Return to Play Following Muscle Strains

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Objective: To assess return to play strategies following muscle strains with the desired outcomes of decreased competition play lost and minimized risk for recurrent injury.

Methods: Literature review of previous studies that examine return to play criteria for the commonly seen muscle strain injuries in sport.

Results: There have been no studies directly comparing different return to play approaches. Studies have instead concentrated on recurrence risk factors and prognosis assessment, particularly for hamstring injuries. There is some literature support for risk factors for recurrence such as persisting strength deficits, larger injuries seen on diagnostic imaging, players in high-risk positions or sports, inability to complete functional tasks without pain, and strains of specific high-risk muscles (biceps femoris, central tendon of rectus femoris, medial head of gastrocnemius, adductor longus or magnus).

Conclusions: There are no consensus guidelines or agreed-upon criteria for safe return to sport following muscle strains that completely eliminate the risk for recurrence and maximize performance. At this time, it may be a sensible strategy to allow earlier return to play in team sports and accept a low to moderate injury recurrence rate. Improved prognostic assessment of muscle strains with injury identification (MRI) and injury assessment (isokinetic testing) may be assist practitioners to lower, but not eliminate, recurrent injuries.

Key Words: muscular re-injury, safe return

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Muscle strain injuries are common in sports that involve high-intensity sprinting efforts, such as the various varieties of football.[1–3] Of all the common sports injuries, muscle strains have one of the highest recurrence rates (incidence of reinjury) after return to play.[1,4,5] The recurrence rate for hamstring strains (the most common muscle strain) is around 12% in professional soccer[5] and around 30% (cumulative recurrence rate for the remainder of the season) in professional Australian football.[1,4,6] Generally, the goal of determination of fitness for return to play from most injuries involves assessment that the recurrence risk is minimal and performance is optimal. However, with respect to muscle strains, allowing an early return to play may be a sensible strategy, albeit with a cost of an increased recurrence rate.[1]

The decision regarding determination of fitness for return to play is generally based on an expert opinion level of evidence only. To our knowledge, there has been only 1 study directly comparing different return to play strategies.[3] Despite the lack of high-quality evidence, our ability to manage return to play may be improving due to better understanding of prognosis,[2,7–11] ability to identify risk factors for recurrent injury, an improved understanding of the mechanism of injury,[2,12,13] identification of risk management strategies,[1] and improved rehabilitation programs.[14]

METHODS

A review of the literature regarding return to play following muscle strain injuries was conducted, with potential papers obtained using PubMed and Sport Discus (January 2005), supplemented by the personal libraries of the authors. The search strategies included the following:

PubMed: "hamstring muscle strain recurrence," which yielded 11 papers of high relevance

Sport Discus: "(hamstring OR muscle strain) AND (return to play OR recurrence)," which yielded 27 papers of high relevance

After our initial search of papers, it was clear that this was not an area in which a meta-analysis of trial results could be performed. No controlled studies comparing different return to play strategies were identified. The majority of studies considering return to play from muscle strain injuries involved the hamstring muscle group. Accordingly, it is unclear at this time whether the findings for this injury parallel those of other major muscle groups such as the adductors.

However, in the papers studied, there were recurrent themes within the advice on return to play following muscle strain injuries that allow us to summarize the expert opinion (ie, generally level 4 evidence) in helping determining return to play under the following categories:

1. Strength and flexibility testing
2. Imaging
3. Functional field testing
4. Risk management strategies.

RESULTS

Strength and Flexibility Testing

Heiser et al presented a comparative study looking at the incidence of hamstring injury and recurrence rates retrospectively prior to, and then after, using an isokinetic (concentric only) strength testing regimen to determine fitness

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to participate. In the interventional phase of the study, players were allowed to begin jogging when the peak torque of hamstrings equalled 70% of baseline. Players were allowed to return to play when peak torque reached a level of 95% of the baseline score or a hamstrings:quadriceps ratio of 0.55 or greater. The authors reported lower rates of hamstring injury and hamstring recurrence with the isokinetic testing regimen in place. The major limitations of this study are that the intervention testing was neither randomized nor blinded and that the epidemiology was neither demonstrated nor discussed. Under the best models of injury prevention, it is not possible to attribute benefit, or otherwise, on the strategy presented in the study by Heiser et al.[15,16]

