# Hamstring Injuries – Myths & Facts

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# DISCLOSURES

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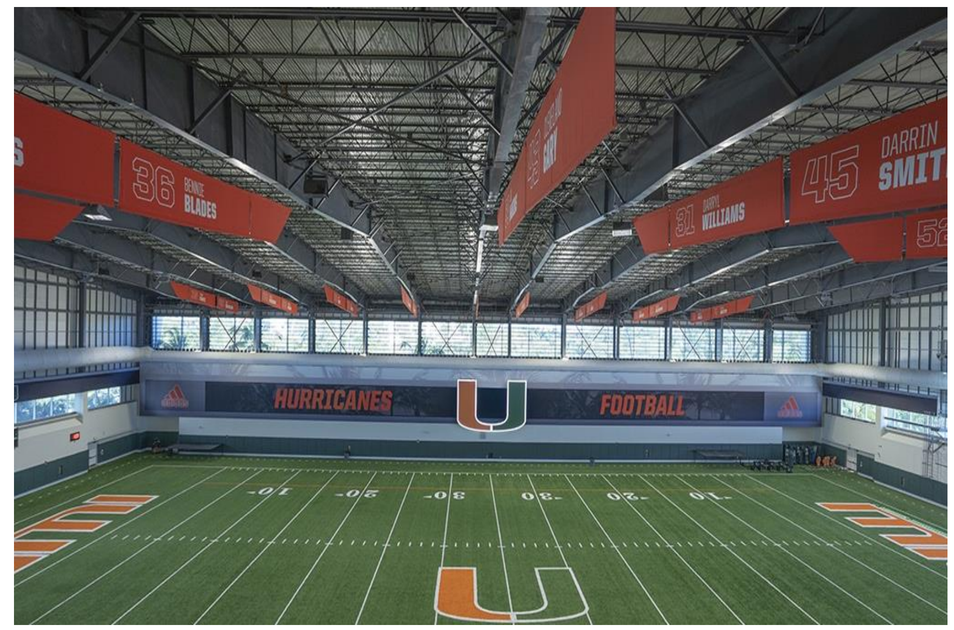
# Outline

- **Treatment**
- **Imaging**
- **Return to sport**
- **Injury prevention**



# Clinical Practice Guidelines

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## Hamstring Strain Injury in Athletes

*Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Academy of Orthopaedic Physical Therapy and the American Academy of Sports Physical Therapy of the American Physical Therapy Association*

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*J Ortho Sports PT* 2023

## Hamstring Strain Injury in Athletes: Clinical Practice Guidelines

# Summary of Recommendations

### REINJURY RISK AND RETURN TO PLAY

**B** Clinicians should use the history of a hamstring strain injury (HSI) in return-to-play (RTP) progression, as a previous HSI is a risk factor for a future reinjury.

**B** Clinicians should use caution in RTP decisions for individuals who did not complete an appropriately progressed, comprehensive impairment-based functional exercise program that specifically included eccentric training.

**B** Clinicians should use hamstring strength, pain level at the time of injury, number of days from injury to pain-free walking, and area of tenderness measured on initial evaluation to estimate time to RTP.

### DIAGNOSIS/CLASSIFICATION

**B** Clinicians should make a diagnosis of HSI when an individual presents with a sudden onset of posterior thigh pain during activity, with pain reproduced when the hamstring is stretched and/or activated, muscle tenderness with palpation, and loss of function.

### EXAMINATION: PHYSICAL IMPAIRMENT MEASURES

**A** Clinicians should quantify knee flexor strength following HSI by using either a handheld or isokinetic dynamometer.

**A** Clinicians should assess hamstring length by measuring the knee extension deficit with the hip flexed to 90°, using an inclinometer.

**C** Clinicians may use the length of muscle tenderness and proximity to the ischial tuberosity to assist in predicting timing of RTP.

**F** Clinicians may assess for abnormal trunk and pelvic posture and control during functional movements.

### EXAMINATION: ACTIVITY LIMITATION AND PARTICIPATION RESTRICTION

**B** Clinicians should include objective measures of an individual's ability to walk, run, and sprint when documenting changes in activity and participation over the course of treatment.

### EXAMINATION: OUTCOME MEASURES

**B** Clinicians should use the Functional Assessment Scale for Acute Hamstring Injuries before and after interventions, intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions in those diagnosed with an acute HSI.

### INTERVENTIONS: INJURY PREVENTION

**A** Clinicians should include the Nordic hamstring exercise as part of an HSI prevention program, along with other components of warm-up, stretching, stability training, strengthening, and functional movements (sport specific, agility, and high-speed running).

### INTERVENTIONS: AFTER INJURY

**B** Clinicians should use eccentric training to the patient's tolerance, added to stretching, strengthening, stabilization, and progressive running programs, to improve RTP time after an individual sustains an HSI.

**B** Clinicians should use progressive agility and trunk stabilization, added to a comprehensive impairment-based treatment program of stretching, strengthening, and functional exercises, to reduce reinjury rate after an individual sustains an HSI.

**F** Clinicians may perform neural tissue mobilization after injury to reduce adhesions to surrounding tissue and therapeutic modalities to control pain and swelling early in the healing process.



**TABLE 2** Grades of Recommendation

| Grades of Recommendation | | Strength of Evidence | Level of Obligation |
|---|---|---|---|
| A | Strong evidence | A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study | Must or should |
| B | Moderate evidence | A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation | Should |
| C | Weak evidence | A single level II study or a preponderance of level III and IV studies, including statements of consensus by content experts, support the recommendation | May |
| D | Conflicting evidence | Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting study results | |
| E | Theoretical/ foundational evidence | A preponderance of evidence from animal or cadaver studies, from conceptual models/principles, or from basic sciences/bench research support this conclusion | May |
| F | Expert opinion | Best practice based on the clinical experience of the guidelines development team supports this conclusion | May |

# ACUTE LOWER MUSCLE STRAIN INJURY: DIAGNOSIS, MANAGEMENT, AND PREVENTION

AN OVERVIEW FOR NBA, WNBA, AND
NBA G LEAGUE MEDICAL STAFF

## NBA TASK FORCE ON ACUTE MUSCLE STRAIN INJURIES

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Eric Waters, MHPS, ATC, United States Ski and Snowboard
Eliot Young, MD, San Antonio Spurs, Team Physician, Sports Medicine

# ACUTE LOWER MUSCLE STRAIN INJURY: DIAGNOSIS, MANAGEMENT, AND PREVENTION

**TABLE 2. MUSCLE STRAIN TREATMENT AND INTERVENTION OPTIONS**

| Intervention | Evidence And Safety |
|---|---|
| **Oral Medications** | |
| **NSAIDs (including COX-2)** | No Convincing Data to Support Use in Expediting Healing or Return to Play<br>Relatively Safe for Symptom relief in Early (Days 1-5) to Mid (Weeks 1-3) Period<br>Potential Side Effects (Including GI, Renal and Inhibition of Muscle Repair)[81,105] |
| **Losartan** | Data for Expediting Healing in Animals in Early to Mid, No Published Human Studies to Support Efficacy[8,89] |
| **Oral Corticosteroids** | Limited Data to Support Use in Expediting Healing or Return to Play in Either Animals or Humans Showing Benefit on Return to Play in Early Period[4,117] |
| **Injectables** | |
| **PRP** | Appears Safe, Data to Support Use in Expediting Healing or Return to Play, for use in Early to Mid Period<br>that Return to Play is Expedited[4,11,16,24,60,112,117,128,129,151,154,158] |
| **Stem Cells** | No Convincing Data to Support Use in Expediting Healing or Return to Play or Pain Relief<br>Potential Side Effects (Including increased risk of VTE) [113]<br>The NBA Team Physicians Society and the NBPA do not recommend the routine use of orthobiologic Stem Cell injections for acute muscle injuries at this time.[33] |
| **Corticosteroids** | Limited Data to Support Use in Expediting Healing or Return to Play [94]<br>Potential Side Effects (Including increased risk of tendon and fascial rupture)[94,117] |
| **Toradol** | No Convincing Data to Support in Expediting Healing or Return to Play<br>Potential Side Effects (Including GI, Renal and Inhibition of Muscle Repair)[81,105] |
| **Modalities** | |
| **Blood Flow Restriction** | Limited Data to Support Use in Expediting Healing or Return to Play, for use in Early to Mid Period<br>Potential Side Effects (Including increased risk of rhabdomyolysis, VTE)[17,32,40] |
| **Dry Needling*** | Limited Data to Support Use for Symptom Relief[39]<br>Proximal and Distal Strains in Early to Late (weeks 3-6), |
| **Soft Tissue Mobilization** | No Convincing Data to Support Use for Expediting Healing or Return to Play<br>However Can be Used in Early to Late Period<br>No Safety Concerns (Athlete/ Clinician Preference)[39] |
| **Ice/ Cryotherapy** | Limited Data for Using Ice at Early Phases Data to Support Use in Expediting Healing or Return to Play<br>No Safety Concerns for Ice with proper use (Athlete Preference)[14] |
| **Exercise** | |
| **Early Mobilization** | Data is Supportive for Return to Play with use in Early Period[81,85] |
| **Trunk Stability** | Data is Supportive for Return to Play with Introduction Early,[78,137,142]<br>Progress Difficulty as Tolerated to Late Period |
| **Isometric Exercise** | Data is Supportive for Return to Play with Isometric Exercises beginning with Submaximal Effort in Early Period with Progression to Maximum Level Isometrics in Late Period [104,109,158,160] |
| **Concentric and Eccentric Exercise** | Data is Supportive for Return to Play with Concentrics and Eccentrics<br>(Short Range) Eccentrics Initially in Mid Period with Progression to Eccentrics at Longer Range of Motion in Late Period.[85,104]<br>Limited Data Support use of High Intensity Eccentric Loading in Early Period for Return to Play.[88] |
| **Plyometrics** | Data is Supportive for Return to Play with<br>Introduction of Movements Initially in Mid Period with Progression to High Level Plyometrics in Late Period[31,151,157] |
| **Other forms of Exercise / Sport Specific Drills** | Limited Data Support use for Return to Play with Balance, Cardio, Sports Specific Drills.<br>Balance Exercises[15], Cardio Exercises as Tolerated Initially in Mid Period with High Speed Running (100% Effort)[85,87], Sport-Specific Drills, Increase in Basketball Activity as Able in Late Period[10,119] |

*Based on Local/State Clinical Practice Act

# TOPIC 1 - TREATMENT

# Platelet-Rich Plasma Shortens Return to Play in National Football League Players With Acute Hamstring Injuries

*Orthop J Sports Med* 2020

James P. Bradley,*† MD, Tracye J. Lawyer,‡ MD, Sonia Ruef,§ MA,
Jeffrey D. Towers,‖ MD, and Justin W. Arner,‡ MD

**Background:** Hamstring injuries are prevalent in professional athletes and can lead to significant time loss, with recurrent injury being common. The efficacy of platelet-rich plasma (PRP) for augmentation of nonoperative treatment of partial musculotendinous hamstring injuries is not well established.

**Hypothesis:** The addition of PRP injections to nonoperative treatment for acute partial musculotendinous hamstring injuries will lead to a shortened return to play in National Football League (NFL) players.

**Study Design:** Cohort study; Level of evidence, 3.

**Methods:** NFL players from a single team who sustained acute grade 2 hamstring injuries, as diagnosed on magnetic resonance imaging (MRI) by a musculoskeletal radiologist from 2009 to 2018, were retrospectively reviewed. Average days, practices, and games missed were recorded. Players who did and did not receive PRP (leukocyte-poor) injections were compared. Those who received PRP did so within 24 to 48 hours after injury.

**Results:** A total of 108 NFL players had MRI evidence of a hamstring injury, and of those, 69 athletes sustained grade 2 injuries. Thirty players received augmented treatment with PRP injections and 39 players underwent nonoperative treatment alone. Average time missed in those treated with PRP injections was 22.5 days, 18.2 practices, and 1.3 games. In those who did not receive PRP injections, time missed was 25.7 days ($P = .81$), 22.8 practices ($P = .68$), and 2.9 games ($P < .05$).

**Conclusion:** Augmentation with PRP injections for acute grade 2 hamstring injuries in NFL players showed no significant difference in days missed or time to return to practice but did allow for faster return to play, with a 1 game overall difference. Owing to the possible large financial impact of returning to play 1 game sooner, PRP injections for treatment of grade 2 hamstring injuries may be advantageous in professional athletes.

