PHYSIOTHERAPY & REHABILITATION PROTOCOL

SOLEUS MUSCLE INJURY — FOOTBALL / HIGH PERFORMANCE RUNNING

ATHLETE: _____	POSITION: _____	INJURY DATE: _____	TARGET RTT: _____
DIAGNOSIS: Soleus Strain _____	**BAMIC GRADE:** ____ Site: ____	**CIT INVOLVED:** YES / NO	**MRI DATE:** _____

1 · EXECUTIVE SUMMARY

The soleus is the primary ankle work generator in stance-phase locomotion, responsible for ~53–74% of ankle positive work via elastic Achilles tendon recoil across speeds of 2–8 m/s (Lai 2014). Its monoarticular architecture, type-I fiber dominance (60–90%), and coupling to the long Achilles tendon define both its role and its injury vulnerability. Soleus injuries in football athletes are dominated by cumulative load mechanisms — not single-event explosive tears — and concentrate at five anatomical sites (MTM, MTL, MTC, MFA, MFP), with the central intramuscular tendon (CIT) involved injuries (MTC/BAMIC-c) carrying the worst prognosis (mean RTP ~44 days, Pedret 2015).

This protocol is criteria-based, not calendar-based. Time estimates are provided as clinical guides, not gates. Progression must satisfy objective strength, endurance, and functional criteria at each phase transition. The two cardinal principles are: (1) knee-flexed loading is mandatory for soleus-specific rehabilitation; (2) sprint exposure must be completed before return-to-training.

PROGNOSIS BY ANATOMICAL SITE (Pedret 2015, n=44)

Site	Location	BAMIC suffix	Mean RTP	CIT involved
MTL	Proximal lateral myotendinous junction	**b**	~19 days	No
MTM	Proximal medial myotendinous junction	**b**	~25 days	No
MFA	Myofascial anterior	**a**	~33 days	No
MFP	Myofascial posterior	**a**	~38 days	No
MTC	Central intramuscular tendon (CIT)	**c**	**~44 days***	YES — worst prognosis

** MTC mean RTP 44.3 ± 23.0 days. CIT injuries follow tendon-grade healing timelines and progress at 1.5–2× slower rate than MTJ injuries.*

2 · SOLEUS REHABILITATION PRINCIPLES

Biomechanical Rationale

- Soleus fibers operate near-isometrically during running — they generate and maintain force while the Achilles tendon cycles through elongation and recoil. Rehabilitation must restore both muscle force capacity and tendon stiffness.
- Elastic energy contribution to ankle work increases from 53% (2 m/s) to 74% (8 m/s). Sprint re-exposure is obligatory for full functional restoration.
- Knee-flexed loading isolates the soleus: with the knee at 30–90°, the gastrocnemii shorten and lose force capacity, making the soleus the primary plantarflexor. Any protocol omitting bent-knee loading under-doses the soleus.
- The Rate of Force Development (RFD) — not peak force alone — governs functional capacity at sprint contact times (~100 ms). Late-phase rehab must include explosive intent and SSC-based exercises.

Loading Hierarchy

- ISOMETRIC → ISOTONIC (CONC/ECC) → HEAVY SLOW RESISTANCE → PLYOMETRIC → SPRINT. Each tier builds on the last. Do not skip phases.
- Isometric contractions (45 s holds, 70% MVC) provide tendon stiffness stimulus and cortical analgesia (Rio protocol), reduce neuromotor inhibition, and allow early loading without tissue stress concentration.
- HSR (65–90% 1RM, 3+3 s tempo, knee-flexed emphasis) is the gold standard for tendon remodelling — induces collagen type-I synthesis, improves MTU stiffness, and restores force-generating capacity.
- Plyometrics and SSC drills restore the elastic energy storage-release mechanism essential for football running and sprinting.
- CIT/MTC injuries require extended HSR phase (minimum 2 additional weeks) before plyometric or running re-exposure.

Pain Monitoring Framework

- Acceptable pain during loading: ≤3/10 on NRS (0–10) during exercise, resolving within 2 hours.
- Next-day response is the gold standard: symptoms at or below baseline 24 h after session = adequate load.
- Do NOT progress if next-day symptom score exceeds baseline by >1 point.
- Deep mid-calf ache on palpation returning during or after load = CIT flare signal. Regress and reassess.

3 · PHASE-BY-PHASE REHABILITATION PROTOCOL

PHASE I — PROTECTION & PAIN CONTROL

Days 0–7 | All injury sites

Tissue protection, neuromotor inhibition control, pain-free ambulation

OBJECTIVES

- Achieve pain-free ambulation without compensatory gait (NRS = 0 at walking pace).
- Control acute oedema and reduce pain at rest to NRS ≤ 2.
- Initiate neuromuscular activation without tissue stress: isometric plantarflexion tolerance ≥ 70% MVC bilateral.
- Maintain cardiovascular fitness via non-impact exercise.
- Establish ankle ROM: full dorsiflexion AROM without provocation.
- Prevent proximal deconditioning (hip, trunk, contralateral limb).

