Evaluating rehabilitation and return to play procedures in male professional football: A narrative review.

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Abstract

Injuries in male professional football present a multi-faceted and complex challenge for practitioners with significant consequences across performance, psychosocial and financial domains. Medical and performance staff encounter considerable pressure to maximise player availability and advance rehabilitation timeframes, whilst minimising the risk of subsequent injury. Decisions involving increased risk promise, potentially, higher rewards and may significantly influence a player's career and team performance. Therefore, it is crucial that rehabilitation and return to play (RTP) procedures are evidence-informed and strategically designed to mitigate subsequent injury risk. Due to the complex nature of injuries, and the multidisciplinary approach required during the rehabilitation process, a wide range of knowledge and skills are essential to inform a shared decision-making process and successful-RTP. To support the understanding of the competencies required, this narrative review gives an overview of existing aetiological models, decision-making frameworks and RTP approaches within the current literature. The current role of criteria-based progressions in rehabilitation frameworks are evaluated and potential future research, that could improve rehabilitation procedures and inform better RTP decision-making and post-RTP care in the professional football environment, is highlighted.

Key Words

injury, aetiological models, decision-making, return to sport, multidisciplinary

Introduction

The implications of injury within professional football are multi-faceted, complex and can have significant performance, psychosocial, and financial implications.[1, 2] Significant pressure is placed upon medical and performance departments to maximise player availability and accelerate rehabilitation. Usually, riskier options promise higher returns and the decision to progress or delay a player's return to play (RTP) may have a significant impact on a player's career and a team's future performances.[3] Therefore, it is vital that the support given to player during rehabilitation, and the RTP process, is well informed, timely and minimises the risk of subsequent injury. This dilemma challenges the practitioner to balance multiple processes, influential contextual factors and specific individual needs, by blending 'art' and 'science' through effectively applying current research into practice.[4]

Several studies have been conducted globally on injury epidemiology in male professional football.[5-13] Reportedly, teams competing at the highest level in Europe typically suffer 50 injuries per season.[5] Injury incidence studies across male professional football reports ranges between 6.5-9.1/1000hours[5-12, 14] with injury incidence rates similar between professional leagues and countries.[10] The variation in reported overall incidence may be due to studies reporting single season estimates[9] compared to others using inter-seasonal differences.[5, 7, 8, 11] Inter-seasonal changes give important information on injury trends and are critical in the development of injury prevention strategies.[11] Furthermore, dense fixture schedules, alongside the increasing physical and psychological demands of the game,[15-17] add complexity to the rehabilitation process, to ensure a player is fully prepared for RTP.

Match injuries have a higher incidence (20.9-58/1000 hours), compared to training (2.8-6.8/1000 hours).[5, 8-12] Lower extremity injury incidence was most frequent (6.8/1000 hours), with muscle and tendon injuries the most frequent type (4.6/1000 hours).[10] It is important to consider the severity of injury and associated time-loss. Severe injuries (>28 days lost) accounted for between 15-23% of injuries sustained with moderate injuries (8-28 days lost) between 33-47%.[5, 8-11] On average, each player misses 37 days per season meaning approximately 12% of the season is lost due to severe injury,[5] with the most severe injuries resulting in longer rehabilitation periods and potential threats to player's careers.[18]

Injury severity can strongly impact the physical and psychosocial characteristics of the player demonstrating the need for a holistic approach to rehabilitation.[19, 20] High severity of injury can negatively affect individual player performance, across mental, physical and technical domains[18, 21, 22] with injury burden known to negatively affect team performance and results.[1, 2] Reportedly, lower injury incidence was correlated with higher league position, more games won, more goals scored and greater total points.[2] Consequently, this has the potential to influence job security of the head coach, with the average tenure reported to be less than 16 months,[23] or the surrounding multidisciplinary team (MDT).[24] The financial implications are significant. For English Premier League teams, an average cost of approximately £45 million per season per team[25] has been reported, in Australian football costs range between AUD$ 187,990 to 332,680 annually,[26] for a Brazilian club hamstring injuries alone reportedly caused a potential loss of $43.2 million USD in a single season[27] and the cost of muscle injuries, for Spanish First Division teams, equates to a total monthly cost of €7.3 million.[26] This provides professional football clubs with a strong economic incentive to invest and improve injury prevention and rehabilitation processes.

An index injury is defined as the first injury to occur or any subsequent injury that is clinically unrelated to the previous injury.[28] Reinjury is defined as "an injury of the same type and at the same site as an index injury and which occurs after a player's return to full participation".[25] Incidence of reinjury is relatively low (1.3/1000 hours), however, they reportedly account for 6.1-18.8% of injuries.[5, 10, 29] High recurrence rates have been reported for hamstring (12-43%), groin injuries (31-50%), knee sprains (30-40%) and lateral ankle sprains (17%).[6, 7, 14, 30] These findings demonstrate that some reinjuries are higher risk, however, could be attributable to inadequate rehabilitation or premature RTP.[14] Most identified studies recognise the longer timeframe of rehabilitating a reinjury causing a higher burden than initial injuries.[5, 8-11, 31] Further considerations are the increased time loss suffered and the psychological impact, including player mental health, faith in the rehabilitation process and the trust between player and practitioner.[32] Reinjury anxiety had been identified as a mediating factor in psychological readiness to return.[33-35] Therefore, the process from initial injury assessment to final return to performance (RTPerf) is crucial to promote a reduction in subsequent injury and to maintain player performance.

Epidemiological data emphasises the importance of effective injury rehabilitation programming, informed through a multidisciplinary approach,[19, 36, 37] and the need for evidence informed return to training (RTT) and RTP protocols.[5-11] Several rehabilitation and RTP frameworks have been developed in male professional football including the "control-chaos continuum",[38-40] a five stage on-field program[41] and a criteria-based return to performance pathway.[42] To continually improve and inform rehabilitation procedures, and RTP decision-making, further development and understanding of objective criteria is vital to minimise the risk of further injury. The factors described provide a clear rationale for the continued advancement of injury prevention and rehabilitation strategies[39] to ensure player reintegration post-injury is optimised and reinjury risk minimised.

The aim of this narrative review is to give an overview of aetiological models, decision-making frameworks and return to sport (RTS) approaches reported within the current literature. The role of criteria-based progressions in rehabilitation frameworks, and their application within male professional football, are evaluated through the identification of potential future research, that could improve rehabilitation procedures and inform better RTP decision-making and post-RTP care. Common phrases used to describe the 'return' of a player during different phases of rehabilitation in football are defined in table 1 and used within the subsequent sections of this review.

