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INVITED COMMENTARY

Return-to-Play Criteria Following a Hamstring Injury in Professional Soccer: Time for a Tailor-Made Approach

Paolo Perna,[1,2] **Fearghal Kerin,**[3] **Ben MacDonald,**[2] **Aleksi Jokela,**[5] **Lasse Lempainen,**[4,5] **and Marco Beato**[1]

[1]School of Health and Sports Sciences, University of Suffolk, Ipswich, United Kingdom; [2]Chelsea Football Club, London, United Kingdom; [3]Kerin Performance, Dublin, Ireland; [4]FinnOrthopaedics, Hospital Pihlajalinna, Turku, Finland; [5]Paavo Nurmi Centre, Sports & Exercise Medicine Unit, University of Turku, Turku, Finland

Purpose: A hamstring injury rehabilitation and return-to-play (RTP) individualized approach based on the anatomical structure involved, the location of the injury, and the mechanism of injury is still missing in most studies. RTP criteria should be chosen following the same principles and the complexity of the injury and should receive more attention from the scientific community given that reinjury risk is one of the main challenges associated with hamstring rehabilitation. The available literature is mainly based on articles in which hamstring injuries are treated as a whole without making distinctions for their specific characteristics. ***Conclusions:*** There is a need to improve how we look at RTP criteria for hamstring injuries to improve decision making and help practitioners design the most suitable RTP protocols. We should consider the anatomical structure and the complexity of the injury to determine the importance of lay-off time and healing, understand the implication of the location of injury and the muscle involved on strength-test selection, and knowledge of the mechanism of injury and workload before the injury to assess the ability to activate the muscles in a sport- and mechanism-specific position and prepare the athlete with an appropriate exposure to high-speed running and technical skills.

Keywords: hamstring muscles, return to sport, rehabilitation, sports medicine

If you asked a practitioner how they rehabilitated a knee injury, you would probably expect the answer to relate to a specific structure. Similarly, for injuries involving the hamstring muscles, a one-size-fits-all approach to rehabilitation may be too broad by not integrating the specifics of each injury. Kerin et al[1] have stated that hamstring injuries are not all the same: Each hamstring injury involves a specific muscle, one or more tissues, and a distinct injury mechanism. Therefore, when we approach rehabilitation, we should consider how these factors collide to influence the risk of reinjury, representing one of the main challenges when rehabilitating hamstring muscle injuries.[2]

Consider the Anatomical Structure and the Injury Complexity

The British Athletics Muscle Injury Classification (BAMIC) has provided a framework for practitioners to understand the complexity and the challenges of each type of injury and how to progress rehabilitation safely.[3] For instance, some research suggests that hamstring injuries that involve the tendon require a longer lay-off time and a more gradual gym-based and on-field progression.[4] Other research does not suggest that the type of injury is an important factor to consider when predicting the length of the RTP process.[5] Despite the debate around the negative implications of a tendon injury on RTP,[6] there is evidence that the extent (ie, complexity and severity) of the injury increases the time needed to complete rehabilitation in professional football,[7] so it is logical that a more serious injury will require longer for the tissues to heal appropriately. However, this, an adequate healing time, is often not respected, and athletes return to play as soon as they can clinically and functionally do so,[8] which can increase the likelihood of reinjuries. Macdonald et al[3] highlighted a directly proportional relationship between the complexity and severity of the injury (and, therefore, the length of the rehabilitation process) and the number and depth of the tests needed to clear athletes to RTP. Their approach, based on magnetic resonance imaging grading using the BAMIC classification, emphasizes that the initial grading of the injury determines the primary pathway for RTP decisions. Specifically, they suggested using mainly clinical criteria when deciding about RTP following a myofascial injury (grade "a" on the BAMIC classification), clinical and strength criteria when deciding about a myotendinous injury (grade "b" on the BAMIC classification), and a combination of clinical, strength, magnetic resonance imaging, and biomechanical tests for an intratendinous injury (grade "c" on the BAMIC classification) based on the idea that an increased injury severity leads to a longer time to RTP[7] and, therefore, a more complex rehabilitation process.[3] The increase in complexity and severity of an injury requires a more thorough and structured approach to RTP criteria selection to mitigate the risk of reinjury. High-quality and objective information is needed for medical and performance practitioners to make informed decisions regarding rehabilitation progression and, finally, the return to team training and match performance.[9] Despite the difficulty and complexity of the RTP decisions, there is a paucity of high-quality research to support the criteria currently used in the applied setting, with the majority of the available literature based on opinion papers.[10]