INTERVENTIONS

- **Calf isometric holds (bilateral, knee extended):** — 5 × 30–45 s at 50–60% MVC, pain-free. Frequency: 2× daily. Analgesic effect via cortical inhibition (Rio protocol adapted). Progress: add knee-flexed variant by D4 if pain-free.
- **Active ankle ROM:** — dorsiflexion / plantarflexion AROM in pain-free range: 3 × 10 reps. No forced stretch.
- **Cycling (stationary, no resistance):** — 15–20 min, pain-free. Maintains VO2 without impact loading.
- **Pool walking / aqua running:** — 20–30 min if pool available. Early cardiovascular maintenance.
- **Hip and trunk strengthening:** — glute med, hip extension, anterior core: 3 × 12 reps each. Maintain kinetic chain.
- **Calf compression + elevation:** — 15–20 min, 2–3× daily for acute oedema management.
- **NSAIDs / analgesics:** — only if medically indicated. No strong evidence for outcome change; use judiciously in early acute phase only.
- **Gentle manual therapy:** — soft-tissue work proximal to injury site as comfort adjunct only, not primary driver.

PROGRESSION CRITERIA

- Pain-free walking at normal speed (NRS = 0).
- Minimal rest pain (NRS ≤ 1).
- Tolerance of bilateral isometric plantarflexion at 70% MVC without flare.
- Full pain-free ankle AROM.
- Oedema: 2+ → 1+ or resolved.

PHASE II — EARLY LOADING — TISSUE STIMULATION

Week 1–3 | MTL/MTM: start W1 | MTC (CIT): start W2

Initiate progressive axial loading of soleus MTU; establish knee-flexed loading; restore basic strength

OBJECTIVES

- Establish pain-free bilateral calf raise (knee extended and knee flexed) × 15+ reps.

- Initiate single-leg calf raise (knee extended) tolerance: 3+ reps pain-free.
- Restore knee-flexed seated heel raise to 50% of contralateral repetition count.
- Progress isometric intensity to 80% MVC without symptom provocation.
- Maintain cardiovascular base: 30+ min low-impact cardio 4× / week.
- Demonstrate pain-free single-leg stance ≥ 30 s.

INTERVENTIONS

- **Seated bent-knee heel raise — bilateral:** (90° knee flexion, dumbbell on knee): 4 × 15–20 reps, bodyweight progressing to 5–10 kg load. 3+1+3 tempo. SOLEUS-SPECIFIC. 3× per week.
- **Standing heel raise — bilateral (knee extended):** : 4 × 15–20 reps, bodyweight + incremental load (10–20% BW). 3+0+3 tempo. Gastrocnemius + soleus stimulus.
- **Single-leg heel raise (standing, knee extended):** : Begin end of W1/start W2 when bilateral ≥15 reps pain-free. 3 × 5–8 reps → progress to 10+.
- **Isometric plantarflexion (seated, knee flexed, HHD or Smith machine):** : 5 × 45 s at 70–80% MVC, 2 min rest. Daily. Tendon stiffness stimulus + analgesia.
- **Ankle proprioception — bilateral board/foam:** : 3 × 30 s, progress to single-leg. Neuromuscular restoration.
- **Cycling or swimming:** : 30–45 min, 4–5× / week. Cardiovascular maintenance. No running.
- **Hip and trunk progression:** : hip hinge, split squat (unloaded, injured limb rear), Romanian deadlift. 3 × 10–12.
- **Gastrocnemius stretch (knee extended):** : ONLY in pain-free range. No end-range stretch force.

PROGRESSION CRITERIA

- Pain-free bilateral calf raise (knee extended AND knee flexed): ≥ 15 reps each position.
- Pain-free single-leg heel raise (knee extended): ≥ 5 reps.
- Seated bent-knee single-leg heel raise: ≥ 50% of contralateral volume.
- LSI isometric plantarflexion (knee-flexed): ≥ 70%.
- NRS during all loading activities: ≤ 3/10, resolving within 2 h post-session.
- No next-day symptom flare above baseline.

PHASE III — STRENGTH DEVELOPMENT — HSR TRANSITION

Weeks 2–4 | MTM/MTL | Weeks 3–5 | MTC

Progress to single-leg loaded work; initiate Heavy Slow Resistance; achieve ≥ 80% LSI

OBJECTIVES

- Pain-free single-leg heel raise (knee extended): ≥ 20 reps at body weight.
- Pain-free single-leg bent-knee heel raise with added load: ≥ 3 × 10 reps.
- Achieve LSI ≥ 80% on isometric plantarflexion (knee flexed, HHD).
- Introduce heavy-slow-resistance protocol with ≥ 65% 1RM load tolerance.
- Demonstrate symmetrical ankle proprioception on single-leg balance task.
- Restore full-range pain-free AROM in plantarflexion and dorsiflexion.