**Keywords:** hamstring injury; platelet-rich plasma; autologous conditioned plasma; muscle injury; biologic enhancement

# Effectiveness of Hematoma Aspiration and Platelet-rich Plasma Muscle Injections for the Treatment of Hamstring Strains in Athletes

*Am J Sports Med* 2021

LUKAS M. TRUNZ[1], JEFFREY E. LANDY[1], CHRISTOPHER C. DODSON[2], STEVEN B. COHEN[2], ADAM C. ZOGA[1], and JOHANNES B. ROEDL[1]

TRUNZ, L. M., J. E. LANDY, C. C. DODSON, S. B. COHEN, A. C. ZOGA, and J. B. ROEDL. Effectiveness of Hematoma Aspiration and Platelet-rich Plasma Muscle Injections for the Treatment of Hamstring Strains in Athletes. *Med. Sci. Sports Exerc.*, Vol. 54, No. 1, pp. 12–17, 2022. **Introduction:** The effect of platelet-rich plasma (PRP) treatment on recovery in acute hamstring injuries is controversial. Previous study results are inconsistent, and a standardized therapeutic approach has not been established yet. **Purpose:** To assess the treatment effect using a combination of hematoma aspiration and muscle strain PRP injection in partial hamstring muscle tears (grade 2 strains) in athletes. **Methods:** Magnetic resonance imaging of athletes with grade 2 hamstring strains were reviewed from 2013 to 2018. From 2013 to 2015, athletes were treated conservatively, and from 2016 to 2018, with a combination of ultrasound-guided hematoma aspiration and PRP muscle strain injection. The outcome, including return-to-play (in days) and recurrence rate, was compared retrospectively between both groups (conservative vs aspiration/PRP) using ANOVA and Fisher's exact test. There was no significant difference in age, type of sport, and muscle involvement (including injury grade/location, hamstring muscle type, and length/cross-sectional area of the strain). **Results:** Fifty-five athletes (28 treated conservatively, 27 with hematoma aspiration/PRP injection) were included. Average return-to-play time (mean) was 32.4 d in the conservative group and 23.5 d in the aspiration/PRP group ($P < 0.001$). Recurrence rate of the hamstring strain was 28.6% (8/28) in the conservative treatment group and less than 4% (1/27) in the aspiration/PRP group ($P = 0.025$). **Conclusions:** Athletes with grade 2 hamstring strains treated with a combination of hematoma aspiration and PRP injection had a significantly shorter return-to-play and a lower recurrence rate compared with athletes receiving conservative treatment. **Key Words:** GRADE 2 STRAIN, ULTRASOUND, MAGNETIC RESONANCE IMAGING, RETURN TO PLAY, RECURRENCE RATE

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# Platelet-rich plasma does not enhance return to play in hamstring injuries: a randomised controlled trial

Bruce Hamilton,[1,2] Johannes L Tol,[2] Emad Almusa,[3] Sirine Boukarroum,[2] Cristiano Eirale,[2] Abdulaziz Farooq,[4] Rodney Whiteley,[5] Hakim Chalabi[6]

*Br J Sports Med* 2015

**ABSTRACT**

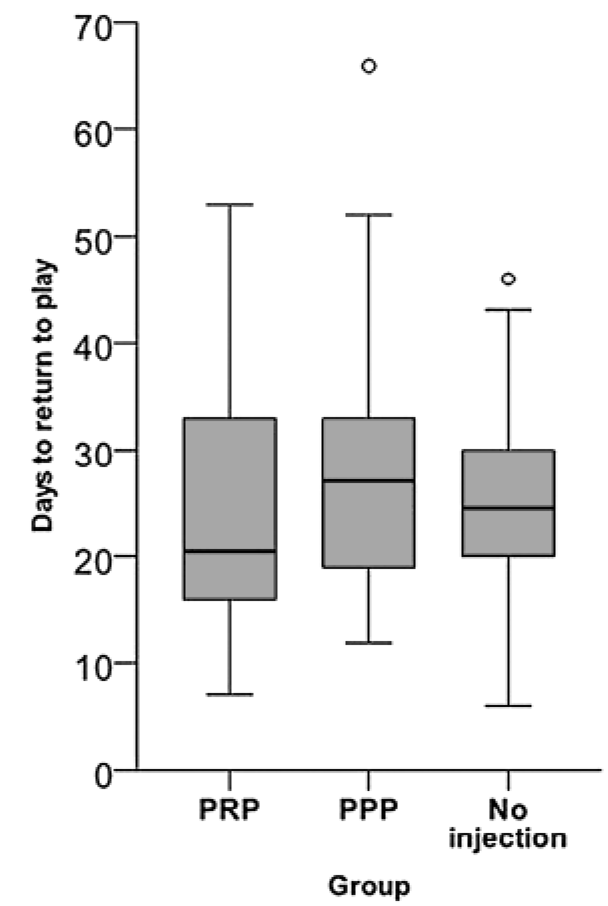
**Background** To evaluate the efficacy of a single platelet-rich plasma (PRP) injection in reducing the return to sport duration in male athletes, following an acute hamstring injury.

**Methods** A randomised, three-arm (double-blind for the injection arms), parallel-group trial, in which 90 professional athletes with MRI positive hamstring injuries were randomised to injection with PRP-intervention, platelet-poor plasma (PPP-control) or no injection. All received an intensive standardised rehabilitation programme. The primary outcome measure was time to return to play, with secondary measures including reinjury rate after 2 and 6 months.

**Results** The adjusted HR for the PRP group compared with the PPP group was 2.29 (95% CI 1.30 to 4.04) p=0.004; for the PRP group compared with the no injection group 1.48 (95% CI 0.869 to 2.520) p=0.15, and for the PPP group compared with the no injection group 1.57 (95% CI 0.88 to −2.80) p=0.13. The adjusted difference for time to return to sports between the PRP and PPP groups was −5.7 days (95% CI −10.1 to −1.4) p=0.01; between the PRP and no injection groups −2.9 days (95% CI −7.2 to 1.4) p=0.189 and between the PPP and no injection groups 2.8 days (95% CI −1.6 to 7.2) p=0.210. There was no significant difference for the secondary outcome measures. No adverse effects were reported.

**Conclusions** Our findings indicate that there is no benefit of a single PRP injection over intensive rehabilitation in athletes who have sustained acute, MRI positive hamstring injuries. Intensive physiotherapy led rehabilitation remains the primary means of ensuring an optimal return to sport following muscle injury.

**Trial registration number** ClinicalTrials.gov Identifier: NCT01812564.



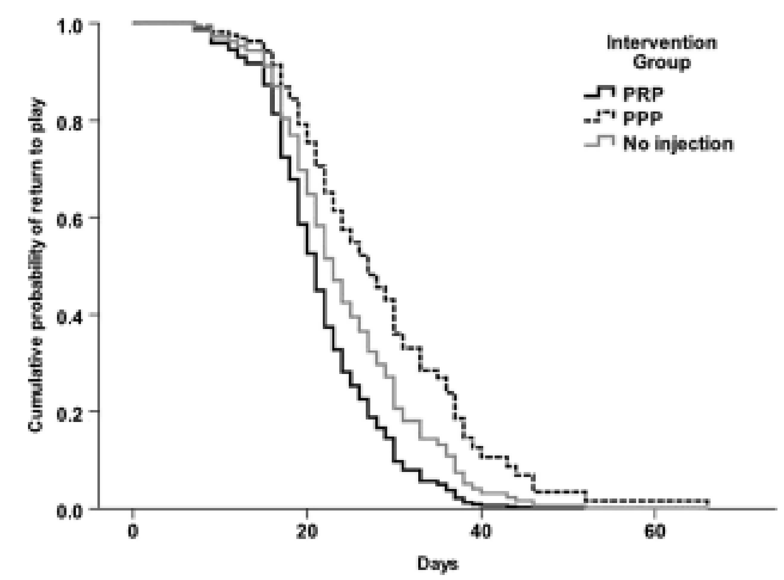




Figure 3 Kaplan–Meier curves showing the cumulative incidence of return to play (PPP, platelet-poor plasma; PRP, platelet-rich plasma).

# Platelet-rich plasma does not enhance return to play in hamstring injuries: a randomised controlled trial

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*Br J Sports Med* 2015

**Table 2** Cumulative reinjury at 2 and 6 months after return to sport

| | 2 months | | | 6 months | | |
|---|---|---|---|---|---|---|
| | Platelet-rich plasma (n=25) | Platelet-poor plasma (n=30) | No intervention (n=26) | Platelet-rich plasma (n=26) | Platelet-poor plasma (n=28) | No intervention (n=29) |
| Reinjury number (%) | 2 (8.0%) | 2 (6.7%) | 2 (7.7%) | 2 (7.7%) | 3 (10.7%) | 3 (10.3%) |

**Table 5** Platelets, leucocytes and RBCs (×$10^9$/L) in whole blood, PRP or PPP (for groups injected)*

| | PRP n=30 | PPP n=30 | No injection n=30 | p Value |
|---|---|---|---|---|
| Whole blood | | | | |
| Platelets | 237.2±50.2 | 256.2±57.1 | 247.9±40.9 | 0.338 |
| Leucocytes | 5.9±2.2 | 6.0±1.5 | 5.7±1.5 | 0.730† |
| RBC count | 5.2±0.4 | 5.2±0.4 | 5.3±0.4 | 0.245 |
| Injection | | | | |
| Platelets | 765.8±423.6 | 30.3±23.0 | NA | |
| Leucocytes | 26.1±13.7 | 0.03±0.03 | NA | |
| RBC count | 1.0±0.9 | 0.001±0.001 | NA | |

*Plus–minus values are mean±SD.
†p Value calculated based on a non-parametric test.
NA, not applicable; PPP, platelet-poor plasma; PRP, platelet-rich plasma; RBC, red blood cell.

## What are the new findings?

- Our findings indicate that there is no benefit of a single platelet-rich plasma (PRP) injection over intensive rehabilitation in professional athletes who have sustained acute, MRI positive hamstring injuries.
- A single PRP injection in combination with intensive rehabilitation reduced the return to sport duration when compared with a single platelet-poor plasma injection and rehabilitation.

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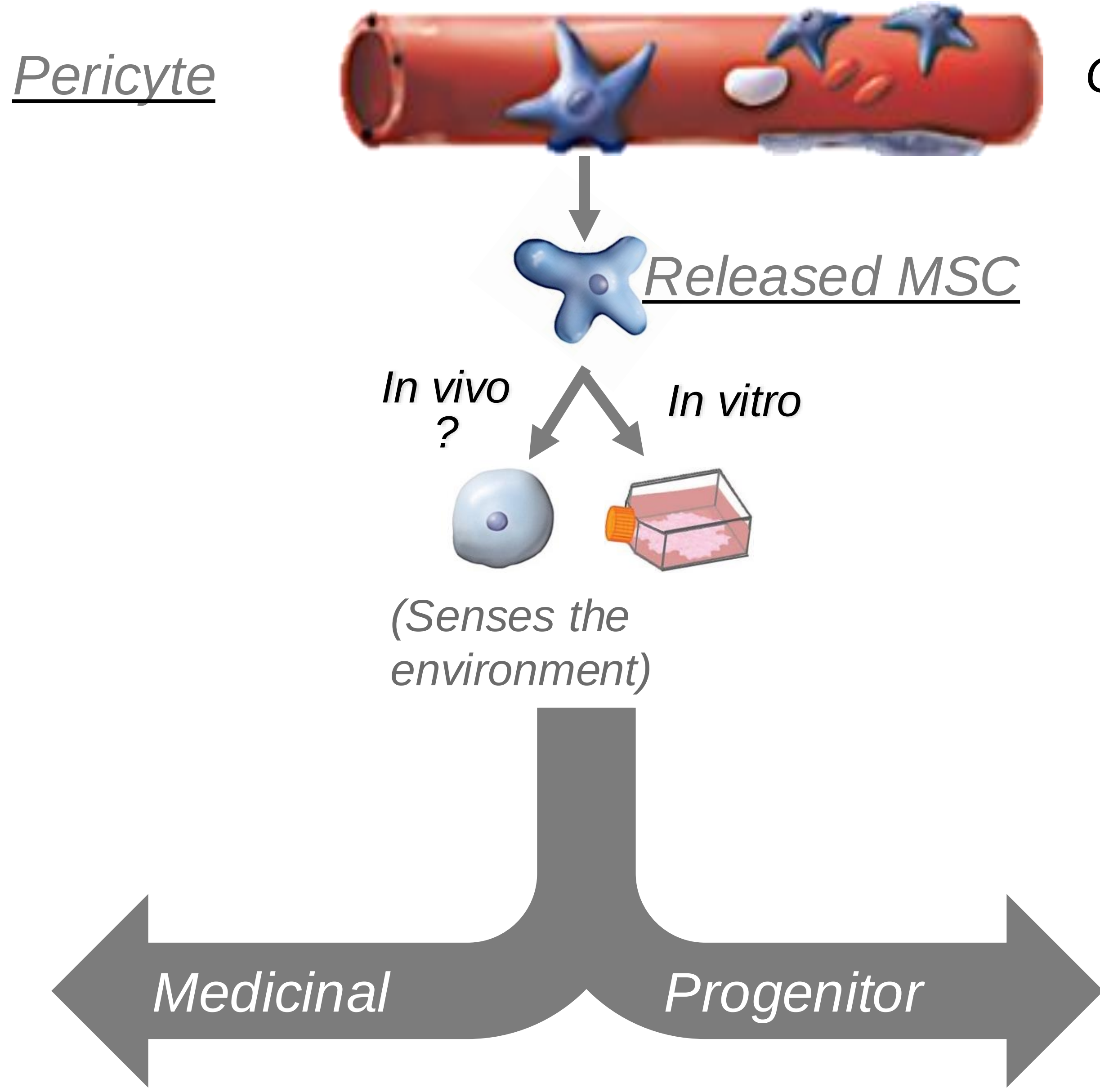
# Mesenchymal Stem Cells (MSCs)

## Alternative fates

*Caplan & Correa; JOR 2011*




**IMMUNO-MODULATION**

*T cells; B cells; Dendritic cells; T Regs*

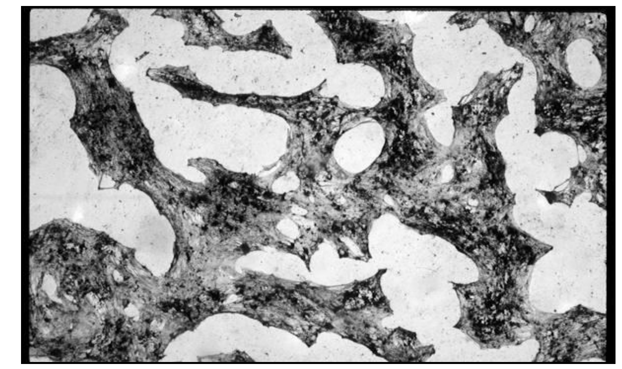
*Immunotolerance*

**TROPHIC**

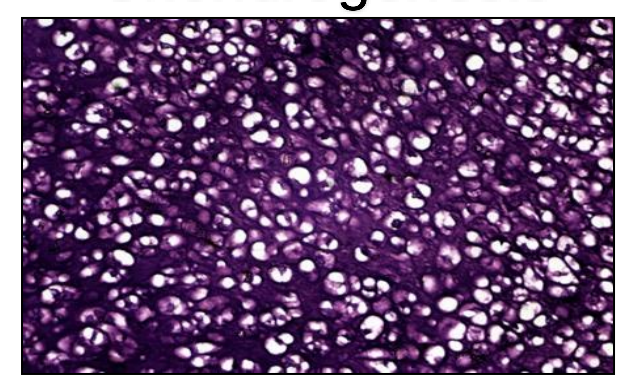
*Angiogenic; anti-scarring; anti-apoptotic; mitotic/support*

*Establish a regenerative microenvironment*

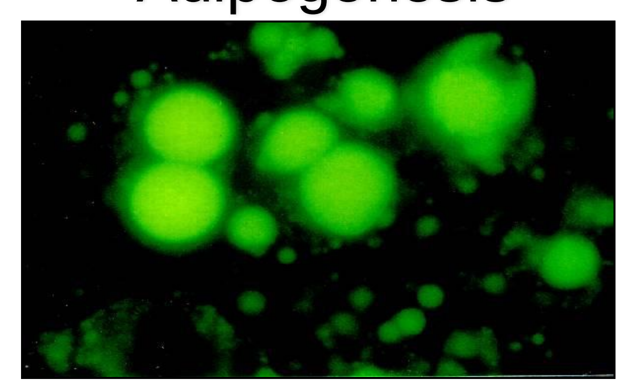
Osteogenesis



Chondrogenesis



Adipogenesis



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*Caplan & Correa; Cell Stem Cell 2011*


