

MANAGING RECTUS FEMORIS INJURIES IN ELITE TRACK AND FIELD

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INTRODUCTION

Rectus femoris (RF) injuries are common in sports requiring maximal acceleration and sprinting¹⁻⁶. In a multi-sport American collegiate study, female track and field (T&F) athletes had the 3rd highest overall quadriceps injury rates behind male and female soccer players⁷. In elite T&F, thigh muscle injury is consistently recorded as the principal injury type and quadriceps injuries account for up to 25% of those injuries^{4,8-10}. Despite the injury burden, there are only a few studies specific to RF injury, and particularly RF injury outcome, within T&F¹¹⁻¹³.

RF injuries are challenging to manage, with high grade injuries and intratendon RF injuries demonstrating significantly longer time to return to full training and high recurrence rates¹⁴. This may be due to the complex structure and function of this important muscle in athletic activity. The RF has an intramuscular bipennate structure and central aponeurosis from the indirect tendon originating at the superior hip acetabular ridge, surrounded by a unipennate superficial portion arising from the direct tendon originating at the anterior inferior iliac spine¹⁵⁻¹⁸. The RF has

been reported as more active in flexion and extension of the hip, rather than flexion and extension of the knee, during maximal running¹⁹. RF cross-sectional area has been positively related to hip flexion moment velocities during the swing phase in sprinters²⁰. In jumping activities, RF has increased activity whilst decelerating the initial countermovement eccentrically and then working concentrically during the push off²¹. With such a complex structure and key functional role, further studies may help with prevention, prognostication and the development of targeted rehabilitation programmes^{15,22-25}. We are particularly interested in the recent article exploring the role of sprint biomechanics in hamstring injury²⁶. Similar biomechanical considerations are likely to be relevant in rectus femoris injury which appears vulnerable to injury at the initiation of hip flexion from maximal hip extension in sprinting and on ball striking in kicking sports.

There is limited research on the classification and categorisation of RF injuries. The British Athletics Muscle Injury Classification (BAMIC)²⁷ has been widely adopted in the classification of

muscle injury and a recent systematic review concluded that there was consistent evidence that BAMIC could provide prognostic and therapeutic guidance in activity related muscle injury in athletes²⁸. BAMIC categorises muscle injuries with respect to tissue type and the extent of muscle injury markers on MRI. The BAMIC classifies injury tissue types as 'a': myofascial; 'b': musculotendinous junction (MTJ) or 'c': intratendinous. The severity grading of injury from 0 to 4 is based on the MRI measurements of cross-sectional area (CSA) and length of injury within the muscle or tendon. The most unique feature of this system is the structural classification (a, b or c) which may inform a more specific rehabilitation approach targeted to the specific tissue injury. This approach has been advocated and demonstrated success in hamstring injury^{29,30}. In RF, hamstring and calf muscle injuries the BAMIC diagnosis has been associated with time to return to full training, in both retrospective and prospective studies^{14,22,28,31-33}.

The paper aims to describe key management principles within elite track and field athletes with RF injuries. It will be achieved in two parts, (i) discussion of the

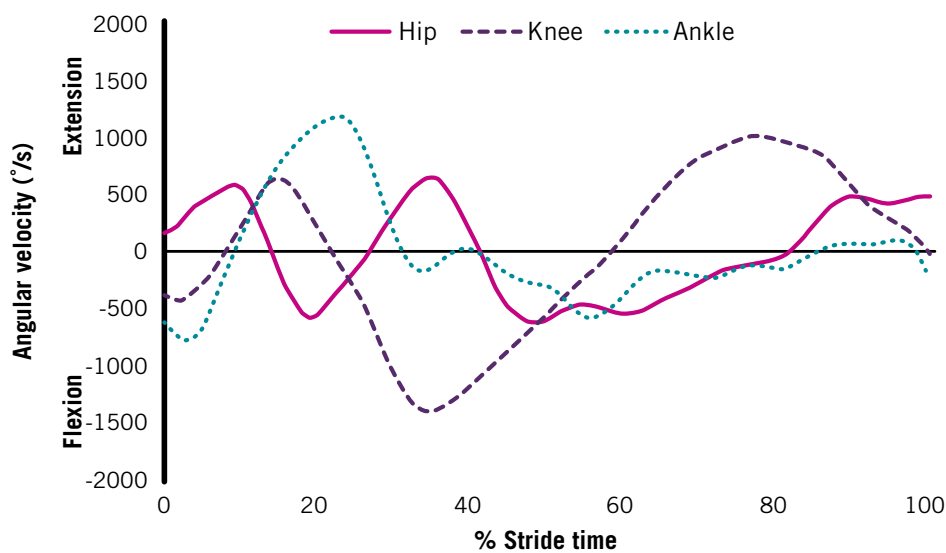


Figure 1: Hip, knee and ankle angular velocity over one stride for gold medallist Tori Bowie at the 2017 World Athletics Championships. Source: 2017 IAAF World Athletics Championships biomechanics study. Used with permission, Bissas et al (2018).

