Return to Sport After Hamstring Injuries

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11.1 Introduction

Returning athletes to training and competition after hamstring injury can be complex. This is evidenced by substantial and unchanged re-injury rates associated with hamstring injury in sport over the last 30 years [1]. Most athletes return to sport (RTS) 3 weeks after a hamstring injury [2, 3]. However, about one in three athletes may re-injure in the first few weeks after returning to sport [2–5]. There is also risk to the athlete of sustaining a subsequent injury to another area of the body [6, 7]. Discussions and different opinions regarding accelerating RTS following hamstring injury have been ongoing for many years [8, 9]. Much of this debate focuses on the potential advantage of increasing the number of available players, which may increase the chance of team success. This point is balanced against the increased risk of re-injury and reduced performance of individual athletes associated with a lack of full hamstring and sprinting function. While athletes in some team sports may be able to perform and be selected to compete despite reduced hamstring function, individual athletes such as sprinters will be more directly affected. Their inability to produce maximal acceleration and velocity and thus achieve optimal running speed and performance makes an early return to competition irrelevant from a performance perspective. Recommendations and reasoning concerning RTS decisions are therefore always specific to the individual sports context and risk-taking assessment.

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This chapter aims to introduce a criteria-based approach designed to monitor athlete progress, which stakeholders can collectively consider when navigating athletes through the rehabilitation and RTS phases.

11.2 Return to Sport Principles After Hamstring Injury

An evidence-based consensus on how to best return athletes to sport after hamstring injury is currently not available to practitioners. A clear RTS definition is also absent in the literature. Attempts have been made to develop consensus statements around the RTS definition, criteria and decision-making in sport generally [10] and football specifically [11, 12]. However, differences remain between these expert-based opinion pieces, evidenced by reports of different RTS criteria within the same sport [11, 12]. A group of 58 international medical experts omitted hamstring strength and training load from their RTS criteria [11], whereas a different study that involved medical practitioners from professional football clubs demonstrated a complete agreement to include hamstring strength and training load parameters in the RTS criteria-based decision-making process [12]. A recent international Sports Physical Therapy consensus statement recommended that RTS processes are aligned with the athlete's sport and their level of participation for the planned sporting return [10]. That statement outlined three steps as part of a RTS continuum: return to participation (modified training), sport (full training) and performance (back to the same level of competition standards), which highlights a gradual progression in function while simultaneously underlining that workload (sport-specific preparation) is an important element in the criteria-based RTS process. To seamlessly map and implement ongoing strategies designed to reduce recurring and subsequent injury, we recommend that tertiary prevention is added as the 'plus one' to the three step RTS continuum outlined by Ardern et al. [10]. The 'three plus one' RTS phases following hamstring injury is outlined in Fig. 11.1. Additionally, Fig. 11.1 illustrates where each criterion is applicable in the RTS continuum according to current evidence.

This chapter also considers the steps in the Strategic Assessment of Risk and Risk Tolerance (StARRT) decision-making model [13] and current available and emerging evidence relevant to returning athletes to sport after a hamstring injury, understanding that the RTS decision is multifactorial and unique to each case and that the StARRT model might be applied at different points during the continuum.

Throughout the rehabilitation and RTS process, athlete progress can be evaluated using clinical and functional tests. Such tests can be considered not only for RTS criteria but also for tertiary prevention. This approach involves performing a range of intrinsic objective and subjective tests on the athlete in the clinical setting, evaluated by medical staff. Functional testing reflects the physical demands of the sport, athlete position and level of competition. Sport-specific readiness involves monitoring and managing workload criteria to provide data on the extent to which the athlete has trained and how well they have performed during their hamstring injury rehabilitation. Sport-specific readiness is considered a critical component in the RTS