Cell Stem Cell

Perspective

Cell PRESS

**The MSC: An Injury Drugstore**

Arnold I. Caplan[1,*] and Diego Correa[1]

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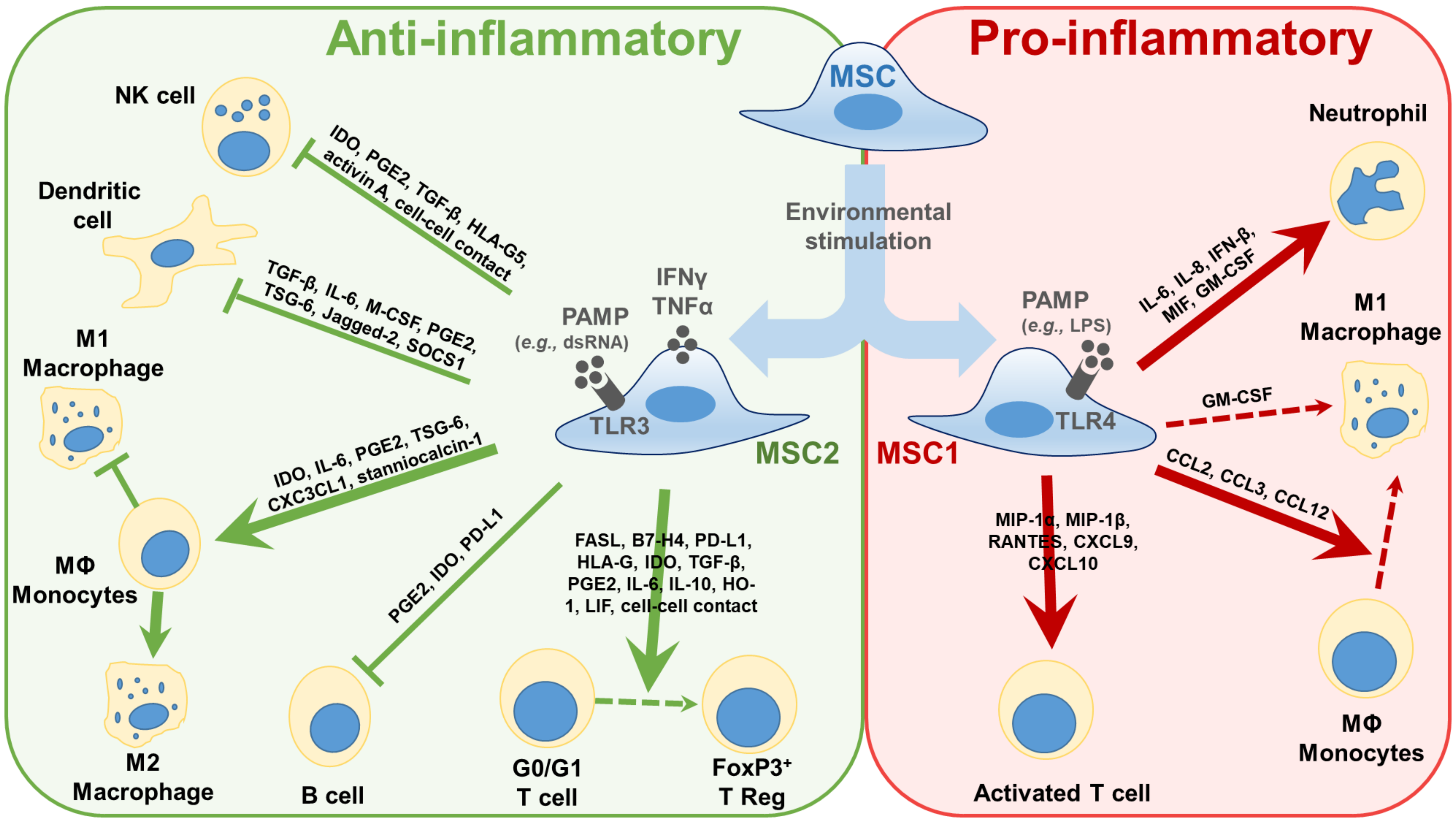
# Physiology of MSC: Immunomodulatory Properties




- MSC polarization spectrum: MSC, under specific environmental stimulation shift from anti- (green) and pro- (red) inflammatory phenotypes, reflected in their effects in immune cells. The main discriminators of this distinctive stimulation are: 1) the presence/absence of IFNγ/TNFα in the local milieu; and 2) the type of toll-like receptor (TLR) stimulated.

***Correa, Kouroupis & Best, 2019***

Review

# The Effects of Nordic Hamstring Exercise on Performance and Injury in the Lower Extremities: An Umbrella Review

*Healthcare* 2024

Hugo Nunes [1,*], Luís Goncalves Fernandes [1], Pedro Nunes Martins [1] and Ricardo Maia Ferreira [1,2,3,*]

**Abstract:** Due to their potential positive outcomes, hamstring eccentric exercises are becoming increasingly popular in training regimens. Among the various exercises, the Nordic Hamstring Exercise (NHE) is the most common. Despite its popularity, there are still some doubts about its benefits and risks. So, the aim of this umbrella review was to summarize the effects of NHE on performance and injury prevention. Following the PRISMA guidelines, a comprehensive literature search was conducted across multiple e-databases, according to the P (injured and non-injured athletes or recreationally active or healthy individuals) I (NHE) C (no intervention, placebo, or other interventions) O (performance or injury) S (systematic reviews) model. The quality of the studies was accessed with the AMSTAR-2. From the 916 systematic reviews found, only 10 could be included. They encompassed 125 studies, enrolling 17,260 subjects. The results from the studies indicate that NHE interventions demonstrated positive effects on sprint performance, muscle activation, eccentric strength, and muscle architecture (fascicle length, muscle thickness, and pennation angle). Furthermore, NHE is effective in preventing hamstring injuries (up to 51%). In conclusion, NHE should be integrated in training (especially, in the warm-up phase) for both enhancing athletic performance and preventing hamstring injuries. For achieving more positive results, it is recommended that high-volume is followed by low-volume maintenance, targeting 48 reps/week.

Review

# The Effects of Nordic Hamstring Exercise on Performance and Injury in the Lower Extremities: An Umbrella Review

*Plos One* 2024

Hugo Nunes [1,*], Luís Goncalves Fernandes [1], Pedro Nunes Martins [1] and Ricardo Maia Ferreira [1,2,3,*]

| | |
|---|---|
| P | Injured and non-injured athletes or recreationally active or healthy individuals |
| I | Nordic hamstrings exercise |
| C | No intervention, placebo, or other interventions |
| O | Performance and injury |
| S | Systematic reviews |

**Figure 1.** Description of the terms used to guide search strategy using the PICOS model: P—Patients; I—Intervention; C—Comparison; O—Outcomes; S—Studies.

**Table 1.** Inclusion and exclusion criteria.

| Inclusion<br>The Studies Must | Exclusion<br>The Studies Cannot |
|---|---|
| have at least one the keywords; | |
| be systematic reviews (with or without meta-analysis), prior to January 2024; | be books, case reports, expert opinions, conference papers, academic thesis, literature reviews or narrative reviews; |
| be published in peer-review journals; | |
| include injured and non-injured athletes or recreationally active or healthy individuals; | include experimental or control groups composed of any kind of animal; |

- Most common protocol was 2-3 sets of 6-12 repetitions, 30s to 3min rest between sets
- Often conducted in isolation or incorporated into strength training, FIFA 11 program, or warm-up routines
- Most common sport - soccer
- Methodological quality – fair to good
- Most common finding – increase in knee flexor strength
- Implementation of high-volume pre-season followed by lower volumes in season produced yielded best results
- No studies on runners

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# Efficacy of rehabilitation (lengthening) exercises, platelet-rich plasma injections, and other conservative interventions in acute hamstring injuries: an updated systematic review and meta-analysis

Haiko IMFL Pas,[1,2] Gustaaf Reurink,[1,3,4] Johannes L Tol,[1,5,6] Adam Weir,[4] Marinus Winters,[7] Maarten H Moen[1,8]

*Br J Sports Med* 2015

**ABSTRACT**

**Background** Our 2012 review on therapeutic interventions for acute hamstring injuries found a lack of high-quality studies. The publication of new studies warranted an update.

**Objectives** To update and reanalyse the efficacy of conservative treatments for hamstring injury.

**Data sources** PubMed, EMBASE, Web of Science, Cochrane library, CINAHL and SPORTDiscus were searched till mid-February 2015.

**Study eligibility criteria** Randomised controlled trials (RCTs) on the effect of conservative interventions versus a control group or other intervention for hamstring injuries (HI) were included.

**Data analysis** The search results were screened independently by two authors. Risk of bias assessment was performed using a modified Downs and Black scale with a maximum score of 28. Meta-analysis was performed, where possible.

**Main results** 10 RCTs (526 participants), including 6 new RCTs, were identified. Two RCTs were of good/excellent quality, the rest were fair or poor (median Downs and Black score 16 (IQR 9)). Meta-analysis of two studies on rehabilitation (lengthening) exercises showed a significantly reduced time to return to play (HR 3.22 (95% CI 2.17 to 4.77), $p<0.0001$) but no difference in risk of re-injury. Meta-analysis of three studies investigating platelet-rich plasma (PRP) showed no effect when compared to control (HR 1.03 (95% CI 0.87 to 1.22), $p=0.73$). Limited evidence was found that progressive agility and trunk stability training may reduce re-injury rates.

**Conclusions** Meta-analysis showed superior efficacy for rehabilitation exercises. PRP injection had no effect on acute hamstring injury. Limited evidence was found that agility and trunk stabilisation may reduce re-injury rates. The limitations identified in the majority of RCTs should improve the design of new hamstring RCTs.

- 10 RCTs (526 participants), 6 new
- 2 RCTs – good/excellent quality, rest – fair/poor
- Rehab (lengthening) exercises = reduced time for RTP but no difference in re-injury risk
- 3 PRP studies – no effect compared to control
- Limited evidence for progressive agility and trunk stability training

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*Br J Sports Med* 2015

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Marinus Winters,[7] Maarten H Moen[1,8]

**Table 1** Article characteristics

| Author | N | Population | Intervention(s) | Follow-up | Primary outcome | Results |
|---|---|---|---|---|---|---|
| Sherry and Best[19] | 24 | Athletes with acute hamstring strain, grades 1 and 2 based on physical examination | I1: rehabilitation programme consisting of PATS exercises and icing<br>I2: rehabilitation programme consisting of static stretching, isolated progressive resistance exercise and icing (STST) | 1 year | Time to RTP<br>Re-injury | I1: 22.2 days (SD 8.3)<br>I2: 37.4 days (SD 27.6)<br>I1: 0/13<br>I2: 7/10 |
| Silder *et al*[20] | 29 | Athletes with suspected HI within the past 10 days confirmed by physical examination and MRI | I1: rehabilitation programme consisting of PATS programme<br>I2: rehabilitation programme consisting of PETS | 1 year | Time to RTP<br>Craniocaudal length of injury | I1: 25.2 days (SD 6.3)<br>I2: 28.8 days(SD 11.4)<br>I1: 7.9 cm (95% CI 2.7 to 13.1)<br>I2: 15.9 cm (95% CI 8.4 to 23.4) |
| Reynolds *et al*[17] | 44 | Patients with sports-related tear of the hamstring, <48 h after injury | I1: two capsules 50 mg meclofenamate and two diclofenac placebo capsules 3 times/day for 7 days<br>I2: two 25 mg diclofenac and two meclofenamate placebo capsules 3 times/day for 7 days<br>C: meclofenamate and diclofenac placebo capsules | 7 days | Sum of pain score (VAS) in the last 24 h | I1: 7.9 (SD 6.6)<br>I2: 8.8 (SD 7.7)<br>C: 3.9 (SD 3.3) |
| Malliaropoulos *et al*[18] | 80 | Athletes with a ultrasonographic grade 2 hamstring strain | I1+I2: during first 48 h PRICE followed by rehabilitation programme<br>I1: four stretching sessions daily<br>I2: one stretching session daily | RTP | Time required for full rehabilitation<br>Time to equalisation of knee ROM | I1: 13.27 days (SD 0.71)<br>I2: 15.05 days (SD 0.81)<br>I1: 5.57 days (SD 3.3)<br>I2: 7.23 days (SD 0.525) |
| Cibulka *et al*[16] | 20 | Patients with a clinical diagnosis of hamstring muscle strain and sacroiliac joint dysfunction | I: moist heat, passive stretching and manipulation of sacroiliac joint<br>C: moist heat, passive stretching | None reported | Hamstring peak torque<br>Passive knee extension ROM | I1: 46.4 ft lbs (SD 17.47<br>I2: 45.7 ft lbs (SD 22.70)<br>I1: 155.0° (SD 14.2)<br>I2: 144.6° (SD 16.7) |
| Askling *et al*[21] | 75 | Elite Swedish football players with MRI (<5 days after injury) confirmed HI | I1: L-protocol aimed at loading the hamstrings during extensive lengthening, mainly during eccentric muscle actions<br>I2: C-protocol consisting of conventional exercises for the hamstrings with less emphasis on lengthening | 1 year | Time to RTP<br>Re-injury | I1: 28 days (SD 15)<br>I2: 51 days (SD 21)<br>I1: 0/37<br>I2: 1/38 |
| Askling *et al*[22] | 56 | Swedish elite sprinters and jumpers with MRI (<5 days after injury) confirmed HI | I1: L-protocol aimed at loading the hamstrings during extensive lengthening, mainly during eccentric muscle actions<br>I2: C-protocol consisting of conventional exercises for the hamstrings with less emphasis on lengthening | 1 year | Time to RTP<br>Re-injury | I1: 49 days (SD 26)<br>I2: 86 days (SD 34)<br>I1: 0/28<br>I2: 2/28 |
| Reurink *et al*[24] | 80 | Athletes with acute hamstring injuries confirmed by physical examination and MRI | I: two 3 mL platelet-rich plasma injections and a standard rehabilitation programme<br>C: two 3 mL saline placebo injections and a standard rehabilitation programme | 1 year | Time to RTP | I: 42 days (IQR 30–58)<br>C: 42 days (IQR 37–56) |
| Hamid *et al*[23] | 28 | Athletes diagnosed with an acute ultrasonographic grade 2 hamstring injury | I: one 3 mL platelet-rich plasma injection and a rehabilitation programme<br>C: rehabilitation programme only | RTS | Time to RTP | I: 26.7 days (SD 7.0)<br>C: 42.5 days (SD 20.6) |
| Hamilton *et al*[25] | 90 | Athletes with acute posterior thigh pain confirmed by MRI as grade 1 or 2 hamstring lesion | I1: one 3 mL platelet-rich plasma injection and a rehabilitation programme<br>I2: one 3 mL platelet-poor plasma injection and a rehabilitation programme<br>C: rehabilitation programme only | 6 months | Time to RTP | I1: 21 days (95% CI 17.9 to 24.1)<br>I2: 27 days (95% CI 20.6 to 33.4)<br>C: 25 days (95% CI 21.5 to 28.5) |

C, control; C-protocol, conventional rehabilitation protocol; I, intervention; L-protocol, loading and lengthening rehabilitation protocol; PATS, progressive agility and trunk stabilisation; PETS, progressive running and eccentric strengthening; ROM, range of motion; RTP, return to play; RTS, return to sport; STST, stretching and strengthening; VAS, visual analogue scale.

