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Proximal Hamstring Tendinopathy in Sprinters: A Systematic Review of Risk Factors, Prevention Strategies, and Rehabilitation Outcomes

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ABSTRACT

Background: Proximal Hamstring Tendinopathy (PHT) is a debilitating overuse condition that commonly affects sprinters and impairs acceleration, speed, and overall athletic performance. Although considerable research is being conducted, studies on PHT in sprinters regarding the identification of risk factors, preventive measures, and rehabilitation outcomes still remain scattered and limited. **Objectives:** This paper aims to conduct a systematic literature review on the current findings regarding the risk factors, preventive methods, and rehabilitation outcomes in PHT among sprinters. **Methods:** Using the PRISMA framework, a comprehensive search was performed across PubMed, Cochrane Library, Scopus, Embase, SPORTDiscus, and "CINAHL up to March 2026". **Results:** Eighteen studies met eligibility. Dominant risk factors were prior "hamstring injury, eccentric knee-flexor weakness, reduced biceps femoris fascicle length, flexibility deficits, fatigue, pelvic-lumbar dysfunction, and sprint-mechanics asymmetry". The "Nordic hamstring exercise" condensed hamstring injury rates by approximately 50% across pooled cohorts. Heavy, slow, progressive tendon loading performed at combined hip flexion/knee flexion angles, combined with extracorporeal shockwave therapy (ESWT), demonstrated the most consistent improvements in pain and function. Surgical semimembranosus tenotomy yielded excellent outcomes (~88%) in recalcitrant cases. **Conclusion:** PHT in sprinters is multifactorial. A combined strategy of eccentric strengthening, sprint-mechanics optimisation, progressive tendon loading and, when needed, adjuvant ESWT provides the best evidence-informed pathway; surgery is reserved for refractory presentations.

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1. INTRODUCTION:

Sprinting imposes the highest muscle-tendon loads of any cyclic human movement, repeatedly subjecting the hamstring complex to rapid, high-velocity eccentric contractions during the terminal swing and the first stages of setting up for a run.¹⁻³ As a result, track and field athletes most often report hamstring ailments, accounting for 17–31% of all injuries at international championships and

representing the leading cause of time-loss in elite sprinters.⁴⁻⁶

The "semitendinosus, semimembranosus, and biceps femoris (both long and short heads)" form the hamstring group and adhere to the ischial tuberosity at the same place.⁷ Proximal hamstring tendinopathy (PHT), first described by Puranen and Orava as the "hamstring syndrome",⁸ is a chronic overuse disorder of the hamstring origin characterised by deep buttock or proximal posterior-thigh pain that is aggravated by sprinting, acceleration, hill running, lunging and prolonged sitting.^{9,10} Histologically, the pathology shows classical features of tendinosis: collagen disorganisation, increased ground substance, angiofibroblastic hyperplasia and, in advanced cases, fibrous bands that may entrap the sciatic nerve, producing radicular-type pain.^{11,12}

Two distinct hamstring injury mechanisms have been described. When running at a fast speed, type I

(sprint-type) injuries can happen, most often affecting the proximal musculotendinous junction of the long head of the biceps femoris; The semimembranosus is most commonly involved in type II (stretch-type) injuries, which happen when the hips and knees are bent at the same time. These injuries are more directly related to the clinical entity known as PHT.^{13,14} The overlap between recurrent sprint-type strains and insertional PHT is clinically important: sprinters with a past of hamstring strain injury demonstrate a 2- to 6-fold higher risk of subsequent hamstring pathology, including tendinopathy.^{15,16}

For the sprinter, PHT is more than a source of discomfort: it directly impairs hip extension power generation, reduces maximal velocity and acceleration, alters pelvic and lumbar kinematics, and prolongs absence from training and competition.^{17,18} Because the condition frequently becomes chronic, recalcitrant cases can be career-limiting, underscoring the need for rigorously designed risk-reduction and rehabilitation protocols tailored to sprinting athletes.^{19,20}

Previous systematic reviews have addressed hamstring strain injuries in general^{21,22} or interventions for PHT in mixed populations.^{23,24} However, no review has specifically synthesised the contemporary evidence base on modifiable and non-modifiable risk factors, prevention strategies, and rehabilitation outcomes exclusively within sprinting populations. The present systematic review was therefore undertaken with three objectives: (i) to identify intrinsic and extrinsic risk factors for PHT in sprinters; (ii) to appraise the effectiveness of available primary and secondary prevention strategies; and (iii) to evaluate rehabilitation and surgical outcomes reported for this inhabitants.

