Current Concepts in Sports Injury Rehabilitation

Abstract

In the modern era, rehabilitation after sports injury has become a domain for specialists, and its evolution has necessarily brought together the sports physiotherapist, the sports physician, and the orthopedic surgeon. The changing profile of sports related injury, as well as limited availability of facilities for rehabilitation in many areas of India, is a matter of concern. Elite sportspersons have some protection, but the average athlete is often left to fend for himself. Key factors in successful sports injury rehabilitation protocols are the application of modern rehabilitation protocols under appropriate supervision, appropriate and well timed surgical interventions, and judicious and need based use of pharmaceutical agents. Modern rehabilitation protocols emphasize teamwork and proper rehabilitation planning, and the rehabilitation team has to be lead by a trained sports physiotherapist, with an understanding of the protocols and interventions required at various stages. Injury specific rehabilitation protocols are being practiced worldwide but need to be introduced according to the nature of the sport as well as available facilities. Even in India, sports physicians are increasingly joining specialist rehabilitation teams, and they can help with medication, nutritional supplements, and specialized tests that could improve injury understanding. Inputs from surgeons are mandatory if surgical interventions have been performed. What is often missing in the underdeveloped world is psychological support and a clear understanding by the athlete of his/her rehabilitation protocols. World over, the primary aims are safe return to sports and minimizing reinjury on return to sport; this involves rehabilitation in stages, and current methodology clearly demarcates acute and chronic phases of injury. Close coordination with trainers and coaches is mandatory, and all need to understand that the reconditioning phase is crucial; skill assessment before progression has now become a specialized domain and needs to be introduced at all levels of the sport. A key factor in all sports injury rehabilitation protocols is injury prevention; this involves data maintenance by teams or trainers, which is still not fully developed in the Indian context. The injury and subsequent problems need to be comprehended both by athletes and their coaches. The current review is an attempt to clarify some of the issues that are important and routinely used world over, with the aim to improving rehabilitation after sports even in the underdeveloped world.

Keywords: *Conditioning, physiotherapy, return to sports, sports injury, sports rehabilitation*
MeSH terms: *Athletic injuries, sports injuries, recovery of function, rehabilitation*

Himmat Dhillon, Sidak Dhilllon[1], Mandeep S Dhillon[2]

Medwest Health Care, Melbourne, Victoria, Australia, [1]Department of Sports Medicine, Sri Ramachandra Medical University, Chennai, Tamil Nadu, [2]Department of Orthopaedic Surgery, Physical Medicine and Rehabilitation Medicine, Sports Injury Clinic, PGIMER, Chandigarh, India

Address for correspondence:
Prof. Mandeep S Dhillon, 1027, Sector 24 B, Chandigarh - 160 023, India.
E-mail: drdhillon@gmail.com

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Introduction

The ever growing popularity of sports worldwide has made the "sports industry" extremely competitive and financially lucrative for athletes, with many striving for elite professionalism. This has consequently intensified the physical and emotional burden of sports, increased the training and practice regimens required, and exposed those involved in this quest to a higher risk of injury. In modern competitive sport, injured athletes are under pressure to return to competition as early as possible, which is often a demand for both the sportsperson and the team management. Athletes also stand a chance of losing their place in the team due to the highly competitive scenario and naturally come under higher pressures to return. Thus, compared to traditional rehabilitation after injury, sports injuries rehabilitation requires more care, a highly structured and sports-specific approach, which should prepare both the athlete and the injured tissue for the following physical and psychological demands at the highest level of sport.

The growing popularity of the recently incepted hockey, football, and kabaddi leagues in India is evidence of a growing sports culture in a country predominantly favoring cricket. These sports are fast paced, played over a short timeline, and often pose a high fatigue and injury risk to the involved athletes. Studies from around the world emphasize the relation between the demands of the sport and the risks of injury.[1] Unfortunately, the lack of research

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and literature regarding structured programs addressing injury management and prevention in Indian athletes shows evidence that our country is lacking in the area in comparison to more developed countries such as the UK, the US, and Australia. A PubMed search using key words such as "Sports AND Injury AND Rehabilitation AND India" gave 26 citations, none of which was relevant, nor did any describe the topic under review. A PubMed search using key words such as "Sports AND Injury AND Rehabilitation AND Current Concepts" gave 79 hits, most of which were not specific to sports injury rehabilitation, and none of which was by an Indian author or focused on Indian athletes.

This article attempts to update the sports rehabilitation personnel about available options and need based interventions for athletes, which could be applied even in the underdeveloped world.