INTERVENTIONS

- **Seated bent-knee heel raise — LOADED (soleus-specific HSR):** : 4 × 8–12 reps, dumbbell or machine (65–70% 1RM equivalent). 3+1+3 s tempo. 3× / week. PRIMARY SOLEUS EXERCISE. Increase load 5–10% when 12 reps completed pain-free.
- **Heel-raise with deficit (step, knee extended):** : 3 × 10–12 reps, increased ROM, bodyweight + 10–20%. Eccentric emphasis. 4 s eccentric phase.

- **Heavy seated calf machine (if available):** : 3 × 8–10 reps at 70–80% 1RM, slow tempo. Provides direct knee-flexed, high-load stimulus.
- **Single-leg standing heel raise (progression):** : 3 × 15–20 reps. Add body-weight vest when 25 reps achieved.
- **Isometric 80% MVC — knee flexed (maintenance):** : 5 × 45 s, daily or 5× / week. Tendon stiffness maintenance.
- **Hip and lower-limb compound work:** : Split squat loaded, goblet squat, Nordic hamstring (prevention). 3 × 8–12.
- **Balance and proprioception progression:** : Single-leg wobble board, perturbation, eyes-closed stance. 3 × 30–45 s.
- **Cycling or swimming:** : 40–50 min, 4× / week. Cardiovascular base maintenance.
- **Ankle dorsiflexion mobility:** : Knee-to-wall (lunge), calf/soleus self-mobilisation. Daily.

PROGRESSION CRITERIA

- Pain-free single-leg bent-knee heel raise: ≥ 10 reps at ≥ 65% 1RM, full ROM.
- LSI isometric plantarflexion (knee flexed, HHD): ≥ 80%.
- LSI seated heel-raise endurance (reps to failure, matched load): ≥ 70%.
- No palpation tenderness over CIT (for MTC injuries) when loaded.
- Ability to hop bilaterally (low amplitude) without pain.
- NRS during all activities ≤ 2/10, NRS 24 h after ≤ 1/10.

PHASE IV — CAPACITY PHASE — HEAVY SLOW RESISTANCE & ECCENTRIC

Weeks 3–5 | MTM/MTL | Weeks 4–6 | MTC

Peak strength development; restore LSI ≥ 90%; prepare MTU for elastic-reactive demands

OBJECTIVES

- Achieve LSI ≥ 90% on all plantarflexion strength measures (knee-flexed and knee-extended).
- Complete seated bent-knee heel raise: ≥ 12 reps at ≥ 75% 1RM equivalent.
- Complete single-leg standing heel raise: matched volume to contralateral side.
- Demonstrate tolerance of double-leg low-amplitude plyometrics (pogo hops).
- Prepare Achilles-soleus MTU for elastic energy storage (stiffness adaptation).
- Introduce early running-specific drills (no running yet): A-skips, pogo, ankling.

INTERVENTIONS

- **Seated bent-knee heel raise — heavy (HSR peak):** : 4 × 6–8 reps at 75–85% 1RM. 3+2+3 s tempo. 3× / week. This is the primary load stimulus for tendon remodelling and soleus hypertrophy.
- **Heel raise with deficit — single-leg:** : 3 × 10–12 reps, full eccentric (4–5 s down), rapid concentric. BW + vest/dumbbell. Eccentric-focused.
- **Leg press (calf station, knee slightly flexed):** : 4 × 8–10 at 80% 1RM. Controlled cadence. Load range wider than standing calf raise.
- **Isometric plantarflexion holds at long MTU length (knee extended, ankle in dorsiflexion):** : 5 × 30 s at 70–80% MVC. Loads tendon at longer length.
- **Double-leg pogo hops:** : 4 × 10–15, small amplitude (~3 cm). Ankle stiffness focus. Introduce SSC demand. Begin only when LSI ≥ 85%.
- **A-skips, B-skips, ankling:** : Running-specific neuromuscular drills, no impact yet. 4 × 20 m. Warm-up.
- **Sled push (light load):** : 4 × 20 m. Plantarflexor demand without free flight. Running preparation.
- **Hip-dominant compound movements:** : hip hinge loaded, single-leg RDL with KB, Bulgarian split squat 3 × 8.
- **Rate of Force Development drills (ISO intent):** : maximal-intent isometric contractions 3–5 × 5 reps, 2-s explosive push. RFD restoration.

PROGRESSION CRITERIA

- LSI isometric plantarflexion (knee flexed, HHD): ≥ 90%.
- LSI seated bent-knee heel raise (reps to failure, equivalent load): ≥ 90%.
- Pain-free double-leg pogo hops (× 15) with no next-day flare.
- Full single-leg heel raise ROM: no height asymmetry vs contralateral.
- NRS during all activities ≤ 1/10.
- For MTC injuries: no tenderness on deep palpation of CIT at rest.