Target the Injured Tissue

Knowing which tissue is injured and the extent of the injury are important factors to consider. Schache et al[11] described the mechanics of the hamstring during sprinting, which helps to guide

Kerin https://orcid.org/0000-0002-7300-4120
MacDonald https://orcid.org/0000-0002-7205-3721
Jokela https://orcid.org/0000-0002-4071-1152
Lempainen https://orcid.org/0000-0002-9877-1342
Beato https://orcid.org/0000-0001-5373-2211
Perna (p.perna@uos.ac.uk) is corresponding author, https://orcid.org/0009-0002-0528-3145

training interventions based around force, length (strain), and velocity of contraction capabilities. The muscle involved may, then, dictate which of these stimuli is prioritized; however, we also have to take into consideration which area of the muscle has been affected.[12] In recent years, many studies have analyzed the ability of specific hamstring exercises to target a particular muscle and area of the muscles.[13–17] This information is key for the rehabilitation exercise selection, and at the same time, it could play a key role in the selection of RTP strength criteria. The hamstring exercises are usually divided into 2 types: hip dominant, when they utilize the hip extension function of the hamstring muscles, and knee dominant when they use the knee flexion function of the hamstring muscles. Previous research has highlighted how hip-dominant exercises have a greater effect on the biceps femoris muscle, whereas knee-dominant exercises have a greater effect on the medial semimembranosus and semitendinosus muscles and the short head of the biceps femoris, although the Nordic exercise, despite the relatively selective activation, still strongly activates the biceps femoris during this exercise.[15,16] Other studies have suggested the hypothesis that region-specific activation of the hamstring muscles is possible.[14,16] Previous magnetic resonance imaging-based studies have divided the hamstring muscles into 3 areas—proximal, middle, and distal—and described changes in distinct areas of the muscles following one training session[14] or a 10-week training program.[16] However, not all the activation studies have found intermuscular and proximal–distal activity patterns activation changes.[13,17] Therefore, targeting the injured muscle may be a realistic goal, but it is not yet fully demonstrated that this can be achieved accurately with a proximal-to-distal focus. Furthermore, Lazarczuk et al[16] found that both the hip-dominant and knee-dominant eccentric exercises significantly affected muscle size but not the tendon or aponeurosis size.

