 2021) and athletes demonstrate continued movement compensation strategies and deficits with vertical jump testing at time of return to sport after ACLR (Kotsifaki et al, 2022)

Anterior Y-Balance PASS/FAIL Athletes who had a greater than 4cm difference in anterior Y-balance scores at 12 weeks were shown to not achieve 90% or greater lower limb symmetry at return to sport testing. (Garrison et al., 2015)

5-0-5 COD, PASS/FAIL Decreased T-test speeds compared to normative data are associated with increased ACL re-injury. (Kyritsis et al., 2015)

Chronic Workload Established, PASS/FAIL "when an athlete's training and playing load for a given week (acute load) spikes above what they have been doing on average over the past 4 weeks (chronic load), they are more likely to be injured" (Gabbett et al. 2015) "tendons are at lowest risk with consistent workloads and susceptible to injury with sudden upgrades in workload" (Orchard et al., 2015)

Complete Nevada PT Return to Sport Testing, PASS/FAIL Of those that actually had objective Return to Sport testing, only 11-33% of patients actually met them. (Paterno et al. 2018, Welling et al. 2019) These numbers are consistent with previous publications showing an average of only 30% of patients meeting testing criteria to be cleared for returning to sport activity. (Herbst et al. 2015, Logerstedt et al, 2014, Toole et al., 2017) Completing the established Return to Sport Criteria detailed above may decrease re-injury (Kotsifaki et al., 2025) and has been shown to facilitate a 4x higher rate of return to elite athletics (Kyritsis et al., 2015).

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Appendix A

Testing Videos

Knee Extension Isometric/Isokinetic

Hamstring Isometric

Hip ABD Isometric

Plantarflexion Isometric

Single Leg Squat

Side Plank ABD (max reps in 30 seconds)

Anterior Y-Balance

Lateral Step Down Test

5-0-5 Agility Test

Vail Lateral Agility

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Appendix B

Force Plates

Countermovement Jump

- 5 attempts
- Cueing: “Starting from an upright position, hands on the hips, jump as high as you can. Get to the bottom quickly and once you land, completely reset prior to the next attempt.”
- 10% or less asymmetry with CMJ concentric impulse
- >90% unweighting with eccentric/braking phase for CMJ
- Eccentric Velocity 1.2 m/s or faster
- CMJ Reactive Sport Index (RSI) >.4 m/s

Hop Test

- 10 reps
- Cueing: “Quick and springy, still want height but think about jumping similar to doing a double-under in Crossfit”
- No obvious lateralization with hop testing
- >4 “crossovers” for both concentric impulse and landing RFD

1L Vertical Jump Test

- 3 attempts per leg, will give a “redemption trial” for the limb tested first as athletes often prime for the test as they complete repetitions.
- Cueing: “Starting from an upright position, balance on one leg and jump as high as you can. Get to the bottom quickly and try to stick the landing. Completely reset between attempts.”
- 10% or less asymmetry with CMJ concentric impulse
- Eccentric Velocity .6 m/s or faster
- 10% or less asymmetry with vertical jump height
- 10% or less asymmetry for RSI

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