PHYSIOTHERAPY & REHABILITATION PROTOCOL

ACL Reconstruction + Anterolateral Ligament (ALL) Reconstruction

Position: Football	**Target RTT:** Week 28-32 — Partial **Target RTP:** Week 36-40 — Full Contact
Diagnosis: ACL rupture **Surgery:** ACL reconstruction (hamstring autograft) + anatomic ALL reconstruction (gracilis)	
Type: Combined intra-articular + extra-articular reconstruction **Graft:** Tripled semitendinosus (ACL) + doubled gracilis (ALL) — HT+ALL technique	

PHASE I — PROTECTION & EARLY ACTIVATION (Weeks 0-2)

Inflammatory control, tissue protection, early quadriceps activation, AMI management

GOALS	• Minimize post-operative effusion and pain (VAS < 2/10) • Achieve full passive knee extension (0°) symmetrical to contralateral limb • Achieve passive knee flexion ≥ 90° by end of week 2 • Restore voluntary quadriceps activation — address AMI early (SANTI classification Grade 0-1) • Maintain cardiovascular fitness via upper-body ergometry • Independent ambulation with crutches, progressive weight-bearing as tolerated (WBAT → FWB)
INTERVENTIONS	• **Cryotherapy:** 20 min every 2-3h for first 72h, then 3-4x/day — moderate evidence for AMI reduction (Sonnery-Cottet et al., BJSM 2019; GRADE: moderate) • **NMES quadriceps (VMO focus):** 15-20 min, 2x/day, superimposed on voluntary contraction — address AMI at spinal reflex level (Sonnery-Cottet et al., KSSTA 2025) • **Patellar mobilizations:** superior, inferior, medial, lateral glides, 2x/day — prevent arthrofibrosis • **Passive/active-assisted ROM:** 0-90° flexion, full extension mandatory, 3x/day • **Quadriceps isometric sets (multi-angle):** 0°, 30°, 60° — 4x15 reps, hold 5-10s, with cryotherapy pre-treatment • **Hamstring co-activation exercises:** prone gentle hamstring isometrics from week 2 (protect graft donor site — tripled ST + gracilis harvest) • **SLR all planes (flexion, abduction, adduction, extension):** 3x15 reps — avoid lag sign before progressing • **Core activation:** supine draw-in, dead-bug progressions, 3x12 • **Upper body conditioning:** UBE 15-20 min at moderate intensity

	• **Gait training:** bilateral crutches → single crutch → independent when quadriceps control restored
PROGRESSION CRITERIA	• Pain = 0 at rest, VAS ≤ 2/10 during exercises • Effusion ≤ 1+ (stroke test) • Full passive extension (0°) symmetrical to contralateral • Passive flexion ≥ 90° • Voluntary quadriceps contraction without extension lag (SLR without lag) • AMI Grade ≤ 1 (SANTI classification — Sonnery-Cottet et al., KSSTA 2025) • Independent FWB ambulation with normal gait pattern
PHASE II — EARLY MOBILITY & TRANSITION (Weeks 2-6)	
Gait normalization, progressive ROM, early CKC loading, proprioception initiation	
GOALS	• Achieve full ROM (0-120°+) — prioritize full extension maintenance • Normalize gait pattern without assistive device • Initiate CKC strengthening with progressive loading • Begin proprioceptive training (static → dynamic progression) • Maintain aerobic fitness (stationary bike, pool if available) • Resolve AMI to Grade 0 (SANTI classification)
INTERVENTIONS	• **ROM exercises:** Active-assisted → active ROM, targeting 0-120°+ by week 6, wall slides, heel slides, prone flexion hang • **Cryotherapy:** Post-session, 20 min — continued AMI management • **NMES + voluntary quadriceps exercises:** Combined protocol (Lepley et al., 2015 — eccentric + NMES superior to NMES alone for LSI restoration) • **Stationary bike:** Start week 3-4, 15-20 min, low resistance, progressive to moderate • **CKC exercises:** Mini-squats 0-45°, leg press 0-60° (3x12, bodyweight → light load), step-ups (10 cm → 15 cm) • **Hamstring strengthening:** Seated isometric → prone concentric curls (light resistance), 3x12 — protect donor site healing (tripled ST graft) • **Proprioception:** Bilateral stance on unstable surface → single-leg stance (stable surface), 3x30s • **Hip strengthening:** Side-lying abduction/adduction, clamshells, banded walks, 3x15 • **Core progression:** Plank variations, pallof press, dead-bug with resistance, 3x12 • **Aquatic therapy (if available):** Pool walking, aqua jogging, ROM exercises in warm water • **Scar tissue management:** Soft tissue mobilization around incisions (ACL + ALL lateral incision sites)