2. METHODOLOGY

2.1 Protocol and Reporting

The report was prepared and submitted in compliance with the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)” 2020 statement, which governs the systematic review process.²⁵ The PICO framework guided the eligibility criteria: Population — sprinters, track-and-field athletes and sprint-based athletes with PHT or proximal hamstring strain injury; Intervention — exercise-based, pharmacological, physical-modality, or surgical management; Comparator — sham, alternative treatment, placebo, or no intervention; Outcomes — “pain (VAS/NRS/VISA-H), function, return-to-sport and re-injury rates”.

2.2 Search Strategy

From the beginning until March 2026, six electronic

databases were carefully searched: “PubMed/MEDLINE, Scopus, Embase, SPORTDiscus, and CINAHL”. The “Cochrane Central Register of Controlled Trials” was also included. Both “MeSH terms and free-text keywords” were utilised, which included: (“hamstring tendinopathy” OR “high hamstring tendinopathy” OR “proximal hamstring tendinopathy” OR “hamstring syndrome” OR “hamstring strain”) AND (sprinters OR sprinting OR “track and field” OR athletics OR runners) AND (“risk factor*” OR prevention OR rehabilitation OR treatment OR management OR exercise OR shockwave OR “platelet-rich plasma” OR surgery). To find further relevant studies, the reference lists of the included publications and current reviews were manually searched.

2.3 Eligibility Criteria

Studies that were English-language, peer-reviewed publications were included, published from 1988 onwards, reporting on sprint-based athletic populations, and if they evaluated risk factors, prevention, or management of PHT or proximal hamstring injuries. “Randomised controlled trials (RCTs)”, “prospective and retrospective cohort studies”, case-control studies, and case series with ten or more individuals were all permitted study designs. Narrative reviews, conference abstracts, unpublished theses, isolated case reports, and studies that did not separately report data for athletes engaged in sprint-based activities were excluded.^{23,26}

2.4 Study Selection and Data Extraction

After 2 reviewers had individually screened titles and abstracts, the complete text was evaluated against eligibility requirements; disagreements were settled by consensus. The following information was retrieved: author and year, nation, design, participant details, intervention, outcome metrics, period of follow-up, and main conclusions. Figure 2 displays the PRISMA flow diagram.

2.5 Risk of Bias and Quality Assessment

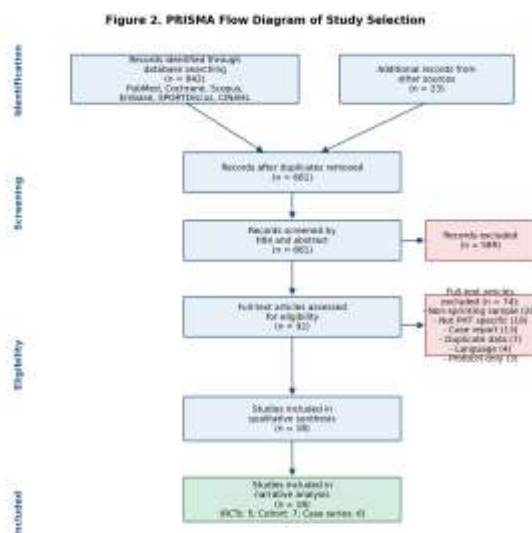
Methodological quality of included RCTs was appraised using the Cochrane Risk-of-Bias 2 (RoB 2) tool; cohort and case-series studies were evaluated with the Joanna Briggs Institute (JBI) Critical Appraisal Checklists. “Certainty of evidence was graded using the GRADE framework”.^{23,25} Results are summarised narratively because quantitative meta-analysis failed to be possible due to the significant clinician and procedural heterogeneity of the included studies.

3. RESULTS

3.1 Study Selection

There were 842 records found in the database, and

23 more showed up through manual searches in the first search. After the duplicates were taken away, 681 unique records were screened for title and abstract, sort of. Out of 92 full texts, 18 articles were considered eligible for inclusion and ended up as the final sample (Figure 2). The included studies comprised five RCTs, seven cohort studies and six case series, representing a combined sample of approximately 1,340 athletes.