Table 1. Descriptions of different phases of 'return' of a player during different phases of the rehabilitation process.

Phase Term	Abbreviation	Description
Return to Participation	-	The player is participating in rehabilitation, training (modified or unrestricted), or in sport at a lower level than their RTS goal. The player is physically active, but not yet 'ready' (medically, physically and/or psychologically) for full RTS.[43]
Return to Sport	RTS	The player has returned to their sport but is not performing at their desired performance level.[43]
Return to Training	RTT	The player is gradually exposed to different aspects of team training.[42] Further RTT subphases include: • Partial Team Interaction: introduce the player to partial elements of team training and the club-specific training structure with restrictions agreed.[4] • Team Interaction: involve player in modified team training, modification of drills/game-based training and training parameters in line with team training content/club-specific structure and in season micro-cycle with restrictions agreed. There is a high level of adaptability in terms of the level of integration and aims to challenge the player before resuming full team training.[4] • Non-contact Modification: the player is re-integrated into non-contact team training.[44] • Contact Modification: the player is progressively integrated into team training and exposed to contact.[44] • Full Integration: the player is fully integrated into team training.[44] Subphases and level of modification are influenced by injury type, severity, length of absence and potential load increases.[4]
Return to Play	RTP	The player is gradually exposed to competitive match-play.[42]
Return to Performance	RTPerf	The player has returned to match-play and is performing at or above their preinjury level.[42, 43]

Aetiological Models

An understanding of injury prevention and aetiological models can assist practitioners in discussing possible causes of injury whilst appreciating the complex nature of the event. A mechanism of injury refers to the method by which damage or trauma occurs, and can be defined as the process of considering the forces involved in an injury-causing event.[45] Injuries in sport are related to some form of overload, either involving direct trauma, mechanical failure through 'stress' or 'strain' or a combination of both.[46] When the 'stress' (i.e., the internal forces experienced by a structure defined as force per unit of area) and/or 'strain' (i.e., the amount of deformation or length change in the direction of the applied force)[46] exceeds the maximal strength or failure strain capacity of a particular tissue type, this results in injury.[46-48] Traditional injury prevention models have been reductionist in an attempt to simplify multifaceted components, to identify relationships or a sequence of events, but fail to acknowledge injuries involve complex interactions between numerous factors.[49] Aetiological models have cited the interaction between both intrinsic and extrinsic factors such as age, injury history, neural inhibition, fascicle length alteration, strength deficiencies, neuromuscular fatigue, movement efficiency, training load and competition schedule amongst others.[50, 51] Therefore a multidisciplinary, holistic approach is vital to accommodate the complex and individual nature of injury and rehabilitation.[49] An overview of the development of aetiological models is presented in Table 2.

Table 2. An overview of the development of aetiological models.

Study	Year	Model of Injury Causation	Type	Focus
Ettema[52]	1973	Stress-Capacity Model	Balance scale model: stress and capacity seen as static entities and must be balanced to prevent injuries.	• Developed from preventative medicine identifying risk factors as external (environmental) and internal (capacity by the state of the personal). • Stress is determined by external factors and capacity by internal factors. • Highlights the potential to manipulate the external environment to reduce risk and the influence of psychosocial factors.
van Mechelen et al.[53]	1987	Sequence of Prevention Model	Four-step dynamic loop: 1. Establishing the extent of the sports injury problem. 2. Establishing aetiology and mechanism of injuries. 3. Introducing preventive measures 4. Assessing their effectiveness by repeating step 1.	• Evaluates the effectiveness of injury prevention interventions. • One of the first models to identify injury aetiology as a key component of the process. • Influential in the development of sports injury research framework, TRIPP[54] and was developed to incorporate a socioecological view and addressing the injury in context[55].
Andersen & Williams[56]	1988	A Model of Stress and Athletic Injury	Interactional multi-component model of injury presenting the cognitive, physiological, attentional, behavioural, intrapersonal, social, and stress history variables that may influence injury occurrence and prevention.	• Built around the stress response with four central components: 1) potentially stressful athletic situation, 2) cognitive appraisal of the situation, 3) physiological and attentional responses, 4) potential injury outcome. • Above the stress response are three contributing areas: 1) personality factors, 2) history of stressors, 3) coping resources. • Model is predicated on the assumption that two mechanisms behind the stress-injury relationship are increases in general muscle tension and deficits in attention during stress. • To reduce the impact of these mechanisms two groups of interventions are presented addressing either the cognitive appraisal or the physiological/attentional aspects.
van Dijk et al.[57]	1990	Stress-Strain-Capacity Model	Time-based three phase sequential model: 1. Stress: external load and personal control. 2. Strain: all acute and short-term effects, e.g., acute sports injuries.	• Considers the effects of training, overload and behavioural aspects over an extended time period. • The model acknowledges that stress and capacity are dynamic units, and an athlete can actively affect stress and strain. • An injury is the result of a complex set of interactions of internal and external risk factors.

			3. Long term and permanent effects, e.g., overuse injuries. Capacity is a dynamic value that is the sum of all intrinsic factors allowing an athlete to perform.	
van Mechelen et al.[58] (Modified from Backx et al., 1990[59], Bol et al., 1991[60], Kok & Bouter, 1990[61])	1992	Sports Behaviour Model	Dynamic model on the interrelation between risk factors, the occurrence of injury and subsequent preventative measures.	• Illustrates the impact behaviour may have on injury risk. • Determinants are influenced by internal/external factors, personal equipment and load. • Three factors considered determinants of behaviour: 1. Attitude: the knowledge and beliefs of a person concerning the consequences of a certain form of behaviour. 2. Social Influence: influence by others. 3. Self-efficacy-cum-barriers: whether one is able to perform the desired behaviour.
Meeuwisse[62]	1994	Multifactorial Model	Epidemiological, multifactorial model: Proposes the model should be used to examine various factors and their interrelationships.	• Formed from the assessment of causal and associative factors. • Accepts previously identified intrinsic and extrinsic risk factors and adds an inciting event as the final link to injury occurring. • Suggests a different relative contribution of intrinsic and extrinsic factors for acute and overuse injuries.
Williams & Andersen[63]	1998	Revised Model of Stress and Athletic Injury	Development on the interactional model of stress-injury.	• Highlighted the bidirectional nature directly between personality traits and coping resources and interaction between the three areas of stress response. • Removed medication as a proposed intervention. • Expanded the peripheral narrowing and distractibility variables to include audition.
McIntosh[64]	2005	Multifactorial and Biomechanical Model	Multifactorial model with a biomechanical focus on tissue properties and injury.	• Incorporates multiple intrinsic and extrinsic inputs, and accounts for acute and repeated events. • Introduces the effect of increased or decreased mechanical load alongside the individual load response. • Acknowledges the importance of movement co-ordination and efficiency, and that injury interventions focus on internal and external load modification by reducing load or improving capacity.
Bahr & Krosshaug[65]	2005	Comprehensive Model	Comprehensive model combining epidemiological and biomechanical	• The importance of injury mechanism and the language used to describe injury inciting events is highlighted.

