

CLINICAL APPROACH TO THE SPRINTER WITH REPEATED HAMSTRING MUSCLE INJURIES

– Written by Nicol van Dyk, Qatar and Phil Glasgow, Ireland

INTRODUCTION

It's almost ten o'clock on a perfect Saturday evening in London. The capacity crowd at the Olympic stadium waits anxiously, smart phones ready, to witness Usain Bolt in his final race. He missed out on the gold in the 100 m, but the 4 x 100 m relay has always been his favourite event. Will this be the fairytale finish for the greatest sprinter of all time? As they enter the final bend, Jamaica sits in third – pressure's on! And then despair; the inconceivable happens – he goes down... with a hamstring injury (Figure 1). A cruel reminder of the small margins that exist between running your best and injury in elite competition. And for this athlete, as for many, it was an injury he had to deal with repeatedly.

Hamstring injuries are the most common injury among elite track and field athletes, especially sprinters and jumpers^{1,2}. It continues to challenge the medical team

and performance staff in both management and return to sport decision-making, as well as structuring training load appropriately to match competition demands. Re-injury rates after first time hamstring injury, range from 0 to 60 per cent^{3,4}. Often it is not just one re-injury, but a pattern of similar injuries that may develop. This often leads to athletes getting stuck in the “chronic rehab” cycle, frustrating both the athlete and clinician, and creating a barrier to successful return to performance.

Rehabilitation and prevention of hamstring injury receives a great amount of research and clinical attention; recently both elite clinical expert review and randomized control trials have allowed us to understand which elements in our approach might prove more effective in managing these injuries. Yet we regularly see athletes with repeat hamstring injuries. In this article we will describe important considerations

when dealing with an elite track and field sprinter experiencing repeated hamstring muscle injuries.

NOT ALL HAMSTRING INJURIES ARE THE SAME, SO HOW DO WE APPROACH REHABILITATION?

This seems to be uncontroversial and intuitively not all injuries would behave the same. Hamstring strains are heterogeneous, and differ in type, location and size⁵. Most hamstring strains are located to the proximal myotendinous junction, although the anatomy is complex, characterised by overlapping tendons and morphological architecture between the different hamstring muscles. But what are the characteristics or qualities that would demonstrate differences in these injuries, and which principles would help us to adjust our approach to each of these different types of hamstring injury?



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Figure 1: Usain Bolt immediately after suffering a hamstring injury during the 2017 World Championships in Athletics at the Olympic stadium in London.

DIFFERENTIATING QUALITIES

Clinical diagnosis

The clinical diagnosis of a hamstring injury is relatively straightforward. Track and field athletes are most likely to experience a hamstring injury during sprinting (high-speed running type), while injuries due to excessive lengthening of the hamstrings (stretching-type) are much less frequent⁶. Differences in the rehabilitation period have been suggested depending on the type of injury; a shorter rehabilitation period expected with high-speed running type injuries.

It is important to make sure a careful history taking is conducted, listening for subtle cues that might identify why repetitive injuries are occurring. We suggest attention to self-perceived readiness after previous injury, changes in training demands (e.g. when junior athletes join senior squads) and competition scheduling. The clinician will then try and identify pain on palpation and deficits in muscle strength and flexibility compared to the uninjured side. The distance between the ischial tuberosity and the point of peak palpation pain has been suggested as an indicator of rehabilitation time (i.e. the

closer to the ischial tuberosity, the longer the rehabilitation period)³. Another useful way of determining severity appears to be the length of time taken for the athlete to walk without pain.

Imaging/Grading

At an elite level, athletes often receive imaging, most often magnetic resonance imaging (MRI). The MRI can be used to assist in identifying more severe injuries (such as full thickness tendon injuries or involvement of the intramuscular tendon), which may influence treatment strategies. However, the usefulness of imaging (and subsequent grading) to determine the prognosis of the injury is debated. If available, imaging is useful to confirm suspicion of a complete rupture (grade 3) or where there is no visible pathology (grade 0) (Box 1), as this will inform rehabilitation approach⁷⁻⁹.