TABLE 1

	Step length (m)	Relative step length	Step rate (Hz)
BOWIE	2.26	1.29	4.72
TA LOU	2.20	1.38	4.76
SCHIPPERS	2.30	1.29	4.59
AHOURÉ	2.07	1.22	4.95
THOMPSON	2.11	1.27	4.67
AHYE	2.15	1.35	4.85
SANTOS	2.18	1.32	4.81
BAPTISTE	2.11	1.26	5.00

Table 1: Mean step length, relative step length and step rate for 2017 World Athletics 100m female finalists, as adapted from Bissas et al (2018).



Figure 2: RF requirements during various stages of the running cycle. EOR – end of range.

function of RF in world class sprinting and jumping performance, and (ii) how those qualities uniquely associated to the RF can be restored to elite function.

RECTUS FEMORIS FUNCTION IN SPRINTING *Acceleration Mechanics*

Whilst most running analysis studies have utilised constant speed running conditions, fewer have investigated the body accelerating from a stationary position. This requires a rapid change in forward kinetic energy and so it follows that the mechanical function of the lower limb joints differs from acceleration to constant speed running³⁴.

Within sprinting, athletes commence from 4-point stance in blocks and gradually transition to upright running. Consequently this acceleration phase varies with each and every step³⁵. However acceleration is characterised by a forward body lean and positive shin angle. These both transition over the drive phase and into transition and ultimately maximal velocity.

Acceleration requires powerful hip³⁶ and ankle³⁷ work to be completed for elite performance.

The musculature around the hips are particularly responsible for generating and absorbing power during human acceleration³⁶, whilst the ankle seems highly implicated in transferring that generated power into the track and ultimately forward momentum.

Max Velocity and Speed Endurance

Ranges of hip joint range of motion (ROM) during upright running for female sprinters can vary from approximately 30-40° of hip extension at toe-off, to approximately 80° of hip flexion during the swing phase³⁸. These female athletes achieve this large ROM in approximately 0.3s swing time.

When we take the range of approximately 120°, and a frequency of >4.5 steps per second, this requires huge eccentric forces to transition from outer range hip extension into the swing phase, see Figure 1^{20,39}. However whilst frequency seems very high, the force applied into the track also remains extremely large, but in very brief time periods. Step lengths of >2m require huge force absorption and generation within each stride, see Table 1.

Tolerating such large forces, which are undertaken in the briefest of time periods, requires excellent reactivity and stiffness through the lower limb at ground contact.

For example, step lengths of >2m seen across elite females are associated with recorded ground contact times of between 0.088 and 0.104s during the 2017 World Championships final³⁵.

In summary, during the running cycle, forces working across the RF are multiple and complex. Large forces are absorbed during the ground contact phase whilst force generation is necessary during midstance. In late stance we see a large eccentric action upon the RF to initiate swing³⁹. During the swing phase we witness a transition from eccentric to concentric action into hip flexion²⁰. This seems to be a particularly vulnerable position for the RF, in what essentially is an outer range Thomas test position whilst undergoing large angular velocities multiple times per second.

MANAGEMENT PRINCIPLES

We have previously described principles for hamstring muscle injury management²⁹. Many of these principles similarly apply to rectus femoris injury management. Shared decision making and collaboration within the multidisciplinary team are usually important for optimal outcome. As shared decision making and collaboration have been discussed elsewhere^{29,40}, we will not focus on these in this section. Instead, we will consider the specific anatomical and rehabilitation considerations for rectus femoris injury in track and field.

Relevant Anatomic Considerations

Injuries in athletes are most commonly sustained in the proximal third of the rectus femoris⁴¹. The proximal rectus femoris arises from two tendon heads. The first, direct head, originates from the anterior inferior iliac spine. The indirect, or reflected head, arises from the rim of the acetabulum. The conjoint tendon is formed from both direct and indirect tendons at the level of the hip joint with the direct head lying superficially. The direct head extends distally forming the fibres of the anterior myofascia. The indirect head, forms the central intramuscular tendon which extends to the distal third of the thigh. The posterior aponeurosis in the proximal third is the forming distal myotendinous junction.

We apply the principles of the BAMIC system in classifying rectus femoris injuries. Myofascial injuries are usually noted laterally or at the posterior myofascia. Injuries at this site are classified as 'a'

injuries, and a numerical grade based on the extent of the muscle oedema as reported in the BAMIC paper. These injuries are usually associated with a good prognosis and time to return to full training of less than 4 weeks.