Epidemiology

Injuries in sport can occur through contact or noncontact mechanisms and maybe of an acute or overuse nature.[2] They may involve muscle, ligaments, or bone, with stress fractures being somewhat unique to sports and overuse. Epidemiological studies have revealed no significant decrease in sports-related injuries over the past two decades, despite the heightened insight into injury mechanisms, prevention programs, and load monitoring techniques in athletes. In a study spanning over 16 years, Hootman *et al*.[3] observed collegiate athletes in 15 different sports in the US. Their results concluded that lower limb injuries accounted for >50% of all sports injuries, with the knee and ankle being predominantly involved. The majority of the injuries were contact injuries, with significantly higher numbers being observed during competition compared to training injuries. Of the 15 sports, they analyzed that football (Gridiron) had the highest injury rate with competitive wrestling being the second largest. Over the 16-year period, the authors also observed that the increased physical demand, participation, and change of rules had a substantial effect on injury trends.

A prime example of such a correlation between injury trends and the demand for the sport is evident on observing the changing injury profile in elite level cricketers since the introduction of the shorter, yet physically demanding, T20 format of the game. Dhillon *et al.*[4] showed a 16.8% incidence of upper limb injury, primarily during fielding, in a prospective evaluation of cricketers. Over the past ten cricket seasons, Orchard *et al.*[5] found that hamstring and thigh injuries are now the most common injuries seen in elite cricket, which they attribute to the change in the format of the game. Tirabassi *et al*.[6] concluded that of all the sporting injuries that led to disqualification on medical grounds, 60% were suffered during competition. Over an 8-year observation, the authors demonstrated lower limb injuries to be the most predominant with the highest incidence in football followed by gymnastics and wrestling. The site of injury could be sports specific, with upper limb injuries predominant in throwers and bowlers, while lower limb injuries predominate in games such as football. In a previous study by us in 2016,[7] we evaluated the incidence of knee injuries in 24 different sports in India, in a study spanning 5 years. Similar to other studies, we observed a significantly higher injury rate during competition as compared to injuries during training. However, we found that a noncontact mechanism of injury was more predominant, with soccer and kabaddi injuries being the two most prevalent. In addition, we found that of all the injured athletes, only 39.8% returned to the sport, a figure significantly lower than a recent metaanalysis that showed 83% of athletes returning to their respective sport.[8] Dhillon *et al*.[9] in a focused review of 76 kabaddi players noted that 88.16% of knee injuries occurred during competitive sports and the anterior cruciate ligament (ACL) was injured in 89.47%; the sole issue was a presentation to treating surgeons fairly late, after a mean duration of 14.4 months after the injury episode. The time lost from sport averaged 16.6 months, with inadequate rehabilitation protocols being documented. A detailed analysis of the lower return to sports rate in India is beyond the scope of this paper; however, we can state that further studies are needed to examine and critique the injury management, rehabilitation, and return to competition programs and protocols administered in our country to shed light on the possible shortcomings.

It is evident that injuries and returning to the sport after that are major concerns among athletes and their treating clinicians, with a risk-free return to the competition being the top priority of rehabilitation. This review aims to present an evidence-based approach to sports injuries followed the world over, incorporating that high-quality interventions and protocols initiated minutes after an acute injury, up to the time the athlete fully returns to competition. It serves as a framework upon which readers can construct individualized rehabilitation programs for athletes at all levels, as a perfect recipe protocol does not exist.

The Framework of Sports Injury Rehabilitation

The team approach and proper planning

In modern sports injury management, a team approach involving the sports physician, physiotherapist, strength and conditioning coaches, sports psychologist, nutritionist, coach, and the athlete is critical. Most importantly the rehabilitation needs to follow a biopsychosocial approach.[10] We need an understanding of the sport and what biomechanical and physiological demands this has on the athlete. Therefore, reviewing the current literature regarding the particular sport will aid in providing the clinicians with the understanding of common types of injury, the mechanism behind them, and the current management

protocols being used globally. Documentation of baseline measures is paramount to compare outcomes to a preinjury level. Baseline measures are usually undertaken during the preparticipation assessments and ideally done at the beginning of the sporting season. The rehabilitation team can then use these as a guide when making any decision regarding return to competition.

Aims of rehabilitation and planning

The primary aim is a return to sports at a preinjury physical and emotional level and to prevent reinjury. It is important to have an end goal in mind, preferably using baseline measures and player attributes documented at preparticipation, and work backward from where you want the player to be. The key points in the rehabilitation program should be planned and charted out.

