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PHASES OF REHABILITATION AFTER INJURY: AN EVIDENCE-BASED LITERATURE REVIEW

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Providing coaches, referees, players, and administrators with the knowledge, skills, and leadership abilities to ensure that safety and best practice principles are incorporated into all aspects of contact rugby.

INTRODUCTION

The physical demands of rugby make the risk of injury to players higher than most other sports [63]. The management of injured players is centred on an early return-to-play, despite 'best practice' principles which consider the biological healing process to ensure complete recovery and rehabilitation from injury. An injured player returning to play too early has a very high risk of getting re-injured. This is not an ideal situation as recurrent injuries in rugby are more severe and result in the player being away from the game for longer [9,10,11]. The following section discusses, where possible, an evidence-based approach to sensible management of injuries sustained during rugby with the ultimate goal of a timely return to the sport.

TYPES OF RUGBY INJURIES

The incidence, nature and severity of injuries in rugby are difficult to evaluate despite the large number of epidemiological studies that have been undertaken. This is the result of differences in methodology and definition [12,28]. Despite these deficiencies it is still possible to detect general injury patterns, which will be presented below.

General injury incidence

The injury incident is presented as a number of injuries per 1000 hour playing exposure. The incidence of match injuries is considerably higher than injuries sustained during training [5,7,9,10]. International players have reported an incidence of between 83.9 per 1000 player hours and 218 injuries per 1000 player hours for World Cup tournaments [6,8,29]. Rugby players have reported an injury rate of between 69/1000 and 91/1000 player hours [5,9]. Professionalism in rugby was introduced in 1995, and since then there has been an increase in the incidence of injury in rugby [5,30].

Injury location

The lower limb is the most commonly injured location when injuries are evaluated cumulatively for both professional and amateur rugby players [5,7-10,29,34]. The lower limb is more frequently injured during both matches and training [6,8-10,34]. More specifically, the knee [5,7-9,11,18,29], thigh [8,9,11] and ankle [8,9] account for the largest number of lower limb injuries, in that order.

The top 3 injuries sustained by professional rugby players included hamstring muscle injuries, calf muscle injuries and thigh haematomas [8]. The top 3 most severe injuries in the same group included anterior cruciate (ACL) injuries, knee cartilage injuries or degeneration and rotator cuff impingement syndrome [8]. A more detailed list is provided in Table 1 and 2.

TABLE 1: MOST FREQUENT INJURIES SUSTAINED BY ELITE RUGBY PLAYERS [8]

Injury	Number of injuries	Average severity (days)
Hamstring muscle injury	14	11
Calf muscle injury	12	11
Thigh haematoma	10	3
Shoulder joint sprain	8	6
Ankle lateral ligament	8	9
Calf shin/haematoma	6	4
Knee joint sprain/jar	6	20
Cervical facet joint	5	3
Rib fracture/contusion	5	6
Adductor muscle injury	5	8

TABLE 2: MOST SEVERE INJURIES SUSTAINED BY ELITE RUGBY PLAYERS [8]

Injury	Number of injuries	Average severity (days)
Anterior cruciate ligament	1	235
Knee cartilage/degenerative injury	1	155
Rotator cuff/ shoulder impingement	3	71
Cervical disc	1	45
Thoracic facet joint	3	35

The most severe knee injury sustained by rugby players, as determined by the number of days' play missed, is injury to the ACL. It accounts for 29% of days missed due to injury [18]. This is closely followed by injuries of the medial collateral ligament (MCL) (25% of days missed). Chondral and meniscal injuries and patellofemoral pain syndromes were other knee injuries commonly reported [18].

Hamstring injuries are a common leg injury and account for on average 17 days missed [9,11]. Running accounted for 68% of these injuries, although kicking was associated with the more severe hamstring tears [11].

Shoulder injuries result in the greatest loss in player time (days), second only to the knee in rugby [8,9]. The number of shoulder injuries sustained by rugby players relative to all other joints is between 6 and 19% [5,6,46]. The most frequently described shoulder injuries include acromioclavicular injury, shoulder or rotator cuff impingement syndrome and shoulder dislocation/instability [5,8,9,32]. Damage to the acromioclavicular

joint (32%) and rotator cuff injury or shoulder impingement (23%) accounted for the greatest number of shoulder injuries [32]. However, dislocation or shoulder instability, which accounted for 14% of shoulder injuries to rugby players, accounted for 42% of days missed due to injury. As a result, dislocation is the most severe shoulder injury experienced by rugby players [32].

Although the head and neck accounted for a greater proportion of injuries than the shoulder, a large proportion of these injuries were lacerations to the face and neck, and concussion, which fall outside of the scope of this document [5-9].