Do Not Forget the Injury Mechanism

Hamstring injury mechanisms are complex and can happen in a variety of positions and movements. Windt and Gabbett[18] described that the etiology of injury is a complex process wherein a series of internal and external factors contribute to sustaining an injury wherein the mechanism represents the inciting event. Video analysis has helped in understanding and recording hamstring injury mechanisms and moving forward from the concept of 2 main mechanisms: sprinting and stretching.[19–21] Sprinting is a common mechanism of injury and has important rehabilitation and RTP implications. During sprinting, the biarticular hamstring muscles have a much greater peak strain, peak force, and energy absorption during the terminal swing phase.[11] In particular, the biceps femoris long head, which is the most commonly injured hamstring muscle in football, sustains the highest peak strain, which could explain, from a biomechanical perspective, why this muscle is more vulnerable than the others.[11] Furthermore, the combination of muscle activation, strain, and speed of contraction during sprinting is superior to any gym-based exercise.[13] Therefore, relying only on gym-based exercises is not an adequate choice to prepare the hamstring muscles to cope with the most intense actions of the game (eg, sprinting). Sprinting becomes a potential cause of injury[22] and a possible solution to adequately prepare athletes during on-field rehabilitation and reduce the risk of reinjuries.[23] The completion of a progressive on-field rehabilitation, which takes into account the requests of the game, is one of the performance criteria to meet before RTP.[10,24] Specifically, for hamstring injuries with a sprinting mechanism during this phase, it is crucial to expose players to high-speed running distance and achieve nearly maximal speed in a more controlled environment before returning to unrestricted team training and participating in official competitions.[25,26] Soccer is a multidirectional sport with a combination of high physical demands and technical skills. During hamstring rehabilitation, practitioners should focus on preparing athletes to return safely and progressively to sport-specific movements and skills (ie, kicking, intercepting balls, controlling highballs), running-based actions (ie, sprinting and decelerating), and physical demands (ie, training and match loads). As said earlier, practitioners should be aware that injury mechanisms and understanding the training/match load prior to the injury can inform the rehabilitation process to individualize the RTP strategies and criteria selection. Due to the variety and complexity of the mechanisms of injury, the decision on the criteria to clear athletes to RTP should reproduce the injury movement and assess the ability of the muscle to be flexible and produce strength in a critical position. Similar to the injury-specific selection of the exercises during RTP, the criteria could be selected based on the test's information capacity and technical characteristics. For instance, flexibility tests like the Askling-*H* test can help assess the ability of the hamstring muscle to lengthen equally.[27] This test can reproduce an open kinetic chain stretching injury mechanism with a combination of hip flexion and knee extension. Isometric exercises and tests can load the muscles at different angles and positions. For example, they can assess muscle strength in a lengthened position similar to the injury and test muscle ability to produce forces under higher strain[11] and in a specific position, depending on the desired muscle activation.[28] Kerin et al[21] described an injury pattern with an ipsilateral trunk rotation component. Practitioners could modify the trunk position during common linear exercises and tests to assess the ability of the athletes to produce equal forces in a vulnerable and injury-specific position. However, isometric tests present some limitations, and one of the main ones is that they do not replicate the type of contraction (eccentric) we see in the sprinting mechanism[11,28] and during a deceleration phase (closed chain), which is also associated with hamstring injuries.[20] Therefore, a test that assesses the eccentric hamstring strength during a dynamic reaching movement rather than in a static position could be particularly useful. This can be achieved using an isokinetic dynamometer, which can assess the eccentric peak torque at different speeds (eg, $60°·s^{-1}$, $180°·s^{-1}$) and the torque–angle curve (using a statistical parametric mapping),[29] and the Nordic hamstring test.[30] Another way to assess hamstring strength is by flywheel resistance tests. Flywheel resistance technology has become much more popular thanks to its versatility for testing and training purposes. This technology can be used to assess sport-specific exercises (eg, hip- and knee-dominant movements), closed and open kinetic chain movements, contractions (concentric and eccentric), and submaximal and maximal intensities (eg, eccentric: concentric ratio greater than one, which defines the achievement of an eccentric overload).[31]

Practical Applications

Practitioners involved in hamstring injury rehabilitation have to face several challenges during the process. The risk of reinjury increases the need to objectively define when an athlete can return to play and support the decision-making process. We suggest considering the anatomical structure, the injury location, and the mechanism of injury when selecting the most appropriate RTP criteria (Figure 1).