Both muscular injuries and muscle-tendon junction injuries are categorised as 'b' injuries. These are usually located approximating the central tendon. Careful evaluation of the MRI and with ultrasound should be performed to exclude an intramuscular tendon component, or extension across the aponeurotic attachment to the central tendon proximally. Injuries that extend into the central intramuscular tendon or across the thickened anterior aponeurotic attachment should be classified as 'c' injuries and are associated with an increased time to return to full training. In classification of 'c' injuries, the specific anatomical location and grade of injury are of diagnostic importance. The key grading variables between 2c, 3c and 4c injuries relate to the cross-sectional area of injury (<50% in 2c, >50% in 3c and 100% in 4c) and the loss of tension/waviness of the tendon (none in 2c, loss of tension/waviness in 3c, retraction in 4c). In elite athletes, substantial 3c and 4c injuries to the direct

head free tendon can be considered for surgical repair. 2c injuries to the free tendon and injury to the free indirect tendon may have good outcomes with a non-surgical approach but should be managed with a targeted rehabilitation approach, and may have a high risk of reinjury. Injuries to the intramuscular tendon usually have a good outcome with a nonsurgical approach, and progressive targeted tendon rehabilitation. However, if there is gapping within the intramuscular component due to a high-grade tendon injury, particularly in the proximal section, surgical consideration may be warranted. A repeat MRI scan after the initial bleeding has improved, and ultrasound imaging can provide further diagnostic information to help with decision making.

A degloving intramuscular injury is a unique injury to the rectus femoris⁴¹. This occurs when the inner bipennate muscle that surrounds the central tendon is torn from the more superficial unipennate muscle forming a separation within the rectus femoris muscle. These injuries are managed with non-surgical rehabilitation. Aspiration of haematoma that separates the injured muscle fibres may be helpful.

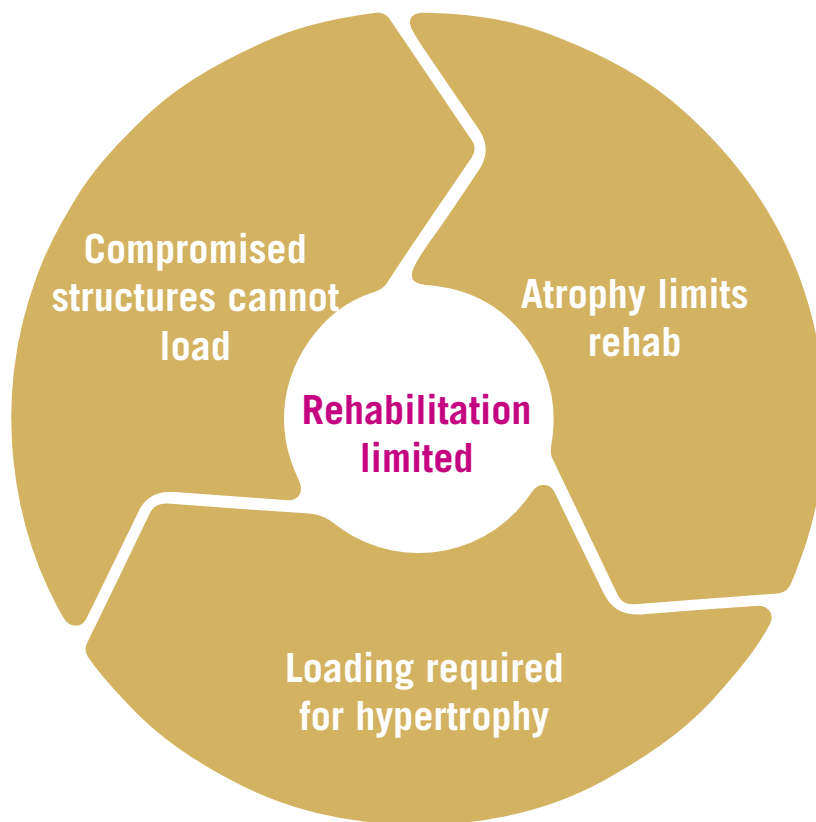


Figure 3: Cycle of reduced loading and atrophy.

