

Physical preparation of the football player with an intramuscular hamstring tendon tear: clinical perspective with video demonstrations

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CASE SCENARIO

Hamstring strain injuries (HSIs) are common injuries in professional sport and the musculotendinous junction the most frequently injured site.^{1 2} MRI proves that the tendon extends into the muscle belly and has increased awareness of the intramuscular tendon injury.³ Some argue that this subtype of HSI may require surgical repair. Currently, there is no consensus on intramuscular tendon injury management; there is agreement that players are at an increased risk of re-injury on return to play (RTP).^{3 4} Evidence suggests that clinical decision-making, based on achieving functional goals, is an essential element of successful rehabilitation.⁴

In this video-supported education review with a strong clinical slant, I outline the rehabilitation of an English Premier League footballer who suffered a proximal hamstring intramuscular tendon injury during competition. The conceptual goal was to mechanically load the muscle–tendon unit hoping to improve tensile strength, elastic stiffness and cross-sectional area. Adequate high and maximal speed running exposure and objective neuromuscular performance data informed progression through rehabilitation and RTP. The player returned to competition in 120 days and remained injury free 13 months later.

MECHANICAL LOADING

During rehabilitation following initial physiotherapy care, isometric hamstring exercises were prescribed, beginning with single-leg heel drives (figure 1), progressing to unloaded, then loaded bilateral isometric hip extension holds (online supplementary video 1),

ISOMETRICS	
Single-leg Heel Drives (30° and 90°)	
Bilateral Isometric Hip Extension	Unilateral Isometric Hip Extension
**Bodyweight	**Bodyweight
**Loaded	**Loaded
**Perturbation	**Perturbation
Elastic (extend + retract)	Elastic (extend + retract)
Resisted Rotation	Lateral Rotation
	Resist Medial Rotation
	Resist Lateral Rotation
3-4 sets of 1-6 reps 3-5s per rep **Cluster sets 5~3-5s (5-10s) - Time under tension	

Figure 1 Progression of isometric strength exercises for hamstring-tendon loading.

then single-leg hip extension holds (online supplementary video 2) emphasising pelvic control before adding dynamic perturbations (online supplementary video 3). These high-intensity isometric exercises, using maximal voluntary contractions (~3–5 s) in cluster sets (ie, 5×5–3–5 s) were included with the theoretical aim of providing cyclic high-strain magnitudes postulated to increase tendon/aponeurosis stiffness, reduce tendon/aponeurosis strain and enhance force development. I mention these mechanistic elements for discussion while being clear that there is no evidence that these hoped for stimuli, or their downstream effects, are being delivered with

STRENGTH		
Kettlebell RDL	Sliding Leg Curl (eccentric only)	Bilateral Heel Elevated Hip Thrust
Barbell RDL	Sliding Leg Curl (concentric: eccentric)	Single-leg Heel Elevated Hip Thrust
Overspeed RDL (reactive)	Sliding Leg Curl (distal load)	Heel Elevated Hip Thrust variations (proximal resistance)
Kettlebell Single Leg RDL (close to centre of mass)	Sliding Leg Curl (variable resistance)	Heel Elevated Hip Thrust variations (variable resistance)
Barbell Single Leg RDL	Sliding Leg Curl (Distal + Variable resistance)	
3-4 sets 1-6 reps Nb: Overload to injured side e.g. 3/2 or 4/2 dependent upon asymmetry		

Figure 2 Progression of strength exercises for hamstring–tendon loading.

this programme. A future challenge is to try to study these processes in vivo.

In conjunction with isometric hamstring exercises, dynamic exercises, including bilateral gluteal bridging, were introduced, and full range of motion

STRENGTH: Intermuscular emphasis	
Kettlebell Single-leg RDL	Split Squat
Barbell Single-leg RDL	Barbell Split Squat
Barbell Single-leg Good Morning	Barbell Reverse Lunge
Barbell Single-leg Good Morning to Box	Barbell Reverse Lunge to Box
	Barbell Split Squat Jump to Box
Hanging Kettlebell Split Squat (imperfect loading)	
3-4 sets Early 6-8 reps End 3-6 reps Nb: Overload to injured side e.g. 3/2 or 4/2 dependent upon asymmetry	

Figure 3 Progression of strength exercises with intramuscular emphasis for hamstring–tendon loading.