Intramuscular tendon

Recently, there has been much discussion regarding the approach to athletes who suffer a hamstring injury that involves intramuscular tendon (sometimes referred to as the central tendon, or these injuries as “intratendinous”). British track and field

athletes experienced a delayed return to play and higher recurrence rate for injuries with intramuscular tendon involvement¹⁰. If the injury was considered (and graded) as myofascial, then rehabilitation was aggressive and return to play earlier with no re-injuries. However, if intramuscular tendon was identified, eccentric loading was delayed and the introduction of running (and its progression) also delayed¹¹.

Although there may be a large amount of variability between athletes, clinicians might consider tendon healing interaction when planning their rehabilitation of an athlete with a repeated hamstring injury that involves the intramuscular tendon.

BOX 1: MODIFIED PEETRONS CLASSIFICATION^{5,21}

Grade 0: Negative MRI without any visible pathology.

Grade 1: Oedema but no architectural distortion.

Grade 2: Architectural disruption indicating partial tear.

Grade 3: Total muscle or tendon rupture.

REHAB IS TRAINING IN THE PRESENCE OF INJURY – OPTIMAL LOADING

How do we define successful rehabilitation? For the athlete, getting back to participation (goal focused) in the shortest possible time is often the main driver. The coach may be more concerned with the performance of the athlete when they return (performance focused), and time pressure is often based around competition schedules. Meanwhile the medical staff's primary aim is usually to prevent any subsequent or recurrent injuries (outcome focused). Understanding this contextual framework is key to successful rehabilitation of injury. It is suggested that successful rehab in the elite sporting context is one that meets each of these components (Goal, Performance and Outcome). In other words, successful rehab is returning the athlete to sport as soon as possible, able to perform at a high level and without re-injury.

From the outset, our goal in rehabilitation should be optimal loading of tissue.

What is optimal loading?

Optimal loading may be defined as the load applied to structures that maximises physiological adaptation and restores function.¹² Achieving optimal loading should be driven by variables such as the tissue type (muscle vs tendon), pathological presentation (grading or mechanism of injury) and the required tissue adaptation for eventual activity (force vs velocity).¹² Once there is clarity on the goals of loading (these may include increased tensile strength, collagen reorganisation, increased muscle-tendon unit stiffness or neural reorganisation) then an appropriate loading plan can be developed to stimulate these adaptations.

When designing a rehabilitation programme it is necessary to ask a number of simple questions:

- What is happening at a tissue level?
- What outcomes are you trying to achieve with your exercise prescription?
- What is the specific adaptation associated with different exercise types?
- Is this exercise being used primarily to reduce symptoms, stimulate tissue adaptation (tissue capacity) or enhance function (movement capability)?

A useful way to plan for effective loading of the tissues is to understand whether the loading prescribed is primarily aimed at 1) reducing pain or enhancing tissue