PROGRESSION CRITERIA	• Pain = 0 during all exercises • Effusion = 0 (no reactive effusion after sessions) • Full ROM 0-120°+ with symmetrical extension • Normal gait pattern without compensations (no Trendelenburg, no knee valgus) • Single-leg stance ≥ 30s on stable surface (eyes open) • SLR all planes without fatigue (3x15) • AMI Grade 0 (SANTI classification) • Quadriceps LSI ≥ 50% (HHD or isokinetic screening)
PHASE III — PROGRESSIVE LOADING (Weeks 6-12)	
Progressive strengthening, neuromuscular control, aerobic base rebuilding	
GOALS	• Full pain-free ROM (0-135°+ symmetrical) • Progressive quadriceps and hamstring strengthening — LSI target ≥ 65-70% • PkTq/BW quadriceps ≥ 1.5 Nm/kg at 60°/s • Advanced proprioception and neuromuscular control (single-leg, dynamic surfaces) • Aerobic capacity rebuilding (bike, elliptical, pool running) • Begin OKC quadriceps exercise (seated leg extension 90-45°) from week 8-10 per current evidence
INTERVENTIONS	• **CKC strengthening:** Leg press (progressive load, 3x10-12), split squat, Bulgarian split squat, step-ups (20-25 cm), single-leg press (from week 10) • **OKC quadriceps:** Seated leg extension 90-45° (safe arc post-ACLR), 3x12, progressive resistance — from week 8 • **Hamstring strengthening:** Nordic hamstring (eccentric, assisted), Romanian deadlift (light → moderate), prone curls (3x10-12) — protect donor site, eccentric emphasis • **Isometric → concentric → eccentric progression:** Follow tissue tolerance, 24h reactivity rule • **Hip complex:** Single-leg RDL, lateral band walks, hip thrust, monster walks, 3x12 • **Proprioception:** Single-leg stance (unstable surfaces), perturbation training, BOSU squats • **Core:** Anti-rotation, anti-extension progressions, cable chops, weighted planks • **Aerobic conditioning:** Bike 30 min (moderate-high), elliptical 20 min, aqua jogging • **BFR training (optional):** Low-load CKC/OKC with blood flow restriction (30% 1RM, 30-15-15-15 protocol) — emerging evidence for quadriceps hypertrophy post-ACLR
PROGRESSION CRITERIA	• Pain = 0 during all exercises • Effusion = 0 (no reactive effusion after loading) • Full ROM (0-135°+) symmetrical • Quadriceps LSI ≥ 65-70% (isokinetic or HHD)

	• Hamstring LSI ≥ 70% • PkTq/BW quadriceps ≥ 1.5 Nm/kg at 60°/s • Single-leg squat with good form (no dynamic valgus, trunk control) • YBT-A SSD ≤ 6 cm • Negative clinical tests (Lachman, anterior drawer, pivot-shift) • MD clearance for running preparation phase
PHASE IV — STRENGTH REBUILD & PRE-RUNNING (Weeks 12-20)	
Significant strength gains, isokinetic assessment, plyometric preparation, running readiness	
GOALS	• Quadriceps LSI ≥ 80% (isokinetic at 60°/s and 180°/s) • Hamstring LSI ≥ 85% • PkTq/BW quadriceps ≥ 2.0 Nm/kg at 60°/s • H:Q ratio ≥ 0.6 (conventional) or ≥ 1.0 (functional eccH:concQ) • Pass Return-to-Run criteria battery • Initiate walk-jog protocol (end of phase if criteria met) • Introduce low-level bilateral plyometrics
INTERVENTIONS	• **Heavy CKC loading:** Back squat, front squat, single-leg press (progressive to 70-80% 1RM), 4x6-8 • **OKC quadriceps:** Full-range leg extension (from week 14-16 if adequate graft healing), 3x10-12, progressive • **Hamstring power:** Nordic hamstring (full eccentric), single-leg RDL (loaded), supine slider curls, 3x8-10 • **Plyometric preparation:** Double-leg box jumps (low height), double-leg hop and hold, lateral bounds (bilateral), 3x8 • **Isokinetic assessment:** At week 16 — 60°/s and 180°/s, concentric quadriceps and hamstrings, eccentric hamstrings • **Return-to-run testing battery:** Apply at week 16-18 (see Baseline Criteria section) • **Walk-jog protocol initiation:** If criteria met (week 18-20) — flat surface, 1 min jog / 2 min walk x 6-8 reps, progressive • **Agility preparation:** Lateral shuffles, carioca, A-skips (low intensity, controlled) • **Aerobic base:** AlterG treadmill (if available) 60-80% BW running from week 14, bike 30-40 min • **Psychological readiness:** ACL-RSI questionnaire baseline, address kinesiophobia if present
PROGRESSION CRITERIA	• Pain = 0 during all exercises including plyometrics • Effusion = 0 (no reactive effusion after high-load sessions) • Quadriceps LSI ≥ 80% (isokinetic 60°/s) • Hamstring LSI ≥ 85% • PkTq/BW quadriceps ≥ 2.0 Nm/kg at 60°/s • H:Q ratio ≥ 0.6 (conventional)