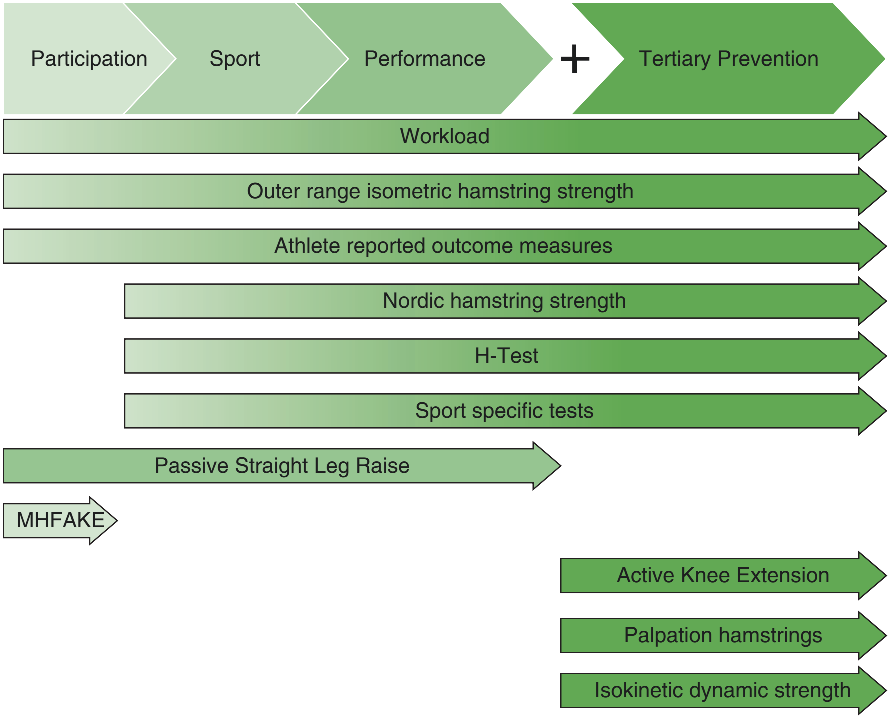

Fig. 11.1 The return to sport continuum [10] complemented by tertiary prevention in a 'three plus one' model that outlines where test criteria can be considered for application on the continuum according to current evidence. *MHFAKE* Maximal Hip Flexion and Active Knee Extension

decision-making process due to its association with increased or decreased risk of injury in sports where hamstring injury is prevalent [14–20]. Such a RTS systems approach, through four domains, presents a progressive scale of standards reflective of a graduated rehabilitation and prevention process. Data collected in each domain can be interpreted in context and assist in providing information to the stakeholders when making a shared RTS decision. The approach aims to facilitate a RTS process that evaluates athlete performance across multiple domains and criteria when transitioning towards a successful return to performance. It reinforces that the RTS process is not an isolated procedure that follows completion of the rehabilitation, but is instead a process that starts concurrently with the initiation of hamstring injury rehabilitation.

11.3 Return to Sport Decision

Elite athletes undertake a host of clinical tests during the year, e.g. baseline screening, in-season monitoring, injury diagnosis and evaluation of rehabilitation progress. Tests might be applied throughout the year to monitor athlete health states or injury susceptibility, whereas some tests are utilised at defined periods during the

RTS continuum. Such an approach reflects the steps in StARRT: assessment of health, activity risk and overall context-specific risk tolerance. Specific information on relevant impairment and performance-based tests and their execution can be found in Chap. 9.

In the absence of a consensus on the best RTS criteria-based process, an overall decision-based model has been introduced to assist practitioners [21]. It provides a three-step process to consider when returning an athlete to sport after injury. The initial step involves examining medical factors to ascertain the current health status of the athlete. The second step reviews sporting risk specifically in relation to modifiable variables such as type of sport, playing position or level of competition. Finally, externally influencing factors such as time of season and pressure from athlete or third parties are considered in the process. A strategic assessment of risk and risk tolerance framework (StARRT) in relation to RTS decision-making has been proposed by Shrier [13]. This framework includes tissue health and stress level assessments of health and activity risks in relation to contextual risk tolerance [13] that may be valuable for RTS decision after hamstring injury (Fig. 11.2).