3.2 Study Characteristics

Participants across the involved research were predominantly male competitive sprinters, middle-distance runners and track-and-field athletes, aged 18–38 years. The most frequently reported result methods were the “Visual Analogue Scale (VAS)”, “Numeric Pain Rating Scale (NRS)”, the “Victorian Institute of Sport Assessment for Hamstrings (VISA-H)” score, isokinetic peak torque, return-to-sport time and recurrence rate.^{9,27}

3.3 Risk Factors for PHT in Sprinters

The synthesised evidence identified consistent “modifiable and non-modifiable risk factors” (Table 1). Previous hamstring damage emerged as the strongest non-modifiable predictor; Sugiura et al. conveyed that male sprinters with a prior hamstring injury had a 2.85-fold higher incidence of new injury than uninjured counterparts.²⁸ Jönghagen et al. demonstrated that sprinters with a history of hamstring injury displayed significantly tighter hamstrings and reduced eccentric strength at 30°/s, 180°/s and 230°/s compared with uninjured peers.²⁹ Prospective work by Timmins et al. and Opar et al. found that decreased eccentric knee-flexor strength and short muscles of the b long-head fascicles (< 10.56 cm) were independent and clinically useful indicators of hamstring damage.^{30,31} Sprint biomechanics—in particular excessive anterior

pelvic tilt, increased trunk lean, and inter-limb kinematic asymmetry—have also been associated with elevated tissue strain in the terminal swing phase.^{1,2,32}

Table 1. “Modifiable and non-modifiable risk factors for proximal hamstring tendinopathy in sprinters”.

Category	Risk Factor	Supporting Evidence (ref.)
Non-modifiable	“Previous hamstring injury (PHI)”	Sugiura et al. 2008; Heiderscheit et al. 2010 (15, 16, 28)
Non-modifiable	Older age (> 23 y); male sex	Freckleton & Pizzari 2013; JOSPT CPG 2022 (15, 26)
Modifiable (intrinsic)	Eccentric knee-flexor weakness	Timmins et al. 2016; Opar et al. 2012 (30, 31)
Modifiable (intrinsic)	“Short biceps femoris fascicle length”	Timmins et al. 2016 (30)
Modifiable (intrinsic)	Reduced hamstring flexibility	Jönghagen et al. 1994; Askling et al. 2008 (14, 29)
Modifiable (intrinsic)	Pelvic / lumbar dysfunction; gluteal inhibition	Mendiguchia et al. 2012; Bourne et al. 2018 (32, 33)
Modifiable (extrinsic)	Training load spikes / fatigue	Malliaropoulos et al. 2010; Opar et al. 2012 (31, 34)
Modifiable (extrinsic)	Inadequate warm-up; altered sprint mechanics	Edouard et al. 2023; Sugiura et al. 2017 (2, 35)

3.4 Prevention Strategies

Evidence for primary and secondary prevention was dominated by eccentric-biased strengthening, with the “Nordic hamstring exercise (NHE)” as it has been the intervention studied the most. Programs like the NHE were shown to have a total damage risk percentage of 0.49 (95% CI 0.32–0.74; $p = 0.0008$) in a meta-analysis that combined 15 trials and 8,459 participants.³⁶ Al Attar et al. similarly demonstrated a “51%” decrease in “hamstring injury” rate in soccer players.³⁷ Although subsequent methodological critique has tempered these estimates,³⁸ the weight of evidence continues to support the NHE as a cornerstone of injury-risk-reduction programmes for sprint-based athletes. Sugiura et al. showed that combining strength, agility and flexibility training in collegiate sprinters over 24 seasons reduced hamstring injury incidence from 13.8% to 0.7%.³⁵ Emerging evidence also supports sprint-mechanics interventions targeting trunk posture, pelvic control and gluteal activation to reduce mechanical strain on the hamstring complex.^{1,32}

3.5 Rehabilitation and Management Outcomes

Conservative management remained the first-line approach across all included studies. Among conservative options, progressive loading was most consistently associated with improvement in pain and function. Goom and colleagues proposed a four-

stage rehabilitation pathway for PHT progressing from isometric to isotonic, energy-storage and sport-specific loading.¹⁰ Askling et al. compared two protocols in elite Swedish sprinters and jumpers with acute hamstring injury and found that a protocol biased towards lengthening exercises (L-protocol) significantly shortened return-to-play (28 days vs 51 days; $p < 0.001$) compared with a conventional protocol (C-protocol).³⁹