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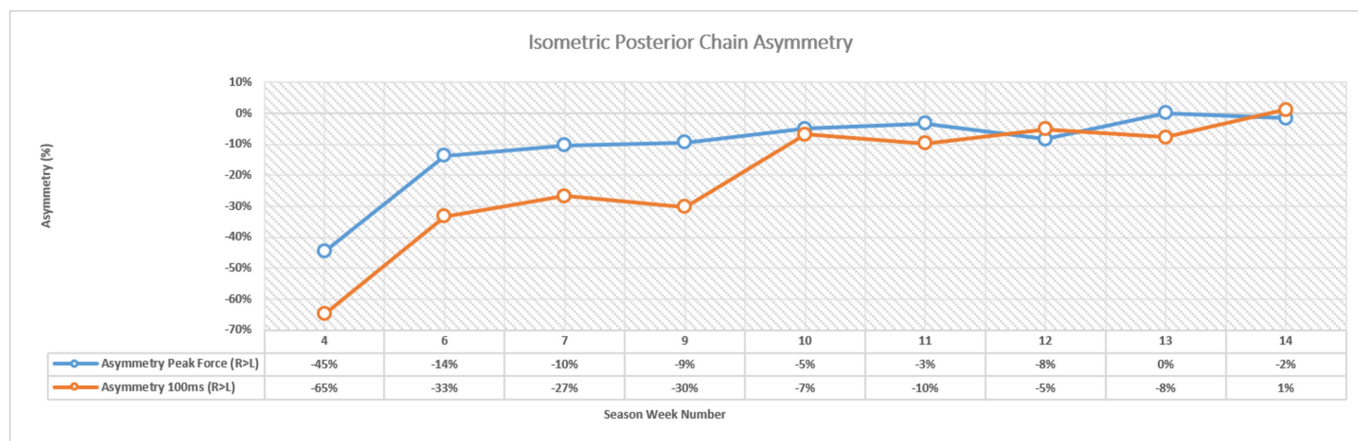


Figure 4 Isometric posterior chain peak force and asymmetry during hamstring–tendon rehabilitation.

unloaded split squats (online supplementary video 4). In my mechanistic model, this would promote collagen synthesis and fibre alignment, and improve tendon tensile strength. Gluteal bridging was progressed in three ways; increasing the lever arm and effective load by elevating the feet, adding load (online supplementary video 5) and selectively overloading the injured limb (online supplementary video 6) to provide a stability challenge alongside increased load. Resistance bands (online supplementary videos 7 and 8) were also used to vary the velocity of contraction and reactivity (figure 2).

The Romanian deadlift was the principal hip-dominant exercise selected, progressing from bilateral (online supplementary videos 9 and 10) to unilateral (online supplementary video 11), increasing recruitment of the injured muscle group, to target hip extensor strength asymmetry. The reverse lunge (online supplementary video 12) was the principal unilateral knee-dominant exercise selected to develop knee/hip extension strength, with a focus on acceleration mechanics, providing a foundation for more advanced variants (figure 3). Again, we postulate that this would promote

intermuscular adaptations specific to the demands of high-speed running (HSR). Exercise progressions focused on increasing intermuscular co-ordination demands, similar to the proximal to distal activation pattern observed during the stance phase of gait, optimising energy transfer from hip to knee and from knee to ankle (online supplementary videos 18, 19 and 20).

Objective criteria for load progression

At week 7, my criterion for phase; progression peak force (PF) asymmetry $\leq 10\%$ in a force platform isometric posterior chain (IPC) test⁵ (figures 4 and 5) was achieved, allowing progression of exercise selection to emphasise hip extension

and eccentric knee flexion. The eccentric-only sliding leg curl (online supplementary video 13) was introduced, then progressed in volume from 2×4 reps to 4×5 reps, followed by the eccentric–concentric version (online supplementary video 14), adding distal load (online supplementary video 15) and resistance bands (online supplementary video 16) to increase speed and strain rate of the eccentric phase, and reactive demands (figure 2).

At week 9, IPC test PF asymmetry was $<10\%$, my criterion for jump-landing and plyometric activity integration (figure 6), part of a multidimensional approach to enhance lower limb stiffness, neuromuscular control and landing biomechanics, and promote reduced joint loading. During weeks 9–10, jump-landing derivatives were introduced, followed by progression to plyometric activities in weeks 11–14 (figure 6) to target fast stretch shortening activities (<250 ms) reflecting HSR ground contact times (online supplementary video 21). Achieving $<10\%$ PF IPC asymmetry was also my criteria for beginning outside preparation. Gradual exposure to high running velocities including $>5.5 \text{ m s}^{-1}$ (online supplementary video 22) was initiated in week 10 and included periodised exposures to relative HSR early in the week (figure 7). An acute ramp in relative HSR began after IPC test force at 100 ms (an indicator of rate of force development) asymmetry was $<10\%$, suggestive of a positive adaptation specific to exposure to the increased load and velocity demands of HSR. Progressive increases in involved limb PF and force at 100 ms drove reduced asymmetry in these variables, and total PF reached 300 N during weeks 13–14 (figure 4 and figure 8). In addition to IPF asymmetry, identified as a risk factor for

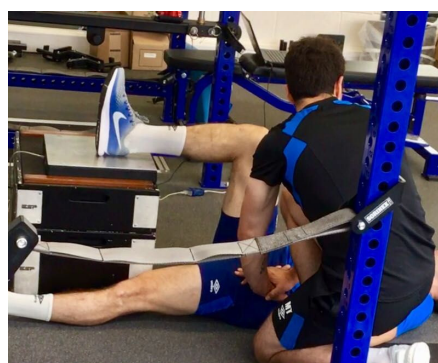


Figure 5 Isometric posterior chain test.