A somewhat similar study has been recently performed by Croisier et al.[17] This study involved a group of athletes with 18 recurrent hamstring injuries and persisting strength deficits who were held out of sport until the strength deficits had been corrected. A zero recurrence rate was reported over a 1-year follow-up. This study provides further indirect evidence that persisting strength deficits may impart greater risk of recurrence, but again, it does not answer the question of whether the time taken out of sport to correct the deficits is greater or less than the time saved in reduced recurrence rates.

Nevertheless, return of hamstring strength (eccentric or concentric) to a specific level is now a regular component of expert advice on determination of fitness to play after hamstring injury. For example, Croisier et al[17] and Croisier[18] recommend waiting until the injured hamstring is 95% of the uninjured side using an eccentric protocol before allowing return to play, whereas Drezner[19] recommends 90% of the uninjured side. The weight of evidence suggests that hamstring strength deficits are a risk factor for injury[3,17,20–23] (not withstanding 1 high-quality study that contradicts this notion[24]). There is also some evidence that decreased strength is a risk factor for adductor strain.[25,26] To date, no study has assessed whether the use of strength criteria in a return to play strategy results in a net positive outcome for the athlete (that is, that any decrease in recurrence rates is not eliminated by a far lengthier initial time away from competition).

It has been long held that correcting any flexibility deficit is equally important to a strength deficit in terms of determining return to play.[12,27–31] However, studies examining hamstring injury risk have consistently failed to show decreased flexibility as a risk factor for hamstring injury,[21,24,32] although definitive studies are lacking. A recent survey of stretching practices among professional soccer teams in the UK has found those teams that do not stretch regularly and/or do not hold their stretches for long periods suffer more hamstring strains.[33] With respect to groin strains, decreased range of hip abduction has been associated with groin injury.[32,34]

A recent group of studies suggests that perhaps it is not the absolute muscle strength (as measured by peak torque) that predicts recurrent hamstring injury but the optimal joint angle of the torque:length curve that is more relevant. In individuals having sustained a hamstring injury, peak knee flexor torque occurs at a greater knee flexion angle compared with both the contralateral side and a group of noninjured subjects.[13,35] Further insights into this theory may come from recent work characterizing muscle kinematics during sprinting, in which the biceps femoris muscle (which is known to have the greatest susceptibility to injury of all the hamstrings) is stretched the most during the late swing phase of sprinting.[36]

Imaging

In recent years, the use of MRI imaging for assessing severity of muscle strain has become more prevalent.[7–11,37] Diagnostic ultrasound may also be used and is a reasonable alternative at a lower cost, although MRI appears to be superior for predicting prognosis.[38] The use of high-resolution imaging has allowed separation of 2 distinct entities of posterior thigh injury—the hamstring muscle strain (as proven by MRI scan) and the MRI-negative posterior thigh injury.[2,7,39]

In general, the size of a hamstring muscle strain (assessed either by cross-sectional or longitudinal size on T2-weighted image) correlates with convalescence time (Fig. 1),[7,8,37,38] with biceps femoris strains having a worse prognosis than other hamstring muscles.[38] MRI-negative posterior thigh injury has a better prognosis than true hamstring muscle strain, both in terms of recovery time and risk of recurrence.[2,7,38] However, to date, although size of lesion correlates well with recovery time, no correlation has been shown with risk for recurrence.[7]

For quadriceps strains, rectus femoris injuries have a worse prognosis than vastus muscle strains. In particular,