Injury and playing position

When the injury incidence was assessed with respect to playing position, the most common injuries amongst the forwards were anterior cruciate ligament injuries, knee meniscal injuries and shoulder instability and dislocation, in that order [9]. The backline players' most common injury in this group was the hamstring muscle injury, followed by shoulder instability/dislocation and medial collateral ligament injuries. When the types of training injuries sustained in professional rugby are assessed, the injuries are largely muscle and tendon injuries [10]. The backline players sustained injuries to hamstring, hip flexor/quadriceps and adductor muscles in that order. The forwards also sustained a large number of hamstring injuries, but these were followed by lateral ankle injuries and lumbar disc nerve root injuries.

Type of injury

Muscle and tendon injuries account for between 20 and 50% of the injuries sustained while joint and ligament injuries account for between 26% and 41% of the injuries sustained by rugby players [5,8,9].

Severity of injury

Severity of injury in rugby is determined by the number of days' play missed. Injury to the knee accounts for the greatest number of playing days missed and as such were classified as severe [5,8,9,18,30].

In a study investigating elite Australian rugby players, 56% of all shoulder injuries were severe [5]. In this study, 80% of these severe injuries were dislocations and all of these players required surgery, resulting in many days of missed play. A further study found that dislocations accounted for 123 days' absence for every 1000 playing hours.

Recurrent injuries

The recurrent injuries were usually more severe and resulted in more days' play lost than acute injuries [9-11]. This finding suggests that the initial rehabilitation of the player was not sufficient and/or, the player returned to play too soon. It is for this reason that it is critical that all members of the medical team,

coach and player be involved in planning the appropriate course of treatment and timeline for the return to play following injury.

Mechanism of injury

In brief, the vast majority of injuries are sustained during contact, with the tackle being the most common form of contact resulting in injury [5,8,9,18,27,29,70]. The most common mechanism for hamstring and other lower limb muscle injuries was running or endurance running during training [10,11]. Kicking also accounted for a small number of hamstring injuries [11]. It is important to understand the forces involved in injury development as this will impact both the intensity and duration of rehabilitation programmes.

STAGES OF HEALING

When a player is injured there are a number of stages of healing that the injured tissue has to go through to enable the player to return to play, and the tissue to return to a functional healthy status. The stages of healing presented here are biased to muscle injury and healing. However, slight differences in healing times and management may exist between the different soft tissues, and these will be highlighted in a later section. There are 4 stages in the management of soft tissue injuries that require specific, evidence-based management following the damage to the soft tissue: [1] the time of injury, [2] inflammatory (lag) phase, [3] fibroblastic (regeneration) phase and [4] the remodelling phase [35] (Figure 1). Phases 1 and 2 are cumulatively described as the destruction phase, during which muscle damage, necrosis and resultant inflammation occurs [42]. Management of the player in each stage will be discussed briefly and the responsibilities of the medical team highlighted. This model of healing has been largely described in muscle but is applicable to all soft tissue healing [35,36,42].

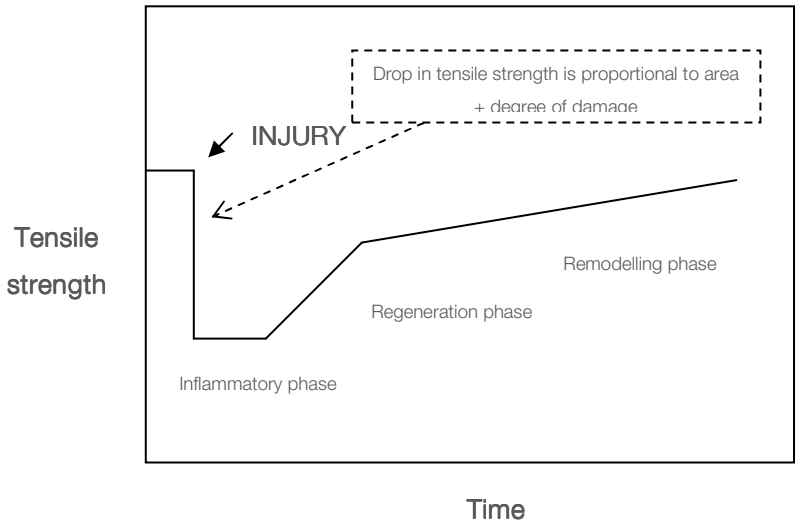


Figure 1. The stages of healing reflected according to the tensile strength associated with each phase (Modified from Hunter, 1994)

(a) Time of injury

When a player is injured there is an initial drop in the tensile strength of the soft tissue [24]. This drop in tensile strength is proportional to the degree of tissue damage [35]. During this phase of tissue 'destruction', tissue necrosis begins and a haematoma is formed.