In addition to injury-specific rehabilitation, it is important to eliminate risk factors and identify why the injury happened in the first place. Another issue of note is the prevention of overall deconditioning, which has to be factored in when designing the rehabilitation protocol.

Restore function and performance to a preinjury level

For this, it is important to have baseline data in as many athletes possible, thus signifying the importance of routine screening of athletes and the documentation of their physical status. However, this may not be possible at all levels in most Indian sports and is not available at the amateur level. Strength and conditioning should aim to achieve power, strength, and endurance somewhat higher than what it was preinjury, as we have to factor in preventive measures for reinjury.[11]

Safe return to the sport

Return to the sport can be interpreted differently by different members of the rehabilitation team; therefore, the clinician needs to specify in what capacity the athlete will be returning. We need to transition from rehabilitation into competition gradually so that athletes do not get injured as soon as they return. The player needs to complete a full training session with the team a few days before game day and should be symptom free throughout the training. One debate is how much of the game he should play in his first match after recovery; this depends on the demands of the sport and the position that he plays. For example, a goalkeeper coming back from lower limb injury could play an entire game, whereas a center forward with the same injury could face limited playing time. Similarly, a goalkeeper with a shoulder injury will have different transitions back into competition as compared to a center forward with a shoulder injury. This further cements the argument for an individualized and tailored rehabilitation approach to athletes. Another determinant is the time of the competition and these players return; some phases, such as finals or playoffs of an important series, require more physical loads on the body compared to normal league games.[12]

Minimize risks of reinjury

Injury is the biggest risk factor for a reinjury. Once athletes are back competing, careful monitoring is required. The importance of monitoring the physical load on players returning to competition is highlighted later in the review, and further, reading on monitoring of acute-chronic workload ratio is highly recommended. Monitoring the physical workload on athletes assists the clinicians in determining the optimum transition back to sport while ensuring minimal reinjury risk.

Stages of Sports Injury Rehabilitation: Evidence-based Practice

For a good sports rehabilitation practitioner, the motto should be "know the sport, review the literature." Once defined, the rehabilitation is broken into different stages, and the athlete progresses through them till he is fit to return to play (RTP). The rehabilitation is based on an active rehabilitation model, with the aim of avoiding prolonged immobilization, which has potentially detrimental effects on muscle tone, strength, and structure.[13] The progression along the rehabilitation continuum and stages should be based on functional criteria instead of being time based, with sport-specific functional testing determining the progression to the next phase. The key factor, however, is tissue healing, and it is important to keep the natural healing process in mind while constructing a program. Since the remodeling phase lasts for over a year, it would be wise to monitor the athlete and continue an ongoing strength and conditioning program for as long as all fitness goals are not met. The team physician could use pharmacological/medical interventions as appropriate at each stage of the rehabilitation process.

Acute phase: Promote tissue healing and avoid deconditioning

Traditionally, clinicians have been employing a protocol inclusive of protection, rest, ice, compression, and elevation (P.R.I.C.E) with the aim of avoiding further tissue damage, reducing associated pain, edema, and attempt to promote the healing process.[14] Although an effective protocol for the general population, immobilization, and rest could potentially have a detrimental effect on muscle tone and strength in these sportspersons, it could negatively affect athletes aiming to return to a preinjury level of participation.[13] Moreover, elite athletes are expected to return to competition at the earliest possible time and therefore require a different, more aggressive approach to rehabilitation, which needs to be initiated in the acute phase itself. Keeping the end goal of risk-free injury performance, it is proposed that clinicians follow a protocol inclusive of protection, optimal loading, ice, compression,

and elevation (P.O.L.I.C.E) in the acute care setting for athletes.[15] Since early mobilization and tissue loading has shown to have a positive effect to promote collagen reorganization and tissue healing,[16] it is wise to initiate a loading program as soon as pain permits. Introductory loading should involve a return to full weight bearing, which can also be achieved through hydrotherapy or weight-assisted treadmills.[17] Owing to its pain inhibitory effects, isometric exercise makes another excellent option as the first line of tissue loading intervention.[18] However, clinicians need to respect the natural healing processes of the body and ensure a balance between loading and timely unloading to avoid damaging the healing tissue. Obviously, we need to protect the injured tissue from further damage, but we cannot allow detraining in the other areas, and simultaneous conditioning of the rest of the body needs to go on. Despite their being only Level IV and Level V studies, low-intensity pulsed ultrasound and neuromuscular electric stimulation are still used in the clinical setting in an attempt to manage inflammation and promote tissue healing.[19,20]