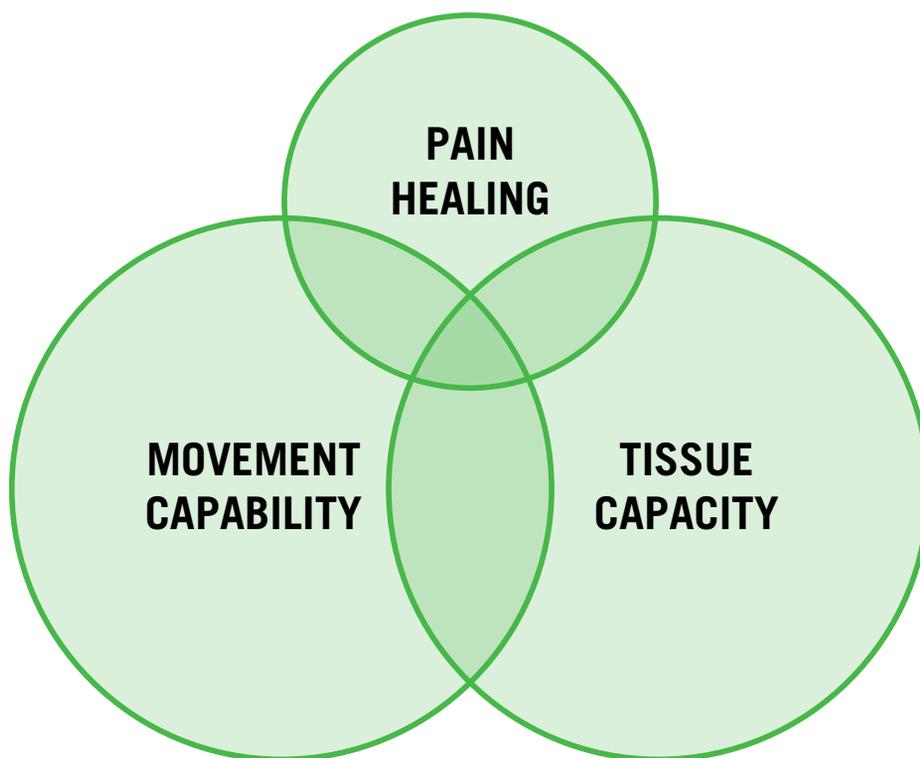


Figure 2: The three components that rehabilitation and/or treatment may be aimed after hamstring injury.

healing, 2) improving and expanding tissue capacity, or 3) incorporating and developing movement capability (Figure 2). Once the desired outcomes of an exercise are clear, it is possible to plan progressions to maximise adaptation. For example, where the goal of loading is to reduce pain and improve healing, exercise selection may be low-level isotonic exercise. While isometric training has been shown to reduce pain in tendinopathy¹³, it is suggested that controlled dynamic movement through range is more effective in reducing pain in muscle injuries¹⁴. Early isometrics may be helpful where there is involvement of the intramuscular tendon¹¹. Where the desired adaptation is increased fascicle length, the intervention may be eccentric loading and the progression will include addition of load, increased speed and range of motion¹⁵. In contrast, where the focus is increased rate of force development, the exercise may be a jump squat and progressions involve a move from high load power (80% of one repetition maximum (1RM) load) to low load power (30% 1RM load).

It is important that loading starts early and there is a logical and sequential progression for each of the training variables. Due to the multi-dimensional nature of sports rehabilitation, the support

team should be able to organize several parallel blocks with different goals and milestones¹⁴.

How do we achieve optimal loading?

Two key components in ensuring your rehabilitation programme will optimally load the injured tissue:

1. Apply basic training principles
2. Criteria-based rehabilitation

Rehabilitation is training in the presence of injury. This simple statement holds the key to designing a rehab programme that will deliver not only recovery from injury, but a robust athlete ready to return to sport. The influence of different combinations of intensity, volume and frequency of training on muscle adaptation has been widely researched in uninjured populations but very few studies have examined their use in rehabilitation.

During rehabilitation, we are trying to facilitate optimal loading of the injured tissue to allow healing while restoring tissue properties able cope with the demands of training and performance. The content of rehab closely resembles what any normal training programme would look like – finding the accurate and appropriate (read optimal) stimulus to drive adaptation in the tissue. We can therefore rely on the