Clinical management: The management of a player begins at this critical stage. It should be the primary aim of the physiotherapist, doctor, trainer or coach to reduce the impact of this injury. Continued play during a game may increase the seriousness of the injury and extend the duration of the healing process. It is therefore essential that if a medical professional declares that a player's injury requires removal from the field, the coaching staff support this decision and do so immediately. Further measures to decrease the risk of secondary damage would include factors such as immobilisation, crutches, RICE and advice on injury management in the next 24-48 hours. This can be undertaken by a physiotherapist or doctor. It is essential that a thorough investigation be done as soon as possible to determine the extent of injury.

The reduction of further damage is the critical factor at the time of injury.

(b) Inflammatory phase (lag phase)

This phase lasts approximately 4-6 days [68]. This is the preparation phase for healing. Inflammatory cells enter the site via the torn blood vessels [79]. A very delicate network of fibrin is laid down, which will mark the site for the deposition of collagen [57,85]. This network is very fragile and needs to be protected to prevent disruption, which may lengthen the healing process [35]. There is bleeding into the tissue and cytokines are released, which signal macrophages and leucocytes to the injury site [72]. These inflammatory cells have a dual function. They clear up the cellular debris and signal tissue repair [31,54]. These cells increase in number with movement and decreases with immobilisation [57]. Clinically the role of medical professionals during this phase would be to strike a balance between too little inflammation and too much inflammation. The physiotherapist is usually the professional in charge of this phase although the process may be started by a medical doctor.

Clinical management: Fundamental to this phase of healing is a period of rest/immobilisation. It is advised that rest for a period of 3-5 days (this recommendation is derived from results of experiments on rats) is beneficial in limiting the extent of the scar tissue and making the scar less dense [60]. This is preferable, as a dense scar is less extensible and may be prone to repeated rupture. Immobilisation or rest should not be for an extended period as this will compromise the ultimate strength of the tissue. To further control the extent of the inflammation the use of the principles of rest, ice, compression and elevation remain critical [35,41]. The use of frictions is not advised as this will prolong the phase of inflammation. Furthermore, there is no collagen or adhesions at this time making the basis for frictions treatment irrelevant [35].

A "hands off" approach with a short period of rest is critical in this phase.

(c) Regeneration/repair phase

This phase lasts from day 5 to 10-12 weeks [35]. The repair/regeneration and remodelling phases overlap and may occur concomitantly [49]. Two processes occur during this phase. Firstly, there is regeneration of the ruptured ends of the myofibres until they adhere to the scar [82], and secondly there is the formation of connective tissue scar [42]. The greatest increase in tensile strength occurs during this stage, as a result of collagen being laid down [68]. Initially collagen Type III is deposited, with collagen Type I only becoming more evident later [57]. As the collagen Type I is deposited, so the tensile strength of the scar increases [57]. The result of this process is a small connective tissue mass. The size of the scar is greater the longer the period of immobilisation [57]. A further motivation for early mobilisation during this phase is that the two intact and regenerating ends of the myofibres need to adhere to the lateral extracellular matrix to provide stability to the scar and prevent the ends of the muscles being pulled away from each other during muscle contraction [47]. Mechanical stress is essential for this process to occur [47]. By Day 10 after the

injury the weakest link of the injured muscle is not the area of the scar but the adjacent muscle [48]. However, despite this more time is needed to restore the muscle to its pre-injury strength. If there is significant trauma, but more importantly a re-rupture resulting in an excessive and prolonged inflammatory process, a dense scar is formed [39]. This is not a functional scar and may place the player at risk of further injury. For this reason it is critical that players do not return to play too soon and so risk this process occurring. This phase is managed by the physiotherapist but a biokineticist may become involved towards the end of this phase during the exercise rehabilitation.

Clinical management: The aim of this stage is to ensure that the collagen is laid down in an organised fashion to assist in accelerating the increase in the tensile strength of the wound [80]. This is achieved by careful tensioning of the injured areas using stretching and specific soft tissue mobilisations [35,36], and general mobility of the area and joints above, around and below the lesion. Rehabilitation in the form of exercise therapy must be initiated during this phase to increase the strength of the muscle tissue adjacent to the scar and to facilitate a healthy, functional scar being laid down.

A "hands-on" approach now occurs with techniques to tension the scar in the line of the tissue.

(d) Remodelling phase

This phase begins at around 21 days and can continue for 6-12 months [68]. This phase only starts when the collagen being laid down (synthesis) is equal in rate to the collagen being absorbed (lysis). At this stage the increase in tensile strength, which is slower than during the regeneration/repair phase, is due to cross-bridge formation and not additional collagen being deposited [35,68]. Furthermore, the collagen fibres tend to contract during this phase [22]. The aim of this scar contraction is to bring the two ends of the regenerating myofibres together until they become interlaced, although it is unlikely that the ends will ever meet [47]. This would result in that area of the muscle potentially shortening. Although the strength of the scar at this stage is still reduced, a study found that the injured muscle had restored strength by 21 days after the injury when the entire muscle was evaluated as a whole [48]. For that reason rehabilitation and strengthening, in addition to increased tensioning of the scar, must be undertaken. It is important to note that the injured site is still vulnerable at this time and that appropriate strengthening is critical in protecting the wound. This phase is managed by the biokineticists and physiotherapists.