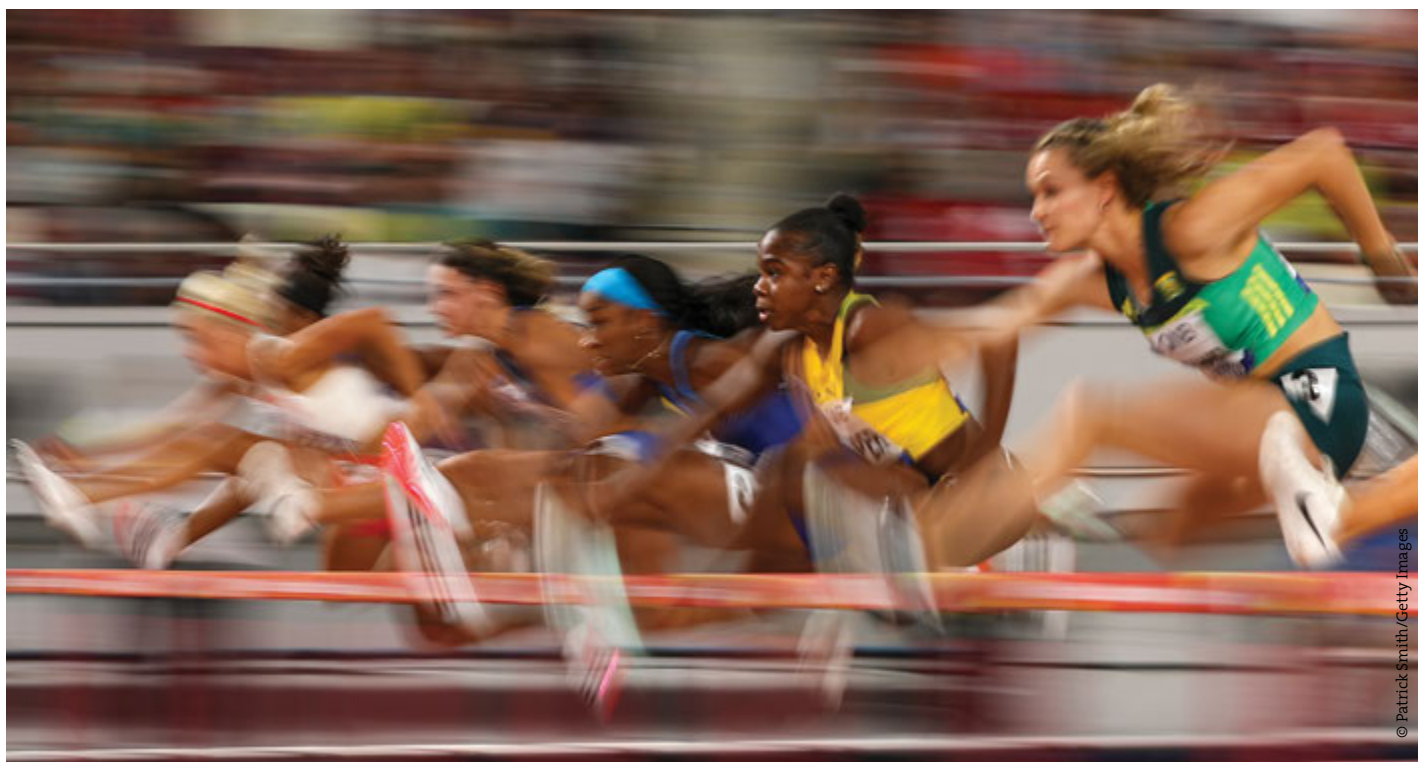


Image: Illustration.

Restoration Of Capacity and Cross-Sectional Area

i. Overcome Inhibition and Reduce Atrophy Effect

Following RF injury onset, regardless of the length of recuperation, deconditioning and atrophy may become a factor that requiring attention. Following the initial acute management, once the athlete is ready for some appropriate loading for the area, it should be administered where possible⁴². Otherwise, athletes can enter a cycle of 'chronic rehabilitation' where reduced tissue tolerance manifests into a chronic recurrent injury pattern.

Early stage rehab may focus upon blood flow restricted techniques in order to maintain muscle mass whilst the tissue may not be able to tolerate much force or strain whilst recovering^{43,44}. Lower intensity strength training, with higher repetitions and reduced recovery may also be possible in this early phase when higher intensities and velocities may not be possible. To maintain muscle mass of unaffected structures and support the whole muscle chain, it is important to train around the injured area. is also possible.

ii. Harness Proximal and Distal Assistance

Within large grade injuries and those affecting the free and intramuscular tendon,

rehabilitation may be longer and injury recurrence may become a factor⁴⁴. Within this framework, secondary assistance to the affected RF may be necessary to facilitate rehabilitation and return to performance.