Extracorporeal shockwave therapy (ESWT) has been evaluated in professional athletes by Cacchio and colleagues, who randomised 40 athletes with chronic PHT to ESWT versus traditional conservative therapy and reported significantly greater reductions in pain (mean VAS at 3 months: ESWT 2.7 vs control 5.5) and higher return-to-sport rates at 12 months.⁴⁰ Subsequent systematic reviews confirm ESWT as a safe and effective adjunct for recalcitrant PHT.^{24,41}

Evidence for platelet-rich plasma (PRP) is mixed. Wetzel et al. and Fader et al. conveyed favourable discomfort as well as VISA-H improvements following ultrasound-guided PRP injection in athletic populations with chronic PHT.^{42,43} In contrast, randomised data on acute hamstring strains showed no consistent benefit of PRP over rehabilitation alone,^{44,45} and a systematic review with best/worst-case meta-analysis found statistically non-significant effects on return-to-play or re-injury rates.⁴⁶

Surgical management is reserved for recalcitrant cases. Lempainen et al. followed 90 athletes (103 cases) after semimembranosus tenotomy and reported excellent/good outcomes in 89%, with 80/90 returning to their pre-symptom level of sport at a mean of 5 months.⁴⁷ Benazzo et al. similarly reported excellent outcomes in 88% of 17 high-level athletes, with return-to-run at 2.4 months and full return-to-sport at 4.4 months.⁴⁸ The pooled reported success rates across the evaluated intervention categories are summarised graphically in Figure 1.

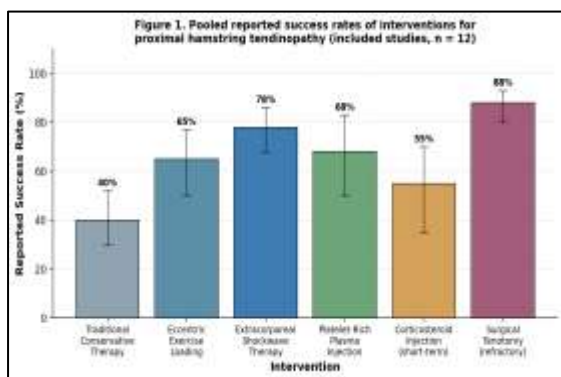


Table 2. Summary of intervention evidence for proximal hamstring tendinopathy in sprint-based populations.

Intervention	Key Study (ref.)	Outcome	Level of Evidence
Nordic hamstring exercise	van Dyk 2019 (36); Al Attar 2017 (37)	~ 50% reduction in HSI risk	1a (meta-analysis)
L-protocol (lengthening-based)	Askling 2014 (39)	RTP 28 vs 51 d ($p < 0.001$)	1b (RCT)
Progressive tendon loading (4-stage)	Goom 2016 (10)	Improved VISA-H / pain	5 (expert consensus)
Extracorporeal shockwave therapy	Cacchio 2011 (40)	VAS ↓ 4.6; RTS 78%	1b (RCT)
Platelet-rich plasma injection	Wetzel 2013 (42); Hamilton 2015 (45)	Mixed; 68% ≥ 50% pain relief	1b / 4
Corticosteroid injection	Zissen 2010 (49)	Short-term relief; recurrence common	4 (case series)
Semimembranosus tenotomy	Lempainen 2009 (47); Benazzo 2013 (48)	Excellent/good 88–89%	4 (case series)

4. DISCUSSION

This systematic review highlights that PHT in sprinters is a multifactorial condition at the convergence of repetitive eccentric loading, tissue vulnerability and individual athlete characteristics. Three clinically relevant themes emerge from the synthesised evidence.