Clinical management: The management of the patient at this stage includes continued stretching, while specific soft tissue mobilisations are critical to ensure optimal length of the muscle [35,36]. Rehabilitation to reduce the effect of any identified risk factors is important. It is essential that the rehabilitation and training be sufficiently vigorous to prepare the injured tissue for the demands of the game. The player will have returned to rugby during this phase and will have ceased physiotherapy or individual rehabilitation

while this process is still continuing. For this reason, continued strengthening and stretching by the player is important.

Continued stretching and the inclusion of functional (skills) rehabilitation is important.

This section provides a detailed description of the soft tissue stages of healing. The principles of healing are fundamental to all tissues although there are differences, which will modify and alter the type of treatment administered. These differences will be discussed below.

GRADING OF INJURIES AND SPECIFIC MANAGEMENT PROTOCOLS

Muscle strains

The muscle injuries sustained in a contact sport such as rugby are most likely to be contusions or strains [42]. The clinical Grading system for muscle injury is presented in Table 3 [41,42]. The healing of muscle strains or contusions follows the stages of the healing model presented previously.

Specific management of muscle strains and contusions

The current best practice treatment of muscle strains are based for the most part on theoretical models with limited evidence for their efficacy. These are presented below:

1. An initial period of immobilisation to protect the scar is followed by early mobilisation thereafter to provide an early return of biomechanical strength [42,66]. The use of crutches and strapping is advocated for lower limb injuries during the immobilisation [42,53]. The players are advised to move carefully in the ensuing 3-7 days but to begin mobilisation in the form of isometric contractions, active movement and soft tissue mobilisations [35,42].

Table 3. The grading system for muscle strains [42]

MUSCLE TEAR CLASSIFICATION	MUSCLE DAMAGE	LOSS OF FUNCTION	ASSOCIATED SYMPTOMS
Mild (1st degree)	Few muscle fibres torn	Minimal loss of strength and function	Mild swelling. Pain with contraction and stretching. Mild muscle spasm.
Moderate (2nd degree)	Greater degree of muscle damage	Clear loss of function	Moderate to severe swelling. Significant pain with contraction and stretching Moderate to severe spasm.
Severe (3rd degree)	Tear extends through cross section of muscle	Severe loss of function	Moderate to severe swelling. No pain with stretching and mild pain with contraction. Moderate to severe muscle spasm.

2. RICE. Initial REST is advocated to protect the scar as mentioned above. ICE has been found to decrease both the size of the haematoma and inflammation [19,38]. COMPRESSION decreases the intramuscular blood flow [78] and ELEVATION decreases the accumulation of interstitial fluid [42].

Combined ice and compression should be applied in the following way: 15-20 minutes in duration, repeated at intervals of 30-60 minutes [18,66].

3. The use of isometric, isotonic and isokinetic training, in that order, should be introduced from 3-5 days within the limits of pain [41,42]. A single study has found that a trunk stabilisation and agility programme decreased the rehabilitation time before returning to sport and reduced the risk of injury when compared to a study which concentrated solely on strengthening and stretching the injured hamstring [75]. As such the rehabilitation may start on the isolated muscle strengthening but should always progress to involve rehabilitation of the kinetic chain as a whole.

4. Stretching is important to counter the contraction of the scar and reduce the body's resistance to stretching [69].

5. The role of non-steroidal anti-inflammatory drugs remains somewhat controversial. Orchard et al., (2008) [66] presented the opinion that the automatic use of anti-inflammatories be discouraged as it masks the pain of injury that may result in a return to sport before the tissue is appropriately healed. Furthermore, injudicious use of non-steroidal anti-inflammatory drugs interferes with inflammation which is an important biological process associated with healing and regeneration.

Time off rugby: This will be dependent on the severity of the strain or the state of recurrence. Return from a hamstring strain takes an average of 17 days, recurrent hamstring strains take 25, and a hamstring injury sustained while kicking takes 36 days to return to play (Brooks et al., 2006).

Ligament sprains

Ligaments are connective tissue structures that connect one bone to another, provide joint stability and an awareness of the joint in space. Injury to the ligament therefore affects its ability to stabilise the joint and control movement of the joint [1]. The time to return to play following ligament injury is dependent on the severity of the injury and is very specific to the location of the ligament [61]. Ligament injuries are graded in a similar fashion to muscle injuries (Table 4).

