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Review Article

# Interpreting Hamstring Injuries and Intervention Strategies in Elite Soccer

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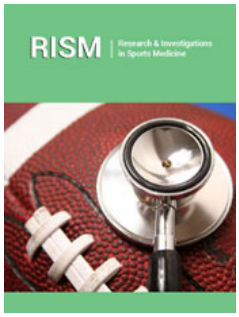


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## Introduction

With hamstring being the most injured site in soccer, practitioners are constantly investigating the latest methodology around protecting this muscle group [1,2]. With a holistic approach, it is important for practitioners to begin investigations by identifying the mechanisms of the Hamstring Muscle group. Specifically, what does the hamstring muscle group consist of and what are the actions of the posterior chain. The Hamstring Muscle complex can be broken down into 4 main groups; the Semitendinosus (ST), Semimembranosus (SM), Bicep Femoris Long Head (BFlh), and BICEP FEMORIS SHORT HEAD (BFsh) [3]. Specifically, the SM, BFlh, and ST all cross the hip and knee joints. The hamstring group (along with other muscles) play a role in knee flexion, hip extension, and internal and external rotation, when concentrically contracting.

When examining the injury occurrence in top-flight soccer, the Bicep femoris group (BF; BFlh and BFsh) account for 84% of total injuries, while the semimembranosus and semitendinosus account for 12% and 4%, respectively [4]. Furthermore, it must be noted that when examining these groups, architectural qualities such as cross-sectional area, volume, fascicle length, and pennation angle can be manipulated through exercise. Therefore, these architectural qualities vary between each individual/player.

Once understanding the basic mechanisms of the hamstring muscle group, the natural progression of investigation is the segmentation of running mechanics, specifically in elite soccer players. Given the chaotic nature of elite soccer, if imperative to understand the role hamstrings play with different movement patterns. More specifically, the demands of each muscle group during different phases of running.

### Acceleration

During the acceleration phase, the body is leaning forward and the player's centre of gravity (torso) is well ahead of their base of support (feet), creating a positive shin angle and strong triple extension when making ground contact. In soccer, players are often trying to accelerate with maximal force in order to beat their opponent to the ball or target zone. To put into perspective, at the elite level in Europe, players have been recorded accelerating 90.7 times per match, and upward of 115 times, at a threshold of>1.0m·s$^{-2}$ [5,6]. However, when we look specifically at higher thresholds (>3.0m·s$^{-2}$), players have shown to produce 26.5 - 34.9 acceleration exposures throughout a 90-minute match, dependant on position [7]. The majority, roughly 48%, of high acceleration outputs are when players are at a starting velocity of 0-1.0m·s$^{-1}$, and have resulted in around 70 seconds between bouts [6-8]. Therefore, we, as practitioners, must understand how the hamstring group contributes to such great outputs throughout the game.

Examining the acceleration phase of a maximum sprint, the activation demand for the ST is higher than the BF in the early-swing and first half of the mid-swing phase of the gait cycle

[9]. Specifically, the loading phase has shown to result in a 66% increase in activity in the medial hamstrings (SM,ST) as opposed to a 34% increase with the BF [10].

### Maximum speed

Compared to the acceleration position of the body, when players are reaching their top speed, their anterior tilt angle of the pelvis, and hip flexion angle are significantly smaller. The hip and knee flexion angles are also significantly different in the maximum speed position, due to the foot strike angle of the upwards posture [11]. Although elite-level players may only be exposed to their near-maximum (>90% of their individual speed) 1-3 times per 90-minute game [12], there is a large stretch in the muscle-tendon unit of the hamstrings [11,13]. Due to different angles at the hip and knee, a greater stretch is required for the BF compared to the ST and SM during the upright maximum speed phase [13]. Conversely, it is of note that the acceleration phase also demands a musculotendon strength of the hamstring group, suggesting that the SM and BF were stretched more in the late stance phase of an acceleration compared to the upright maximum speed positions [11].

Although there may be a greater stretch in the BF, compared to the ST and SM in the maximum speed phase, the activation of the ST is greater than the BF from the late-stance to the end of the mid-swing [9]. However, during the terminal swing phase, the BF activity still increases around 67%, compared to 37% in the MH group [10].