# Efficacy of rehabilitation (lengthening) exercises, platelet-rich plasma injections, and other conservative interventions in acute hamstring injuries: an updated systematic review and meta-analysis

Haiko IMFL Pas,[1,2] Gustaaf Reurink,[1,3,4] Johannes L Tol,[1,5,6] Adam Weir,[4] Marinus Winters,[7] Maarten H Moen[1,8]

*Br J Sports Med* 2015

**Table 4** Interventions and outcomes of RCTs

| Intervention | Outcome | Effect | Best evidence synthesis | Quality ratings of studies |
|---|---|---|---|---|
| Progressive loading during eccentric lengthening | Time to RTP[21 22] | + | Meta-analysis | Fair[21 22] |
| | Re-injury[21 22] | = | Meta-analysis | |
| PATS exercises | Time to RTS[19 20] | = | Moderate | Fair[19 20] |
| | Re-injury[19] | + | Limited | |
| | Craniocaudal length of injury at RTS[20] | + | Limited | |
| | Physical examination at RTS[20] | = | Limited | |
| | MRI characteristics at RTS[20] | = | Limited | |
| Stretching exercises | Time to RTP[18] | + | Limited | Poor[18] |
| | Time to equalisation of knee ROM[18] | + | Limited | |
| Platelet-rich plasma | Time to RTP[23–25] | = | Meta-analysis | Good[24 26] |
| | Re-injury[24 25] | = | Meta-analysis | Fair[23] |
| | Adverse events[23–25] | = | Strong | Good/excellent[25] |
| | Change in pain score[23] | = | Limited | |
| | Isokinetic testing[25] | = | Limited | |
| | Changes in T2-weighted MRI after 3 weeks[25] | = | Limited | |
| | Adherence to rehabilitation programme[25 26] | = | Strong | |
| | Physical examination[26] | = | Limited | |
| | Hamstring outcome score[26] | = | Limited | |
| | Patient satisfaction[26] | = | Limited | |
| | oedema on MRI[26] | = | Limited | |
| NSAIDs | Pain score[17] | = | Limited | Fair[17] |
| | Isokinetic testing[17] | = | Limited | |
| | Swelling[17] | = | Limited | |
| | Adverse events[17] | – | Limited | |
| Sacroiliac manipulation | Hamstring flexibility[16] | = | Limited | Fair[16] |
| | Isokinetic testing[16] | = | Limited | |

=, No effect of intervention compared to control or no differences between intervention and control; +, favours intervention; –, favours control; NSAID, non-steroidal anti-inflammatory drug; PATS, progressive agility and trunk stabilisation; RCT, randomised controlled trial; ROM, range of motion; RTP, return to play; RTS, return to sport.

**What are the new findings?**

- Meta-analysis of lengthening and loading rehabilitative exercises in acute hamstring injuries show a positive effect on return to play.
- Meta-analysis of platelet-rich plasma injections in acute hamstring injuries shows no effect.
- Progressive agility and trunk stabilisation may reduce re-injury rates.

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# Hamstring Injury Treatments and Management in Athletes

## A Systematic Review of the Current Literature

Mohammad Poursalehian, MD*
Mohadeseh Lotfi, MD*
Sahar Zafarmandi, MD
Razman Arabzadeh Bahri, MD
Farzin Halabchi, MD

*Investigation performed at Joint Reconstruction Research Center, Tehran University of Medical Sciences, Tehran, Iran*

*JBJS Reviews* 2023

**Abstract**

**Background:** The field of sports medicine presents a varied landscape of research on hamstring injuries in athletes, characterized by inconclusive and sometimes conflicting findings on effective treatment and rehabilitation strategies. This discordance prompted the current systematic investigation.

**Methods:** Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were followed for conducting the systematic review. Multiple international bibliometric databases (Scopus, PubMed, Web of Science, and Embase) were searched to identify studies evaluating any treatment option for the management of hamstring injuries in athletes. Eligible studies were appraised for quality using Joanna Briggs Institute and Risk of Bias 2 tools.

**Results:** A total of 30 studies with 1,195 participants were included. Of the reviewed studies, treatments varied from aggressive rehabilitation, platelet-rich plasma (PRP) injections, manual techniques, various exercise protocols to modalities like high-power laser and nonsteroidal anti-inflammatory drugs. Evidence suggested benefits from treatments like extensive muscle lengthening during eccentric actions, progressive agility, and trunk stabilization. PRP injections produced mixed results regarding return to sport and reinjury rates. Stretching exercises, sometimes combined with cryotherapy, showed benefits.

**Conclusion:** Treatments for hamstring injuries exhibit varied efficacy. Although rest, ice, compression, and elevation remains essential for acute management, rehabilitation focusing on muscle strengthening and flexibility is crucial. The potential benefits of PRP injections, especially for chronic cases, require more conclusive research. A comprehensive approach, combining evidence-based practices and patient-centric factors, is vital for effective management and recovery.

**Level of Evidence:** Level IV. See Instructions for Authors for a complete description of levels of evidence.

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*JBJS Reviews* 2023

**TABLE III Return-to-Sport Outcomes of RCT Studies***

| Study | Intervention Group (N) | Intervention Group Return to Sport Mean ± SD | Control Group (N) | Control Group Return to Sport Mean ± SD |
|---|---|---|---|---|
| Askling et al., 2013[25] | L-protocol (37) | 28 ± 15 | C-protocol (38) | 51 ± 21 |
| Askling et al., 2014[31] | L-protocol (28) | 49 ± 26 | C-protocol (28) | 86 ± 34 |
| Guillodo et al., 2015[33] | PRP + rehabilitation (15) | 50.9 ± 10.7 | Rehabilitation (19) | 52.8 ± 15.7 |
| A Hamid et al., 2014[30] | PRP + PATS (12) | 26.7 ± 7.0 | PATS (12) | 42.5 ± 20.6 |
| Hamilton et al., 2015[34] | PRP + rehabilitation (28) | 21.0 ± 12.6 | Rehabilitation (27) | 25.0 ± 6.6 |
| Hamilton-2, 2015 | PRP + rehabilitation (28) | 21.0 ± 12.6 | PPP + rehabilitation (30) | 27.0 ± 10.3 |
| Hickey et al., 2020[46] | Pain allowed during rehabilitation (21) | 16.7 ± 6.5 | Pain free rehabilitation (22) | 15.6 ± 4.5 |
| Malliaropoulos et al., 2004[20] | Intensive rehabilitation (40) | 13.2 ± 0.7 | Normal rehabilitation (40) | 15.0 ± 0.8 |
| Medeiros et al., 2020[48] | Low-level laser (11) | 23 ± 9 | Placebo (11) | 24 ± 13 |
| Reurink et al., 2015[35] | PRP (41) | 42.0 ± 20.7 | Placebo (39) | 42.0 ± 14.0 |
| Sherry et al., 2004[21] | PATS (13) | 22.2 ± 8.3 | STST (11) | 37.4 ± 27.6 |
| Silder et al., 2013[28] | PATS (16) | 25.2 ± 6.3 | Running and eccentric rehabilitation (13) | 28.8 ± 11.4 |
| Vermeulen et al., 2022[54] | Early lengthening (38) | 27.6 ± 2.9 | Delayed lengthening (33) | 33.9 ± 2.5 |

*PATS = progressive agility and trunk stabilization, PPP = platelet-poor plasma, PRP = platelet-rich plasma, RCT = randomized controlled trial, and STST = STatic STretching, isolated progressive hamstring resistance exercise, and icing.

# TOPIC 2 - IMAGING

| Location of Injury | MRI Findings | Ultrasound Findings |
|---|---|---|
| **Hamstring Strain** | ***Injury findings and prognostication for hamstring strains are typically classified by*** *British Athletics muscle injury classification (BAMIC)* [121,124]<br><br>**Grading further subclassified by location:**<br>**a**: myofascial<br>**b**: myotendinous junction<br>**c**: tendinous<br><br>**Grade 0:**<br>Normal MRI or Patchy signal change throughout one or more muscle<br><br>**Grade 1:**<br>< 10% Cross section area involvement<br>< 5cm of length<br><br>**Grade 2:**<br>>10%, <50% Cross section area involvement<br>**a,b:** >5cm fiber disruption 5-15cm length<br>**c:** <5cm length, no discontinuity in tendon<br><br>**Grade 3:**<br>Extensive tearing with high signal along area of injury<br>>50% Cross section area involvement<br>**a,b** : >15cm of length and fiber disruption >5cm<br>**c:** > 50% Cross section area involvement, <5cm length<br><br>**Grade 4:**<br>Full-thickness tear with retraction | Ultrasound for acute hamstring strains will display typical findings of acute myotendinous injury: hypo-echogenicity in area of injury, most typically at the myotendinous junction.<br><br>**Grade :1**<br>Poorly defined subtle intramuscular changes, may be hypoechoic or hyperechoic, may have swelling at the aponeurosis minimal fiber disruption<br><br>**Grade 2:**<br>Partial tearing of fibers, gapping may be seen. Hemorrhage may appear hyperechoic acutely, later in course will appear hypoechoic<br><br>**Grade 3:**<br>complete tearing with discontinuity of muscle fibers, mixed echogenicity or hypoechoic gapping and tendon retraction of muscle which is highlighted with passive movement. Hemorrhage appearing hyperechoic initially, later on will appear hypoechoic [12,79] |

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# Characterization of acute effects of football competition on hamstring muscles by muscle functional MRI techniques

*Plos One* 2024

Sandra Mechó[1,2]*, Alicia Palomar-Garcia[3]*, Manuel Wong[2], Juan C. Gallego[1,2], Francesc López[1,2], Xavier Valle[2], Ferran Ruperez[2], Ricard Pruna[2], Juan R. González[4,5,6], Gil Rodas[2,7,8]

Muscle functional MRI identifies changes in metabolic activity in each muscle and provides a quantitative index of muscle activation and damage. No previous studies have analyzed the hamstrings activation over a football match. This study aimed at detecting different patterns of hamstring muscles activation after a football game, and to examine inter- and intra-muscular differences (proximal-middle-distal) in hamstring muscles activation using transverse relaxation time (T2)–weighted magnetic resonance images. Eleven healthy football players were recruited for this study. T2 relaxation time mapping-MRI was performed before (2 hours) and immediately after a match (on average 13 min). The T2 values of each hamstring muscle at the distal, middle, and proximal portions were measured. The primary outcome measure was the increase in T2 relaxation time value after a match. Linear mixed models were used to detect differences pre and postmatch. MRI examination showed that there was no obvious abnormality in the shape and the conventional T2 weighted signal of the hamstring muscles after a match. On the other hand, muscle functional MRI T2 analysis revealed that T2 relaxation time significantly increased at distal and middle portions of the semitendinosus muscle (p = 0.0003 in both cases). By employing T2 relaxation time mapping, we have identified alterations within the hamstring muscles being the semitendinosus as the most engaged muscle, particularly within its middle and distal thirds. This investigation underscores the utility of T2 relaxation time mapping in evaluating muscle activation patterns during football matches, facilitating the detection of anomalous activation patterns that may warrant injury reduction interventions.

# Correlation of Player and Imaging Characteristics With Severity and Missed Time in National Football League Professional Athletes With Hamstring Strain Injury A Retrospective Review

Molly A. Day MD , Lee H. Karlsson PT, DPT, MScPH, Mackenzie M. Herzog PhD, MPH, Leigh J. Weiss, PT, DPT, MS, ATC, Shane J. McGonegle, MD, Harry G. Greditzer IV, MD, Vivek Kalia, MD, MPH, MS, Asheesh Bedi, MD, and Scott A. Rodeo, MD

*AJSM* 2024

Purpose: To describe player, football activity, clinical, and imaging characteristics of NFL players with HSIs, as well as determine player characteristics, clinical examination results, and magnetic resonance imaging (MRI) findings associated with injury occurrence, severity, and missed time.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: A retrospective cohort of NFL players with acute HSI (n = 180) during the 2018-2019 season was identified. Injury data were collected prospectively through a league-wide electronic health record system. Three musculoskeletal radiologists graded MRI muscle injury parameters using the British Athletics Muscle Injury Classification (BAMIC) system. Player, football, clinical, and imaging characteristics were correlated with HSI incidence and severity and with missed time from sport.

Results: Of the 1098 HSIs identified during the 2018-2019 season, 416 (37.9%) were randomly sampled, and 180 (43.3%) had diagnostic imaging available. Game activity, preseason period, and wide receiver and defensive secondary positions disproportionately contributed to HSI. The biceps femoris was the most commonly injured muscle (n = 132, 73.3%), followed by the semimembranosus (n = 24, 13.3%) and semitendinosus (n = 17, 9.4%) muscles. The most common injury site was the distal third of the biceps femoris and semitendinosus muscles (n = 60, 45.5% and n = 10, 58.8%, respectively) and central part of the semimembranosus muscle (n = 17, 70.8%). Nearly half of the injuries (n = 83, 46.1%) were BAMIC grade 2; 25.6% (n = 46), grade 3; and 17.8% (n = 32), grade 4. MRI showed sciatic nerve abnormality in 30.6% (n = 55) of all HSIs and 81.3% (n = 26) of complete tendon injuries. BAMIC grade correlated with both median days and games missed. Combined biceps femoris and semitendinosus injuries resulted in the highest median days missed (27 days).