In addition to the physical requirements, the multidisciplinary team needs to address the mental and emotional demands of elite sport as well. It is recommended that elite athletes undergo psychologically[21] and nutritional interventions[22] early in the program, to ensure all well-being, and provide the injured tissues with high quality nutrients to allow optimum healing. Progression of interventions to the next phase of rehabilitation is strictly based on achieving a predetermined set of functional criteria, timelines of which would differ regarding individual athletes. Table 1 shows an example of such predetermined criteria that an athlete with a muscle injury would need to full fill to progress to the next phase in the rehabilitation continuum.[23] Although there is no Level I evidence validating the progression criteria, the clinicians should be guided by their knowledge of the specific sport, the healing process, and sound clinical reasoning to make an informed decision.

Details of medical intervention during rehabilitation such as medication, nonsteroidal anti-inflammatory drugs, and injections are beyond the scope of this review. However, many issues come into play and the occasional use of steroid injections for some acute conditions, or platelet-rich plasma injections for some healing situations are something to be kept in mind. Nutritional optimization is essential for healing and again is beyond the scope of the current article.

Table 1: Progression criteria for a muscle injury

Resolution of pain during activities of daily living
Pain free ROM >75% of contralateral side
Demonstrate pain free isometric contraction in mid, inner and outer range
Complete resolution of inflammatory signs

Reconditioning phase

Rehabilitation involving strength and conditioning in athletes could be highly variable as compared to the general population. Rupture or injury to the ACL is one of the most common lower limb injuries seen in sports, with potential career ending outcomes as some athletes may fail to achieve preinjury level of performance.[24] Reinjury and graft rupture have been reported as a result of returning to play too early resulting in excessive load on a poorly rehabilitated knee.[25] Therefore, it is highly important to continuously monitor the athlete rehabilitation to ensure optimum loading of injured and recovering tissues through an individualized approach according to the sport and its physical demand.[26] Due to the physical demands of high-level sports, graded load progression plays a significant role in a successful sports injury rehabilitation program.[27] Cardiorespiratory loading to maintain and improve aerobic capacity, in conjunction with neuromuscular training to maintain overall muscle strength, flexibility, and proprioception, has been well defined in literature.[28,29] In addition, various sports-specific speed, strength, agility, and flexibility drills, when incorporated early in the rehabilitation, have proven to be effective in the initial stages in avoiding overall deconditioning and positively affecting return to participation. While progressive loading plays a key role in an efficient RTP, the clinicians need to monitor for undue overloading. In a systemic review in 2016, Drew and Finch[30] demonstrated a significant relationship between excessive training loads and risk of reinjury. However, their review also exhibited a protective effect against injury when optimal loading was employed. Weiss *et al.*[31] found a similar correlation, with their study demonstrating an increase in injury with excessive loading in professional basketball players. Load monitoring using devices such as global positioning satellite (GPS) and accelerometers (external) and rate of perceived exertion (RPE) and heart rate monitoring (internal) are commonly employed in the US, the UK, Australia and are methods that should be considered at various levels in India as well. To monitor the athletes for optimal loading in sports rehabilitation, many authors have recommending monitoring the workload through determination of the acute-chronic (A/C) workload ratio, which assists in avoiding any sudden spikes in training volume and intensity, which could potentially result in reinjury. The A/C workload ratio is defined as the training load during the current week divided by the average of training load in the four preceding weeks.[32] Blanch and Gabbett[32] recommend an A/C workload ratio between 1.0 and 1.5 with a higher ratio associated with higher reinjury risk. The A/C workload ratio also helps the clinicians to determine the amount of training the athletes have undergone during their rehabilitation and whether it was enough to meet the demands of their respective sport. For instance, a cricketer who has been bowling an average of 120 balls in training/rehabilitation over the past

4 weeks and has to bowl 240 balls in his return to match participation will have an A/C workload ratio of 2.0 that puts him at higher risk of reinjury. The rehabilitation team is thus also tasked with monitoring any acute spikes in the A/C workload ratio, all the while safely ensuring an overload of 10%–15%;[33] this involves good coordination with the team coach/manager also. The incorporation of wearable sensory technology such as accelerometers and GPS devices allows the clinicians and athlete to monitor their physiological load and movement patterns both in training and competition and aid in preventing reinjury by keeping the load demand in check, all the while aiding in a timely RTP.[34]

Return to sport

Once the rehabilitation criteria for the reconditioning phase have been fulfilled, a decision to RTP needs to be taken. As a clinician and a member of the rehabilitation team, it is important to understand that the decision of returning to the sport is not one taken in isolation. Although a collaborative decision needs to be made by the entire rehabilitation team, the athlete himself is the final judge on RTP. Nonetheless, the responsibility of a safe and timely return to sport lies on the shoulders of the clinicians and coaches in the rehabilitation team. The strategic assessment of risk and risk tolerance (StAART) is a theoretical framework that aids the clinicians in making informed decisions while gradually returning the athletes to their respective sport.[12] Figure 1 demonstrates the three-step framework which assists sports injury clinicians to estimate risks associated with short and long term outcomes associated with the sport.