To summarise, both the acceleration and maximum speed outputs, demanding regularly in soccer games, require large stretch and activation of the hamstring group. Therefore, the evidence suggests that both forms of sprinting increase the elongation load of the hamstrings, thus, resulting in an increased risk of injury in games.

## Why do Hamstring Injuries still Occur Frequently in Elite Soccer?

Given that we know hamstring are the most common soft-tissue injury in elite soccer [14], researchers have recognised a 4% increase in hamstring injuries across 13 years of soccer in Europe [1]. Furthermore, across 18 years or European soccer, an overall rate of injury has decreased in training and matches [15]. However, muscle injury rates noted no change in this longitudinal study. Positively, it was noted that re-injury rates and number of player absences has decreased.

### The game

It has been well documented that the game has evolved (as has sport science) over the past few decades [16]. We used to see players go into games with no-warm up, no monitoring, and at times, very little training regimes.

Research indicates that over 7 seasons in the English Premier League (from 2006-2013), players have incrementally demonstrated greater physical outputs each year [17]. Although the total distance covered showed small increases, ~2% across 7 seasons, the high-intensity running distances increased 24-36% (depending on position). Furthermore, overall sprint distances increased by roughly 50% from the 2006 season until 2013. Therefore, we can suggest that the speed of the game is increasing. Thus, creating a greater physical demand (especially posteriorly) for players if they plan to compete at the elite level. Researchers have even suggested that "a typical 25-player squad can thus expect about seven hamstring strains each season. It can be speculated that the high risk of hamstring strain reflects the high intensity of modern professional football" [18].

### Types of injury

Hamstring injuries can be broken down into two types of incidence categories; stretching and sprinting (Table 1) [19,20]. Out of these sub-categories, we know that the "predominant hamstring injury mechanism in football occurs during high-speed running or acceleration efforts" [21].

**Table 1:** Two incident categories surrounding hamstring injuries in elite soccer.

| Stretching | Sprinting |
|---|---|
| • Reaching | • Accelerating |
| • Kicking | o Rolling Start |
| • Decelerating | o Deadstop |
| • Re-stabilising | • Max Sprint (and sub-max) |

## Interventions

Intervention strategies for minimising hamstring injuries in elite soccer are some of the most researched areas to date. However, putting research into practise seems to be the most discussed topic [22]. Therefore, the greatest question to be asked is, 'What can we, as practitioners, do to mitigate the risk of hamstring injury in soccer?'

Identifying the controllables within the elite soccer environment is the initial step to determine invention strategies (Table 2). IE. What are the modifiables and non-modifiables within hamstring injuries within your cohort (Table 3) [23,24].

**Table 2:** Players' attributes in determining interventions strategies.

| Modifiable | Non-Modifiable |
|---|---|
| • Knee Flexor Eccentric Strength | • Previous Hamstring Injury |
| • Bicep Femoris Fascicle Length | • Age |
| • Strength Imbalance | • Environmental Factors |
| • Weekly Speed Exposure | • Schedule Constraints |
| • Aerobic Fitness | o Time between games, etc |

**Table 3:** Modifiable attributes for minimising hamstring injury risk in Elite Soccer.

| Exercise Variables | Load Management |
|---|---|
| • Knee Flexor Eccentric Strength | • Weekly Speed Exposure |
| • Bicep Femoris Fascicle Length | • Aerobic Fitness |
| • Strength Imbalance | |

Timmins has illustrated over the past decade that the biggest hamstring injury risk factors for running-based athletes are short


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and weak fascicle lengths of the BF [24]. Furthermore, Timmins also investigated how quickly we can make positive adaptations in our players' hamstring architecture [25]. Exposing players to eccentric-biased (or only) activities is the quickest way to increase fascicle length as soon as 2 weeks.

### Exercise selection

**The Nordic:** One of the biggest hamstring injury studies has already shown us the power of the Nordic exercise, siting that hamstring injuries can be reduced by ~50% with the inclusion of this exercise in a regular regime [26]. Although the Nordic exercise has been identified as an incredibly effective antidote, it isn't the only route for desired muscular adaptations. In fact, there are still many practitioners not implementing Nordics into their program, due to "muscle soreness in players" [27].