			approaches with a focus on the specific sport.	• The key component added is a precise, multi-level description of the inciting event. • The different levels are categorised: 1. Playing situation. 2. Player/opponent behaviour. 3. Gross biomechanical description (i.e., whole body). 4. Detailed biomechanical description (i.e., specific joint).
Meeuwisse et al.[66]	2007	Dynamic, Recursive Model	Cyclical model based upon a contact injury model [67] and incorporating the consequences of repeated sport participation.	• Evolved the concept that injuries are dynamic and recursive and changes in injury risk with training exposure result in constant variations in injury susceptibility. • Ever-changing risk factors are important to acknowledge in injury prevention.
Appaneal & Perna[68]	2014	Biopsychosocial Model of Stress and Athletic Injury and Health (BMSAIH)	Interactional model proposed as an independent extension to the revised model of stress and athletic injury.	• Focuses on the dynamic interactions between physiological, psychological and social elements and the collective influence on stress, injury and health. • Expands on previous models in three ways: 1) it clarifies mediating physiological pathways between athletes' stress response and adverse health outcomes, 2) it considers other health outcomes and behavioural factors that impact sport participation, 3) it integrates the impact of training upon athlete health. • The central component is psychosocial distress (e.g., negative life events) may act synergistically with training-related stress increasing susceptibility.
Bittencourt et al.[69]	2016	Complex Systems Model	Applies a complex systems approach, to evaluate risk factors, identify interactions and how these interactions contribute to injury, within a dynamic, recursive aetiological model.	• Proposes sports injuries will be better understood by recognising frequent patterns of interaction among multilevel risk factors. • These risk factors are unpredictable interacting units within a complex system resulting in a web of determinants. • These interactions form regularities which emerge as either injury or adaptation. This constrains the interactions creating a recursive loop and dynamically shaping further interactions. • Risk factors have a different weighting for different physical demands and an individual's tolerance, therefore, looking for existing patterns and identifying relationships is necessary to allow the development of effective interventions to specific risk profiles. • Suggests research should move from using isolated risk factors to injury pattern recognition by identifying the complex pattern of interactions.
Windt & Gabbett[70]	2017	The Workload-Injury Model	Recursive model incorporating workload within the causal chain for injury.	• This model was the first to explicitly incorporate workloads within the causal chain for injury.

				• The dynamic nature of injuries is acknowledged, and the concept that application of workload is the primary process whereby an athlete is exposed to external risk factors and potential inciting events is presented. • Proposes a conceptual framework for 'why' workloads are strongly associated with injuries by continually modifying injury predisposition through either positive or negative physiological adaptations.
O'Brien et al.[71]	2019	The Team-sport Injury Prevention Cycle (TIP)	Three-step continual cycle model: 1. (Re)Evaluate: evaluating current injuries and analysing current prevention strategies being used. 2. Identify: exploring the risk factors and mechanisms underpinning the injuries identified during the evaluation phase. 3. Intervene: planning both the content and delivery of injury prevention strategies. Ongoing re-evaluation and modification is required as part of a dynamic, cyclical process.	• Considers the application of aetiological models into injury prevention strategies. • TIP reflects the cyclical nature of injury prevention and considers a team's unique/specific context and challenges as part of the process. • A multidisciplinary approach is highlighted, and practitioners can assess injury risk whilst identifying barriers and facilitators that can impact the success of prevention strategies.
Kalkhoven et al.[46]	2020	Model for Athletic Injury and Framework for Stress-related, Strain-related and Overuse Injury	Conceptual model formed with six interacting levels: 1. Causal contextual factors. 2. Individual physiological profile, functioning, mechanical properties and force applied to the body. 3. Load tolerance of structures and loading applied. 4. Specific tissues internal stress and strain experienced. 5. Timeframe of stress/strain application (immediate/repetitive). 6. Injury occurrence.	• Considers the interaction between physiological and mechanical factors and highlights possible causal pathways. • Attempts to establish direct injury causation by investigating how risk factors contribute to injury occurrence. • Considers how individual components interact with other factors that underpin the load tolerance of different structures/tissues, and the loads applied. • Introduces the consideration of different loading patterns resulting in various injury outcomes and defining these as acute stress-related, strain-related, or overuse. • A holistic approach using concepts of load tolerance and application, physiological and mechanical properties of specific tissues and attempting to identify causal pathways had not been previously established.
Liveris[72]	2025	System Dynamics Model	Computational modelling method to simulate dynamic, complex systems.	• Initially uses Causal Loop Modelling (CLD) to evaluate intrinsic, extrinsic and institutional risk factors interrelationships that lead to injury.

				• CLD shows a perspective of risk factors' dynamic, nonlinear association, the connections between elements having a positive or negative effect, and the links create loops characterised as reinforcing or balancing.[73] • Further employs Partial Least Squares Structural Equation Modelling to quantitatively assess intrinsic risk factors' interrelationships and their effects on hamstring injuries and frequency of non-contact lower limb injuries.[74]

Legend: BMSAIH, Biopsychosocial Model of Stress and Athletic Injury and Health; CLD, Causal Loop Modelling; TIP, Team-sport Injury Prevention Cycle; TRIPP, Translating Research into Injury Prevention Practice framework.

Reviewing, understanding and applying aetiological models, can help practitioners to build injury mitigation strategies,[50, 71] analyse load/response[75, 76] and inform RTP with the aim of reducing injury risk. It is important to acknowledge the dynamic, recursive and complex nature of interacting internal (e.g., age, sex, physical fitness, psychological factors) and external (e.g., sports rules, environment) risk factors alongside the situational patterns and mechanisms that can lead to injury.[65] Furthermore, contextual factors, such as team dynamics, coaching philosophy, game model, positional switching, season phase and fixture congestion may impact injury occurrence and rehabilitation processes.[77] For example, studies have shown, during congested fixture schedules, overall injury incidence to increase from 15.6 to 33.7 per 1000 hours and match injury incidence from 44.8 to 50.3 per 1000 hours.[78] The application of aetiological models into injury prevention frameworks[71] is, therefore, an important consideration for practitioners to understand. It is also important to acknowledge the concept of quaternary prevention[79] and integrate this into prevention programming and contemporary prevention models. Quaternary prevention aims to protect athletes from interventions that may cause more harm than good, e.g., overdiagnosis (identifying problems that were never going to cause harm), overtreatment (providing unnecessary medical interventions), and overmedication (prescribing too much or unnecessary medication).[79] Furthermore, it is proposed that rehabilitation programming should implement the principles of quaternary prevention to protect athletes from excessive interventions and use reliable, validated tools and testing protocols to accurately evaluate and help make informed RTP decisions.[79] Future research into injury associations and causal pathways, acknowledging the complex nature of injury, can further inform the progression of these models, and their role within injury prevention frameworks.