To ensure a graded progression of physical demands of the sport, Creighton *et al*.[35] proposed a continuum that would see the athlete return to participation, return to sport, and return to competition. The rehabilitation team should be well aware of the demands of the sport, the potential risks

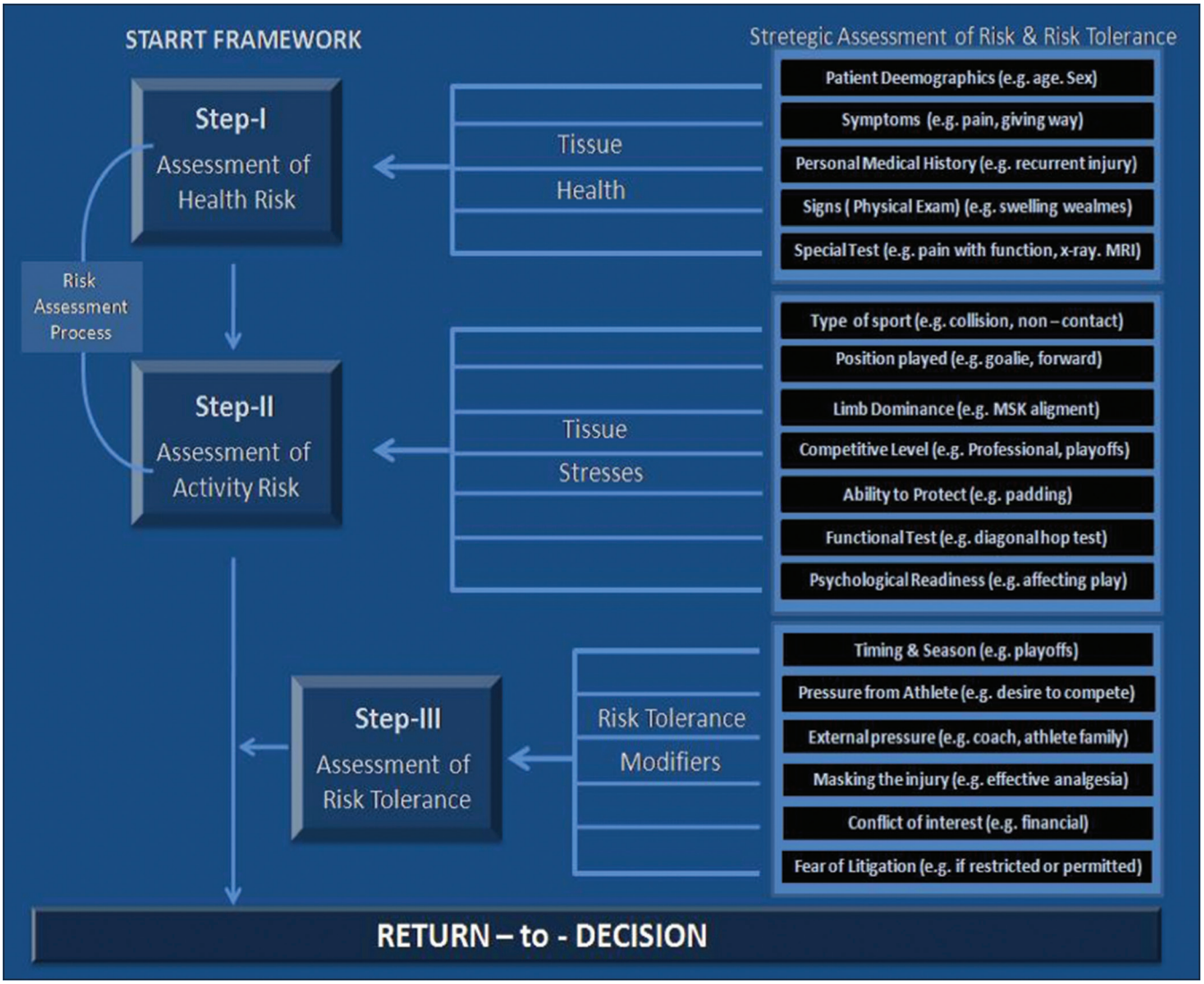

Figure 1: Strategic assessment of risk and risk tolerance protocol (Modified from Shrier 2015)