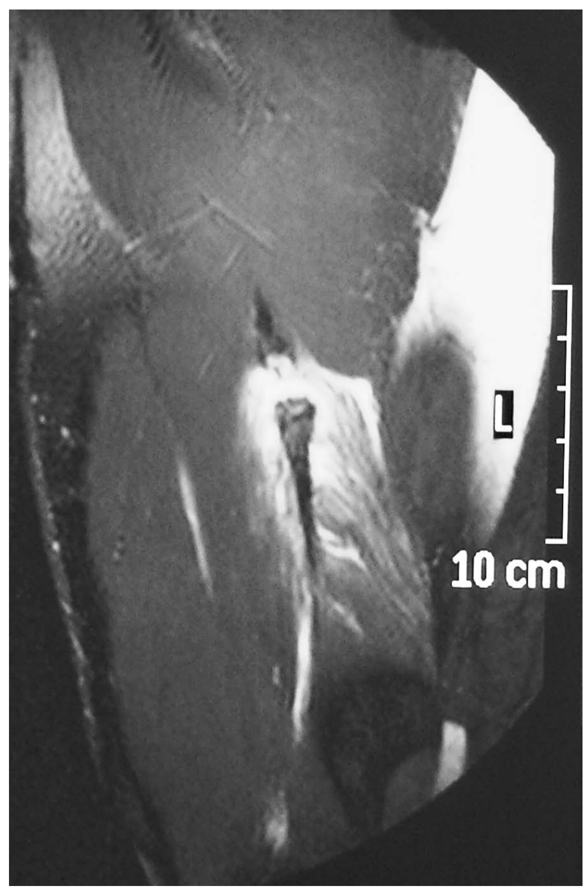

FIGURE 1. Coronal T2 MRI scan showing severe injury of proximal hamstring muscles.

TABLE 1. Key Indicators for Hamstring Strains Over 1997 to 2004 in the AFL

Season	1997	1998	1999	2000	2001	2002	2003	2004
Incidence (new injuries/team per season)	6.8	6.4	6.8	5.8	6.1	4.5	5.9	6.3
Prevalence (missed games/team per season)	21.0	21.0	22.6	22.9	21.4	15.7	18.8	21.7
Severity (missed games per new injury)	3.1	3.3	3.3	3.9	3.5	3.5	3.2	3.4
Recurrence rate (percentage of new injuries that recur within the same season)	37%	36%	30%	39%	25%	30%	27%	22%

rectus central tendon lesions (the so-called *bull's eye lesion*) have a much longer duration of recovery.[11]

A recent study has shown that a significant number of Australian football players have persistent hamstring abnormalities on imaging even after successful return to play (at 6-week follow-up).[38] The exact significance of this recent observation is unknown, but the finding does raise the question of return to sport in the setting of what appears to be ongoing local tissue inflammation and edema.

Functional Field Testing

The traditional method for determining fitness for return to play has been the following:

1. Allow training after manually assessed strength and flexibility have returned to levels comparable to the unaffected side
2. Test functional ability (to accelerate, reach maximum speed, change direction) at training and allow return to play if all tasks can be completed without pain or obvious limitation

It is recognized that these steps can almost certainly be passed before a player has returned to full strength (as measured by isokinetic device) or the abnormal signal on MRI scan has resolved.[1,38]

The rigor of a functional test can be theoretically increased by adding tasks beyond what is normally expected of players at training (for example, extra run-through sprints in a fatigued state with a team mate after field training has finished). This may increase the likelihood that a player will fail the fitness test and be declared unfit to play. However, a substantial number of muscle strain injuries and reinjuries occur during training itself, so the trade-off for a more rigorous testing session is likely to be an increase in risk of recurrence at that session. With respect to the functional activity most likely to cause an injury or reinjury, full sprinting and bending forward (e.g., to catch a football) while running at high speed are thought to be the activities of greatest risk for hamstring strains, whereas it is taking off (acceleration) for calf strains, kicking on the run for quadriceps strains, and change of direction for adductor strains.[40]

There is recent evidence that a rehabilitation program focusing on functional progression and core stability leaves an athlete less prone to recurrent injury than a more traditional one emphasizing strengthening and stretching.[14] Twenty-four athletes with an acute hamstring strain were randomized to 1 of the 2 treatment groups. Although there was no difference between the groups in time for return to sport, the reinjury rate was higher in the group completing a stretching and strengthening program both at 2 weeks and 1 year than a group employing progressive agility and trunk stabilization exercises.