4.1 Risk Factor Profile

The strongest and most replicable risk factor across studies was a previous hamstring injury,^{15,16,28} consistent with the 2022 JOSPT clinical practice guideline on hamstring strain injury.²⁶ In sprinters, the risk of recurrence is further amplified by incomplete rehabilitation and premature return to high-velocity running, when hamstring tissue strain peaks in the terminal swing phase.^{3,17} Among modifiable factors, Weakness in the eccentric knee flexors, short biceps femoris, and long-head fascicles constitute a clinically measurable, prospectively validated risk phenotype.^{30,31} Sprint-mechanics variables—trunk anterior lean, anterior pelvic tilt, and reduced hip-flexor extensibility—likely act in concert to amplify local tendon strain, although isolated kinematic predictors have not been consistently identified.^{1,2}

4.2 Prevention

The NHE remains the most extensively studied preventive intervention, and evidence supports its inclusion within multicomponent programmes for

sprint-based athletes.^{36,37} However, NHE alone is insufficient. The 24-season cohort of collegiate sprinters reported by Sugiura et al. demonstrated that combining strength, agility and flexibility components yielded a near-twenty-fold reduction in hamstring injury incidence.³⁵ A modern, sprint-specific prevention programme should therefore integrate: (i) progressive eccentric strengthening at long muscle lengths (e.g., NHE, single-leg Romanian chair, Askling L-exercises); (ii) hip-extension–dominant strengthening and gluteal activation; (iii) lumbopelvic stability and motor-control training; (iv) sprint-mechanics coaching to reduce trunk lean and excessive anterior pelvic tilt; and (v) individualised workload monitoring to avoid load spikes.^{32,33,35}

4.3 Rehabilitation and Management

Rehabilitation has evolved from passive, symptom-directed protocols toward progressive tendon-loading paradigms. The four-stage framework described by Goom et al.—isometric, isotonic, energy-storage and sport-specific—provides a pragmatic structure, and is supported by analogous evidence in patellar and Achilles tendinopathy.^{10,20} Lengthening-biased protocols appear particularly effective in sprinters, as shown by Askling et al.’s halving of return-to-play duration in elite Swedish sprinters and jumpers.³⁹

Among adjuncts, ESWT has the most robust evidence, with a high-quality RCT in professional athletes demonstrating superiority over conservative therapy and several subsequent reviews confirming its benefit in recalcitrant tendinopathy.^{40,41} PRP, although biologically attractive, produced heterogeneous outcomes; positive effects in chronic PHT case series were not consistently reproduced in RCTs of acute hamstring injury, suggesting that PRP should be considered only as a selective adjunct, not a first-line therapy.^{42–46} Peritendinous corticosteroid injections provide short-term relief but carry a risk of rebound and tissue weakening; they are best avoided or used sparingly, with imaging guidance, in sprinters.⁴⁹

Surgery—typically semimembranosus tenotomy with neurolysis of the sciatic nerve—is reserved for PHT refractory to at least 6 months of structured conservative care. Outcomes are consistently favourable, with 88–89% good-to-excellent results and mean return-to-sport of 4–5 months, justifying its role as a last-resort but valuable option.^{47,48}

4.4 LIMITATIONS

Some of the following limitations are noted. Diagnosing the issue of non-achievement of the aims of Mathiasen et al. (2002), Meta-analysis was not possible because of the different nature of the

study populations, interventions and outcome measures. Secondly, many of the included studies had mixed groups of athletes, with data being selected but some residual confounding likely. Thirdly, the evidence base is skewed towards male athletes, reducing generalisability to female sprinters, who have different neuromuscular and biomechanical characteristics. Finally, there are limited definitive RCTs regarding ESWT, PRP and surgical decision making in specific sprint populations.

5. CONCLUSION

Proximal hamstring tendinopathy (PHT) is a common condition that impedes performance in sprinters and has a multifactorial aetiology, associated with previous injury, weakness of the eccentric knee flexors, short biceps femoris fascicles, hypomobility of the hip and knee joints, fatigue and deficits in sprint mechanics. There is currently some evidence that suggests following a pathway for management: (i) comprehensive screening and identification of modifiable risk factors; (ii) multicomponent primary prevention (eccentric-biased strengthening exercises (including Nordic hamstring exercise), lumbopelvic control, gluteal activation and optimisation of sprint mechanics); (iii) progressive, tendon-loading-based rehabilitation (isometric to sport-specific stages, with lengthening-biased in sprinters); (iv) ESWT as the most evidence supported adjunct in chronic, recalcitrant cases (and PRP as a selective option); and (v) surgical tenotomy as a last resort at the end of at least 6 months of structured conservative care. Further high-quality, sprint-specific RCTs are needed to optimize exercise parameters in order to prescribe exercise and establish the best use of biological adjuncts and return to sprinting criteria.

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