Strengthening of the hamstring and adductor muscle group to facilitate a powerful and forceful ground contact and stance phase may help support a compromised RF during the stance phase. Similarly with the adductors, tensor fascia lata and iliopsoas may be utilised to facilitate a greater contribution during the swing phase. While there is limited academic studies, coaches have regularly detailed the importance of trunk musculature in running gait and mechanics. Control of pelvis and trunk rotation with effective abdominal and dorsal musculature contraction has been postulated to created effective and useful torsion transferable from the upper to lower limbs during running⁴⁵. There has been more recent interest in lumbopelvic mechanics and injury risk in hamstring injury recently and we think this is an important area of future study^{26,46,47}.

It is worth dedicating rehabilitation focus to foot and leg (shank) function in relation to RF injury and rehabilitation. If ground contact is weak and lacking in stiffness, the resultant swing phase must be generated primarily from the hip and RF. Stiff, precise

and forceful ground contacts can generate momentum from the floor, so reducing the strain on the RF from early to late swing phase, from eccentric to concentric motion.

Soleus function seems important in this regard, with the high force generating capacity of the muscle⁴⁸ advantageous for brief and stiff ground contacts. For stiffness at ground contact, it seems reasonable that high rate of force development is required through the triceps surae muscle group. Improvement in this physiological quality can be achieved with high force generating strength modalities⁴⁹, of which the soleus seems well-suited for.

iii. Restore Muscle-Tendon Unit Capacity and Develop Fatigue Resistance

In the weeks/months following successful initial return to training and/or competition, the RF seems particularly susceptible to reinjury. There seems to be a large strength endurance element necessary for successful RF rehabilitation and this element should not be ignored. Strength endurance-type circuits can be incorporated intermittently right along the rehabilitation timeframe along with more higher force training prescription. Earlier in the rehabilitation, lower intensity strength endurance type circuits may be incorporated to the affected area whilst higher intensity work may be

suitable for unaffected areas. Circuits can be time or repetition based but with the overall goal of increasing the tissue capacity of the area, short recovery, and repeating activities for a strength endurance component. As rehabilitation progresses, increased intensity circuits may be chosen but all with the goal of increasing the tissue's capacity to complete work, recover and repeat again. Balancing the continuums of exercise selection, intensity, duration, volume, and recovery is where the art and science of rehabilitation become more blurred. Experience, understanding athlete response and the nature of their injury will all be necessary to achieve a good outcome in this regard.

Force Generation, Absorption, and Transfer

The complexity of RF function is well recognised, both in relation to the anatomical specialisation of the muscle and its diverse role in numerous phases of the running cycle. Targeted strength training prescription for the desired adaptation is required during appropriate stages of the rehabilitation⁵⁰. Too often within rehabilitation the load or repetition ranges are not aligned with the adaptation necessary for progression. Below are some important topics and training modalities within RF rehab that warrant further discussion.

i. Maximal Strength Training

Once muscle inhibition and atrophy have been successfully targeted during rehabilitation, a healing RF injury will need to undergo progression towards maximal strength training exposure. The block of maximal strength work is usually preceded by a hypertrophy strength block to equip the tissues suitably to undergo more maximal intensities. Rehabilitation to enhance force absorption and generation is characterised by lower repetitions, heavier loads, and potentially elongated eccentric time-portions of the movement⁵¹.

Below is an example of an exercise variation widely used within RF rehabilitation, the split squat (Figure 4). Different exercise options exist to achieve RF adaptation- if we apply suitable load, cueing, and appropriate repetition ranges.

It is possible to manipulate variations of the exercise to achieve the desired adaptation (Figure 4). Examples of other exercise choices which can be manipulated