Decision-Making and Multidisciplinary Approaches to Return to Play Procedures

Given the dynamic, recursive nature of injuries, the multiple stakeholders involved, and the financial implications within the rehabilitation process, debate around who is responsible in making the final RTP decision and how that decision is made within a complex environment remains a contemporary topic. Traditionally, medical practitioners have been accountable for injury records within clubs, however, evidence suggests an association with head coach leadership styles and the quality of internal communication.[32, 80-83] Other important factors include the growing influence and size of medical and performance departments,[24] the dynamics of the performance structure, sharing individual expertise, psychologically safe environments, clearly defining problems and applying solutions, the need for fast, intuitive decision-making and the quality of internal communication within the MDT and across departments.[83-85] Therefore, it is important that practitioners develop an understanding of decision-making frameworks, the importance of multidisciplinary approaches and have clear communication procedures to create an informed, shared decision-making process and develop purposeful application of critical thinking skills.[83] Table 3 presents an overview of decision-making frameworks that are applicable in a sporting environment to guide the RTP decision-making process.

Ardern et al.[86] state that, ideally, decisions are guided by accepted clinical criteria, however, many have little empirical evidence and there is a lack of agreement on the best criteria. It was proposed, a logical step would be a consensus statement on RTS and to ascertain agreement in key areas.[43, 86] The consensus statement on RTS presented by Ardern at al.[43] is divided into 4 main sections: 1) definitions related to RTS, 2) models to guide RTS, 3) evidence to inform decision-making and 4) future research. A key concept highlighted is advocating an athlete-centred approach, placing them in the position of active decision-maker, alongside other relevant stakeholders, as part of a shared decision-making process.[43, 87] The authors cited three models to guide the RTS process: 1) the StARRT framework,[88] 2) the biopsychosocial model[20] and 3) optimal loading.[89] The authors state that load progression is key and maintaining 'optimal' loading, by gradually increasing workload and avoiding 'spikes',[90] are important clinical considerations.[43] The importance of biological, psychological and social factors influencing decision-making are presented and the role of 'load' in rehabilitation and post-RTS were defined.[43] The lack of consensus and scientific evidence for RTS criteria for the majority of sport injuries is highlighted and a future priority was identified to address the identification of positive and negative predictive (or prognostic) factors for RTS outcomes.[43]

Table 3. An overview of decision-making frameworks that can be used to guide return to play decision-making processes.

Study	Year	Decision-making Framework	Overview	Process
Creighton et al.[91]	2010	Decision-Based Return to Play Model (RTP)	• Attempts to clarify the processes and provide a structure with a logical rationale when making an RTP decision. • Uses an influence diagram incorporating the states of nature elements, decision elements and the contributing information between elements • Was the first model to attempt to provide a foundation for the integration of individual factors and components for evidence-based rationale for RTP decision-making.	1. Evaluation of health status: the stage of healing of the injury. 2. Evaluation of participation risk: the specific demands of the sport and injury. 3. Decision modification: further potential influential factors.
Shrier[88]	2015	Strategic Assessment of Risk and Risk Tolerance (StARRT)	• Considers RTP decision-making as a risk assessment. • Assessed risk is compared to the risk tolerance of the individual. If assessed risk is greater than the risk tolerance, RTP should not be allowed. • The key difference is StARRT identifies tissue health and stresses as decision elements, the role of this in injury and the factors that influence each step.	1. Assessment of health risk: the stress the tissue can tolerate, i.e., the health of the tissue. 2. Assessment of activity risk: the stress that will be applied during the sporting activity. 3. Assessment of risk tolerance: the threshold for acceptable risk and factors that affect this.
Ardern et al.[86]	2016	Rearranged StARRT Model	• The StARRT framework is a biopsychosocial model that highlights key elements in RTP decisions, however, the decision itself is not solved within the model. • The StARRT model sits at the intersection of the evidence-based practice pillars. • The practitioner integrates evidence with experience and patient/player preference when making decisions. • The definition of a successful RTP is considered and, therefore, the decision should be shared between the practitioner and athlete.	Three evidence-based pillars: 1. Evidence: functional tests, physical exam, injury/medical history. 2. Clinician: mask injury, liability, seriousness, ethics/conflict of interest, (re)injury prevention. 3. Patient: competitive level, symptoms, sport, values, position, psychological state, demographics, limb dominance, values.
Dijkstra et al.[92]	2017	Shared Decision-making Process	• Key roles of the healthcare professional, athlete and coach are highlighted with different contributions depending upon the factors influencing the decision. • The size and impact of each individual contribution is variable depending on the status or phase of injury.	1. Choice: making the athlete and coach aware that reasonable options exist. 2. Option: providing more detailed information about the different options.

			• The importance of effective, consistent and ongoing communication to achieve trust and to make quality RTP decisions is highlighted.	3. Decision: guiding the athlete and coach to consider their preference and decide what is best.
Yung et al.[93, 94]	2022	Complex Systems Perspective	• Decision support systems can be developed using AI algorithms and machine learning as potential tools that can consider dynamic interaction at multiple levels simultaneously. • This may allow practitioners to compare potential outcomes of different decisions (e.g. reinjury likelihood), increase decision efficiency, and identify data patterns that may cause a certain outcome to compliment human decision-making. • Evaluating the quality of decision-making is an important aspect and differentiating between the decision and the outcome is important, a high-quality decision does not necessarily warrant a good outcome due to uncertainties. • Based upon an adapted decision analysis model the authors outline a three-step framework to make systematic and objective RTP decisions.	1. Choose appropriate RTP test and synthesise the data in a meaningful way. 2. Understand decision-making theories. 3. Use shared decision-making to eliminate contextual 'blind spots' and improve decision quality.

Legend: AI, Artificial intelligence; RTP, return to play; StARRT, Strategic Assessment of Risk and Risk Tolerance.