TABLE 4. THE GRADING SYSTEM FOR LIGAMENT SPRAINS [13]

GRADE	LIGAMENT DAMAGE	JOINT STABILITY	ASSOCIATED SYMPTOMS
Mild (1st degree)	Few ligament fibres torn	No loss of joint stability	Local tenderness
Moderate (2nd degree)	Greater proportion of ligament damage	Increased joint laxity. Definite end point when stressing ligament.	Swelling Marked tenderness
Severe (3rd degree)	Complete tear of ligament	Significant joint laxity when stressing ligament with no definite end point.	Significant swelling Tenderness can be mild to severe. May be pain free.

Healing after ligament injury follows the same process as that outlined in the stages of healing [25]. However, healing is very ligament specific with some ligaments requiring surgery [62]. The medial-collateral ligament (MCL) in the remodelling phase (phase 3) is not able to withstand load as effectively as a healthy ligament [25]. The whole process of remodelling can take between 6-12 months and even after this phase the strength of the scar is consistently weaker [61]. In some cases (i.e. the ACL), healing is unlikely to occur and due to the resultant joint instability surgery is required [33].

Specific management of ligament injuries

1. RICE (Rest, ice, compression and healing is important for healthy scar formation)
2. Mobilisation. Early mobilisation in the first 3 weeks may be detrimental to collagen orientation and should be minimised [64]. However, following this time frame mobilisation is essential to increase tensile strength of this ligament. Additional modalities such as massage and electrotherapy, in particular laser, may be useful [13,62].
3. Surgery: This is frequently an option, particularly in the anterior cruciate ligament (ACL) of the knee [2].

4. Exercise rehabilitation: This is essential to increase the stiffness and strength of the healing ligament [86]. The principles of muscle strengthening, proprioception and functional training are essential for return to play [13].

Time off rugby: Again the time off rugby is dependent on the severity and location of the injury. However, the following basic guidelines for ligament injury and return to play may be used. The following performance deficits exist for the different grades of injury [56]:

- Mild ligament sprain: Minimal deficit lasting a few days
- Moderate ligament sprain: Performance deficits lasts up to 6 weeks but may be improved by protective bracing
- Severe ligament sprain: Performance deficits may be permanent, and will be apparent for a minimum of 6-8 weeks. If surgery is required, return to sport will take months and will be guided by the orthopaedic surgeon.

Ligament healing of partial ligament injuries takes several months. However, return to sport may occur earlier, especially if added protection is provided to the joint in the form of bracing or strapping.

Tendon injury

The histopathology of tendon injuries is quite different from that of ligament and muscle injuries, although it is accepted that there is an inflammatory response to macrotrauma or mechanical loading in acute tendon injuries. Hence, this is termed tendinitis [73]. Inflammation is also found in the paratendinous structures [55]. However, inflammation is not a phase observed in chronic tendon injuries [17,51]. The pathology process is more degenerative in nature and is referred to as a tendinopathy.

Histologically there are a number of changes:

1. There is a change in cell function with an increase in tenocyte formation [3].
2. This leads to an increase in the amount of ground substance [3].
3. Collagen degradation occurs with replacement of Type I collagen with the weaker Type III collagen [23,51]
4. Neovascularisation occurs with collagen degradation [3].

As these components of tendon pathology are also involved in the repair process, tendinopathy is referred to as a failed healing response [17]. Healing of tendon injuries is reported to be sufficient to allow

function but never appears to reach a point of completion [26]. Healing is a prolonged process in tendon injuries. The metabolic rate is slower in tendons than in muscle and it can take 2-3 weeks for a tissue response to occur [45] and more than 100 days to synthesise collagen [81]. As such, the rehabilitation of a chronic tendon injury takes months and not weeks.

There is no reliable grading system for tendinopathies and the grading of mild, moderate and severe is commonly used [13] (Table 5).

TABLE 5: THE GRADING SYSTEM USED TO CLASSIFY TENDINOPATHY [13].

Grade	*Symptoms*
Mild	Pain is felt after the activity. If pain is felt after activity it disappears when activity stopped
Moderate	Pain during sporting activities but not during activities of daily living
Severe	Pain during activities of daily living

Specific management of chronic tendon injuries

1. Relative rest is required to initiate healing. As the tissue response only occurs at 2-3 weeks modification of the load on the tendon is beneficial. Complete rest and immobilisation causes weakening of the tendon, so it is preferable to rather decrease the load, to decrease pain and so facilitate rehabilitation [16].

2. Electrotherapy and ice traditionally used in the first phase of treatment of muscle and ligament injury is not proposed in the management of chronic tendon injuries because they are used to treat inflammation, which is not a component of chronic tendon injury [52].