JUMP-LANDING PREPARATION + PLYOMETRICS	
Bilateral	Unilateral
Hurdle Jumps + Holds	Hurdle Hop + Holds
Hurdle Jumps	Hurdle Hops
Hurdle Jumps (> horizontal distance)	Hurdle Hops (Medial + Lateral)
Hurdle Jumps (differential)	Hurdle Hops (> horizontal distance)
	Hurdle Hops (differential)
	Multiple Hurdle Hops to Box
3–5 sets 2–4 jumps or 2–3 hops each side Nb: Overload to injured side e.g. 3/2 or 4/2 dependent upon asymmetry (termination based upon ↓ quality of movement/↑ ground contact time)	

Figure 6 Progression of jump-landing and plyometric exercise for hamstring–tendon loading.



Acceptable asymmetry was my criterion for exposure to higher cumulative weekly HSR workloads and subsequent progression to loads reflective of relative

In the 'fast' elite sports environment, rehabilitation was underpinned by research, clinical evidence and experience.¹⁰ Progression was driven by delivery of specific loading stimuli in both on and off pitch conditioning, assessed with neuromuscular tests quantifying the player's response to load. These data



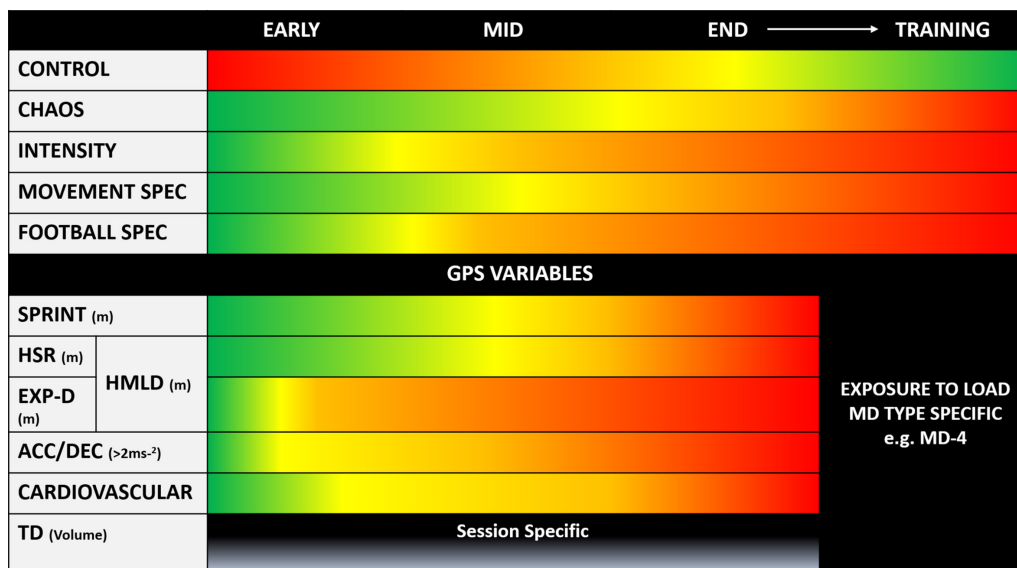


Figure 10 Outdoor physical preparation model for hamstring–tendon rehabilitation. Preparation begins with control moving towards chaos interlinking GPS performance variables (red=high>green=low). GPS (global positioning systems), HSR(high-speed running), EXP-D (explosive distance), HMLD (high metabolic load distance), Acc (accelerations), Dec (decelerations), TD (total distance), MD (match day)

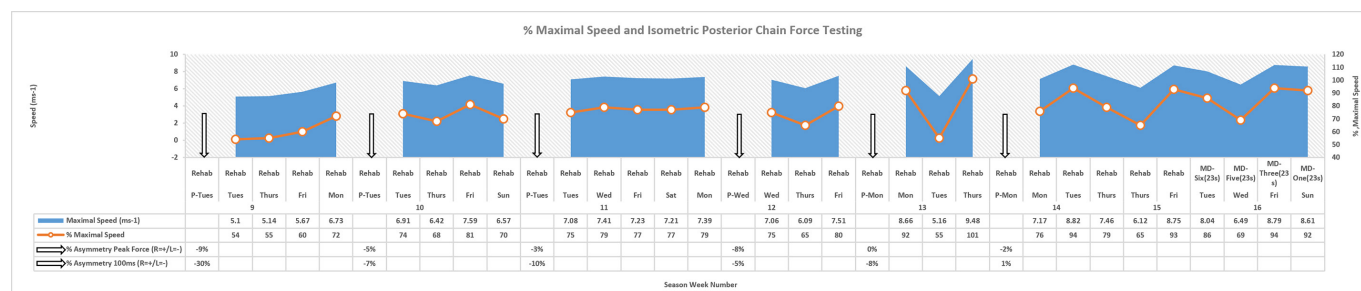


Figure 11 Percentage of relative maximal speed and isometric posterior asymmetry testing during hamstring–tendon rehabilitation.

then informed decisions to facilitate a successful outcome, blending art and science.

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