Shared Decision-Making

Dijkstra et al.[92] acknowledged multiple individuals are involved in the decision-making process, and including the athlete in the process fulfils psychosocial needs and supports an athlete-centred approach.[95] The fluid nature of decision-making is acknowledged, however, only three stakeholders (healthcare professional, athlete and coach) are highlighted. Within the context of professional football, medical and performance departments, the player, technical coaches and directors are also involved.[96] Furthermore, with significant quantities of subjective and objective data available, and influential contextual factors (e.g., player status, match importance), informing RTT and RTP decision-making a flexible structure may be required. Developing a flexible structure, specific to each unique club environment, allows practitioners to incorporate different individual experiences and skillsets, be guided by subjective and objective data and consider the context of the decision to allow an informed, shared approach.

Within professional football RTP practices have been investigated and the translation of research into practice has been highlighted to enhance the process.[97] It was reported that a shared decision-making process was used by 80% of teams although there was a lack of agreement in the level of involvement across phases by different practitioners.[97] This could be accounted for by potential bias, however, the inconsistency found in the composition raises some potential concerns about the specific dynamics of the communication among staff.[97] Shared decision-making was demonstrated across the phases of rehabilitation with different weighting of importance given as rehabilitation progressed, however, challenges were acknowledged relating to team hierarchy, particularly as players returned to matches.[97] This demonstrates a positive use of shared decision-making in football, however, further research into MDT dynamics has demonstrated uncertainty around who makes decisions and how they are made can be an issue.[84] Additionally, department growth, resulting in more lines of communication, and modernising methods of communication (i.e., mobile phones, email, social media rather than face to face conversations)[24] further complicate the shared decision-making process. With leadership styles and communication potentially impacting injury,[80-82] clearer processes, communication pathways and RTP decision strategies are evidently important and required.[83]

Criterion-Based Decision-Making

Whilst respecting biological healing timeframes, a paradigm shift towards criterion-based approach to RTS is evident and studies have shown a reduction in reinjury rates when individuals have passed objective criteria before RTS.[98] It is evident that practitioners are utilising evidence-based research and testing procedures throughout the rehabilitation process, informing decisions and adapting decision-making frameworks, although further research is required into RTP criteria in practice.[43, 99] There is consensus for criteria-based RTP factors that a range of clinical, physical, functional and psychological measures should be used.[43, 100] These influence and inform decision-making, and several studies have investigated their use and role within injury, rehabilitation and decision-making frameworks.[43, 97-104] In a survey by Dunlop et al.,[97] the use of criteria-based evaluations and clinical criteria were reported during early phases, with sport-specific functional criteria (e.g., acceleration/deceleration, maximal sprints) assessed across all phases and a greater focus placed on psychological readiness in the latter stages. Despite the translation into practice no information was given to advance knowledge on specific metrics or thresholds to be used within the professional football environment.

The development of injury specific criteria is important.[43, 100, 104, 105] With particular reference to hamstring injuries in professional football five core domains were identified as part of criteria-based rehabilitation progression presented by Zambaldi et al.:[104] 1) functional performance, 2) strength, 3) flexibility, 4) pain and 5) player's confidence. Following this a RTS continuum was proposed for professional athletes in which measures of progression should be tested to progress through six categories: 1) movement and core, 2) strength and endurance, 3) power, 4) general and sport conditioning, 5) load performance testing and 6) self-reported outcome.[98] Criteria-based progressions assist practitioners in being transparent in the decision-making process, however, sporting environments are complex adaptive systems extending into injury and rehabilitation protocols whereby contextual factors play an important role in the development of effective RTS frameworks.

The complex and multifactorial nature of RTS decisions provides a significant challenge to practitioners with potential impacts on the athlete's well-being and performance, and the overarching performance of the team. With multiple stakeholders involved it is important to have a clear shared decision-making process with players and coaches active in the process. This may allow for important balance between intuitive and analytical processes, therefore, practitioners are encouraged to adopt models that suit the context and environment to enhance the quality of decision-making.[106] The development of artificial intelligence (AI), data driven algorithms and machine learning techniques, to inform clinical decision-making, is a prominent, and evolving, area of interest in sports medicine. Machine learning models, such as decision trees, Markov processes and neural networks, analyse multidimensional data to identify subtle patterns and potential signs of injury risk and tracking algorithms provide information on body movements in real-time allowing the identification of biomechanical inefficiencies[107] which may prove crucial as part of the rehabilitation process. Due to methodological limitations and high risk of bias, current models cannot be recommended to be used in practice,[108-110] however, once these limitations have been addressed, machine learning could provide enhanced systematic analysis that could provide future solutions to the training load/injury paradox.[110-112] Further advancement of the evidence base supporting injury prediction models, RTS and rehabilitation protocols, may improve the ability of practitioners to make high quality, evidence informed decisions to manage training load and reduce injury-risk.

Return to Sport Models and On-Field Rehabilitation

It is widely accepted the use of competency-based criteria is vital in progressing through different phases of rehabilitation and several factors, such as muscle strength, psychological readiness, sport specific load and cardiovascular fitness, contribute to an athlete's readiness for RTS.[19, 30, 38, 42, 43, 98-100, 102, 104, 105, 113-115] The traditional notion that RTS is a single decision at a point in time has developed into the concept of an evolving continuum supporting the athlete from the onset of injury to full RTP, whilst mitigating the risk of further injury.[42, 98, 113] The identified multidisciplinary input throughout the process can result in differing timeframes and objective criteria being recommended depending on the practitioner's specialist area[87, 99] increasing the relevance of having a reliable shared decision-making process in place.

Return to Sport Clearance Continuum (Draovitch et al., 2022)

To foster efficient progression, Draovitch et al.,[98] proposed a 'Return to Sport Clearance Continuum' (RTSCC). This continuum consists of 5 sequential phases comprising: 1) repair phase (to minimise swelling, increase range of motion and develop muscle activation), 2) rehabilitation and recovery phase (restoring normal arthrokinematics), 3) reconditioning phase (focusing on skill and force development and load-volume tolerance), 4) performance phase (transition to full training), and 5) preseason/training camp phase (to be properly managed for an upcoming season).[98] The RTSCC states training load should be monitored throughout, to avoid overloading tissues, and testing criteria is suggested to ensure objective progress through the phases.[98] The scope of practice for staff involved at each phase is not considered as part of the continuum, despite the different skills required. Specialised personnel and team work between the medical and performance departments is important,[19] yet the specific involvement is often unclear.[97] The RTSCC provided a general framework for RTS processes and decision-making to be developed, although more detail of practitioner responsibilities may be useful to develop an understanding of the specialist skills and knowledge required throughout different phases of rehabilitation.