Conclusion: Among NFL players with acute HSIs, the most common injury was a moderate-severity injury of the distal biceps femoris. BAMIC grade was associated with missed time.

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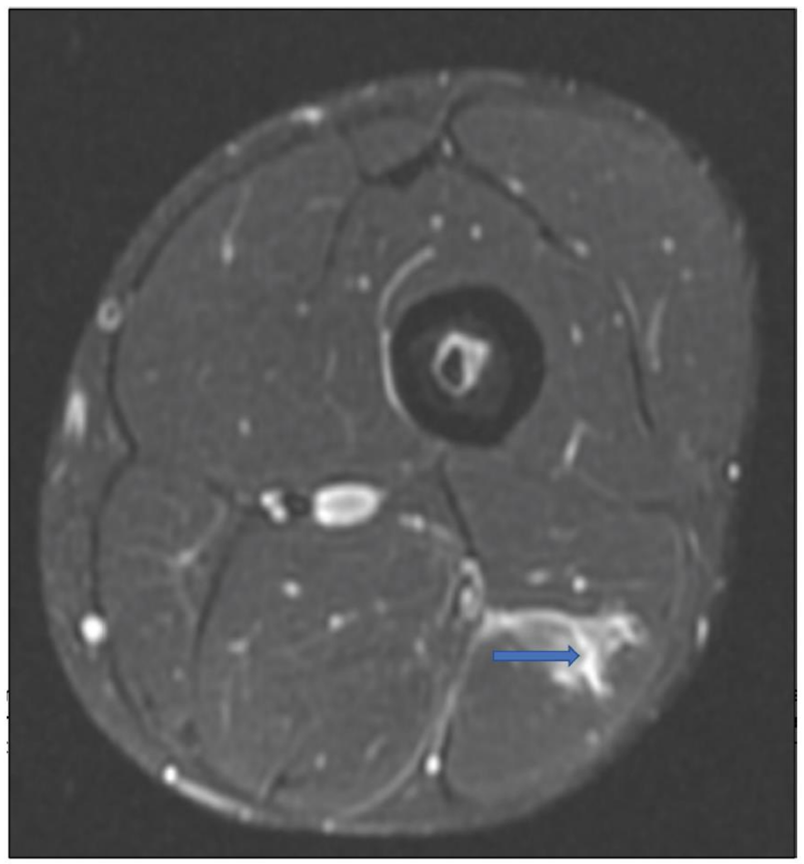
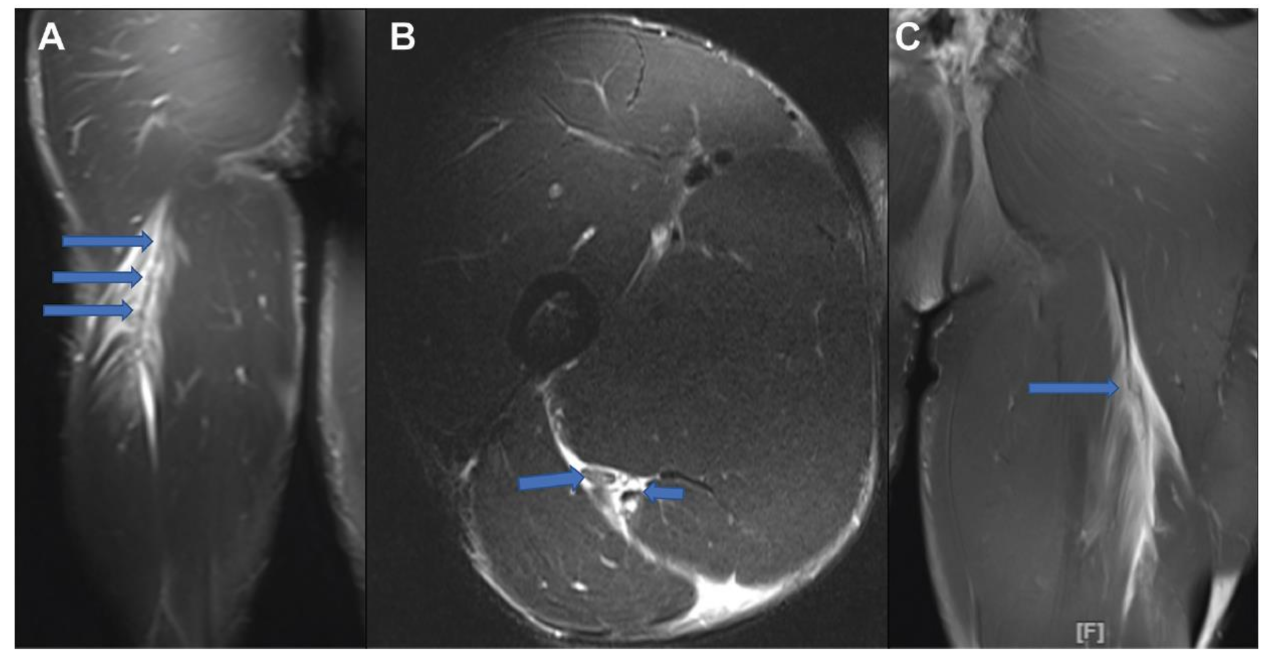
*AJSM* 2024



Grade 2a shown on an axial short tau inversion recovery image of player's left distal thigh. Arrow indicates edema in the long head of the biceps. Edema is seen in up to 50% of the cross section of the belly.




(BAMIC) grade 3c shown on a coronal short tau inversion recovery image of a player's right proximal thigh. The image shows a high-grade partial-thickness tear in the intramuscular portion of the right proximal long head biceps femoris (LHBF) tendon.

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SPORTS MEDICINE AND BIOMECHANICS

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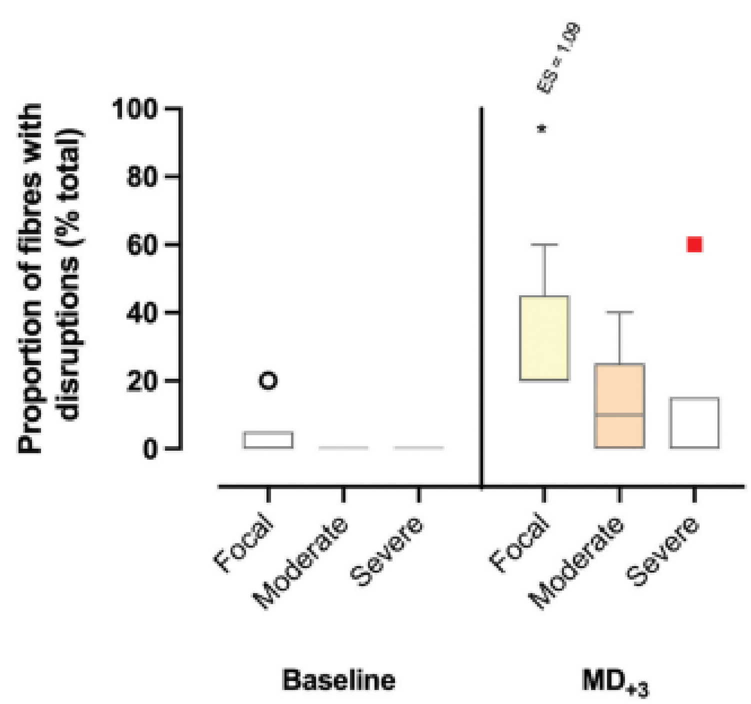
# Hamstrings on focus: Are 72 hours sufficient for recovery after a football (soccer) match? A multidisciplinary approach based on hamstring injury risk factors and histology

Gerard Carmona[a], Lia Moreno-Simonet[b], Pedro Luís Cosio[b], Andrea Astrella[c,d], Daniel Fernández[e], Joan Aureli Cadefau[b], Gil Rodas[f,g,h], Cristina Jou[i,j,k], José César Milisenda[h,l,m], María Dolores Cano[l], Raquel Arànega[l], Mario Marotta[n,o], Josep Maria Grau[h,l,o], Josep Maria Padullés[b] and Jurdan Mendiguchia[p]

*J Sports Sci* 2024


## ABSTRACT

This study aimed to assess acute and residual changes in sprint-related hamstring injury (HSI) risk factors after a football (soccer) match, focusing on recovery within the commonly observed 72-h timeframe between elite football matches. We used a multifactorial approach within a football context, incorporating optical and ultrastructural microscopic analysis of BFlh (biceps femoris long head) muscle fibres, along with an examination of BFlh fibre composition. Changes in sprint performance-related factors and HSI modifiable risk factors were examined until 3 days after the match ($MD_{+3}$) in 20 football players. BFlh biopsy specimens were obtained before and at $MD_{+3}$ in 10 players. The findings indicated that at $MD_{+3}$, sprint-related performance and HSI risk factors had not fully recovered, with notable increases in localized BFlh fibre disruptions. Interestingly, match load (both external and internal) did not correlate with changes in sprint performance or HSI risk factors nor with BFlh fibre disruption. Furthermore, our study revealed a balanced distribution of ATPase-based fibre types in BFlh, with type-II fibres associated with sprint performance. Overall, the results suggest that a 72-h recovery period may not be adequate for hamstring muscles in terms of both HSI risk factors and BFlh fibre structure following a football match.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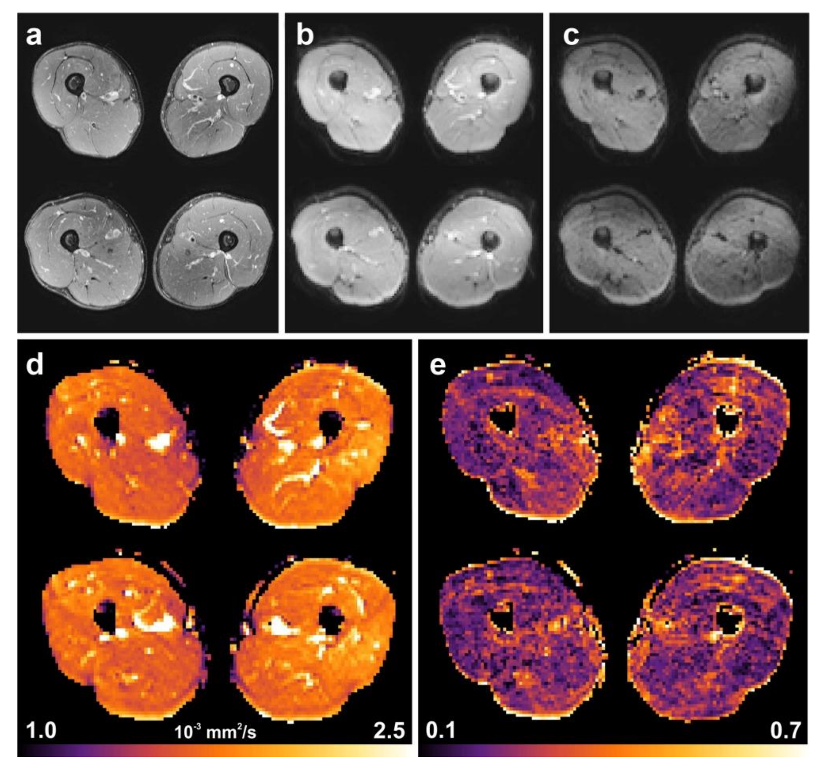
Relationships between quantitative magnetic resonance imaging measures at the time of return to sport and clinical outcomes following acute hamstring strain injury

*J Biomech* 2024

Christa M. Wille[a,b,c], Samuel A. Hurley[d], Mikel R. Joachim[a,c], Kenneth Lee[d], Richard Kijowski[e], Bryan C. Heiderscheit[a,b,c,*]

- At time of return to sport (RTS), injured limb can show strength deficits relative to uninjured limb and uninjured athletes (Maniar et al. 2016, Ribeiro-Alvares et al. 2021)
- Reduced biceps femoris fascicle length (Timmins et al. 2016) and atrophy (Sanfilippo et al. 2013) often persist
- Strength deficits at RTS thought to be linked to MRI changes on T2 sequences at the gross anatomical level
- Diffuse tensor imaging (DTI) – generates contrast from water diffusion to inform about tissue microstructure
- Preliminary evidence – relationship between DTI metrics and calf strength (Scheel et al. 2013)

Purpose – determine association of between-limb quantitative MRI measures at RTS following HIS with between-limb eccentric hamstring strength and reinjury



# Relationships between quantitative magnetic resonance imaging measures at the time of return to sport and clinical outcomes following acute hamstring strain injury

*J Biomech* 2024

Christa M. Wille [a,b,c], Samuel A. Hurley [d], Mikel R. Joachim [a,c], Kenneth Lee [d], Richard Kijowski [e], Bryan C. Heiderscheit [a,b,c,*]

ABSTRACT

Hamstring strain injuries (HSI) are a common occurrence in athletics and complicated by high rates of reinjury. Evidence of remaining injury observed on magnetic resonance imaging (MRI) at the time of return to sport (RTS) may be associated with strength deficits and prognostic for reinjury, however, conventional imaging has failed to establish a relationship. Quantitative measure of muscle microstructure using diffusion tensor imaging (DTI) may hold potential for assessing a possible association between injury-related structural changes and clinical outcomes. The purpose of this study was to determine the association of RTS MRI-based quantitative measures, such as edema volume, muscle volume, and DTI metrics, with clinical outcomes (i.e., strength and reinjury) following HSI. Spearman's correlations and Firth logistic regressions were used to determine relationships in between-limb imaging measures and between-limb eccentric strength and reinjury status, respectively. Twenty injuries were observed, with four reinjuries. At the time of RTS, between-limb differences in eccentric hamstring strength were significantly associated with principal effective diffusivity eigenvalue $\lambda_1$ ($r$ = -0.64, $p$ = 0.003) and marginally associated with mean diffusivity ($r$ = -0.46, $p$ = 0.056). Significant relationships between other MRI-based measures of morphology and eccentric strength were not detected, as well as between any MRI-based measure and reinjury status. In conclusion, this preliminary evidence indicates DTI may track differences in hamstring muscle microstructure, not captured by conventional imaging at the whole muscle level, that relate to eccentric strength.