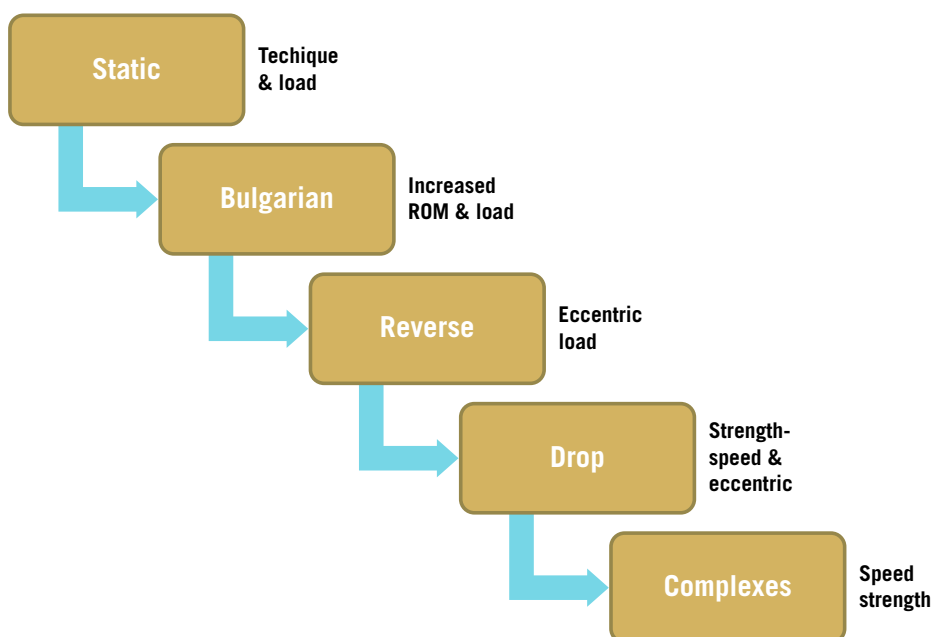


Figure 4: Split squat variations and potential useful adaptations.

to suit maximal strength work include: squat variations, Romanian dead lift, step up variations, snatch or clean pulling derivatives, prowler pushing, and hip thrusting. Again, programming of these will require some artistic and scientific balance to elicit the desired training block adaptation.

ii. Implementing Isometric Training

Within hamstring injury research, athletes with a history of injury exhibit both acute and chronic responses to pain causing maladaptive neural responses in the central nervous system⁵². In the initial stages post-injury, it has been suggested that reduced myoelectric activity in the muscle serves as a protective mechanism to unload the healing tissue⁵³. Similarly, for RF injury, inhibition may be evidenced following a large injury or following multiple insults to a similar area, potentially compromising rehabilitation and muscular adaptation. Isometric training may avoid the inhibitory mechanisms that occur during early rehabilitation or chronic cases, where voluntary muscle activation has been shown to be higher during isometric contractions⁵⁴.

As rehabilitation progresses, high force isometrics may be utilised to achieve a specific tissue adaptation. Free or intramuscular tendon tears, or chronic fibrotic tissue may respond to high force isometrics when pain and disability are

greater, to improve motor unit recruitment, prior to implementing eccentric loading.

iii. Develop Tolerance to High Eccentric Force
In the running requirements section, we described the high eccentric forces experienced during sprinting, particularly the rapid transition from hip extension to hip flexion early in the swing phase. It is extremely difficult to replicate the forces and velocities experienced during sprinting through range in a gym-based setting. Nonetheless, tissue modification and eccentric torque tolerance will not be achieved without eccentric strength training tissue exposure and forms a crucial part of the rehab process.

Eccentric loading for the quadriceps does seem possible with gym based loading⁵⁵. Shifting the angle of peak torque to higher ranges may help protect in outer range hip extension where the RF seems particularly exposed. RF dominant gym lifts, eccentric flywheels, manual eccentrics, isokinetic dynamometry (IKD) with altered seating angles can all be utilised to load the RF specifically in an eccentric fashion.

Table 2 shows an example of eccentric load being integrated with isometric loading in the rehabilitation of a proximal RF tear, with a specific focus on tendon loading.

Re-institution of Running Pattern and Drills

Sprinting is a complex, co-ordinated

TABLE 2

<i>Monday</i>	
<i>Flywheel eccentric Hip Flexion</i>	<i>4x10 reps</i>
<i>Isometric hip flexor in extension</i>	<i>2x25 seconds</i>
<i>Manual eccentric hip flexor</i>	<i>2x5</i>
<i>Wednesday</i>	
<i>Flywheel eccentric hip flexion</i>	<i>4x10 reps</i>
<i>Isometric hip flexor in extension</i>	<i>4x25 seconds</i>
<i>Friday</i>	
<i>Flywheel eccentric Hip Flexion</i>	<i>4x10 reps</i>
<i>Isometric hip flexor in extension</i>	<i>2x25 seconds</i>
<i>Manual eccentric hip flexor</i>	<i>2x5</i>

Table 2: RF specific isometric and eccentric loading.

movement, and restoring normal movement patterns is essential prior to returning to higher intensity running and sprinting. Progressive running drills will load the RF in a functional manner, with a gradual increase in velocity of movement and lengthening of the muscle, both of which are important loading characteristics⁵⁶. Poor 'backside mechanics' have been theorised to be a potential risk factor in hamstring and RF injury within sprinting^{26,45}.

Backside mechanics refer to where an athlete finishes toe-off and continues swinging the knee and ankle posteriorly resulting in large knee flexion angles moments. 'Front-side' mechanics have been coached to promote hip flexion immediately following ground contact. Increased hip flexion⁵⁷ and the ability to apply force in a horizontal direction⁵⁸ are key determinants of high speed running, and running drills can be used to retrain these elements in a rehabilitation setting⁵⁹.