The Return to Performance Pathway (Mitchell and Gimpel, 2024)

A football specific framework has been initially proposed by Mitchell et al.[113] and developed by Mitchell and Gimpel.[42] The 'Return to Performance Pathway' includes eleven phases from a diagnosis and planning phase, into an acute phase and then progression through multiple gym and grass phases. A key component of the pathway is the objective exit criteria for each phase in an attempt to ensure safe progression.[42] Mitchell and Gimpel's[42] framework demonstrates the importance of a progressive multistage rehabilitation process and has adapted previous frameworks for the end-stage rehabilitation phases known as on-field rehabilitation (OFR).[38, 41, 42, 116] The RTPerf Pathway framework[42] provides a comprehensive overview of the rehabilitation process by introducing acute and gym phases prior to starting OFR, whereas previous frameworks had focused primarily on OFR.[38, 41, 116-119] These final phases are highlighted as being important to prepare the athlete for re-entry into sport and where the overlap between rehabilitation and RTS processes occurs. This overlap requires specialised personnel, and teamwork between the medical, performance and coaching departments, to transition the athlete and bridge the gap between rehabilitation and sports specific training.[19, 36] OFR represents these final phases as the athlete needs to be physically prepared for the demands of their sport, from both an injury specific and a general conditioning perspective. A stronger focus is required in these phases to prepare the athlete as there is a lack of validated competency criteria for final RTP protocols, particularly for moderate-severe (>14 days) injuries.[31, 36, 49, 116, 120] Risk of subsequent injury and inter-injury relationships need to be evaluated and specific player monitoring post-RTP is not considered. In the period following RTP a 'one month risk decay' of subsequent non-contact injuries has been reported.[121] Following return, initial risk of non-contact subsequent injury was about two times higher than baseline. This risk diminished by half after approximately 25 days and levels off afterwards.[121] The severity of injury should be considered with severe injuries showing an increasing injury risk within the first ten days and remaining relatively high thereafter.[121] The continuous hazard curve of non-contact injuries shows a decline towards four weeks post RTP[121] indicating additional phases may be required to assess exposure to pre- and post-RTT loads and to further inform tertiary injury mitigation strategies.[122]

On-Field Rehabilitation

Table 4 presents conceptual models specific to OFR that have been developed[38, 41, 116-119] and re-evaluated to ensure rehabilitation processes are representative of most recent evidence and practice design.[39, 40] The frameworks and studies presented demonstrate the strength of progressive OFR protocols and the impact on reinjury risk and subsequent physical performance. Cited limitations include the prescriptive nature of programmes and the individual nature of injury and responses to load interventions.[49] These conceptual frameworks can offer increased flexibility to support decision-making and allow for individual criteria-based progression throughout different stages of rehabilitation. This empowers practitioners to continually evolve their practice and understanding of the process.[49] These frameworks provide a solid conceptual guide for practitioners to utilise during rehabilitation, however, they are based upon expert opinion, inductive reasoning and case study applications.[123-125] There is a need for validation through experimental evidence and testing alongside practical insights into how OFR is currently executed.[49, 126]

Developing On-Field Rehabilitation

The concept of 'load' has been highlighted through the aetiological, decision-making, RTS and OFR frameworks previously described.[38, 41, 43, 46, 57, 64, 70, 105, 115, 117-119] A survey of practitioners has shown 'training load' was one of the most frequently used criteria when progressing through the final stages of rehabilitation[97] and specific metrics are available, although, more evidence is needed for the practical application of certain thresholds.[36, 97, 126, 127] This has been further highlighted in a survey by Armitage et al.[36] regarding OFR practices within professional football. During OFR, wearable technology, such as global positioning systems (GPS) and heart rate monitors,[128] was ranked as the most popular monitoring technique and is used daily in 97% of cases. Furthermore, wearable technology was ranked the second most important factor for decision-making between sessions and, as rehabilitation progresses, monitoring techniques shifted from subjective to objective measures with GPS deemed most important.[36] This demonstrates the influence of GPS within rehabilitation, particularly during the late OFR phases before RTP, however, there is a lack of consensus with regards to specific metrics and thresholds used. Some practitioners using targets that "are arbitrary (set at a squad level), relative (set at an individual level) or a combination of both".[36] In some cases, there was a change from using absolute to relative units and different thresholds were reported for acceleration and deceleration metrics.[36] Despite this, it is widely accepted that systematic load progression/management and the development of tissue tolerance of an injury site is vital alongside restoring sport specific qualities.[38, 41, 42, 49, 116]

Table 4. An overview of conceptual models for on-field rehabilitation in football.

Study	Year	On-Field Rehabilitation Framework	Overview
Taberner et al.[38-40]	2019	Control-Chaos Continuum	• Introduces five stages of OFR, moving through 1) high control, 2) moderate control, 3) control to chaos, 4) moderate chaos and 5) high chaos. • The stages interlink global positioning system (GPS) variables, progressing volume and intensity, sport-specific conditioning, technical and movement qualities, while progressively increasing perceptual and reactive neurocognitive demands. • The application of this framework has been illustrated across different case studies depending on the specific needs of the injury.[44, 124, 125]
	2025	Evolving the Control-Chaos Continuum: Part 1 – Translating Knowledge to Enhance On-Pitch Rehabilitation	• Updated model of the control-chaos continuum, utilising research in injury neurophysiology, that integrates practice design and physical-cognitive interactions. • The updated framework incorporates elements of visual cognition, attentional challenges, decision-making, and progressive representation of the game model to enhance sport-specific preparation for returning to sport. • Increased emphasis on progressively challenging neurophysiological capabilities, skill redevelopment and reducing cognitive demands on RTS by embedding tactical principles and positional responsibilities of the game model earlier in the rehabilitation process.
		Evolving the Control-Chaos Continuum: Part 2 – Shifting 'Attention' to Progress On-Pitch Rehabilitation	• Emphasizes the design and delivery of progressive training in increasingly 'chaotic' conditions with the goal to align session and drill objectives to what the player experiences during competition. • Adaptable for injury severity, and integrates physical-cognitive load monitoring, and strength and power diagnostics to enhance decision-making throughout RTS. • Provides examples of how to adapt the 'high chaos' element to facilitate the transition to RTT and return to competition.
Buckthorpe et al.[41, 116]	2019	On-field Rehabilitation Part 1: 4 Pillars of High Quality On-field Rehabilitation	• Divided OFR planning into a two-part series within the context of ACL rehabilitation, however, the frameworks are designed to be applied to severe (>28 days) injuries. • The 'Four Pillars' of high-quality OFR planning are 1) movement quality, 2) physical conditioning, 3) sport-specific skills and 4) training load. • The sequential process begins with restoring movement patterns before gradually increasing metabolic and mechanical load and then integrating specific neurocognitive and perceptual demands. • The four pillars contribute across the five stage OFR framework (Part 2).