PHASE V — ELASTIC & REACTIVE PHASE — RUNNING ENTRY

Weeks 4–6 | MTM/MTL | Weeks 6–8 | MTC

Restore SSC capacity; introduce progressive running exposure; achieve walk-run tolerance

OBJECTIVES

- Complete 25 min continuous jog at conversational pace, pain-free.

- Demonstrate pain-free single-leg pogo hops × 10 and single-leg forward hops × 5.
- Restore LSI ≥ 90% on all functional tests (single-leg hop, triple hop).
- Achieve running volume of 15–20 min continuous on flat surface.
- Initiate running-specific elastic drills: bounding, skipping.
- Maintain HSR strength alongside running progression.

INTERVENTIONS

- **Walk-run progression (Stage A):** : 1 min jog / 1 min walk × 10. Progress: 2/1 → 3/1 → 4/1 → 5/1. Only advance if pain-free during AND 24 h after. Flat, even surface only.
- **Continuous running (Stage B):** : 10 min → 15 → 20 → 25 min. Conversational pace (RPE 4–5/10). 2–3× per week. Progress session duration before frequency.
- **Single-leg pogo hops:** : 3 × 10 reps per side, maximal stiffness intent. Begin bilateral, progress unilateral.
- **Single-leg forward hops:** : 3 × 5 reps, stick landing. LSI assessment. Introduce when double-leg SSC pain-free × 2 sessions.
- **Bounding and skipping for height:** : 4 × 20–30 m. Powerful plantarflexion demand. GPS-monitored.
- **Seated bent-knee heel raise — maintenance HSR:** : 3 × 8 at 75–80% 1RM. Maintain soleus-specific strength. 3× / week alongside running.
- **Single-leg eccentric heel raise (deficit):** : 3 × 8–10. Maintain eccentric capacity. 2–3× / week.
- **Change-of-direction (low intensity):** : 45–60° cuts at easy pace. Lateral shuffles. Introduce COD stimulus without speed.
- **Pool running or AlterG:** : Optional adjunct for higher volume with reduced impact loading.

PROGRESSION CRITERIA

- 25 min continuous running, pain-free, no next-day flare.
- LSI single-leg hop for distance: ≥ 90%.
- LSI triple hop: ≥ 90%.
- Single-leg pogo hops × 10 per side: pain-free, symmetric height.
- LSI seated bent-knee heel raise (endurance): ≥ 90%.
- NRS during running: 0/10. NRS 24 h after: ≤ 1/10.

PHASE VI — PROGRESSIVE RUNNING — SPEED REINTRODUCTION

Weeks 5–7 | MTM/MTL | Weeks 7–9 | MTC

Advance running volume to sport-specific level; introduce moderate-intensity strides and fartlek

OBJECTIVES

- Achieve 40–45 min continuous running at moderate pace without symptom provocation.
- Introduce pace-variation running: fartlek, strides at 70–80% max pace.
- Complete 30 m controlled strides × 6 at 80–85% perceived max without discomfort.
- Advance to uneven terrain, gentle gradients when flat-surface running is fully established.
- Demonstrate explosive-intent drills: single-leg bounds, lateral bounds.
- Maintain calf strength and endurance benchmarks throughout this phase.

INTERVENTIONS

- **Progressive running (Stage C–D):** : 30–45 min with terrain variation. Include 2× weekly sessions. Fartlek (30–60 s moderate-hard segments). No sprinting yet.
- **Controlled strides:** : 6–8 × 60–80 m at 80–85% perceived max. Full recovery (60–90 s). Monitor calf 24 h after first session.
- **Acceleration drills:** : 6 × 15–20 m, emphasis on push-off mechanics. 80% velocity. Not full sprint.
- **Single-leg lateral and forward bounds:** : 3 × 5 per side. Power and force direction variation.
- **Drop jumps — bilateral:** : 3 × 5 from 20–30 cm box. Landing mechanics quality. Ground contact time target < 250 ms.
- **Change-of-direction (progressive intensity):** : 90° cuts, 180° turns, 4-corner agility at 70–80% max speed. Reactive COD introduction.
- **Seated bent-knee heel raise — heavy maintenance:** : 3 × 8 at 80% 1RM, 2× / week.
- **Full-body power training:** : clean pull from floor, hip drive, lower limb elastic work. Sport performance standard.

PROGRESSION CRITERIA

- 40+ min continuous running at moderate pace: pain-free, no next-day flare.
- 8 × 60 m controlled strides at 85%: pain-free, no calf tightness next day.
- LSI drop jump ground contact time: < 10% asymmetry.
- LSI all hop tests: ≥ 90%.
- NRS: 0/10 during all running. Calf stiffness score stable at baseline.