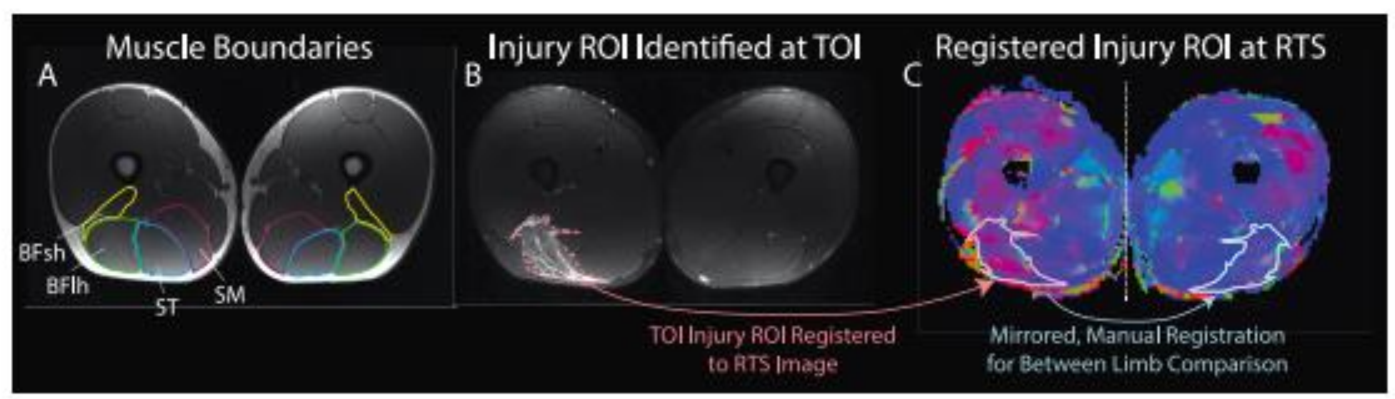



**Fig. 1.** Mean quantitative diffusion metrics were calculated within manually outlined regions of injury (ROI) on the injured limb defined by the hyperintense region of signal on T2-weighted imaging at the time of injury (TOI). Injury ROIs were registered to follow-up scans at return to sport (RTS) (peach arrow). For between-limb comparisons, ROIs were mirrored and manually registered to the uninvolved limb (white arrow). Data shown are from one slice of a representative participant. Biceps femoris short head (BFsh), biceps femoris long head (BFlh), semitendinosus (ST), semimembranosus (SM).

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# TOPIC 3 – RETURN TO SPORT


**Prognosticating Return-To-Play Time Following a Hamstring Strain Injury Using Early Flexibility Asymmetry and Musculoskeletal Ultrasound Imaging Outcomes: An Exploratory Study Among Canadian University Football Players**

Patrick Gendron, PT, BSc,* Martin Lamontagne, MD,*†‡ Camille Fournier-Farley, MD,‡§ and Dany H. Gagnon, PT, PhD‡§

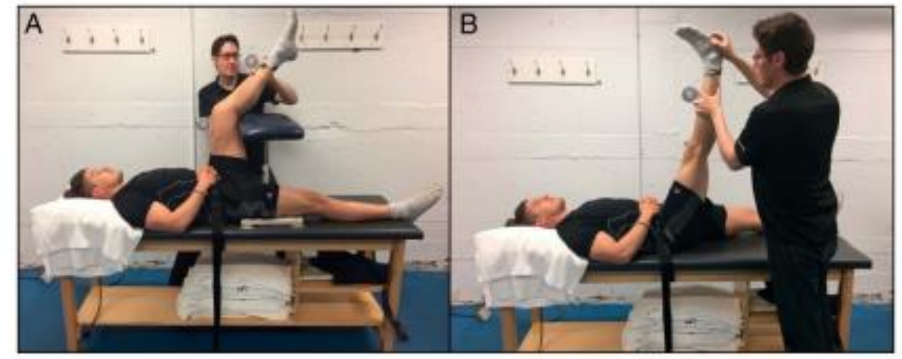
*Clin J Sport Med* 2024

- Frequency of hamstring strain injury (HSI) recurrence is high (up to 35% in same season depending on sport; Elliott et al 2011; Ekstrand et al 2012)
- Determining return-to-play (RTP) remains challenging
- Traditional approach has shortcomings as the risk for reinjury has not changed in decades
- Shared decision-making weighing risks and benefits now favored (for all RTP issues)
- Recent recommendations take into account combining clinical assessment with imaging (MRI or point-of-care US (POCUS))

# Prognosticating Return-To-Play Time Following a Hamstring Strain Injury Using Early Flexibility Asymmetry and Musculoskeletal Ultrasound Imaging Outcomes: An Exploratory Study Among Canadian University Football Players

Patrick Gendron, PT, BSc,* Martin Lamontagne, MD,*†‡ Camille Fournier-Farley, MD,‡§ and Dany H. Gagnon, PT, PhD‡§

*Clin J Sport Med* 2024




**Abstract**

**Objective:** Identify key flexibility and point-of-care musculoskeletal ultrasound (POCUS) measures for prognosticating return-to-play (RTP) following a first hamstring strain injury (HSI) and informing the clinical decision–making process. **Design:** Exploratory prospective cohort study. **Setting:** Sport medicine and rehabilitation clinic of a Canadian university. **Participants:** One hundred and sixty-seven elite Canadian university football athletes followed over 5 seasons. **Interventions:** Clinical and POCUS measures collected within 7 days after HSI and preseason clinical measures. **Main Outcome Measures:** Active knee extension (AKE) and Straight Leg Raise (SLR) to quantify hamstring flexibility, POCUS-related outcomes to characterize tissue alteration, and RTP until full sport resumption were documented (categorized as Early [1-40 days] or Late [>40 days] RTP). **Results:** A total of 19 and 14 athletes were included in the Early RTP (mean RTP = 28.84 ± 8.62 days) and Late RTP groups (mean 51.93 ± 10.54 days), respectively, after having been diagnosed with a first HSI. For the clinical results, height and a greater flexibility asymmetry measure with the AKE or SLR when compared with both ipsilateral preseason and acute contralateral values significantly increases the chance of facing a long delay before returning to play (ie, RTP). For the POCUS-related results, the Peetrons severity score, extent of the longitudinal fibrillary alteration, and novel score lead to similar results. **Conclusions:** Early hamstring flexibility asymmetry following acute HSI, particularly the AKE, along with some POCUS-related measures are valuable in prognosticating late RTP following among Canadian university football athletes.

**Key Words:** musculoskeletal abnormalities, pain, rehabilitation, sports medicine, ultrasonography

(*Clin J Sport Med* 2024;34:436–443)

**Prognosticating Return-To-Play Time Following a Hamstring Strain Injury Using Early Flexibility Asymmetry and Musculoskeletal Ultrasound Imaging Outcomes: An Exploratory Study Among Canadian University Football Players**

Patrick Gendron, PT, BSc,* Martin Lamontagne, MD,*†‡ Camille Fournier-Farley, MD,‡§ and Dany H. Gagnon, PT, PhD‡§

*Clin J Sport Med* 2024

- *Hypothesis* 1 – extent of hamstring flexibility asymmetry and greater HSI severity (based on POCUS) would be associated with late sport RTP
- Point 1 – within first 7 days post-injury, greater flexibility asymmetry (compared with ipsilateral preseason or contralateral measures) correlated with later RTP
- Contrasts with studies on dancers (Askling et al 2006) and elite sprinters (Wangensteen et al 2015)
- *Hypothesis* 2 – POCUS severity (Peetrons severity score, extent of fiber disruption, and composite score) will correlate with time for RTP
- Montreal composite POCUS score better predicted delayed RTP than Peetrons severity score
- Longitudinal fiber alteration main difference between the 2 measures

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*Research Article*

# Biceps Femoris Fascicle Lengths Increase after Hamstring Injury Rehabilitation to a Greater Extent in the Injured Leg

*Translational Sports Medicine* 2022

**Rod Whiteley**[1,2] **Jack T. Hickey**[3,4] **Robin Vermeulen**[1,5] **Ryan Timmins**[3,4]
**Thomas M. Best**[6] **Ebonie Rio**[7] **and David Opar**[3,4]

*Objectives*. Document changes in fascicle length during rehabilitation from hamstring injury of the injured and uninjured legs and secondarily to describe any association between these changes and reinjury rate. *Design*. Multicentre case series. *Methods*. Fifty-two prospectively included hamstring injured athletes had their biceps femoris long head fascicle lengths measured at the start and end of rehabilitation using two-dimensional ultrasound. Absolute and relative changes in fascicle length were compared for each leg using linear mixed models. Participants were followed for six months after being cleared to return to sport for any reinjury. Fascicle lengths and rehabilitation duration were compared for those who reinjured and those who did not. *Results*. Injured leg fascicle length was shorter at the start of rehabilitation (9.1 cm compared to 9.8 cm, $p < 0.01$) but underwent greater absolute and relative lengthening during rehabilitation to 11.1 cm (18% increase) compared to 10.2 cm (8% increase, $p < 0.01$) for the uninjured leg. There were no significant differences in any fascicle length parameter for the 5 participants who reinjured in the 6 months following their return to sport compared to those that did not reinjure. *Conclusions*. While both injured and uninjured legs displayed increases in fascicle length during rehabilitation, the larger fascicle length increases in the injured leg suggest that either a different training stimulus was applied during rehabilitation to each leg or there was a different response to training and/or recovery from injury in the injured leg. Reinjury risk appears to be independent of fascicle length changes in this cohort, but the small number of reinjuries makes any conclusions speculative.

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# Early introduction of high-intensity eccentric loading into hamstring strain injury rehabilitation

*J Sci Med Sports* 2022

Jack T Hickey [1], Ebonie Rio [2], Thomas M Best [3], Ryan G Timmins [4], Nirav Maniar [4], Peter F Hickey [5], Morgan D Williams [6], Christian A Pitcher [7], David A Opar [4]

## Abstract

**Objectives:** This study aimed to investigate the number of days following hamstring strain injury (HSI) taken to introduce high-intensity eccentric loading (HIEL) into rehabilitation based on exercise-specific progression criteria, and whether pain resolution during isometric knee flexion strength testing occurred before or after this milestone.

**Design:** Cohort study.

**Methods:** We included 42 men (mean ± sd; age = 26 ± 5 years; height = 181 ± 8 cm; mass = 86 ± 12 kg) with HSIs, who performed fully supervised rehabilitation twice per week until they met return to play clearance criteria. Isometric knee flexion strength testing was completed before every rehabilitation session and HIEL was introduced via the Nordic hamstring exercise and unilateral slider once participants could perform a bilateral slider through full eccentric knee flexion range of motion. We reported the median (IQR) number of days following HSI taken to introduce HIEL, along with participant's pain rating during isometric knee flexion strength testing before that rehabilitation session. We also reported the median (IQR) number of days following HSI taken for participants to achieve pain resolution during isometric knee flexion.

**Results:** HIEL was introduced 5 (2-8) days following HSI, despite 35/42 participants reporting pain during isometric knee flexion strength testing immediately prior to that rehabilitation session, which was rated as 3.5 (3-5) on a 0-10 numeric rating scale. Pain resolution during isometric knee flexion strength testing was achieved 11 (9-13) days following HSI.

**Conclusion:** HIEL can be safely introduced into early HSI rehabilitation based on exercise-specific progression criteria, without needing to wait for pain resolution during isometric knee flexion strength testing before doing so.

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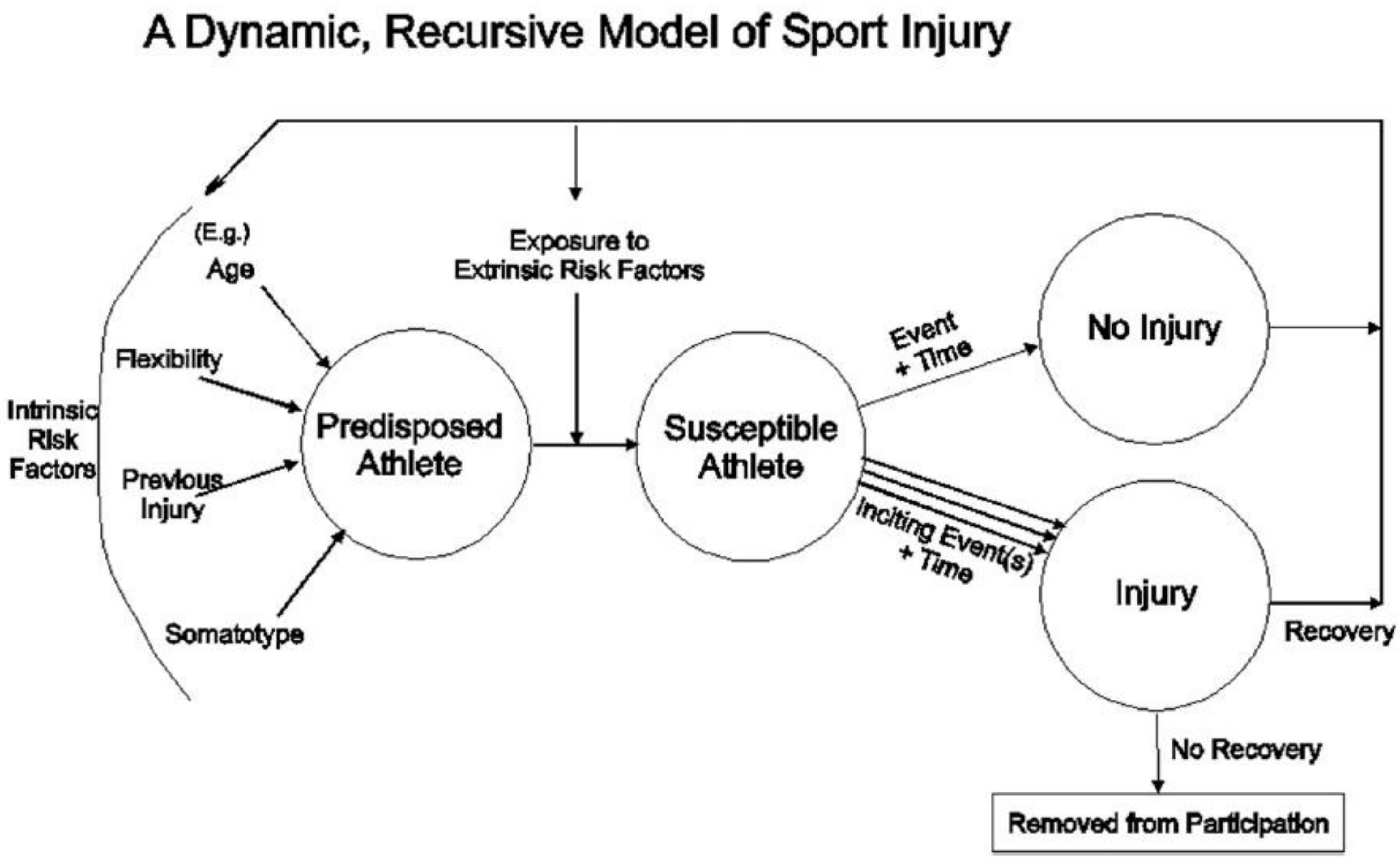
# Topic 4 – INJURY PREVENTION