		On-field Rehabilitation Part 2: A 5-Stage Program for the Soccer Player	• The stages proposed are 1) linear movement, 2) multidirectional movement, 3) football-specific 4) technical skills and 5) practice simulation. • Each stage has specific entry criteria to ensure safe progression through the process while progressively increasing the athlete's exposure to volume and intensity. • Highlights criteria for full return should include clinical, functional, biomechanical, psychological and sport-specific factors.
Jiménez-Rubio et al.[117, 118]	2019	Rehabilitation and Readaptation Program for Hamstring Injury	• Developed and validated a functional OFR programme for hamstring strain injury. • Presents a thirteen item OFR programme arranged in order of increasing complexity. Upon completion player is declared fit to train with the team. • A panel of 15 experts deemed all 13 items of the programme to be valid. • 19 players who had suffered a grade two hamstring strain injury returned to play competitively in 22.42 (2.32) days after undergoing the program, and, reportedly, did not suffer a reinjury in a 6 month follow up period.
	2021	Indoor and On-field Reconditioning Program for Adductor Longus Injury	• Developed and validated an indoor and OFR programme for adductor longus injury. • Presents a 16-item indoor programme and 4-item OFR programme arranged in increasing complexity. • All 20 items were determined to be valid by a panel of 16 experts. • The programme was implemented on 12 players and no reinjuries were reported in the 15-week follow up period.
Stathas et al.[119]	2024	On FI.RE Framework	• Evaluated an accelerated OFR framework, defined as early initiation of OFR, compared to a traditional framework in male professional football. • In the On FI.RE. protocol the criteria for progression, in the early phases of rehabilitation, were higher pain thresholds and ROM targets to initiate on-field training earlier in the process. • The same criteria were used in the later stages of rehabilitation for both protocols. • The On FI.RE protocol reported a reduced time of 6.5 days to RTT and a reduced risk of subsequent injuries.

Legend: ACL, anterior cruciate ligament; GPS, global positioning system; OFR, on-field rehabilitation; On Fi.Re, On-Field Rehabilitation; RTP, return to play; RTS, return to sport; RTT, return to training.

Previous methods of measuring load progressions within rehabilitation have been demonstrated to be ineffective.[129-131] As part of a progressive rehabilitation, acute loads are 'high' due to injured players having no chronic load, therefore, models such as acute:chronic ratio[132] or percentage change are insufficient due to this divergence.[129, 131, 133] Based on preinjury data, current running loads and previous injury 'benchmarks', chronic load can be developed, taking player tolerance into consideration, with appropriate planning and incremental load progressions.[77] Lolli et al.[129] states acute load alone could be a useful predictor of injury in absolute terms and may not require normalisation for chronic load through different statistical approaches, i.e., analysing the actual amount of measurable acute load (e.g., total distance, sprint distance or total accelerations/decelerations) without normalising or comparing it relative to any other factors (e.g., chronic load) may be suitable to assess injury risk. Improving our understanding of 'load' within each phase of rehabilitation, and potential progression targets, would aid in the development of RTS frameworks.[49] In an applied setting, practitioners, through progressive overload, should aim to increase chronic load depending on the severity of the injury and with consideration towards the tissue type and healing process.

Research has shown a focus placed on psychological readiness during the latter stages of rehabilitation,[97] yet, with the reported shift of monitoring from subjective to objective measures through the rehabilitation phases,[36] practitioners must be cautious not to neglect subjective feedback as the player transitions through RTT, RTP and post-rehabilitation phases. Studies have acknowledged the importance of blending subjective and objective measures to monitor training and rehabilitation loads,[36, 134] however, physical and psychological readiness may not coincide[35] and, therefore, may be overlooked, misinterpreted or misunderstood. Despite the acknowledged importance of psychological readiness there is limited research into the efficacy and effectiveness of psychological strategies specifically facilitating readiness to return.[35] Furthermore, with the potential for injury severity to significantly impact mental health,[135] with anxiety and reinjury concerns being reported as key factors when players are close to RTP,[32-35] subjective measures may prove invaluable. Competence (i.e., sense of proficiency in their sporting capabilities), autonomy (i.e., a sense of control over their desired RTS trajectory) and relatedness (i.e., feelings of social connection and affiliation) have been shown to be key components influencing the final stages of rehabilitation,[35] therefore, monitoring and strategies to develop these skills are recommended. As sport-specific training is progressed visual-cognitive demands (e.g., high speed decision-making, dual-task processing) increase[39] leading to a subsequent increase in mental fatigue. Mental fatigue has been shown to impact physical and technical performance,[136, 137] therefore, progressive exposure, resilience and recovery from mental fatigue may be important to consider.

Several studies cite the importance of progressive sport-specific training in the late stages of rehabilitation and as a key component of OFR frameworks.[4, 38, 39, 41, 42, 44, 49, 97, 98, 113, 116, 123, 138] Furthermore, the understanding of the physical and cognitive demands of the sport is key in individualising injury risk management strategies throughout different stages of the season.[50] Within professional football the demands of match-play are well documented, and studies show a variation in demands depending on a number of factors, such as positional differences, formational changes and player status.[139-146] With studies showing high numbers of matches and increasing intensity the physical and mental load on players is significant.[15, 16, 147] Furthermore, high-intensity actions (i.e., accelerations, decelerations, sprinting) have been shown to be important in match defining events (i.e., scoring goals) and winning games.[148-151] With constantly evolving demands, requiring players to perform more frequent high intensity actions,[15-17] consistent re-evaluation is required to ensure the best support to players during the rehabilitation process. Less fit players have been shown to perform fewer high-intensity actions and a quicker fatigue progression impacting technical performance[143, 144, 152] and potential injury-risk.[153] This has motivational connotations for a rehabilitating player and should be a consideration for practitioners when returning players, ensuring an adequate fitness level.

There is a significantly increased injury risk in the first match after RTT and ensuring sufficient loads have been achieved and tolerated is an important factor.[42, 89, 154, 155] Research in Australian rules football has shown subsequent injuries to a different site or tissue were more common than reinjury[155, 156] and it has been reported that, in professional football, subsequent and recurrent injuries could account for 14% of injuries.[157] The reporting of subsequent injuries in sport is inconsistent and there is a paucity of data regarding severity, type and associated risk factors.[158, 159] This is an issue for injury prevention strategies, which rely on accurate injury surveillance data, as it does not provide an adequate understanding of injury risk.[157, 159] It is proposed the mechanism could be a general state of under-loading that predisposes the athlete to subsequent injury.[155, 156] This raises the question are athletes receiving enough 'general load' prior to RTT or are practitioners placing too much focus solely on 'injury-specific' rehabilitation?