11.3.1 Multidisciplinary Review of Standards

It is clear that most athletes RTS with hamstring impairments, which may increase the risk of re-injury. A multidisciplinary and shared decision-making process is therefore recommended [10] when evaluating an athlete's capacity and the risk involved in returning to sport. Practitioners are advised to communicate a proposed set of standards for key stakeholders' consideration, including seeking a consensus on the decision-making process and level of risk tolerance at the outset, to optimise rehabilitation and RTS outcomes. It reflects that, in elite and professional sport, shared-decision-making is ideally collaborative and collective; no single entity holds a veto on RTS criteria post hamstring injury. Once a multidisciplinary, shared criteria-based RTS decision has been made, the athlete should remain in tertiary prevention irrespective of whether they have returned to training, competition or top performance. Based on available data, this should be in place for at least 3 years post-injury. Planning (including roles and responsibilities) and producing the tertiary prevention programme should be part of finalising RTS processes. This is warranted due to the high rates of recurrence and subsequent injury and will involve an array of interventions including exercise programmes, load and athlete monitoring. It is acknowledged that contextual circumstances such as timing of season, athlete age, importance of event, chance of winning versus risk of losing and other 'risk tolerance modifiers' might influence how the four domains are utilised in individual cases within the continuum. A truly shared decision-making model collects broad perspectives that include nonphysical measures to gain understanding of the athlete's psychological and physical readiness to RTS.