	• YBT-A SSD ≤ 4 cm, composite ≥ 95% LL • Single-leg squat (10 reps) with good dynamic alignment • CMJ < 15% inter-limb asymmetry • Pass Return-to-Run criteria (see section below) • MD clearance for running phase
PHASE V — RUNNING & ADVANCED STRENGTH (Weeks 20-28)	
Progressive running program, low plyometrics, linear acceleration-deceleration, GPS monitoring	
GOALS	• Complete walk-jog → continuous jog → tempo running progression • Achieve HSR ≥ 60% of pre-injury match reference • Quadriceps LSI ≥ 90% (isokinetic at 60°/s) • Hamstring LSI ≥ 90% • PkTq/BW quadriceps ≥ 2.5 Nm/kg at 60°/s • Introduce linear ACC-DEC drills • Progress unilateral plyometrics
INTERVENTIONS	• **Running progression:** Continuous jog (20-30 min) → tempo runs (70-80% max) → interval running (progressive volume/intensity) • **GPS monitoring:** Total distance, HSR (>19.8 km/h), sprint distance (>25.2 km/h), number of ACC/DEC events — weekly load tracking • **Linear ACC-DEC:** 10-20m accelerations, controlled decelerations, progressive intensity • **Plyometrics:** Single-leg hop and hold, single-leg box jump, drop jump (low height), lateral hop sequences, 3x6-8 per leg • **Heavy strength maintenance:** Squat, deadlift, single-leg press (4x5-6 at 80-85% 1RM) • **Hamstring high-velocity work:** Flywheel eccentric, loaded Nordic progressions, supine sliders (speed emphasis) • **Core anti-rotation under speed:** Medicine ball rotational throws, cable rotations with stance • **Agility:** Ladder drills, mini-hurdle patterns, T-test preparation (controlled speed) • **Isokinetic re-assessment:** At week 24 — 60°/s, 180°/s, 240°/s, eccentric hamstrings
PROGRESSION CRITERIA	• Pain = 0 during running and plyometrics • Effusion = 0 after running sessions • Quadriceps LSI ≥ 90% (isokinetic 60°/s) • Hamstring LSI ≥ 90% • PkTq/BW quadriceps ≥ 2.5 Nm/kg at 60°/s • H:Q ratio ≥ 0.6 (conventional), ≥ 1.0 (functional) • Continuous running 30 min without pain or effusion • HSR ≥ 60% of pre-injury reference