Further research could use functional field testing as a control method of determining return to play, with the addition of isokinetic testing and/or diagnostic imaging as interventions, to test whether these interventions lead to a lower recurrence rate. Historically, the Australian Football League (AFL), which measures recurrence rates for all injuries as part of its annual injury survey, has found a trend toward lower recurrence rates for muscle strains in recent years (Tables 1 and 2).[6] This may reflect a more conservative approach or may be due to a superior predictive value of successful return to play because of modern imaging, for example. It will be important to replicate these findings in other settings, such as track and field sprinting, to help determine the exact reason for this recent observation.

Risk Management Strategies

Because it is recognized that many players can successfully return to competition prior to full recovery, Orchard and Best[1] have suggested an approach of risk minimization rather than risk elimination. It has been shown in the AFL that while a substantial percentage of muscle strains recurs at a later stage during the season, of the recurrent injuries, only a minority are reinjured in the first return match.[1] This observation suggests to us that to reduce the recurrence rate to much closer to zero, players would need to be kept out for perhaps double the recovery time rather than simply an extra week. Waiting for complete recovery of the muscle strain injury in a team sport may be an unnecessarily conservative approach, because while it would certainly decrease the recurrence rate of injury, it

TABLE 2. Key Indicators for Quadriceps Strains Over 1997 to 2004 in the AFL

Season	1997	1998	1999	2000	2001	2002	2003	2004
Incidence (new injuries/team per season)	2.5	3.0	2.4	2.0	1.6	1.7	2.0	1.9
Prevalence (missed games/team per season)	8.6	9.5	6.7	5.6	3.8	4.3	6.0	4.2
Severity (missed games per new injury)	3.4	3.2	2.8	2.8	2.3	2.6	3.1	2.2
Recurrence rate (percentage of new injuries that recur within the same season)	35%	20%	20%	18%	10%	17%	9%	3%

would increase the overall time missed through muscle strain injuries (as it would preclude many players who would have otherwise successfully returned from being able to play). While many players in team sports are able to return to play successfully without complete recovery of the muscle group, they are probably doing so with subtle biomechanical alterations that protect the injured muscle but that may also minimally sacrifice maximum performance. In a team sport in which speed is only a small parameter that contributes toward performance, these alterations may be acceptable (as opposed to the 100-m sprinter, for whom speed is inseparable from performance).

If a risk minimization approach is taken, it is worth bearing in mind the other known risk factors for muscle strain injury, such as player age (older players are more likely to suffer hamstring and calf injuries[24,32,39,41,42]), player race (black players are more likely to suffer hamstring strains[5,39]), and past history of injury (a risk factor for all muscle strains[1,24,32,39,41]). Certain sports present a greater risk than others, with Australian football known to have a greater risk of muscle strain than the rugby codes.[43] Within sports, there are certain positions at greater risk, such as the outside backs in rugby[43] and wide receivers in American football. Along with strength and flexibility deficits and significant changes on MRI scans, a predictive model for recurrence can be made that will help the decision as to whether to be conservative or aggressive in a given case. The stage of the season is also relevant, given the high cumulative recurrence rates for muscle strains. It makes sense to take a more conservative approach in the earlier stages of the season, but it may be acceptable to be more aggressive in the playoffs. Another factor that may be relevant in a team sport is the standard of the player and whether a fully fit substitute could possibly play to the same standard as the injured player. Table 3 illustrates factors that may all be taken into account when assessing fitness to play, some of which relate to the injury itself and others of which relate to the baseline risk or other circumstances.

Dealing With the Player Who Has Multiple Recurrences

The primary recommendation for the player who has had multiple recurrences is to address any underlying reversible risk factors of poor strength and poor flexibility. On rare occasions, a complete rupture of a tendinous insertion can lead to persistent strength deficits that are not correctable without surgical repair of the avulsed tendon.[44,45] MRI assessment may be indicated where this may be clinically suspected, although the exact timing of surgery to maximize recovery is not well known.