Key areas considerations when performing running drills:

- Trunk posture
 - Consist of a neutral upright posture
 - Controlling rotation around the

- thorax - creating effective torsion
- Foot contact at ground contact should comprise of:
 - Impact close to centre of mass (COM)
 - A neutral foot angle upon landing, not too plantar flexed
- Athlete cued to:
 - Generate tension in the ankle upon ground contact
 - Attack the ground from above and immediately apply force through the ground
 - Can be cued with 'big toe up'
- During stance stance/thrust phase athlete should focus on:
 - Co-ordinated push off from proximal to distal through a stiff ankle
 - Quick ground contact but forceful
 - Hip and knee are not fully extended to minimise forward rotation at toe-off
- During the swing phase
 - Hip and knee flexes almost simultaneously upon toe-off
 - Athlete should focus on 'triple flexion' of the ankle, knee and hip to

- promote front side mechanics
- 'Whip from the hip' can be used as a cue
- Arm movement should be:
 - Synchronised and symmetrical with lower body to counter rotate the hips
 - Coupled with good torsion through the trunk
- Co-ordination between swing and stance legs
 - Prior to ground contact on contralateral side and whilst in flight, swing leg will commence a powerful hip extension moment
 - Involuntary scissor-like reflex between swing (triple extension) and stance leg (triple flexion).
 - Early powerful initiation of hip extension reinforces the force through the stance leg on ground contact
 - Early initiation of swing immediately post hard ground contact
 - Knees together or swing leg ahead of support knee during stance on contralateral side.

In Table 3, we summarise drills that may be even more specific to the RF. These can be used to prepare the tissue for running in the early stages of rehab, or as part of the warm up later in the rehab prior to full running. These may even form part of the circuits mentioned in the previous section.

Running Progressions

Drilling is useful to transition back to activity whilst the intensities remain lower as a protective mechanism; however, transitioning back to activities of normal sprint training are eventually required. During this period, utilising the skills and experience of the coach—in collaboration with the medical team—are recommended to achieve the best possible outcome for the athlete^{29,40}. It is also good practice to return to the normal weekly periodisation strategy employed by the coach in order to return the athlete to their normal routine, regardless if intensities are at a lower level. We will look at running progressions in 3 different categories: acceleration, upright running and maximal velocity.

Sample acceleration progressions:

1. Prowler push – a) walking b) slower run c) faster

TABLE 3

Drill		Mode	Hands on hips	Dowel at shoulders	Dowel overhead
A-variations	B-variations	Walk	Low intensity	Low-Moderate intensity	Moderate intensity
			Co-ordination through trunk and hips	Increased demand through trunk and hips	Increased demand through trunk and hips
			Movement mastery	Rhythm	Rhythm
		Skip	Moderate intensity	Moderate intensity	High intensity
			Reflexive	Moderate trunk and proximal hip demand	High trunk and proximal hip demand
			Rhythm focus	Reflexive and quick ground contacts	Maintain form despite increased lengthening
		Run		High intensity	High intensity
			N/A	High trunk and proximal hip demand	Maximal trunk and proximal hip demands
			?Non transferable	Rhythm and anti-rotation component	Anti-rotation and flex-extension reflexes
					?High level athlete

Table 3: Rectus femoris specific running drill progressions.

2. Dribbles to acceleration
3. Walking into acceleration
4. Acceleration from standing
5. Accelerations 3-point stance
6. Acceleration with resistance from standing
7. Acceleration with resistance from 3-point stance
8. Accelerations from 4-point position

Initially acceleration can be performed in training shoes on a non-slipping surface and progressively transfer to spikes when demands/velocity increases.

Maximal velocity progressions

More maximal velocity work must be controlled in the context of the prognosis, tissue type involvement, and what similar work has been done so far in the rehabilitation process. Hollow runs can be a good way of progressing, whereby the athlete has designated acceleration, maintenance, and deceleration zones. The speed achieved at the end of the acceleration zone is the velocity at which they can use during the maintenance speed zone. Adjusting the distance of the acceleration and maintenance zones, controls the velocity of the runs.

Faster max velocity runs can be undertaken slightly more safely within floating or broken runs. Here the athletes accelerate over a distance of 15-20m, but have a maintenance or 'floating period' where the athlete maintains pace for 15-20m. However, following the float period, the athlete can reaccelerate again for 15-20m, for example. The result is the athlete can achieve a higher velocity without having to push so hard to achieve it from a standing start.

These types of runs are just two samples of what could be used. Gradually, the acceleration and max velocity runs need to start merging as the athlete comes closer to the end of their rehabilitation and returning to full training.

Sample maximal velocity sample progression:

1. Build-ups
 - Speed of run increases gradually so athletes can continue to focus on good mechanics
2. Repeated runs over short distances at set velocity
 - 3 x 3 60m with 30-60m at percentage of maximum velocity. (e.g. 85%, 90% etc.)