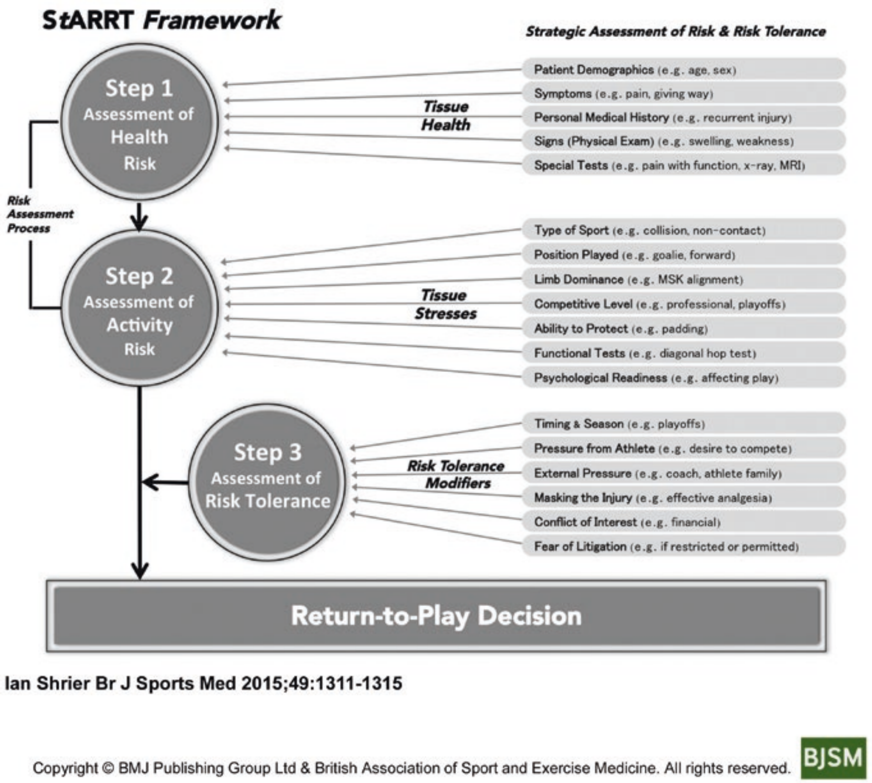

Fig. 11.2 The Strategic Assessment of Risk and Risk Tolerance (StARRT) framework for return-to-play (RTP) decisions. This framework illustrates that patients should be allowed to RTP when the risk assessment (steps 1 and 2) is below the acceptable risk tolerance threshold (step 3), and not allowed to RTP if the risk assessment is above the risk tolerance threshold. The StARRT framework groups factors according to their causal relationships with the two components of risk assessment (Tissue Health, stresses applied to tissue) and risk tolerance, as opposed to the three-step framework that groups factors according to the sociological source of the information. In some cases, apparently a single factor can have more than one causal connection and would be repeated. For example, play-offs will increase the competitive level of play and therefore increase Tissue Stresses and increase risk. However, it is also expected to affect a patient's desire to compete (i.e. mood, risk of depression) and could affect financial benefit as well. These causal effects would lead to increased risk tolerance. In this framework, each outcome is evaluated for RTP, and the overall decision is based on the most restricted activity across all outcomes (see text for details)

11.4 Psychological Factors in Return to Sport

At the time of RTS, athletes may develop negative psychological responses including anxiety, low self-esteem and fear [22]. These emotions can impact both on the time taken to, and level of, RTS athletes achieve post-injury [22]. The psychological responses might be heightened in athletes returning from severe injuries such as recurring, injury sequela and hamstring tendon pain. Athlete anxiety is also a potential predictor for recurring and subsequent injury at the time of RTS [23, 24]. A premature RTS can lead to fear, anxiety, recurring and subsequent injury, depression and poorer performance [25]. Psychological readiness to RTS is multifaceted, complex and reliant on several factors [26]. Validated outcome measures to monitor 'psychological readiness' exist, and the information might be considered in a shared multidisciplinary decision process to evaluate this parameter [22, 26] during the RTS continuum.

11.5 Sport-Specific Readiness

During the RTS process, athlete sport-specific readiness is ascertained to establish if sufficient training, workload and performance have occurred to successfully RTS at the desired level of the continuum. This process involves a gradual increase in training and workload that is monitored and managed towards performance criteria. Most sports, particularly at the elite level, require complex coordinated movements to sprint, kick or change direction at high speed. The restoration of normal sport-specific kinematics at speed should therefore be considered within progressive rehabilitation and assessed prior to RTS, as this may influence hamstring re-injury risk and optimise sporting performance [27–29].

11.5.1 Workload

Monitoring and management of workload has become routine in elite and professional sport. A recent consensus statement suggests that load monitoring is an essential assessment tool for determining the effectiveness of training adaptations, athlete response to training, fatigue and recovery and minimising risk of injury and illness [30]. Load is generally classified as internal or external. Internal loads refer to physiological and psychological athlete responses to external loads. The actual workload performed by the athlete in training and competition is reported as external load. Monitoring both categories of load has been recommended where possible, since they can produce diverse risk profiles [6, 15]. Load monitoring and associated athlete management is an ongoing process including periods of rehabilitation; return to participation, sport, performance; and tertiary prevention phases. Monitoring of running load is of particular interest since this is the main hamstring injury mechanism [6, 20, 31]. Commencing running during rehabilitation within 4 days of lower limb muscle injury (41% hamstring) resulted in significantly increased risks of recurring and subsequent injuries compared to when running started 5–9 days post-injury [6]. Importantly, delaying running to at least 5 days post-injury did not delay RTS [6]. Workload appears to have a greater influence on the risk of recurring and subsequent injuries than the results of clinical tests such as active knee extension and outer range isometric hamstring strength [6, 32]. Additionally, the number of training sessions completed from the time of medical clearance after injury to match play have been shown to influence muscle re-injury rates [33]. Completion of fewer than four training sessions was associated with a reinjury rate that was three-fold higher than the average muscle injury rate in professional football [33]. This risk was reduced by 13% for each additional training session completed before the first match after injury [33], and this highlights the importance of sport specific preparation and readiness as part of the RTS and tertiary prevention processes after hamstring injury.