	• CMJ < 10% inter-limb asymmetry • Single-leg hop LSI ≥ 85% (single, triple, crossover) • ACL-RSI score ≥ 60 • MD clearance for sport-specific phase
PHASE VI — RETURN TO SPORT PREPARATION (Weeks 28-36+)	
HSR, sprinting, COD, sport-specific drills, functional testing battery, team integration	
GOALS	• Achieve maximal sprint speed ≥ 95% of pre-injury • Complete all COD patterns at match intensity • Pass full Return-to-Sport testing battery (see criteria below) • Complete progressive team training integration (partial → full contact) • Psychological clearance for return to competitive play • Quadriceps LSI ≥ 90% across all velocities • GPS external load ≥ 85% of pre-injury match reference
INTERVENTIONS	• **Sprint progression:** 70% → 80% → 90% → 100% max velocity, 20-40m efforts, GPS-tracked • **COD drills:** 45° cut, 90° cut, 180° turn, reactive COD, progressive from planned → unplanned • **Sport-specific:** Ball work, positional drills, small-sided games (3v3 → 5v5 → 8v8), match simulation • **Single-leg plyometrics:** Repeated single-leg hops, depth jumps, lateral bounds, sport-specific agility (high intensity) • **Contact preparation:** Controlled body contact → full contact drills → match simulation with contact • **Strength maintenance:** 2-3x/week, emphasis on power and RFD (Olympic lifts, trap bar jumps, loaded jumps) • **Functional testing battery:** At week 32-34 (see Baseline Criteria section) — single hop, triple hop, crossover hop, 6m timed hop, CMJ, Y-balance • **Team integration:** Partial team training (non-contact) from week 28 → full team training from week 32-34 → match squad from week 36+ • **Psychological:** ACL-RSI re-assessment, mental performance preparation, competition readiness
PROGRESSION CRITERIA	• Pain = 0 during all sport-specific activities • Effusion = 0 after full training sessions • Quadriceps LSI ≥ 90% (isokinetic 60°/s, 180°/s, 240°/s) • Hamstring LSI ≥ 90% • PkTq/BW quadriceps ≥ 2.5 Nm/kg at 60°/s • H:Q ratio ≥ 0.6 (conventional), ≥ 1.0 (functional ecc/conc) • Single hop, triple hop, crossover hop, 6m timed hop: LSI ≥ 90% on all 4 tests • CMJ < 10% inter-limb asymmetry (off-shift) • YBT-A SSD ≤ 4 cm, composite ≥ 95% LL

	• GPS: Total distance ≥ 85%, HSR ≥ 85%, sprint ≥ 90% of pre-injury match reference • ACL-RSI score ≥ 70 (ideally ≥ 80) • Negative pivot-shift, Lachman, anterior drawer • Full MD clearance for competitive play • Isokinetic assessment: No deficit >20% in eccentric or concentric hamstring strength (per Sonnery-Cottet protocol — AJSM 2015, 2017)
RETURN TO TRAINING / RETURN TO PLAY	
RTT Partial (Week 28-30)	• Full ROM, pain-free, effusion-free • Quadriceps LSI ≥ 90% (isokinetic 60°/s) • Hamstring LSI ≥ 90% • Hop tests LSI ≥ 85% • Completed linear running + COD program • Non-contact team training tolerated without reaction • MD clearance
RTT Full (Week 32-36)	• All RTT Partial criteria maintained • Hop tests LSI ≥ 90% (all 4 tests) • CMJ < 10% asymmetry • GPS match load ≥ 85% pre-injury reference • Full contact training tolerated x 2 weeks minimum • ACL-RSI ≥ 70 • Psychological readiness confirmed • MD + coaching staff clearance
RTP (Week 36-40)	• All RTT Full criteria maintained for ≥ 2 weeks • Full match simulation completed • No reactive effusion or pain after full-intensity sessions • Sprint speed ≥ 95% of pre-injury maximum • Competition readiness: psychological, physical, tactical *Note: For pivoting contact sports, RTP timeline 8-9 months per SANTI Study Group protocol (Sonnery-Cottet et al., AJSM 2015, 2017). ALL reconstruction may allow earlier return due to reduced graft rupture rate (HR 0.327 HT+ALL vs 4HT; Sonnery-Cottet et al., AJSM 2017).*

CLINICAL NOTES

- AMI Management: AMI is a centrally mediated protective reflex inhibiting quadriceps (especially VMO) activation following ACL injury/surgery. The SANTI AMI classification (Grades 0-3) provides bedside screening. 56.7% of acute ACL patients present with AMI; 80% resolve with in-consultation exercises (VMO activation, prone hamstring fatigue). Failure to address AMI preoperatively is associated with stiffness and poor outcomes (Sonnery-Cottet et al., KSSTA 2025). AMI may recur postoperatively in up to 48% despite pre-op resolution (Le Guen et al., KSSTA 2025).
- AMI Interventions: Moderate evidence supports cryotherapy and physical exercise (OCC + CCC with resistance, hamstring fatigue protocols) for quadriceps activation

recovery (Sonnery-Cottet et al., BJSM 2019; GRADE: moderate). Low evidence for NMES/TENS. No evidence for TMS, taping, bracing, heat, or soft tissue release.