3. Hollow runs
 - Gradually increase distances and velocities but careful not both at same time
4. Broken runs
 - Manipulate lengths of float and acceleration phases.

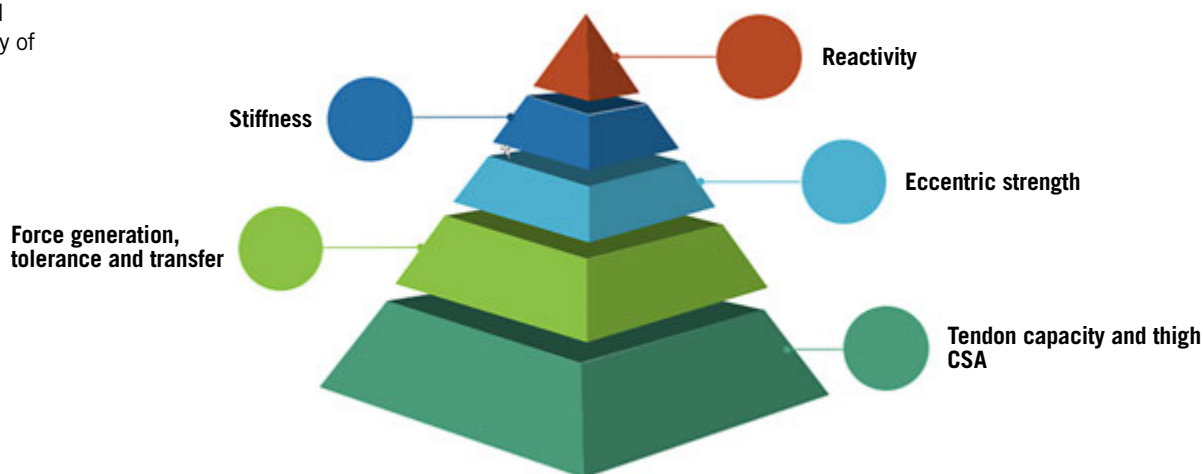
Upright Running Progressions

Similarly for more speed endurance work, we can utilise modifications such as: spikes, bend-running, distances, target intensities, recovery times and running with training partners. Surfaces such as grass or others can be used depending on the event.

Sample upright running progression:

1. Walking swing leg retraction
 - Focus on stepping down onto foot with swift hip extension and firm foot at ground contact
2. Pushing prowler walk
3. Dribbles – low to high
4. Dribbles to running
 - Technical focus from above is applied and stride opens progressively as speed increases
5. Hollow run progressions similar to max velocity progressions.

Figure 5: Physiological requirements hierarchy of the RF for sprinting.



Return to Training and Return to Competition Decision Making

A full discussion of the complexities of return to competition decision-making is beyond the scope of this paper. We apply the principles of shared decision-making outlined in previous papers^{29,40}. The role of the clinician is to provide information based on risk and the role of the athlete and coach is to place that in context and make decisions based on risk tolerance. There will be many unique contributing factors in each case. The clinician's role in providing information on risk can be supported by additional imaging, strength diagnostic testing and clinical assessment. While there are no imaging findings that can definitively support or exclude a successful return to play, we take heed of MRI findings of ongoing muscular oedema or a lack of intratendinous tension or integrity and consider that these are likely to increase the risk of reinjury⁶⁰. These are important contributions to the RTP decision-making process but far from the only variables to be considered.

We have detailed the qualities of the RF in sprinting and jumping, which are multifaceted and complex. It requires:

- Activation through a large range of motion
- A large strength endurance component to operate across two joints
- High eccentric work tolerance in outer range during upright running and maximal velocity running
- Rapid contractions during acceleration tasks

- Stiffness at ground contact to react efficiently from the track.

Figure 5 shows how these necessary characteristics may be organised and the order of attaining these physiological qualities within a rehab setting. With such a varied set of necessary qualities, it is no wonder the RF seems particularly susceptible to injury and reinjury¹⁴. Assessment and restoration of these qualities is necessary for RF injury management outcome. Therefore, biomechanical running data including stride length and ground contact times, jump testing, strength diagnostics using isokinetic dynamometry, clinical assessment, imaging, and tolerance of running progressions thus far will all form a picture of the athlete's preparedness for return to training and subsequent competition.

SUMMARY

This paper recommends key principles within RF rehabilitation to be implemented as part of a systematic and structured approach. Utilising these RF-specific principles, in conjunction with previously published injury management principles in hamstring injury management²⁹, can help clinicians and coaches to rehabilitate elite track and field athletes back to world-class competition.

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