3. Rehabilitation: As with all injuries, exercise rehabilitation is the cornerstone of a successful treatment. Exercise rehabilitation is successful in treating chronic tendon injuries [44,76,77]. The following factors are important for successful exercise rehabilitation in these patients:

    a. Unlike the rehabilitation of muscle injuries, a degree of pain is allowed when rehabilitating tendon injuries, as a number of studies have demonstrated excellent results when allowing a degree of pain [44,76].

    b. Eccentric loading is an essential component of the rehabilitation programme [44,65,76]. The mechanism behind the effectiveness in treating tendinopathy is not clear.

    c. Eccentric training programmes have a significantly greater effectiveness if performed outside of the player's competitive season [84,87].

d. Although there is little evidence linking trunk stability and control with lower limb tendinopathies, it is still regarded as an essential component of the rehabilitation [52].

e. Stretching to increase ankle dorsiflexion ROM and the range of movement of the hamstring and quadriceps is necessary [52].

4. Orthotic intervention may be useful in Achilles tendinopathy [52].

Time off rugby: Due to the slow healing rate of tendons, return to sport can take months and not weeks when treating effectively.

Bone injury

There are 2 distinct types of bone injury that can occur: fractures and stress fractures. The healing of bone follows the 3 phases of healing, namely inflammatory, repair and remodelling.

Fractures: Unlike the healing of other tissues, bone healing happens by a process of regeneration during which the ends of a fractured bone that are in contact regenerate to form a united fracture. During the repair a callus is formed, which is referred to as clinical union. However, full function can only occur when consolidation of the bone is achieved. Healing times for fractures vary depending on the site of the fracture and its severity.

Specific management of fractures

1. A fracture needs to be reduced and then maintained in that position with the use of pins, plates, plaster cast or braces. This management of the fracture from reduction to healing will be overseen by an orthopaedic surgeon. Many of the decisions regarding mobilisation and loading will be done in consultation with the surgeon.

2. This is followed by a period of immobilisation to allow the bone to unite and consolidate. This area of immobilisation for the fracture needs to be limited to reduce the negative impact of immobilisation on both the muscles and bones in the area [40,50].

3. Management of the soft tissue surrounding the fracture and the joints above and below follows the standard principles and modalities of soft tissue healing but are restricted by the loading and movement permitted around the fracture site.

Time off rugby: Healing time for fractures vary from 6-12 weeks in the upper arm to 8-20 weeks in the lower limb depending on the location of the fracture [4]. The further the location of the fracture is from the midline the longer healing will take. Once consolidation has taking place there must be a gradual increase

in the loading of the bone. As a result the time off rugby will be months once the rehabilitation programme is complete.

Stress fractures: Remodelling constantly occurs in bone. Stress fractures are the result of repeated micro-trauma that is not corrected adequately by this remodelling phase. The time from diagnosis to return to sport is determined by the site of the stress fracture, length of the symptoms pre-diagnosis and the severity of the lesion [50]. Stress fractures can be graded, using imaging, from mild (bone strain) to severe (bone stress) [13].

Specific management of stress fractures

1. The management of stress fractures includes an avoidance of the activity that is associated with the stress fracture development [13]. However, continued activity that does not load the area of the stress fracture is necessary to maintain fitness levels and rehabilitation needs to start early to correct certain risk factors which may have been identified.

2. Strengthening the muscles is important when managing stress fractures as this increases the amount of force that can be absorbed by the muscle, and so decreases the load on the bone [74]. Similarly, flexibility and stability need to be evaluated and treated.

Time off rugby: An uncomplicated stress fracture takes 4-8 weeks to heal before the player can return to sport. However, as a result of the loading nature of the sport the return to sports activity must be done gradually to prevent overloading and recurrent injury at that site.

It is important to note that the healing, grading and treatment of muscle, tendon, ligament and bone injuries is given as a guideline. There are a number of factors which influence the time off rugby and therefore need to be considered when the management is planned and implemented.

PHASES OF REHABILITATION

The management of injuries for the stages of healing has been established. Dynamic loading in the form of exercise rehabilitation can be started as soon as the repair phase has begun (Figure 2).

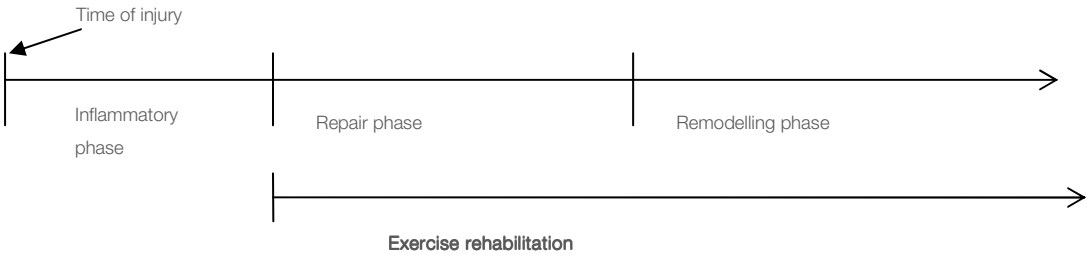


Figure 2. The interaction between the stages of healing and exercise rehabilitation.