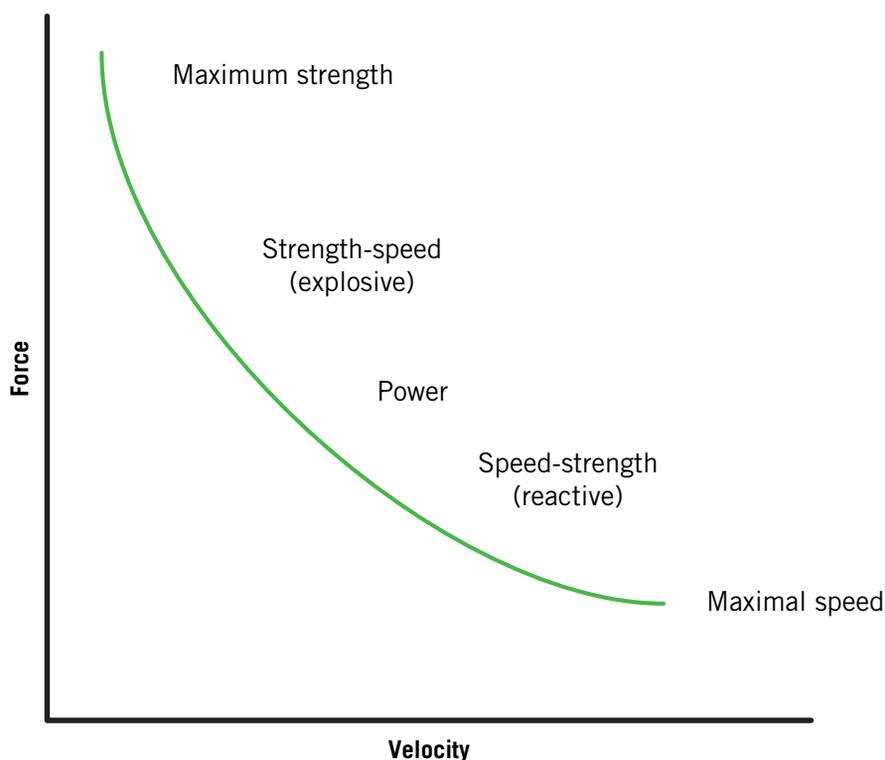


Figure 3: The force-velocity curve.

basic training principles to direct us in this process, guided by what we are trying to achieve in a session or week with the athlete.

A criteria-based rehabilitation protocol requires that set criteria (specific physical testing) is achieved prior to allowing progression to the next stage. The move towards a criteria-based progression protocol is crucial for successful rehabilitation and will allow the clinician to better integrate objective measures as well as subjective measures into the clinical reasoning process. Daily measurements of subjective pain, pain with palpation, range of movement or flexibility, and strength allows the clinician to adapt the protocol for the player on the day of treatment. This is done in conjunction with the presentation of the individual and allows the clinician to identify the response to the previous day's treatment. Using measurable outcomes to drive rehabilitation choices and exercise prescription diminishes the need for clinical sub-categorization, as the measures will demonstrate when an athlete is ready to progress and allow for the gradual progression of exercise to meet with the clinical presentation of the athlete¹⁶.

Since loading healing tissue beyond its elastic limit might result in further exacerbations, signaled by the presence of

pain with this loading, all exercises should generally be performed close to pain free limit. The main feature of any protocol for elite sprinters is the early but safe resumption of repeated high-speed running.

Are we missing something?

When managing athletes presenting with recurrent hamstring injury, it is important to review whether these goals are being met. Consider the exercise selection to improve tissue capacity, whether a longer period is needed for tissue adaptation allowing architectural changes to occur, or whether the shift towards movement capability has been too rapid. Attention to detail here in terms of symptom response, psychological readiness as well as effective execution of the exercises will inform more targeted progressions. There is no need to search for "miracle" exercises or training techniques. Instead, apply your clinical reasoning around how the key exercises that have demonstrated value in hamstring strengthening, such as the hip extension and Nordic hamstring exercise, may be used.

Manipulation of variables for the chosen exercises will allow more focused development of specific goals such as power, hypertrophy, strength or endurance.

Using the appropriate load and speed of the movement allows athletes to effectively "surf" the force velocity curve (Figure 3) and develop specific functional adaptations¹⁴.

It is not enough to isolate our thinking to the progressive increase in magnitude of load as tissue adapts, but we should also consider variation in the rate and direction of that load in order to facilitate motor learning and develop the appropriate coordinated motor strategies. During sporting activities, muscles are constantly 'tuned' to enable an individual to maintain position, move voluntarily and react to perturbation¹⁷. It is well established that injury and/or pain reduces the ability of an athlete to effectively 'tune' the motor system to a given task. While great attention has been given to the role of neuromuscular control (NMC) in ligament rehabilitation, it has often been overlooked in muscles. Importantly, when the rehabilitation process moves towards movement capability, movement variability creates adaptation that is ultimately also important for performance, sometimes referred to as "repetition without repetition;" a phrase that gained popularity from the experiments conducted by Nikolai Bernstein in the 1920's.