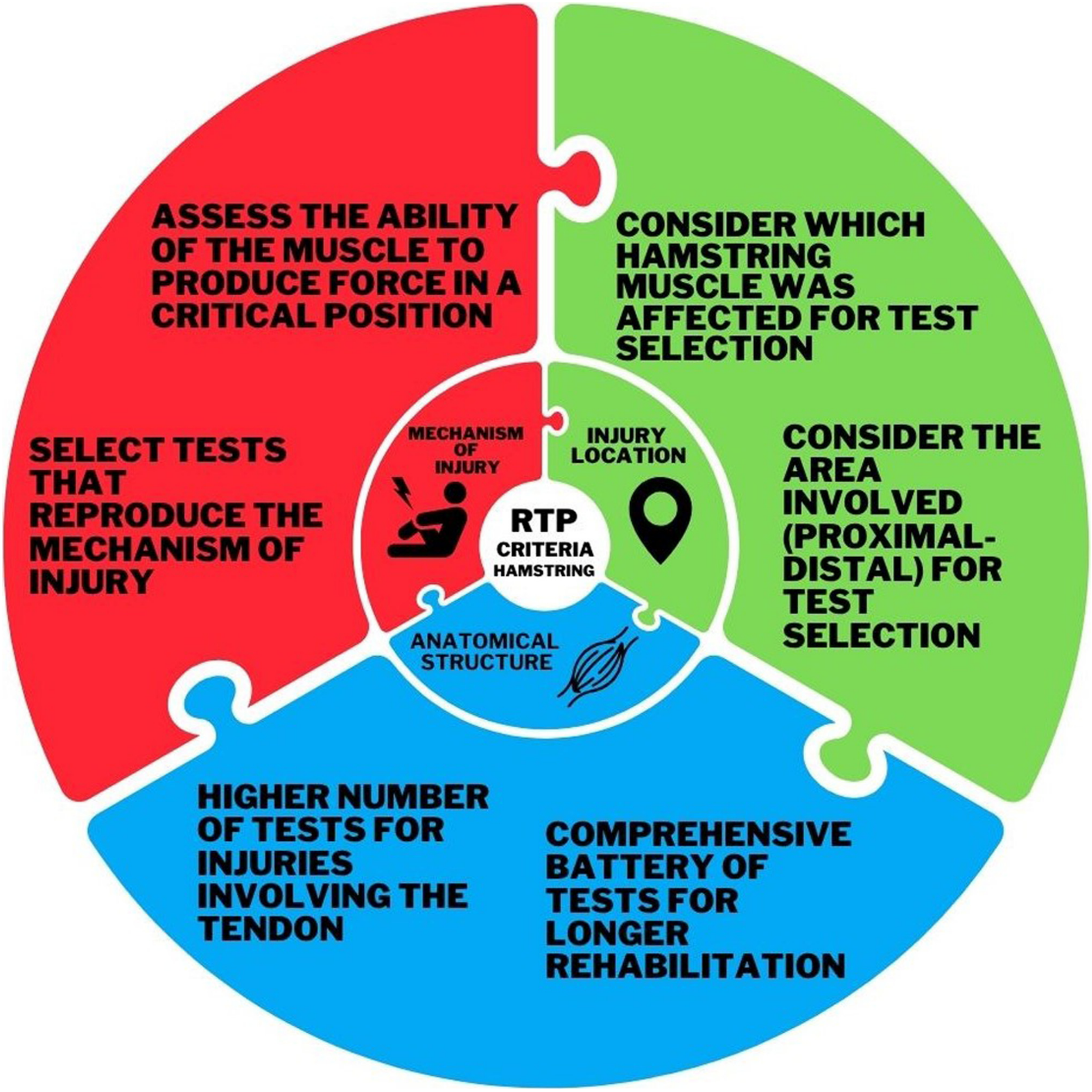

Figure 1 — Summary of the factors to consider when selecting return-to-play (RTP) criteria following a hamstring injury.

Considering the anatomical structure and the complexity of the injury when designing the RTP criteria is crucial to determine the importance of lay-off time and healing. The complexity will guide the selection of the number and depth of the information to collect. Not all hamstring injuries are the same, and an accurate diagnosis of the injury location is paramount to managing the injury appropriately.

Based on the location and the muscle involved, it is possible to select strength tests that primarily activate the affected area and give more information on the ability of that particular muscle to function following an injury. Other less specific tests might provide general information on the ability of the hamstring to produce forces. Still, they might lead to a false sense of achievement, which is, in reality, the result of different muscle activation or a compensatory mechanism.

Knowledge of the mechanism of injury and the on-field workload prior to the injury will help in retraining and assessing the ability to activate the muscles in a sport- and mechanism-specific position and prepare the athlete with an appropriate exposure to high-speed running and technical skills.

Conclusions

Despite the great attention and focus on hamstring injury rehabilitation and return to play (RTP) in recent years, an individualized approach to rehabilitation and RTP-criteria decisions based on the tissues affected, the extent of the injury, the muscle characteristics, the location of the injury, and the mechanism of injury is still missing in most studies; therefore, further attention should be given to these aspects (eg, in the methods and description of RTP protocols). The available literature is mainly based on opinion articles in which hamstring injuries are treated as a whole without making distinctions for their characteristics (as explained earlier). There is a need to improve the way we look at RTP criteria for hamstring injuries to improve decision making and help practitioners design the most suitable RTP protocols.

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