Exercise rehabilitation for an injury is classically described to have 3 phases (cognitive, associative and autonomous [67,71]. For the player, an additional phase relevant to return to play is added. The aims of the four phases are presented in Table 6.

TABLE 6. THE PHASES OF EXERCISE REHABILITATION OF THE INJURED PLAYER

	Phase 1 Cognitive phase	Phase 2 Associative phase	Phase 3 Autonomous phase	Phase 4 Return to play
Aims of the phase	To activate and isolate the local stabilisers of the joint	To retrain movement patterns and isolated muscles	The aim is dynamic stabilisation with emphasis on skill training and functional rehabilitation.	This includes the process by which the player returns to the team in a graded process until full return

A summary of rehabilitation based on the 3 stages of healing is presented in Table 7. This table presents the member of the support team responsible for each phase and the basic management associated with each phase.

TABLE 7. THE SUMMARY OF THE REHABILITATION PROCESS OF A PLAYER ACCORDING TO THE STAGES OF HEALING.

Phase	Duration	Description	Management	Phase managed by
Injury event		Strength of tissue drops, tissue tears, bleeding starts	Reduce impact of injury. Remove from field. Immobilise.	Physiotherapist, doctor, medic, or coach.
Inflammatory phase	1-5 days	Inflammatory cells enter the injury site and a delicate scar network is formed. There is no increase in tensile strength.	RICE. Immobilisation for the first 1-3 days.	Medical doctor or physiotherapist.
Regeneration phase	Day 5-10 to week 10-12 (Dependent on the extent of the damage)	Collagen is laid down and a scar is formed. There is a gradual increase in tensile strength.	Mobilisation of the scar and joints. Exercise rehabilitation and stretching.	Initially physiotherapist, biokineticist may become involved later in the phase.
Remodelling phase	Starts around Day 21 to 6-12 months	Strength increases as cross-bridges (connections between muscle fibres) are formed. The scar starts to contract.	Stretching is essential. Continued strengthening of the muscle unit occurs.	Physiotherapist, biokineticist, trainer and coach

For the rehabilitation process to be successful, communication between the medical team, player, coach and trainer is critical. An interdisciplinary approach to the player's injuries has been described [14]. The ideal scenario would involve the medical team (team doctor, physiotherapist, biokineticist), trainer, coach, player and any other necessary people meeting at the time of the injury and discussing diagnosis and management to ensure that each member of the team supports the process being undertaking prior to starting the rehabilitation.

RETURN-TO-PLAY

Return-to-play is defined as *'the process of deciding when an injured or ill player may safely return to practice or competition"* [59]. Early return to training and sport are considered sensible goals if the rate of return is based on the muscle affected, the severity of the injury and the position of the player [66]. This should remain true for most injuries although the time-frame for returning to rugby may be different due to the contact nature of the sport.

There are 2 basic principles guiding the return to sport specific training following a muscle injury. Firstly, the flexibility of the injured tissue should be the same as the uninjured tissue, and secondly, there should be pain-free use of the muscle during basic movements [42]. This is a sensible guideline to use for all injuries.

Radiological evidence of tendinopathy may persist for longer than the symptoms [15], so assessment of return to sport needs to be made on the basis of reliable outcome measurement tools and specific clinical tests [52]. Regular evaluation using questionnaires such as the VISA questionnaire for patella and Achilles tendons allows progress to be monitored throughout the rehabilitation programme [83]. Functional clinical tests to assess the muscle tendon function (such as heel-raise test) and pelvic and lower limb kinetic chain function (such as a number of the hop test) need to be constantly evaluated to ensure rehabilitation is progressing.

Guidelines for return-to-play are difficult to apply as there are a number of factors which may influence the recommendations [59]. Firstly, there is a medical component, which is constantly changing as the base of knowledge improves. Secondly, social and economic factors constantly influence a player's return to play, especially with regards to income. Thirdly, the "political" influence of who makes the final decision on return-to-play, has an impact on the decision. Finally, the legal issues surrounding return-to-play, and the medical team's responsibility with regard to player safety need to be considered. For this reason it is imperative that guidelines for return-to-play be compiled by the medical support team to ensure that there is a standard process which can be followed. Although there are already a number of return-to-play documents prepared for different types of injuries (e.g. shoulder instability and lumbar spine conditions [21,58] it is important that each team develops its own guidelines.

Once a player has been medically cleared to return-to-play there are some fundamental steps that need to be followed:

1. The player has to fulfill the fitness standards of the team he is returning to.
2. The player needs to pass some skill specific tests applicable to his playing position.
3. The player may then begin practicing with the team.
4. Exposure to the match situation should be gradual, with the match time gradually increasing.