Running fast is a skill that should be re-trained when rehabilitating a sprinter with a hamstring injury. Early examples of this include sport-specific drills such A and B drills, skips and Ankling drills. During this phase, particular attention should be given to facilitating effective loading of tissues through functional patterns, maximizing myotendinous and myofascial energy storage and release and the ability to decelerate. Progression to high speed running should be gradual and in line with the criteria mapped out at the beginning of rehabilitation. At all times the quality of the movement is monitored and where maladaptive patterns are adopted, exercises should be regressed to ensure correct running form.

Often these athletes are the victims of chronic low training loads, putting them at greater risk of injury.¹⁸ It is therefore imperative that the rehabilitation period is used to reintroduce training volume, with regular sessions (if not daily) and the appropriate adjustment of each sessions to ensure gradual progression is achieved. Importantly, determine whether the athlete is achieving the critical velocities that is needed for return to sport and performance.

Wangenstein et al has demonstrated that almost 80% of re-injuries occur in exactly the same muscle in exactly the same location.⁹ This raises two important questions – was the rehabilitation process adequate to return to athlete not only to training, but also to the demands of competitive sport and performance? And secondly, was the injured tissue mature enough to meet the demands of the load it is placed under during high-speed running?

HAS THE ATHLETE TRAINED ENOUGH TO RETURN TO SPORT?

Return to sport is not a decision taken in isolation at the end of the rehabilitation process. Instead, return to sport should be viewed as a continuum, paralleled with recovery and rehabilitation (Figure 4)²⁰. Return to participation describes when an athlete is physically active, but not yet ‘ready’ (medically, physically and/or psychologically) to return to sport. While it is possible to train to perform, this does not automatically mean return to sport. This might overlap with the sport specific phase of the rehabilitation process, and treatment sessions will start to reflect regular training sessions. Return to sport defines what is usually considered the end of the rehabilitation process, and the athlete has returned to track training and their regular programme but is not performing at his or her desired performance level. Return to performance extends the return to sport element and the athlete has gradually returned to his or her performance (at or above the preinjury level). In track and field, this is characterised by qualifications standards for major competitions and personal best performances.



Figure 4: The three elements of the return to sport (RTS) continuum. Clare L Arden et al Br J Sports Med 2016. Recreated with permission.

As a consequence of injury, the athlete will naturally experience a decrease in workload, especially the chronic workload that accumulates over time¹⁸. With hamstring injuries, minor injuries might keep an elite sprinter out of training only for a week to 10 days. Nevertheless, an assessment of this change in workload is important as it may have an important impact when the athlete return to regular training. For sprinters with repetitive injuries, too often it is this miscalculation that causes a knock-on effect, where workloads become chronically reduced in a reaction to re-injury, and the athlete struggles to escape the “chronic rehabber” cycle.

For elite sprinters, it is possible to quantify the loads we are expecting athletes to endure when returning to sport, so an assessment of the workload should be included in the return to play decision-making process. Workloads may be evaluated in terms of the total distance, maximum velocities and the density (amount of metres covered at certain speeds) of the running sessions. It also important to consider workloads in terms of the tissue load (number of stretch-shortening cycles) and neural load (e.g. maximum efforts, explosive starts).

Another factor to consider is tissue healing. The approach at British Athletics is to be aggressive with injuries that are classified as myofascial (typically a shorter

rehabilitation period) than with injuries that are classified with intramuscular tendon involvement (typically a much longer rehabilitation period)^{10,11}. In Qatar, Whiteley et al reported that all athletes who re-injured had greater quadriceps and hamstring strength at return to sport than those who did not²¹. Although this cohort did was not exclusively sprinting athletes, we may consider whether the tissue (and scar tissue) has adequately matured to withstand the potentially greater forces. Usually these athletes who recover quickly with full restoration of strength would be seen as successful rehabbers, but we might be more cautious when return these athletes to training.

Typically, the return to sport period after hamstring injury is reported as 21 days^{22,23}, although the British Athletics team reported injuries with intramuscular tendon involvement may take twice as long¹⁰. The main processes involved in muscle regeneration, mainly the replacement of immature newly formed scar tissue and the growth of the fibres to their original size as well, continue beyond well beyond 30 days²⁴. This is important, as the space occupied by the original muscle fibres have been lost, so a strong growth stimulus will be required for the new fibres to regain their original space²⁴. This provides strong evidence for the continuation of an optimal



From the outset, our goal in rehabilitation should be optimal loading of tissue. And failure to achieve this is the most likely reason why athletes may get trapped in the “chronic rehabber” cycle.



loading programme even after the athlete has returned to sport; crucial to protect against repeated injuries.