PHASE VII — HIGH-SPEED RUNNING & FIELD INTEGRATION

Weeks 7–9 | MTM/MTL | Weeks 9–11 | MTC

Progressive sprint exposure; repeated sprint tolerance; full-training-load reintegration

OBJECTIVES

- Complete full near-maximal sprint series (6 × 30 m at 90% max) without symptom provocation.
- Demonstrate repeated sprint tolerance: 6 × 30 m with shortened recovery (20 s) — match-simulation demand.
- Complete a 45–60 min full training session (no match contact) without restrictions.
- Achieve LSI ≥ 95% on all strength and functional tests.
- Full change-of-direction volume at sport speed.
- Subjective confidence score ≥ 8/10 for sprint and cutting activities.

INTERVENTIONS

- **Sprint exposure — Stage 1: Accelerations:** : 6 × 15–20 m at ~80%. Full recovery (60 s). Introduce D1 of this phase.
- **Sprint exposure — Stage 2: Near-maximal:** : 6 × 30–50 m at 90%. Full recovery (90 s). Introduce when Stage 1 pain-free × 2 sessions.
- **Sprint exposure — Stage 3: Maximal:** : 4–6 × 30–60 m at 100%. Full recovery. Only after Stage 2 cleared.
- **Sprint exposure — Stage 4: Repeated sprint:** : 6 × 30 m with 20 s recovery (RSA demand). Match-simulation intensity.
- **Match-simulation session:** : 11v11 small-sided game, 45–60 min, monitored via GPS. Target: ≥ 85% pre-injury HSR reference values.
- **Full training participation (no contact):** : progressive inclusion in group sessions, monitored subjective and objective load.
- **Strength maintenance: HSR + plyometrics:** : 2× / week. Bent-knee HSR 3 × 8 at 80% + single-leg plyometric circuits. Do NOT stop strength work once running resumes.
- **GPS monitoring:** : track distance, HSR (>19.8 km/h), sprint distance (>25.2 km/h), acceleration volume. Compare vs squad norms.

PROGRESSION CRITERIA

- LSI: ≥ 95% on bent-knee heel raise (endurance and loaded) and isometric plantarflexion (HHD).
- LSI: ≥ 90% on single-leg hop, triple hop, crossover hop.
- Pain-free completion of all sprint stages (1–4) with NRS = 0.
- GPS: HSR distance ≥ 85% of pre-injury reference in simulated match session.
- No residual palpation tenderness on CIT or MTJ sites.
- No next-day symptom flare after highest-intensity session.
- For MTC injuries: consider follow-up MRI before clearance.

PHASE VIII — RETURN TO TRAINING & PERFORMANCE CONSOLIDATION

Weeks 8–10 | MTM/MTL | Weeks 10–12+ | MTC

Full unrestricted training; match selection criteria; performance restoration

OBJECTIVES

- Full unrestricted participation in team training with no activity restrictions.
- Match selection: all RTP criteria met (see Section 8).
- Return to pre-injury performance benchmarks (GPS, strength, power).
- Establish maintenance program to prevent recurrence (2× / week calf HSR year-round).
- Validate symptom stability over 2+ full training weeks before first competitive match.

INTERVENTIONS

- **Full team training:** : unrestricted. Match contact included. Full tactical demands.
- **Match simulation → competitive match:** : staged match participation (45 min → full match). Monitor GPS load relative to pre-injury reference.
- **Maintenance strength program:** : 2× / week year-round. 3 × 10–12 seated bent-knee HSR at 70–75% 1RM. Non-negotiable post-soleus injury.
- **Monthly calf re-testing (first 3 months post-RTT):** : bent-knee heel raise endurance + HHD plantarflexion strength. Alert threshold: >8% LSI decline.

- **Training load monitoring:** : no week-over-week spikes > 10–15%. GPS monitoring of HSR and sprint volumes for 6 weeks post-RTT.
- **Pre-session soleus activation:** : 2 × 10 bent-knee calf raises + isometric plantarflexion hold × 30 s, as warm-up routine.

PROGRESSION CRITERIA

- ALL RTT criteria met (see Section 8).
- 2 consecutive full training weeks without symptom flare.
- LSI ≥ 95% on all strength and functional tests.
- GPS: sprint distance and HSR within 95% of pre-injury reference.
- Athlete psychological readiness ≥ 8/10.