# Hamstring Strain Injury Risk Factors in Australian Football Change over the Course of the Season

*Med Sci Sports Exer* 2023

AYLWIN SIM[1,2], RYAN G. TIMMINS[3,4], JOSHUA D. RUDDY[3,4], HAIFENG SHEN[1,2], KEWEN LIAO[1,2], NIRAV MANIAR[3,4], JACK T. HICKEY[3,4,5], MORGAN D. WILLIAMS[6], and DAVID A. OPAR[3,4]

## ABSTRACT

SIM, A., R. G. TIMMINS, J. D. RUDDY, H. SHEN, K. LIAO, N. MANIAR, J. T. HICKEY, M. D. WILLIAMS, and D. A. OPAR. Hamstring Strain Injury Risk Factors in Australian Football Change over the Course of the Season. *Med. Sci. Sports Exerc.*, Vol. 56, No. 2, pp. 297–306, 2024. **Background/aim:** This study aimed to determine which factors were most predictive of hamstring strain injury (HSI) during different stages of the competition in professional Australian Football. **Methods:** Across two competitive seasons, eccentric knee flexor strength and biceps femoris long head architecture of 311 Australian Football players (455 player seasons) were assessed at the start and end of preseason and in the middle of the competitive season. Details of any prospective HSI were collated by medical staff of participating teams. Multiple logistic regression models were built to identify important risk factors for HSI at the different time points across the season. **Results:** There were 16, 33, and 21 new HSIs reported in preseason, early in-season, and late in-season, respectively, across two competitive seasons. Multivariate logistic regression and recursive feature selection revealed that risk factors were different for preseason, early in-season, and late in-season HSIs. A combination of previous HSI, age, height, and muscle thickness were most associated with preseason injuries (median area under the curve [AUC], 0.83). Pennation angle and fascicle length had the strongest association with early in-season injuries (median AUC, 0.86). None of the input variables were associated with late in-season injuries (median AUC, 0.46). The identification of early in-season HSI and late in-season HSI was not improved by the magnitude of change of data across preseason (median AUC, 0.67). **Conclusions:** Risk factors associated with prospective HSI were different across the season in Australian Rules Football, with nonmodifiable factors (previous HSI, age, and height) mostly associated with preseason injuries. Early in-season HSI were associated with modifiable factors, notably biceps femoris long head architectural measures. The prediction of in-season HSI was not improved by assessing the magnitude of change in data across preseason. **Key Words:** HAMSTRING, INJURY, AUSTRALIAN FOOTBALL SEASON

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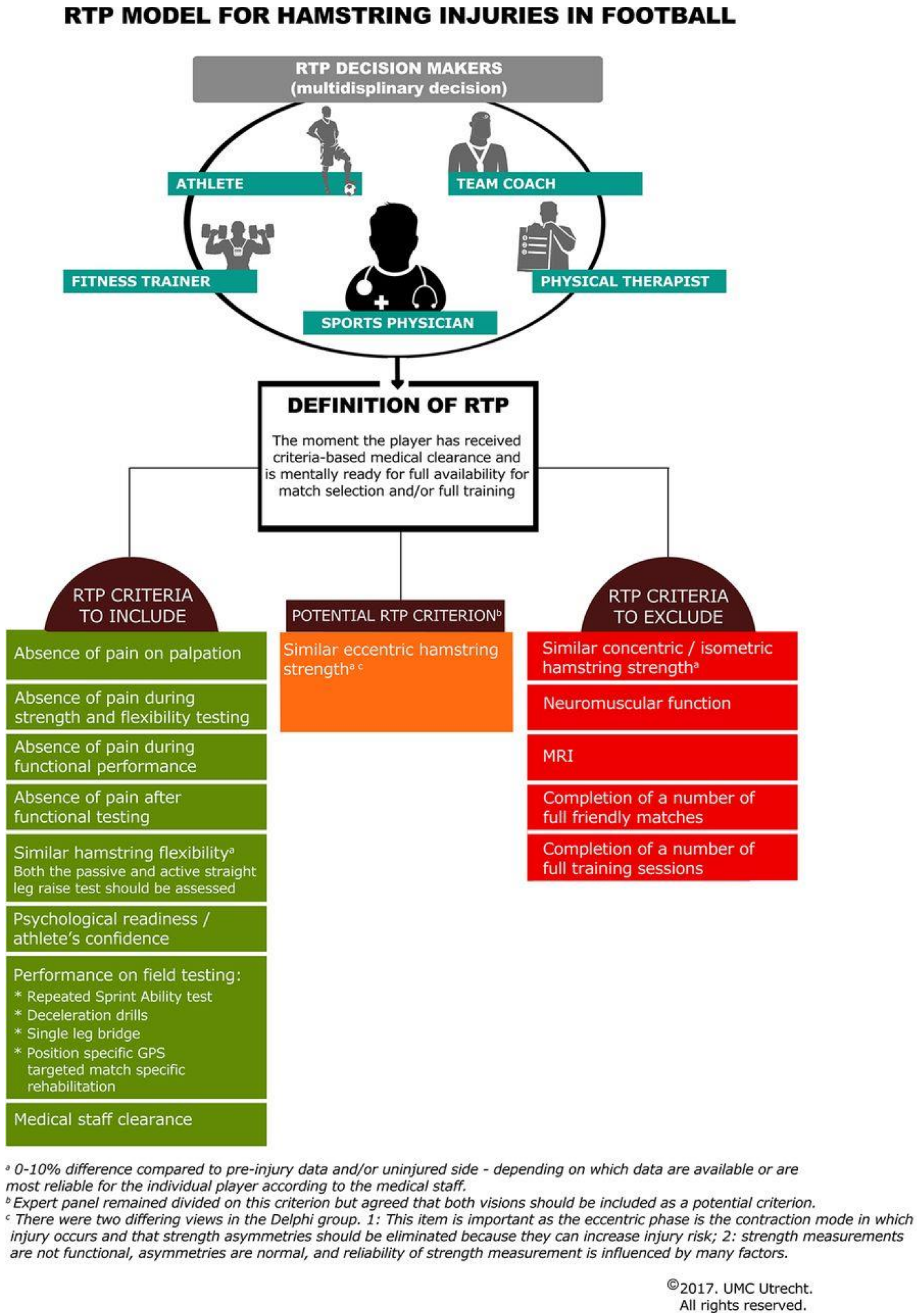
# Return-to-play (RTP) model for hamstring injuries in football. GPS, global positioning system.




Nick van der Horst Br J Sports Med doi:10.1136/bjsports-2017-098630

BJSM

STUDY PROTOCOL Open Access

# The development of a HAMstring InjuRy (HAMIR) index to mitigate injury risk through innovative imaging, biomechanics, and data analytics: protocol for an observational cohort study

Bryan C. Heiderscheit[1*], Silvia S. Blemker[2], David Opar[3], Mikel R. Stiffler-Joachim[1], Asheesh Bedi[4], Joseph Hart[5], Brett Mortensen[6], Stephanie A. Kliethermes[1,7] and The HAMIR Study Group

*BMC Sports Science, Medicine and Rehabilitation* 2023

**Abstract**

**Background:** The etiology of hamstring strain injury (HSI) in American football is multi-factorial and understanding these risk factors is paramount to developing predictive models and guiding prevention and rehabilitation strategies. Many player-games are lost due to the lack of a clear understanding of risk factors and the absence of effective methods to minimize re-injury. This paper describes the protocol that will be followed to develop the HAMstring InjuRy (HAMIR) index risk prediction models for HSI and re-injury based on morphological, architectural, biomechanical and clinical factors in National Collegiate Athletic Association Division I collegiate football players.

**Methods:** A 3-year, prospective study will be conducted involving collegiate football student-athletes at four institutions. Enrolled participants will complete preseason assessments of eccentric hamstring strength, on-field sprinting biomechanics and muscle–tendon volumes using magnetic-resonance imaging (MRI). Athletic trainers will monitor injuries and exposure for the duration of the study. Participants who sustain an HSI will undergo a clinical assessment at the time of injury along with MRI examinations. Following completion of structured rehabilitation and return to unrestricted sport participation, clinical assessments, MRI examinations and sprinting biomechanics will be repeated. Injury recurrence will be monitored through a 6-month follow-up period. HAMIR index prediction models for index HSI injury and re-injury will be constructed.

**Discussion:** The most appropriate strategies for reducing risk of HSI are likely multi-factorial and depend on risk factors unique to each athlete. This study will be the largest-of-its-kind (1200 player-years) to gather detailed information on index and recurrent HSI, and will be the first study to simultaneously investigate the effect of morphological, biomechanical and clinical variables on risk of HSI in collegiate football athletes. The quantitative HAMIR index will be formulated to identify an athlete's propensity for HSI, and more importantly, identify targets for injury mitigation, thereby reducing the global burden of HSI in high-level American football players.

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*BMC Sports Science, Medicine and Rehabilitation*
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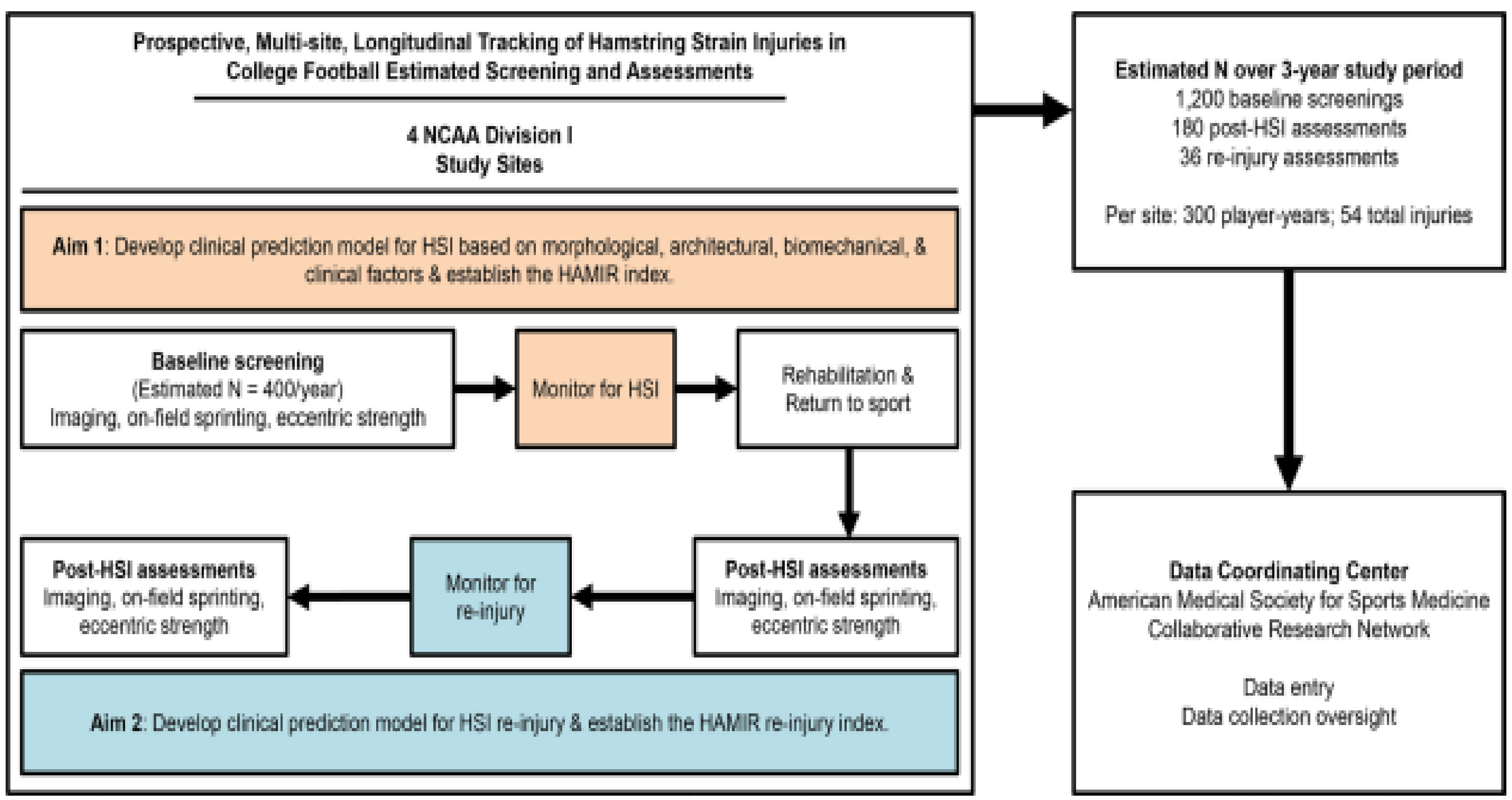