THE DEVIL IS IN THE DETAIL (SOMETIMES)

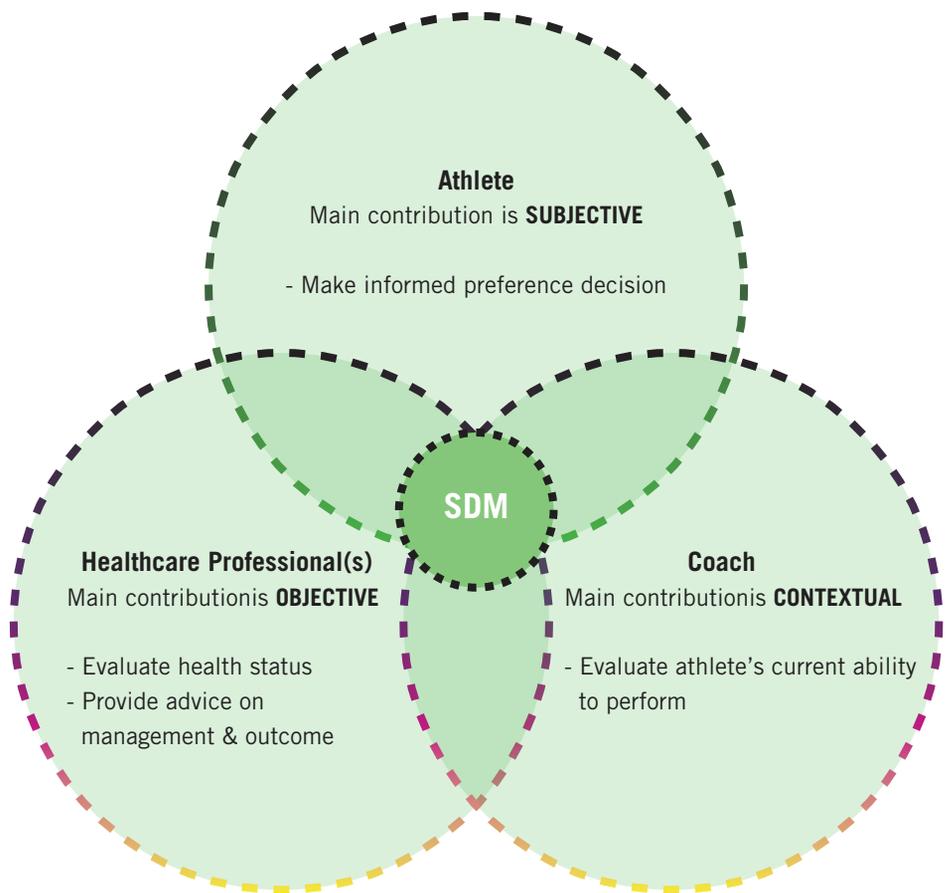
When a sprinter is experiencing repeated injuries, it is important to assist the coaching staff to determine whether any component of their technique or sprinting mechanics might be considered a potential contributor. This is not always easy to do, since we often don't have baseline measures of the different properties that make up sprinting. However, imbalances, deficits, or performance parameters may be identified that will assist in targeting specific components during rehabilitation or return to sport.

For instance, horizontal force production has been demonstrated as a key driver of sprint performance, and there is a strong correlation between hamstring muscle function and horizontal force²⁵. Identifying deficits in muscle activity that may contribute to a lack of horizontal force production might assist in designing exercises targeting this aspect of a sprinter's make up. Assessing the ability of the sprinter to effectively accelerate and maintain maximum velocity over repeated efforts can assist in achieving this outcome. Building tissue capacity is key, with exercises that activate either biceps femoris or the medial hamstrings predominantly, or developing movement capability using time under tension exercises with the muscle in lengthened position.