There is a proposed association between recurrent hamstring and/or calf muscle strains and degenerative changes at the L5/S1 level in the lumbar spine through a mechanism of subtle L5 nerve root entrapment.[42]

DISCUSSION

Functional field testing has historically been the standard of practice for determining fitness for return to play following muscle strains. Despite this rather common practice, we found minimal scientific evidence to support this strategy. Adjunct isokinetic muscle strength testing and/or diagnostic imaging results (sonography and/or MRI) are being evaluated, but the value of these special tests has not been proven at this point in time. As the common outcome of an apparently incorrect decision to return to play is virtually never catastrophic and simply requires a few extra weeks of rehabilitation, this may not be a priority area for research funding. However, by comparison, superior tests for assessing return to play for injuries such as concussion and after knee and shoulder reconstruction surgery are needed as a greater priority. In the area of muscle strains, primary prevention is a more important area of research than return to play assessment, as the greatest risk factor is a history of past injury.[1,2,24,32,41]

Isokinetic strength testing and MRI assessment may be appropriate steps toward the clearance of an elite 100-m sprinter for a major event, as in this circumstance, full functional recovery is probably needed to allow a good performance. For team sports players, adjunct tests should be used as risk assessors rather than as absolute hurdle requirements. In team sport athletes to date, MRI scans have general been used to assist in determining prognosis for the initial injury (which may help rehabilitation strategies) rather than as screening for return to play.

TABLE 3. Factors That Can Guide the Decision Regarding Return to Play

Factors Indicating a More Conservative Approach	Factors That May Allow More Rapid Return to Play
Persisting strength deficit	Strength equal to uninjured side
Persisting flexibility deficit	Flexibility equal to uninjured side
Inability to complete full training without pain or limping	Ability to do all functional activities at training
Large area of abnormal signal on imaging	Normal ultrasound and/or MRI scan
100-m sprinter or team player in high-risk position (Australian footballer, rugby outside back, wide receiver, outfield soccer player)	Team sport player in low-risk position (e.g., offensive lineman, goalkeeper, rugby forward, basketball player)
Older player	Younger player (but with experience of playing with injury)
Early stage of season	Playoff or must-win game with no adequate replacement player
Strain in high-risk location (biceps femoris, central tendon of rectus femoris, medial head of gastrocnemius, adductor longus or magnus)	Strain in low-risk location (semimembranosus, vastus muscles, lateral head of gastrocnemius, gluteal muscles)

A typical professional Australian football team has 6 players suffer a hamstring injury per season, with players generally missing 3 weeks per injury but with a 30% recurrence rate (Table 1).[6,46] In a typical professional soccer team, 5 players suffer a hamstring injury per season, missing an average of 18 days each, with a recurrence rate of 12%.[5] An obvious question is whether an across-the-board more conservative (or even aggressive) approach in either of these sports would lead to an overall decrease in missed playing time. Data from the AFL suggest that if each of the 6 new hamstring injuries missed 4r games from the initial injury, the recurrence rate would be lower but still not zero, and therefore more playing time would be missed overall.[1] If all hamstring injuries came back a week earlier than is currently the case, there might actually be a decrease in the overall number of missed games, as some players might survive playing a week earlier. However, there would probably be a greater incidence of recurrence, and this would also result in a greater number of players performing poorly due to the greater prevalence of functional deficits. Recent trends from the AFL suggest a slightly more conservative (and more accurate) approach toward return to play (Table 1).

In trying best to assess the performance of a medical/fitness team in a team sport, a less than 100% success rate in preventing recurrence is probably the ideal outcome (that is, if say 90% to 95% of football players avoid recurrence in their first game back, this might be preferable to 100%, which might reflect too conservative an approach). To aim for a zero recurrence rate in a team sport would require criteria that are too impractically conservative to be adopted, with potentially fit players staying out of professional sport for too long. In numerical terms, it is preferable to have the average hamstring strain in a football player return at 3 weeks with a 90% success rate (in the first match back) than for the average injury to take 8 weeks to recover with a 95% to 100% success rate.

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