- Combined ACL+ALL Reconstruction: The HT+ALL graft (tripled ST + gracilis ALL) is associated with significantly reduced graft rupture rates: 4.13% at 38.4 months vs 10.77% (4HT) and 16.77% (B-PT-B) in pivoting sport athletes (Sonnery-Cottet et al., AJSM 2017). HR 0.327 (HT+ALL vs 4HT). Higher odds of returning to preinjury sport level (OR 1.938 vs 4HT).
- Graft Donor Site Protection: Tripled semitendinosus + gracilis harvest requires careful hamstring rehabilitation. Avoid aggressive early hamstring loading (weeks 0-4). Eccentric emphasis from week 6-8. Monitor hamstring:quadriceps ratio throughout. Isokinetic deficit >20% in eccentric or concentric hamstring strength at 6 months delays RTS (Sonnery-Cottet et al., AJSM 2017).
- Rotational Stability: Combined ACL+ALL technique addresses rotational laxity. 91.6% negative pivot-shift postoperatively vs 49.4% grade 1 preoperatively (Sonnery-Cottet et al., AJSM 2015). No increased risk of stiffness or limited ROM with ALL reconstruction.
- Long-Term Graft Outcomes: SB and DB ACLR with hamstring autograft show comparable long-term results at >14 years (graft rupture ~10%, no significant difference). Risk factors for graft failure: age ≤25y (HR 3.433), preoperative laxity >7mm (HR 3.2). Contact sport participation trend toward higher risk (Todd-Hems et al., OJSM 2025).
- Arthrofibrosis Prevention: Prioritize full extension from day 1. Patellar mobilizations 2x/day. Monitor for cyclops syndrome (5-6% incidence post-ACLR). If extension deficit >5° persists beyond week 6, escalate intervention.
- Re-Injury Risk Monitoring: Young age (≤25y) and contact pivoting sport are primary risk factors. Progressive exposure to sport-specific demands. GPS-guided return to external load. Contralateral ACL rupture rate 7.6-8% — bilateral neuromuscular prevention programs recommended.

BASELINE CLINICAL CRITERIA PRIOR TO RETURN TO RUN → JUMP → SPORT

Baseline Criteria (Common to All Milestones)

- Pain = 0 during daily activities and training
- Effusion = 0
- Full ROM symmetrical to contralateral
- Negative Lachman, anterior drawer, pivot-shift
- Normal gait pattern confirmed
- No reactive symptoms after 24h of last session

Return to Run Criteria (Week 16-20)

- Quadriceps LSI ≥ 70% (isokinetic 60°/s)
- PkTq/BW quadriceps ≥ 1.8 Nm/kg at 60°/s
- YBT-A SSD ≤ 4 cm
- Single-leg squat 10 reps with good alignment
- Single-leg calf raise ≥ 25 reps
- CMJ < 15% asymmetry

Return to Jump Criteria (Week 24-28)

- Quadriceps LSI ≥ 80% (isokinetic 60°/s)
- PkTq/BW quadriceps ≥ 2.0 Nm/kg at 60°/s
- Single hop LSI ≥ 80%
- CMJ < 10% asymmetry
- YBT-A composite ≥ 95% LL
- Continuous running 20 min pain-free

Return to Sport Criteria (Week 32-36+)

- Quadriceps LSI ≥ 90% (isokinetic 60°/s, 180°/s, 240°/s)
- Hamstring LSI ≥ 90%
- PkTq/BW quadriceps ≥ 2.5 Nm/kg at 60°/s
- H:Q ratio ≥ 0.6 (conventional), ≥ 1.0 (functional ecc/conc)
- Single hop, triple hop, crossover hop, 6m timed hop: LSI ≥ 90%
- CMJ < 10% off-shift
- ACL-RSI ≥ 70
- GPS: HSR ≥ 85%, sprint ≥ 90% of pre-injury match reference
- Full MD clearance + coaching staff clearance

SCIENTIFIC REFERENCES

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