There are simple guidelines which need to be developed by each team with contributions and support from each member of the medical team.

CONCLUSION

This document has provided evidence for principles of best practice relative to muscle, tendon, ligament and bone. Guidelines have been provided with regards to the process and the time-frame associated with injury to these tissues. Below is an example of how these principles have been applied to a hamstring injury in a rugby player.

CASE STUDY EXAMPLE

A brief case study of a 24-year-old with recurrent hamstring injury to his right leg is presented to demonstrate the treatment of a patient with respect to the stages of healing. This is a common injury amongst rugby players. Further, the risk of a hamstring injury recurring is high.

A 24-year-old rugby player sustained a hamstring injury while sprinting for the tryline in the second half of a game. He felt his hamstring "go" and stopped running abruptly. The physiotherapist attended to him on the field. The player was assessed on the field and based on pain and inability to straight leg raise beyond 40º, was removed from the field. Clinical findings and an ultrasound confirmed a Grade 2 injury of the right hamstring. This was a recurrent injury, with the primary injury occurring two weeks prior.

Immediate management The player was removed from the field. The principles of RICE (rest, ice, compression and elevation) were applied. The patient was placed on crutches and given a compression bandage.	(a) Crutch walking (b) Ice therapy  
Management of the inflammatory phase Immobilisation was continued for 2 days. Then gradual weight bearing was started. RICE was continued. Ultrasound treatment was provided from Day 2.	(a) Ultrasound 

Management of the repair phase

Specific soft tissue mobilisation (SSTM) was started on Day 5. This involves transverse mobilisation of the soft tissue to provide mechanical loading for the developing scar. By the start of week 3, the SSTM was combined with a physiological stretching position to further load the scar. Graded stretching was started on Day 5. Stretching was done to a point short of pain by the start of week 3. This was done with minimal discomfort. Dynamic loading in the form of exercise rehabilitation was started at this stage. This included a progression from isometric, to concentric, to eccentric loading (The exercise rehabilitation programme initiated in this phase is discussed in detail below).

(a) Specific soft tissue mobilisation (SSTM)

These techniques apply a longitudinal tension by exerting a pressure 90º to the soft tissue [35]

(b) Physiological loading

A longitudinal stretch is applied by the therapist [35]

(c) Combination of (a) + (b) [35]

Management of the remodelling phase Exercise rehabilitation is the primary focus of this phase. The player continued through until functional and skills rehabilitation was complete.	Rehabilitation protocol is presented below. Stretching: 3x30 seconds, 3xdaily. This is started in the repair phase but is only done to the point of mild discomfort.   

Exercise rehabilitation: This included hamstring and trunk stability rehabilitation, which proceeded to full-body, functional rehabilitation.

Initial or cognitive phase (Day 5-8) This included isometric contractions of the hamstring muscle and isolation of the transversus abdominis.	(a) Isometric contraction of the hamstring muscles. (b) Isolation and activation of the transversus abdominus. 

Dynamic loading or associative phase (Day 6-14)

This phase included simple exercises aimed at both the isolated hamstring muscle and basic trunk stability exercises. Exercises included hamstring wobbles, bridging, bridging on the ball, segmental bridging.

Hamstring exercises

(a)Hamstring wobbles [37]

(b) Bridging series on the ball

(c) The 'interflora'

(d) Cycling (non-weight bearing) for cardiovascular fitness

Functional loading or autonomous stage

The stage was characterised by functional loading activities and the introduction of skills training. Exercises included the diagonal arm squat, bridging with leg extension, and ball crunches. Functional loading included a graded running programme (started at Day 10) in straight lines, progressing to multiple directions by the 3rd week. Agility and ladder drills.

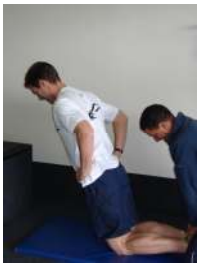
Advanced hamstring exercises

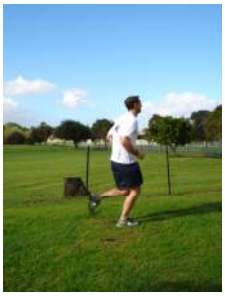
(a) Alternate leg raise from bridging on ball

(b) Diagonal arm squat

(c) Ball crunches

(d) Forward lean of trunk from kneeling (37)



	Functional loading strategy (a) Walking-jogging-walking progressing to sprinting gradually with specific protocols  (b) Agility drills   

RETURN TO SPORT

This player joined practice at half pace (50%) at the end of week 3, progressing to a full practice by the end of week 4. He played the first half for the next 2 weeks and only returned for a full game by week 7. He continued with his hamstring stretching and functional rehabilitation exercises for 6 months after the injury.

AUTHOR'S BIOGRAPHY

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