**Fig. 1** Overall design of the 3-year HAMIR study. NCAA, National Collegiate Athletic Association

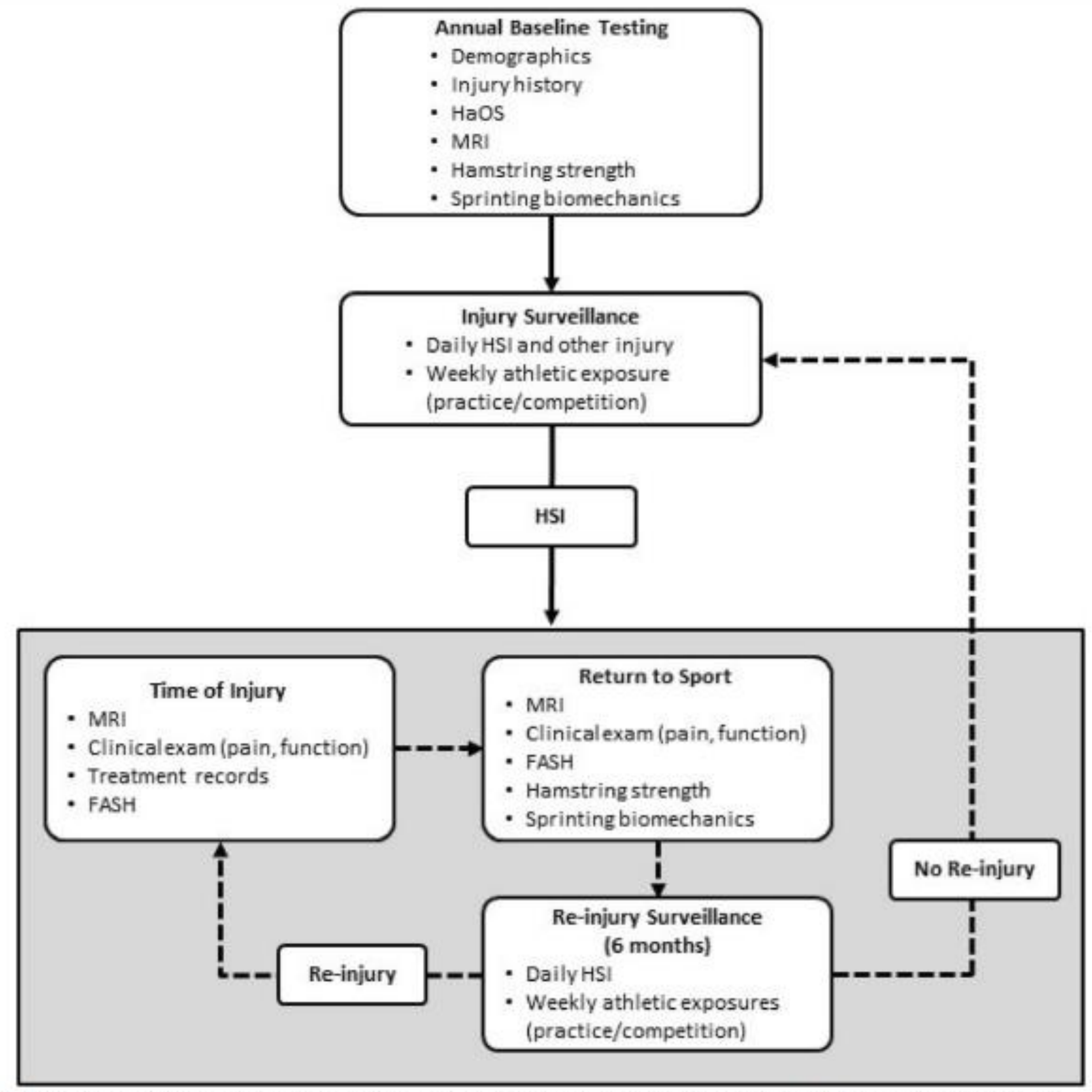


**Fig. 2** Annual injury tracking and data collection process. HaOS, Hamstring Outcome Score; FASH, Functional Assessment Scale for Acute Hamstring Injuries

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# Multimodal Approach to Mitigating Hamstring Injuries in Division I College Football Athletes: A Project Report

Jeffrey T Ruiz[1,2], Ignacio A. Gaunaurd[2], Thomas M. Best[3], David Feeley[1], Bryan Mann[1], and Luis A, Feigenbaum[1-2]*

[1] Department of Athletics, University of Miami, Coral Gables, FL 33146, USA
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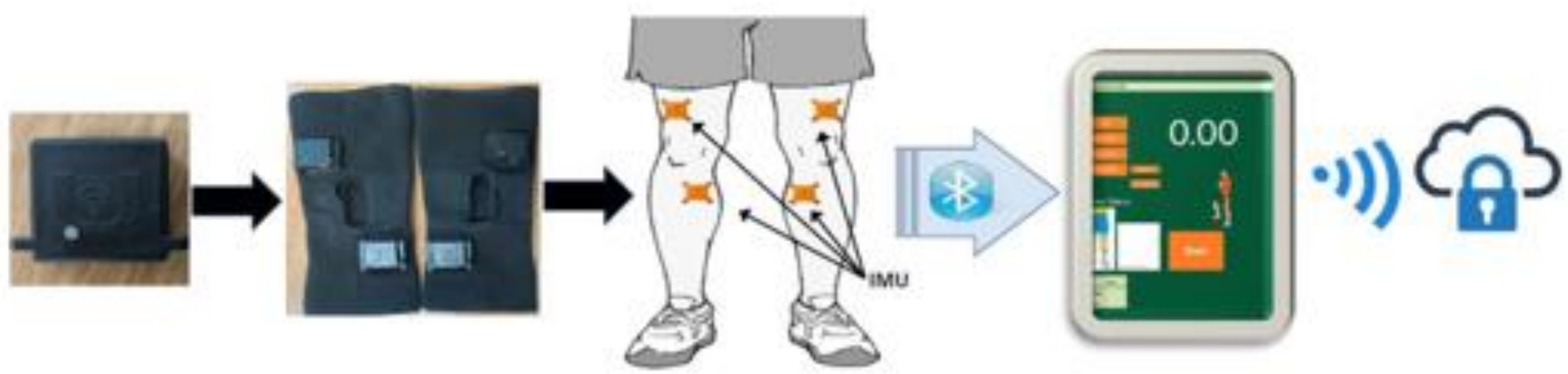
*MDPI* 2024

**Definition:** Hamstring injuries (HSI) are common in sports requiring high-speed change of direction, kicking, and sprinting. HSI are a significant reason for time-loss in training, practice, and competition and increased healthcare costs. The primary step in addressing HSI is to prevent the initial injury. A multi-factorial approach implemented with a collegiate Division I varsity football program that included serial administration of outcomes, data interpretation, and adopted a programmatically fluid strength and conditioning program, resulted in no game time-loss due to HSI over a three-year period.

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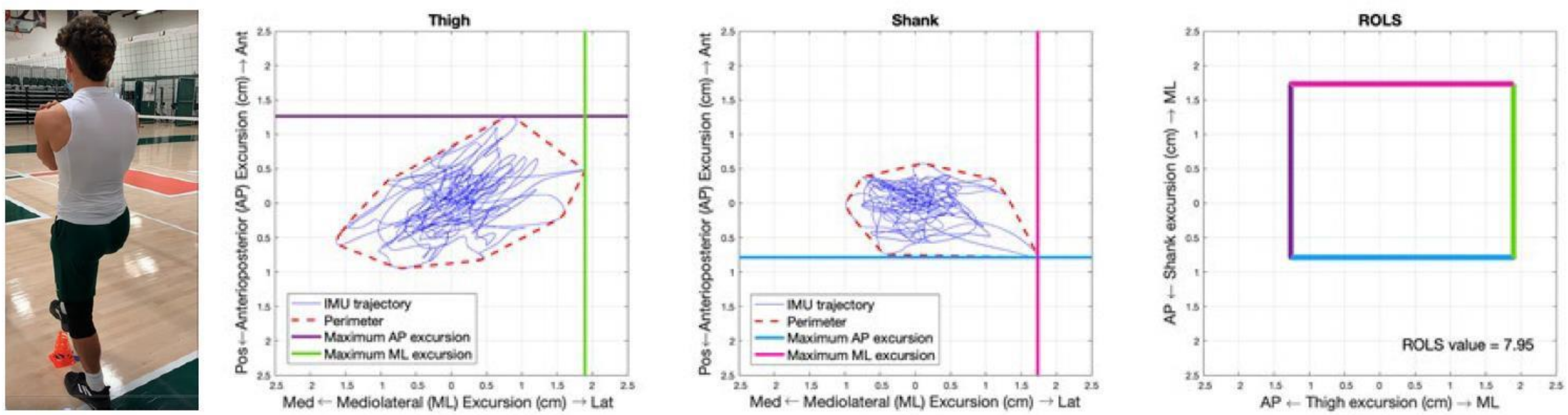
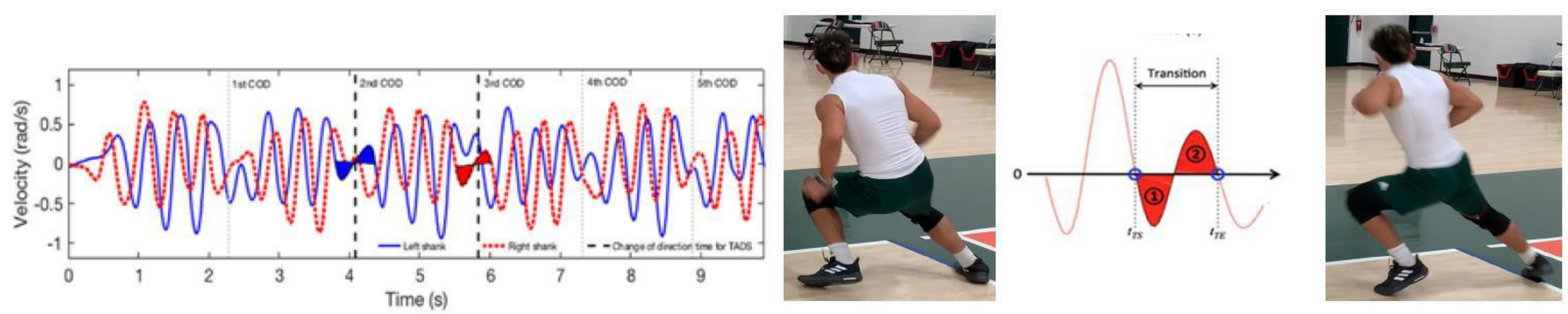
*MDPI* 2024




(a) (b) (c)




(a) (b)

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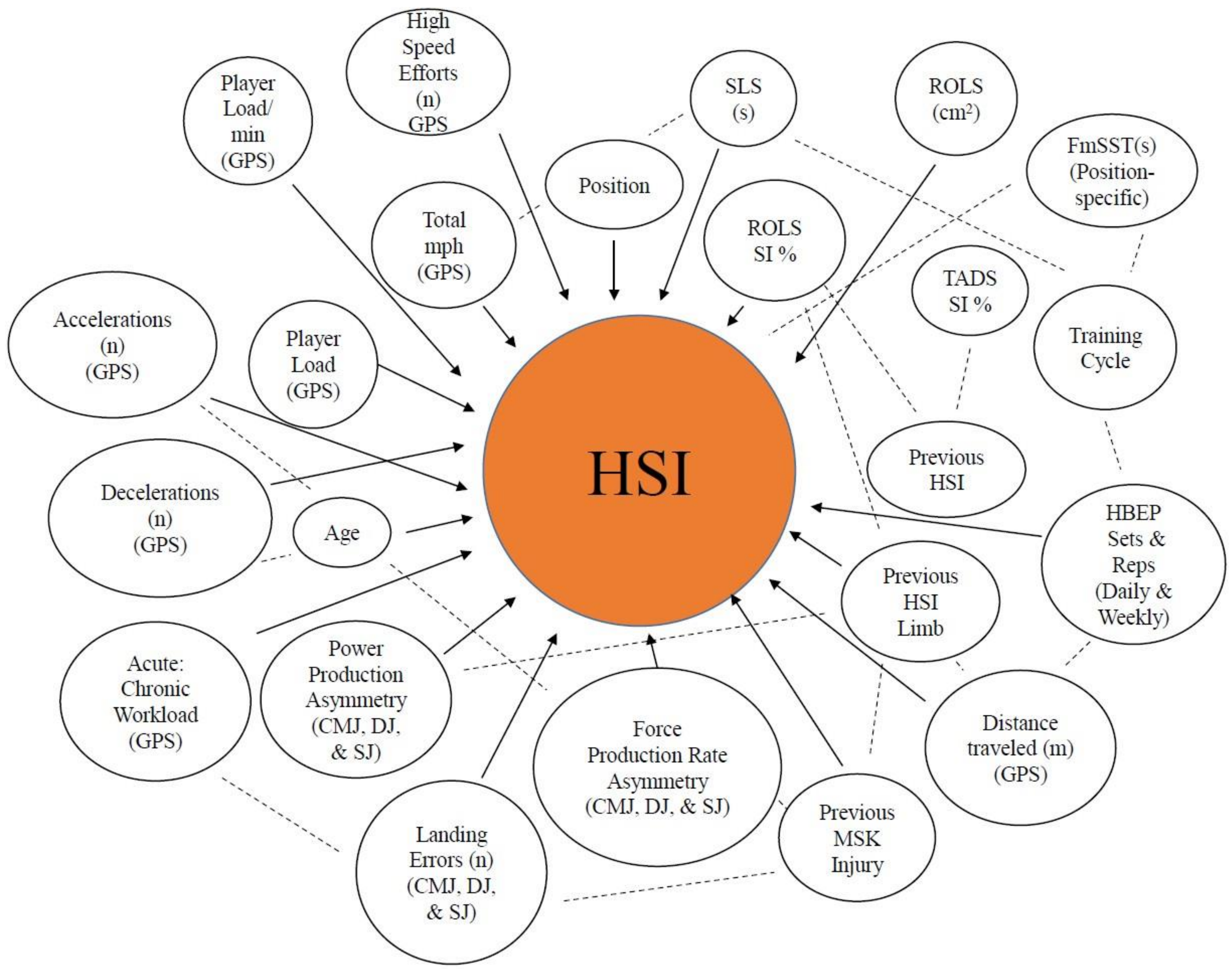


Our approach has yielded striking results. Prior to its implementation, in the previous two seasons, 10 football players had HSI which resulted in a total loss of time of 14 games. Following its implementation, there have been a combined 11 football players who have had HSI with 0-game time loss, resulting in a 100% decrease over two seasons.

# Summary

- Emerging evidence for progressive eccentric strengthening and Nordic hamstring training programs for faster RTP and decreased risk for re-injury
- Optimal role of PRP yet to be defined, hematoma aspiration appears beneficial
- Progressive agility and core stabilization offer benefit
- Imaging (MRI (DTI) and/or US) may have role in predicting time loss and RTP
- Earlier introduction of tissue loading during rehab appears safe and leads to quicker RTP with no increased risk of injury

# Thank-you !

“Three things cannot be long hidden, the sun, the moon and the truth” Buddha

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