4 · SOLEUS-SPECIFIC TESTING BATTERY

Test	What it measures	Phase to use	Threshold / Criterion	Limitations
NRS Pain log (rest + activity)	Symptom irritability; tissue reactivity	All phases, daily	**≤ 3/10 during load; 0–1/10 at 24 h**	*Subjective; mood and catastrophizing bias*
Palpation tenderness — CIT / MTJ	Tissue healing status; local reactivity	Ph I–IV, weekly	**0 = no pain; tolerance progressive**	*Poor sensitivity (US ~27% for soleus)*
Ankle dorsiflexion — knee-to-wall (cm)	Distal lower-limb mobility; Achilles length	Ph I–III, entry + exit	**Side-to-side symmetry, no pain**	*Not soleus-specific; confounded by Achilles*
Isometric plantarflexion — knee FLEXED (HHD, N)	Soleus-specific force	Ph I–VIII, weekly	**LSI ≥ 70% → 80% → 90% → 95%**	*Requires calibrated HHD; angle standardisation*
Seated bent-knee SL heel raise — reps to failure	Soleus endurance capacity (c_i parameter)	Ph II–VIII, every 1–2 wk	**Match contralateral; LSI ≥ 90%**	*Load must be matched session to session*
Standing SL heel raise (knee ext.) — reps + height	Combined triceps surae endurance + ROM	Ph II–VIII	**LSI ≥ 90%, no height asymmetry**	*Primarily gastrocnemius; not soleus-specific*
SL hop for distance	Functional SSC plantarflexion power	Ph V–VIII	**LSI ≥ 90%**	*Balance confound; learning effect*
Triple hop for distance	Repeated SSC tolerance	Ph V–VIII	**LSI ≥ 90%**	*Technical variance; requires 3+ practice trials*
Crossover hop for distance	Lateral force direction tolerance	Ph VI–VIII	**LSI ≥ 90%**	*Requires COD confidence first*
Bilateral pogo hops — ground contact time	Ankle stiffness; SSC efficiency	Ph IV–VIII	**< 10% asymmetry; GCT < 250 ms bilateral**	*Requires force plate or timing gate*
Sprint tolerance test (6 × 30 m at 85%)	Sprint-specific MTU reactivity	Ph VII–VIII	**NRS = 0 during + 24 h after**	*High load — never use before LSI ≥ 90%*
GPS session tracking (HSR km, sprint m)	External load against squad reference	Ph VII–VIII	**≥ 85% pre-injury reference**	*Reference data needed; position-specific*
Athlete confidence (0–10)	Psychological readiness; kinesiophobia screen	Ph VI–VIII	**≥ 8/10 for sprint/cutting**	*Subjective; optimism bias risk*

5 · CLINICAL DECISION TRAFFIC-LIGHT SYSTEM

Status	Criteria	Action
GREEN	NRS ≤ 3/10 during load; NRS 0–1 at 24h; LSI ≥ phase target; no palpation tenderness increase	**Progress to next load step. Record and advance.**
AMBER	NRS 4–5/10 during load; OR NRS 2–3/10 at 24h; OR LSI 5–10% below phase target; mild tenderness increase	**Maintain current load level. Do NOT progress this session. Reassess in 48 h. Review weekly volume.**
RED	NRS > 5/10 during load; OR NRS > 3/10 at 24h; OR deep CIT ache returning; OR new tenderness over CIT or MTJ; OR strength regression > 10%	**STOP loading. Regress one phase. Reassess with medical staff. Re-image if CIT injury or persistent RED status > 48 h.**

6 · WEEK-BY-WEEK REHABILITATION CALENDAR

Timeline assumes criteria-based progression from MTM/MTL injury. MTC/CIT injuries: add 2–3 weeks to each phase transition. Do not advance on calendar time alone.

WK	Phase	Key Priorities	Loading Target	Re-test Milestone
1	Ph I–II	Pain control, bilateral calf raises, isometrics, cardiovascular	Bodyweight bilateral / ISO 70% MVC	Isometric HHD baseline
2	Ph II	Seated bent-knee HR, single-leg standing HR entry, proprioception	BK HR bilateral loaded +5–10 kg	BK SL heel raise (reps)
3	Ph III	HSR entry — loaded BK HR, deficit HR, heavy ISO	65–70% 1RM seated; 4×10–12	LSI ISO knee-flexed HHD
4	Ph III–IV	Heavy seated HSR, eccentric deficit, pogo hops (bilateral) entry	70–75% 1RM; pogo 4×10	BK SL HR endurance; LSI ≥ 80%
5	Ph IV–V	Peak HSR load; walk-run Stage A begins (MTM/MTL); bounding drills	75–85% 1RM; W/J 1:1 × 10	SL hop for distance LSI
6	Ph V	Continuous running 15–20 min; single-leg pogo; strides (MTM/MTL)	20 min jog + HSR maintenance	Triple hop LSI; endurance ≥ 90%
7	Ph V–VI	Running 30+ min; fartlek segments; COD entry; (MTC: Ph IV peak HSR)	3+ × 20 min runs / week	Crossover hop; GPS distance
8	Ph VI	Controlled strides 80%; drop jumps bilateral; (MTC: walk-run entry)	8 × 60 m strides at 85%	Drop jump GCT asymmetry
9	Ph VII	Sprint Stage 1–2: accelerations + near-maximal (MTM/MTL RTT week)	6 × 20 m + 6 × 30 m at 90%	Sprint tolerance NRS; LSI ≥ 95%
10	Ph VII	Sprint Stage 3: maximal; match simulation; (MTC: sprint Stage 1–2)	Maximal sprint + GPS sim session	All hop tests + GPS vs reference
11	Ph VIII	Full training integration; sprint Stage 4 (repeated sprint)	RSA 6 × 30 m / 20 s; full session	LSI all tests ≥ 95%; confidence ≥ 8
12+	Ph VIII / RTT	Match selection when ALL RTP criteria met; maintenance program starts	Competition load, monitored GPS	Monthly re-test for 3 months

MTC/CIT timeline: add W2–3 to Phase III–IV transitions; walk-run entry at W8–9; sprint entry at W11–12; RTT at W12–14+.