A blend of exercises that challenge the hamstring in different ways may include a focus on hip (biceps femoris preferential load) or knee dominant (medial hamstrings) loading patterns²⁶. Altering foot and trunk position relative to the pelvis can also enhance the challenge for different parts of the hamstring. Dynamic trunk flexion and rotation might also be considerations that become important in hamstring rehabilitation with repeated injuries, and can help prepare the athlete for all aspects of training and competition.

THE RISK AND REWARD OF SHARED DECISION-MAKING

There are some difficult decisions along any rehabilitation process for elite athletes. Although we've discussed some key aspects of return to sport, including performance, it is not always a straightforward process, and



H Paul Dijkstra et al. Br J Sports Med 2017;51:419-420

Figure 5: The size of the contributing circles to the shared decision-making (SDM) processes are influenced by different factors, including health status, participation risk and other decision modifiers. The position of the SDM circle might therefore vary: in the case of the athlete and coach travelling alone to a training camp/competition, the healthcare professional might be absent from the SDM process. (Dijkstra et al BJSM 2016, with permission)²⁷.

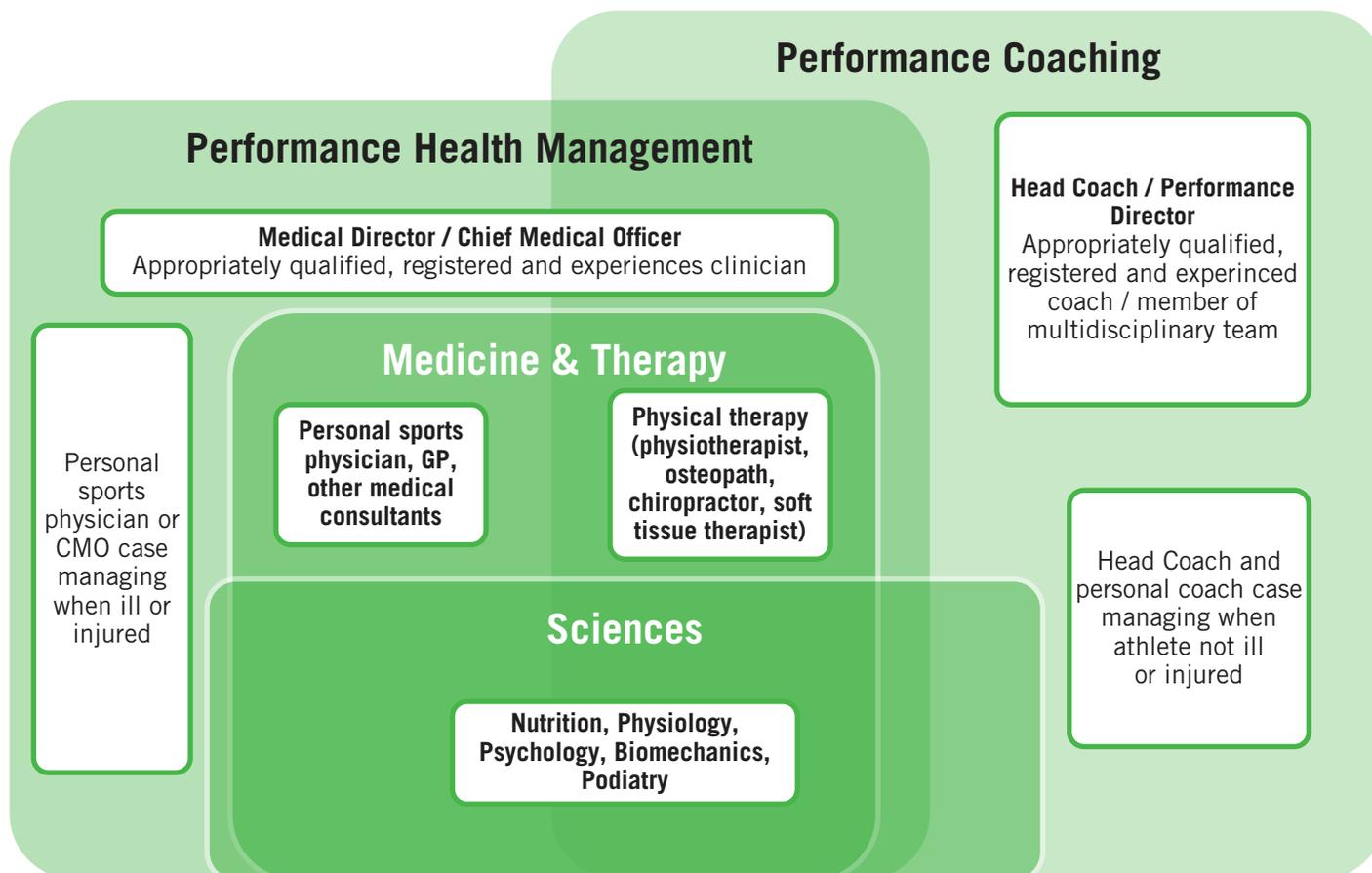
poses challenges to both the athlete and the team. Do we prolong the rehab a little longer, or do we risk it to get to competition? What is more important right now – risk or reward? Will the athlete have this opportunity again? When faced with these scenarios, Dijkstra et al proposed a shared decision-making process that will improve the satisfaction with the outcome²⁷. The three key steps are:

1. Choice: making the athlete and coach aware that reasonable options exist;
2. Option: providing more detailed information about the different options;
3. Decision: guiding the athlete and coach to consider their preference and decide what is best.

Importantly, understanding the context of each individual athlete is crucial in the

decision-making process. It is influenced by different domains that the individual is immersed in, as outlined by Bolling et al²⁸. An athlete will be influenced by his or her own traits at an individual level, the type of sport and social structures that is associated with that sport – in this case, track and field athletics. Then the team or coaching environment that is part of his/her life, together with the administrative body will influence the decision through policy, budget and governance. Lastly, the country and the status of the athlete will also play a role, as the popularity of the sport and the athlete may create certain pressures and expectations. These factors all need to be considered by each member in the shared decision-making process (Figure 5).

Here again, it is important to emphasise the overlap between health and



H Paul Dijkstra et al. Br J Sports Med 2014;48:523-531

Figure 6: The Integrated Performance Health Management and Coaching Model. All the specialties operate in the performance health and coaching ‘box’. Health (injury, illness and prevention) is managed by specialist sports medicine physicians (led by the CMO/Medical Director); coaching is managed by the Head Coach. Both departments are managed by the Performance Director or (CEO) depending on the structure and size/culture of the organisation/club. CEO, Chief Executive Officer; CMO, Chief Medical Officer; GP, general practitioner. (Dijkstra et al BJSM 2014, with permission)²⁹.

performance. The integrated performance health management and coaching model (Figure 6) represents how all the specialties often involved in elite care is represented in the performance health and coaching components, overseen by a performance director in most organizations²⁹. It is imperative that the health and coaching departments operate in synergy and also ‘independently’ with appropriate autonomy at times. This type of system allows openness and transparency, ultimately assisting the athlete in understanding risk better, and allowing a shared decision-making process that is not solely dependent on the outcome, but rather creates trust in the process of making the decision. Ultimately, our goal is to assist the athlete in performing at their best, and to manage the risk of injury in the best way possible. When dealing with repeated injuries,

where athletes often become frustrated and pressure builds on the medical and coaching team to make decisions that pleases the public or organizers, having such a system in place makes it possible to protect both the health of the athlete and their performance.

SUMMARY

The demands of elite track and field performance will continue to expose athletes to risk of injury. When an injury does occur, it is important to allow the healing muscle tissue to repair, and then allow the recovered tissue to restore its full loading capacity while the athlete reclaims their capability to perform. Making good decisions through an integrated health and performance framework and a shared decision-making process will allow us to provide athletes with optimal outcomes, and return to performance.

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*Nicol van Dyk PT., Ph.D.
Physiotherapist & Clinical Researcher
Aspetar – Orthopaedic and Sports
Medicine Hospital
Doha, Qatar*

*Phil Glasgow PT., Ph.D.
Head of Physiotherapy and Rehabilitation
Irish Rugby Football Union
School of sport, Ulster University
Ulster, Ireland*

Contact: nicol.vandyk@aspetar.com