11.5.1.1 External Load Monitoring

Monitoring workload with individual global positioning system (GPS) units produces data that might be of interest in returning athletes to sport after hamstring injury. Variables of particular interest include acceleration, deceleration and the type, speeds, volume and distances of running. It has been established that higher sampling rates of GPS units are associated with improved validity and reliability [30]. The precision of GPS running speed data is decreased in the presence of large speed variability [30]. A recent consensus statement on monitoring athlete workload with GPS recommends caution when interpreting acceleration, deceleration, change of direction and within-subject test-retest data [30]. In game scenarios, where precise athlete test-retest results from explosive actions and high-speed running are required to establish sport-specific readiness, GPS data might best be presented with indications of the minimal detectable change with 95% confidence intervals (MDC 95%CI).

11.5.1.2 Internal Load Monitoring

External load monitoring and exposure to high-speed running in particular appear to be important in the management of rehabilitation, RTS and risk with respect to hamstring injury. Internal load monitoring is also commonplace and typically includes rate of perceived exertion (RPE) [30]. RPE provides a subjective report on the athlete's physiological and psychological response to loading. The relationship between recent and historical internal load data appears to be associated with fatigue, injury and re-injury. It may therefore be useful to monitor internal workload to monitor sport-specific readiness. However, internal load monitoring provides no correlate of high-speed running exposure.

Acute-to-Chronic Workload Ratio

The acute-to-chronic workload ratio (ACWR) is an index of an athlete's workload in the most recent 1-week period (acute load) usually compared to their cumulative average workload over the last 3 or 4 weeks (chronic load) [18, 34]. The index is based on internal and/or external load data [15, 18, 35] to provide information on sport-specific readiness [36]. Inclusion of ACWR as a RTS criteria has been recommended [37] since rapid increases in acute workloads are associated with increased injury risk in a host of sports [15, 17, 18, 38] as are low chronic workloads. A high chronic load combined with a balanced acute load appears protective against injury [18]. This is an important recognition that should be reflected in rehabilitation plans by commencing modified training (return to participation) early while still considering the pathobiology of a muscle injury, to retain or regain sufficient chronic sport-specific loading. An early return to participation should be balanced against the possibility of increased recurrence and subsequent injury rates if running is commenced prematurely out of sync with muscle pathobiology [6]. Risk management of re-injury associated with ACWR as an injury risk factor is reflected in the sport-specific and decision modifiers of the StARRT framework. The actual ACWR index linked to injury or re-injury differs between sports, cohorts and individual athletes [15, 18, 34]. A universal ACWR 'sweet spot' does not appear applicable and the ACWR RTS criteria should reflect context-specific data. Additionally, recent discussions about how best to calculate ACWR data are ongoing and involve using rolling averages and exponentially weighted moving averages [36, 39]. Recent data show that large spikes in ACWR in either model are associated with significantly increased injury risk [36].

11.6 Ongoing Monitoring and Prevention

Passing and progressing through agreed RTS standards including all or some of the clinical, functional, sport-specific readiness and RTS criteria does not mean that an athlete has arrived at a designated end point of injury management. Once an athlete has sustained a hamstring injury, they host a potent non-modifiable injury risk factor: previous injury. A symptom or consequence of previous hamstring injury is impaired function demonstrated by deficits in: running performance [28], isometric and eccentric strength [27, 40], high-repetition concentric hamstring strength and reduced resilience to withstand fatiguing sporting demands [41] and difficulty improving Nordic exercise strength [42] for up to 3 years after the injury. Subsequently, the risk of recurring or subsequent injury is elevated [7, 43, 44]. Management should commence early, within 7 days, upon RTS [32]. This represents the stage of tertiary prevention. Tertiary prevention describes 'clinical activities' aimed at preventing deterioration or reducing complications of a diagnosed condition [45]. Components of tertiary prevention in relation to hamstring injury in sport include regular exposure to eccentric hamstring stimuli, high-speed running and sprinting, load monitoring and management and in-season athlete monitoring of hamstring function.