7 · RUNNING & FIELD REINTEGRATION ROADMAP

Stage A — Walk-Run Intervals (Ph V, ~2–4 sessions)

- 1 min jog / 1 min walk × 10 → progress to 2/1, 3/1, 4/1, 5/1.
- Flat, even surface. Consistent footwear and pace.
- Advance only when pain-free during AND 24 h after. Do not rush Stage A.
- Entry criteria: LSI ≥ 85% isometric, pain-free double-leg pogo hops ×15.

Stage B — Continuous Easy Running (Ph V, ~4–6 sessions)

- 10 min → 15 → 20 → 25 min continuous at conversational pace (RPE 4–5/10).
- 2–3× per week with at least 48 h between sessions.
- Delay terrain or footwear changes until 25 min continuous is fully tolerated.
- Uphill running increases soleus demand — introduce only after Stage B established.

Stage C–D — Volume Progression and Pace Variation (Ph VI)

- 30–45 min with gentle terrain variation; fartlek segments (30–60 s at moderate-hard pace).
- Controlled strides: 6–8 × 60–80 m at 80–85% perceived max. Full recovery between.
- Monitor calf stiffness score morning after first stride session.
- Change-of-direction at 60–80% pace: included once continuous running is fully established.

Stage E — Sprint Exposure (Ph VII)

- Stage 1: Accelerations — 6 × 15–20 m at ~80%. Full recovery. 2 sessions × GREEN before advancing.
- Stage 2: Near-maximal runs — 6 × 30–50 m at ~90%. Full recovery (90 s). 2 sessions × GREEN before advancing.
- Stage 3: Maximal sprints — 4–6 × 30–60 m at 100%. Full recovery. 2 sessions × GREEN.
- Stage 4: Repeated sprint ability (RSA) — 6 × 30 m / 20 s recovery. Match simulation demand. Final gate before RTT.
- RULE: Never skip a stage. Never advance after a RED/AMBER session.
- For MTC injuries: each sprint stage requires 2+ sessions of GREEN before advancing.

8 · RETURN-TO-TRAINING CRITERIA

Return to Run (RTR) — Minimum Criteria

- Pain-free daily activity and clinical examination (NRS = 0).
- LSI isometric plantarflexion (knee-flexed, HHD): ≥ 85–90%.
- Single-leg bent-knee heel raise (seated): LSI ≥ 85%, full ROM.
- Tolerance of double-leg plyometrics (pogo hops × 15) pain-free.
- For MTC/CIT injuries: imaging review or clinical confidence that CIT reactivity is resolved.

Return to Full Training (RTT) — Criteria Checklist

Criterion Domain	Minimum Standard	Ideal Standard
Strength — Knee-flexed (soleus-specific)	LSI ≥ 90% isometric HHD	LSI ≥ 95% loaded heel raise endurance
Strength — Knee-extended	LSI ≥ 90% single-leg standing HR	LSI ≥ 95%
Endurance (c_i parameter)	Seated SL HR = contralateral reps × same load	Full match of volume AND load
Functional SSC (q_i parameter)	LSI ≥ 90%: SL hop, triple hop	LSI ≥ 90%: crossover hop, drop jump GCT
Sprint exposure	Stage 1–3 completed (all GREEN)	Stage 4 RSA completed (pain-free)
Running volume	Full sport-specific run volume tolerated in training week	GPS HSR ≥ 85% of position reference
Symptom status	NRS = 0 all clinical tests + running	No next-day flare after hardest session
24 h tissue reactivity	Stable calf stiffness 24 h after hardest session	Calf stiffness = pre-injury baseline
Clinical examination	No palpation tenderness (CIT/MTJ)	MD clearance with clinical confidence
Imaging (selective)	CIT involved: MRI review recommended	No residual high signal on MRI if MTC
Athlete confidence	≥ 7/10 for sprinting and cutting	≥ 8/10 subjective readiness
Observation window	1 full training week without restriction	2 consecutive training weeks, no flare

RTT vs RTP vs Return to Performance: RTT = unrestricted training participation. RTP = match selection approved. Return to Performance = full pre-injury performance output restored (GPS, power, reaction time benchmarks). The soleus-specific risk: RTT is easy to declare; premature RTP without RSA exposure is the most common recurrence driver. Stage 4 sprint exposure is mandatory before match selection.