involved, and the time of participation before making their final decision. Return to participation ideally involves the athlete training with the team to include sports specific training to the ongoing rehabilitation. Load monitoring at this stage is vital to prevent sudden peaks in acute training load and avoid reinjury or any potential new injuries. Once the athlete has undergone an incident-free training session, a partial return to sport is recommended, which may include not playing an entire game or coming on as a substitute, to avoid a sudden increase in acute workload.[32]

With the StAART framework as a guide, the athletes need to be clinically assessed for RTP that should test their physical and psychological readiness.[36,37] Functional testing, inclusive of a battery of sport-specific tests assessing both open and closed skills, is essential to determine whether the athlete can meet the physical demands of the sport without sustaining a reinjury.[38,39] In addition, the ACL return to sport after injury scale has shown to be an efficient outcome measure to determine the psychological readiness of athletes returning to the sport after ACL reconstruction.[40] Table 2 demonstrates some of the criteria that need to be fulfilled to return to the sport after common injuries. As these criteria are highly variable and based on the injured tissue, the severity of the injury, and the type of sport, it is highly advised that the treating clinicians familiarize themselves with the demands of the game and with current literature available to guide with successful rehabilitation.

Table 2: Criteria that need to be fulfilled to return to the sport

Type of injury	Return to sport criteria
Acute knee Injury	Efficient symptom free direction changes
	Reactive agility testing
	Psychological readiness: ACL Return to Sport after Injury Scale
Hamstring Injury	Athlete should be pain free
	Minimal ROM and strength deficits compared to contralateral side
	Symmetrical hopping performance
	Successful completion of sports specific field testing
	Attain pre-injury sprint speed
	No evidence of apprehension during sports specific movements, during full speed sprints, -ve Asklings H-test
Achilles Tendinopathy	Pain not exceeding >5/10
	Pain after physical activity should subside completely the following morning
	No increase in pain or stiffness over the following week
Shoulder Injury	A minimum of 10% increase in rotator cuff strength on dominant side as compared to pre-injury strength
	External rotation/Internal rotation ratio 65% Isokinetic and 100% isometric

Prevention of reinjury

A previous injury is the highest predictor of a risk of reinjury,[3] and therefore, it is extremely important to monitor the athlete even when he has gone back to full participation. A meta-analysis conducted by Soomro *et al.*[41] highlighted the efficacy of injury prevention programs (IPPs) in adolescent team sports. The authors attributed the success of IPPs to improve muscular strength, flexibility, and proprioceptive balance. In addition to incorporating IPPs in athletes returning to elite levels, ongoing load monitoring is also highly recommended. IPPs such as the FIFA 11 and the FIFA 11+ protocol focus on strength, flexibility, and core stabilization, are highly recommended for the prevention of primary injuries as well as reinjury in recovering soccer players.[42] Although injury prevention interventions through exercise programs, biomechanical assessments, protective equipment, and rule changes may have yielded positive results, there is still no high-quality evidence in support of screening for injury risk.[43] Periodic health examinations aid sports injury clinicians in measuring the modifiable factors such as strength, range of movement and movement analysis, and the absence of any intervention studies in support of screening for arguable risks which makes it near impossible to predict sports injuries. Further high-quality research is needed to examine the properties of various screening tests being used in clinical sports medicine setting.

Conclusions

Rehabilitation after a sports injury is a crucial aspect to ensure full recovery, minimize time off from sports, and to prevent reinjury. Modern rehabilitation methods have surpassed traditional management protocols and are based on an active rehabilitation framework that demands equal participation from the athlete and the entire rehabilitation team. Attempts are made to ensure the earliest RTP, and even though the sports clinicians are responsible for a safe transition back to competition, it is important to remember that the athlete has the final say. The role of surgical interventions, as well as pharmaceutical requirements, is need based and beyond the scope of this manuscript, but the major work on a sportsperson after injury is done by the rehabilitation team. In addition, one must not ignore nutritional supplementation and psychological intervention, which have a major role in getting the athlete back to full fitness, along with injury-free return to sports at the same level when he was injured.

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Conflicts of interest

There are no conflicts of interest.

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