11.6.1 In-Season Athlete Monitoring of Hamstring Function

Ongoing athlete monitoring post-RTS is indicated. Hamstring function is influenced by sport-specific demands and previous injury, which suggests that hamstring injury risk is dynamic during in-season periods [41, 42, 46–49]. This is further supported by recent findings of substantially reduced resilience by previously injured hamstrings to cope with the physical demands of sport up to 2 years post-injury [41]. Single preseason or one-off RTS criterion testing of hamstring strength is unable to evaluate possible in-season fluctuations in hamstring function and increased injury

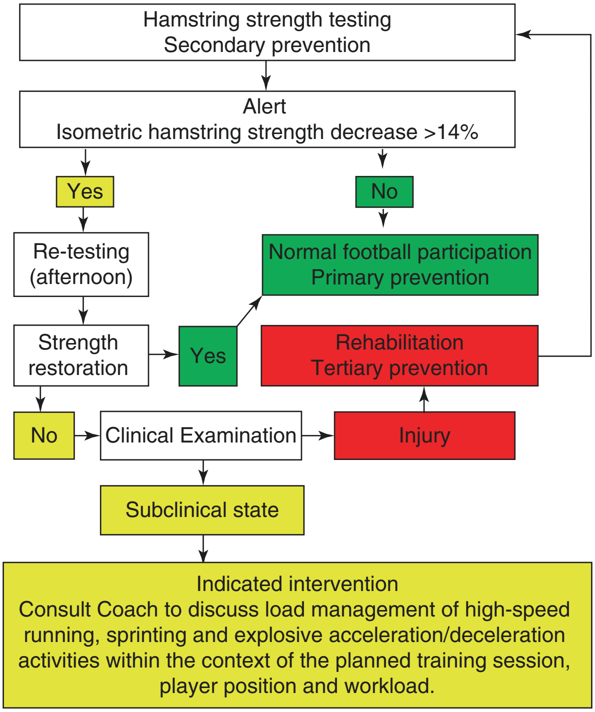

Fig. 11.3 Athlete monitoring process of isometric hamstring strength reductions as part of secondary and tertiary prevention strategies [51]

susceptibility. RTS and preseason testing are therefore best served for baseline measures and preseason identification of athletes required to commence secondary or tertiary prevention. A recent systematic review recommended testing hamstring strength post competition (match play) to identify functional impairments to assist in individual athlete management [50]. Since no difference in isometric or eccentric magnitude of change post competition was found, isometric hamstring testing has been put forward as the safer option [50]. Potential test options and their respective MDC 95%CI have been outlined in the clinical assessment chapter (Chap. 9) for practitioners' consideration. In-season monitoring of hamstring strength in athletes that never had a hamstring injury is a secondary prevention strategy. It involves a two-step clinical screening process that occurs in the subclinical stage of injury (Fig. 11.3). It is implemented in-season to facilitate early detection and management of hamstring injury susceptibility in elite athletes [48, 49, 51]. The same in-season monitoring process specifically for previously injured athletes occurs in tertiary prevention. Considering the elevated susceptibility of hamstring injury recurrence, associated with RTS in the short term and previous injury history in the long term, continuous athlete monitoring of hamstring strength is indicated as part of a tertiary prevention strategy during and beyond all three phases of this RTS process.

11.7 Conclusion

RTS after hamstring injuries involves multidisciplinary expertise collaborating to reach a shared decision about the case-specific requirements to facilitate a successful athlete outcome. The shared decision-making process is supported by the StARRT to reflect the individual context of each case. This chapter reflects that rehabilitation is gradual and progressive which involves a graded return to modified training (participation), full training (sport) and eventually the same level of competition standards (performance). A 'three plus one' approach is introduced by the addition of tertiary prevention to seamlessly map and implement ongoing management aimed at reducing the susceptibility of re-injury after returning to sport. This RTS approach is supported by four domains that monitor athlete progressions against clinical, functional, sport-specific readiness and RTS standards. Ongoing monitoring after hamstring injury is recommended to track functional and performance impairments which typically persist and possibly contribute to elevated susceptibility to reinjury after RTS.

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