Perhaps another reason for avoiding Nordics is the lack of consist prescription advice in the literature. For example, previous research has suggested 3 sets of 8-10 reps three times per week as a prescription [28]. From a practical perspective, this just isn't realistic. Some more up-to-date research has looked at the minimal-effective-dosage in prescribing Nordics for running-based athletes to ensure wanted adaptations are in place. On study suggests that 8 reps per week can maintain BF fascicle length, as long as the athlete has been exposed to an eccentric-biased overall prior [29]. Another study went as low as 4 reps of Nordics per week, but paired it with 6 reps of a modified stiff-leg deadlift [30].

**What else?** As forementioned, practitioners may seek some other exercises available that yield positive adaptations to reduce the risk of hamstring injuries. Focusing on the joints of interest, it is imperative that pracitioners include both Hip-dominant and knee-dominant exercises. The understanding of exercise selection based on hip and knee dominant exercises have been previously investigated.

Bourne and crew compared the Nordic exercise with a 45° hip extension exercise and how they both affect hamstring strength and architecture [31]. After 10 weeks of training, both groups significantly improved eccentric knee flexor strength, as well as BF fascicle length, compared to a control group. However, the Nordic hamstring group took a slight advantage in the BF fascicle length category compared to the hip extension group. Additionally, Nordics resulted in a greater BFlh volume, whereas the ST saw its greatest increase in volume in the hip extension group.

Alongside adding appropriate hip extension exercises one's regime, practitioners may have players who cannot complete a complete Nordic with integrity. Perhaps another reason why practitioners are also shying away from the exercise. Therefore, it is vital that practitioners develop an exercise progression for the knee-flexor group, with Nordics being the end goal.

## Exercise Continuums

Understandably, there are various ways to develop an exercise selection menu. Given the forementioned information (Figure 1-4), these basic templates are purely based on the evidence-based criteria mentioned above (Table 4 & 5).

**Figure 1:** Double leg glute bridge slide out.

**Figure 2:** Single Leg slide out on TRX.

**Figure 3:** BB RDL (Eccentric Only).

**Figure 4:** BB SL RDL (Eccentric Only).


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**Table 4:** Knee flexor exercise continuum.

| Knee Flexor Exercise Continuum | | | | | |
|---|---|---|---|---|---|
| **Exercise** | **Glute Bridge with Heel Walk Out** | **Glute Bridge with Double Leg Slide** | **Glute Bridge with Single Leg Slide (Sliders or TRX)** | **Banded Nordics (from Chest to Waist)** | **Nordics** |
| Sets/Reps | 2-3 x 6 | 2-3 x 4-6 | 2-3 x 3-4e | 2-3 x 3 | 2-3 x 3 |

**Table 5:** Hip extension exercise continuum.

| Hip Extension Exercise Continuum | | | | | |
|---|---|---|---|---|---|
| **Exercise** | **Bodyweight Goodmornings** | **Askling's Diver [32] (Changing the Tempo)** | **Glute Bridge with Double Leg Slide** | **BB RDL (Eccentric only)** | **BB SL RDL (Eccentric only)** |
| Sets / Reps | 2-3 x 5 | 2-3 x 6 | 2-3 x 4-5 | 2-3 x 3-4 | 2-3 x 3-4e |

## Conclusion

Practitioners working in elite soccer are constantly investigating ways to enhance current return-to-play protocols. As the most injured site in elite soccer, the hamstring muscle group seems to cause the most burden for soccer organizations. Therefore, having a thorough understanding of the mechanisms and role that hamstring play in elite soccer is imperative. Developing preventative strategies as well as an exercise continuum can help practitioners yield desired adaptations in order to increase overall robustness of the hamstring muscle group [32]. It is recommended that practitioners use a holistic approach, including regular knee-flexor eccentric exercises, hip-extension eccentric exercises, and sprint exposures regularly as part of their prescriptions. Having a continuum within one's performance department allows for more effective prescriptions, and potentially minimizing time lost due to hamstring injuries.

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