9 · COMMON ERRORS & CLINICAL RED FLAGS

The 8 Most Common Rehabilitation Errors

- **1.** Testing and clearing on standing heel raise only — misses soleus-specific deficits. Always include knee-flexed testing.
- **2.** Stopping rehabilitation at pain-free jogging — most common recurrence driver. Run full sprint exposure stages before RTT.
- **3.** Not progressing to heavy loads (< 65% 1RM throughout rehab) — inadequate tendon remodelling stimulus.
- **4.** Calendar-based progression for MTC/CIT injuries — these injuries require tendon healing timelines. Criteria FIRST.
- **5.** Dropping strength work once running begins — strength maintenance is mandatory. Continue HSR 2× / week throughout.
- **6.** Ignoring next-day symptom response — progressing despite AMBER/RED signals creates cumulative damage.
- **7.** Skipping sprint stages (jumping from jog to full training) — the mismatch between jog tolerance and sprint demand is where recurrences occur.
- **8.** Not addressing Achilles tendinopathy or ankle dorsiflexion restriction coexisting with soleus injury — these increase soleus MTU load redistribution.

Clinical Red Flags — Stop and Reassess

- New or returning deep mid-calf ache on palpation (CIT location) → STOP loading. Re-image within 48 h if CIT injury.
- Increasing heel-raise pain during progressive sessions over 2+ consecutive sessions.
- Next-day symptom flare > baseline after any session for > 2 consecutive sessions.
- Progressive loss of heel-raise endurance (heel raises declining week-over-week).
- Failure to progress strength (LSI stagnating or declining) over 2+ weeks in Phase III–IV.
- Persistent palpation tenderness beyond 4 weeks in MFA/MFP; beyond 6 weeks in MTC.
- Calf tightness developing during a running session → immediate stop; reassess next day.
- Athlete reports loss of 'spring' or 'push-off power' persisting > 1 week — possible unresolved strength or stiffness deficit.

10 · RESEARCH GAPS & AREAS OF UNCERTAINTY

Established Evidence (High Confidence)

- Knee-flexed loading isolates the soleus vs gastrocnemius (Fujisawa 2015, EMG evidence).
- CIT/MTC injuries carry significantly worse RTP prognosis (Pedret 2015, n=44, r=0.51 for age).
- Elastic tendon contribution to ankle work increases with speed: 53→74% at 2–8 m/s (Lai 2014).
- Heavy slow resistance is equivalent or superior to eccentric-only loading for tendinopathy (Beyer meta-analysis).
- Isometric contractions (≥15 s) produce tendon stiffness adaptation (Kubo 2006, 2017).

Inferred Clinical Framework (Moderate Confidence)

- LSI ≥ 95% on bent-knee tests as RTT threshold — extrapolated from ACL rehab symmetry standards. Not validated in soleus-specific RCTs.
- 10% load progression rule per week — general sports medicine principle, not soleus-specific.

- 48–72 h recovery between HSR sessions for tendons — reasonable based on mechanotransduction biology but not tested in soleus muscle-tendon units directly.
- 1.5–2× slower progression rate for CIT vs MTJ injuries — logical from healing timelines but not from soleus-specific prospective RCT.

Speculative / Unknown (Low Confidence — Explicitly Labelled)

- Optimal HSR dose for soleus CIT remodelling — frequency, load, volume have not been tested in soleus-specific RCTs.
- Whether plyometrics before full sprint exposure specifically reduces recurrence (plausible but not proven in soleus cohorts).
- Role of individual CIT morphology (Theobalt 2024 variability data) in predicting injury risk and recovery — no prospective data.
- Optimal maintenance program dose post-RTT — the '2× per week' recommendation is pragmatic, not evidence-based.
- Whether repeat imaging at RTP improves outcomes in MTC injuries — clinically logical but not formally validated.

11 · FINAL INTEGRATED CONCLUSION

Soleus injury rehabilitation in high-performance football demands respect for four non-negotiable principles: (1) knee-flexed loading throughout, (2) criteria-based — not calendar-based — phase transitions, (3) mandatory sprint exposure before return-to-training, and (4) extended timelines for CIT/MTC injuries. The protocol presented integrates the biomechanical reality of the soleus as a near-isometric, elastic-energy-dependent plantarflexor with the clinical evidence base available in this vault.

The catapult mechanism — short soleus fibers pre-loading the long Achilles tendon — demands that rehabilitation restores not only muscle force (c_i parameter) but also the neuromuscular timing and RFD required for 100 ms sprint contact cycles (q_i parameter). Stopping at strength restoration and ignoring sprint exposure is the most common cause of the ~19% recurrence rate observed in AFL and equivalent football cohorts.

An athlete cleared to play who has never completed a repeated-sprint protocol is not ready to play. The difference between a successful and a failed return is almost always sprint exposure — not time, not scan findings, not pain level.

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