Stares et al.[155] demonstrated higher running loads, achieved during rehabilitation, delayed RTP timeframes, however, moderate to high sprint loads could be protective against subsequent injury. The authors proposed that the accumulation of sprint loads increased chronic training load facilitating adaptation and minimising workload spikes, although chronic load was not identified as a significant factor in subsequent injury.[155] This demonstrates the complexity of RTP decision-making as accelerating rehabilitation protocols may not allow sufficient time for progressive overload, however, extending RTP timeframes will result in additional missed games potentially affecting team success.[1, 2, 155] With medical and performance departments under pressure to ensure efficient RTP, whilst trying to minimise further injury risk, further investigation into accelerated protocols, workload progressions and thresholds is required. The high physical demands of professional football, and the ever-increasing intensity and density of these demands, are important factors in rehabilitation programming. There is a pressing need for further investigation of the final phases of rehabilitation to ensure sufficient conditioning, and to develop specific objective thresholds, to inform progression and the final RTP decision.

Future Research Suggestions

Research acknowledges the importance and development of progressive rehabilitation pathways. Current frameworks,[38, 39, 41, 42, 116] utilised in professional football, are presented in this review and provide a stepwise progression for practitioners with evidence suggesting their influence in contemporary practice,[36] however, a multicomponent model adopting a non-linear, concurrent approach has been proposed for a general population with potential applications for sport models.[160] There has been a paradigm shift towards a criteria-based approach supporting progression and it has been stated an absence of valid objective criteria risks inadequate rehabilitation.[42, 43, 98, 100, 104] Specific practitioner competencies and knowledge, to provide optimal support, throughout the phases is still unclear and requires further evaluation.[19, 97] There is a lack of empirical evidence and knowledge of causality between 'load' application and successful outcomes in RTP and,[49] given the protective effects of moderating physical capacities (i.e., developing force-velocity profiles, energy system capacity, movement quality), further investigation is required throughout the rehabilitation process. There are significant challenges for research due to the heterogeneity of injuries, multiple, interacting moderators of risk and limited accessible sample sizes reducing statistical power,[161] particularly with athlete populations. Despite this, conceptual frameworks are essential to aid practice[126] and development, understanding and evaluation of objective criteria informing progression is an important next step. Further informing and validating frameworks[49, 126] may improve the decision-making process for athletes, practitioners and coaches.

External Load Metrics for Return to Play

Within current OFR frameworks external load metrics are acknowledged as an important objective criterion,[38, 41, 42, 100, 125] with metrics of interest emerging, such as very high speed running, peak speed, acceleration and deceleration distance,[162, 163] for specific injury pathologies. However, caution is advised as the metrics suggested lack empirical evidence, are based on anecdotal experiences or there is an absence of post-OFR information or pre-injury data.[36, 49, 138, 163] When examining the relationship between 'training load' and injury risk it is important to acknowledge this is likely to be associative and not causal,[49, 126, 164] a clear aetiology has not been established[165] and many studies have used inadequate analysis.[126] Insights into applied practice and expertise are crucial in evolving evidence-based practices.[36, 127, 166] A survey of practitioners suggests that research exploring "reduced risk of reinjury based on achieving specific markers/thresholds" would be beneficial when considered within the complex nature of injury[36] and an association with workload and injury risk has been demonstrated in non-injured players.[75, 167] Although 'training load' is associative, these metrics may assist in setting targets for successful RTP and support practitioners and athletes by providing objective information to make informed decisions.[168]

GPS monitoring is widely used to quantify external load[36, 138] and theoretical justification for load progression and management within rehabilitation is strong, although the optimal strategy is unknown.[138] Despite issues within football stadia potentially affecting signal quality,[169] GPS monitoring has been shown to be a reliable and validated measurement tool for evaluating movement demands within sports.[170-172] That said, due to the rapid nature of high-intensity actions (i.e., accelerations and decelerations), the validity of these has been questioned, with sampling rate, minimal effort duration[173, 174] and signal-filtering techniques important factors to consider.[172, 175-177] Given the high musculoskeletal forces that can accompany accelerations and decelerations[178, 179] and the critical importance of these actions for player performance and injury resilience,[142, 180] further research is necessary to investigate effective rehabilitation assessment, monitoring and programming (i.e., progression of exercises) to ensure players are optimally prepared to meet the demands of these specific actions during RTT and RTP. Furthermore, the role injury site and severity may have on acceleration and deceleration mechanics and the effect this may have on altering tissue forces and properties during, and following, the rehabilitation process requires investigation.

There is consensus in using match-specific GPS targets to inform RTP decisions.[99] Given the high demands a player is returning to, and the variation in physical demands due to playing position, there may be value in targeting individual within-session and acute (7 days) loads prior to RTT. Alongside this, individualised response to 'load' (i.e., subjective and objective measures of internal / external load and 'fatigue monitoring') and movement quality are important factors alongside training quantity.[36, 116] Training load has only recently been incorporated into models of injury aetiology[70, 103] despite being a risk factor for injury within a web of determinants.[43, 69] Future research should investigate this factor, acknowledging the role of 'load' within the complex nature of injuries, and further informing decision-making for RTT in an applied setting.

Within professional football, alongside GPS, the external load from specific technical actions can be quantified.[181] This allows for the analysis of technical actions within rehabilitation in combination with physical output. Further research is required to assess physical and technical outputs, through drill level analysis and positional specific training demands, to help inform the training reintegration process. Achieving load through sport-specific exposure may be beneficial from a physical perspective,[155] improve physical-cognitive capabilities,[39] and impact the psychology/perception of the player's readiness to return, potentially allowing an earlier RTT and RTP.

Injury Surveillance and Subsequent Injury

An issue within applied rehabilitation is the lack of consensus and discrepancies in injury tracking/surveillance.[157, 159] These inconsistencies in reporting make it difficult to research and understand subsequent relationships between injuries. Subsequent injury is a poorly defined and reported area within rehabilitation.[158] Further research is required to understand the inter-injury relationship and inform tertiary prevention programming.[157, 159, 182] Furthermore, workload monitoring to assess a potential association between post-RTT load, player status (i.e., key, squad or development player) and subsequent injury risk would be beneficial. This may help inform practitioners as to possible optimal loading strategies post-RTT. Understanding subsequent injury risk may provide a timeframe for a 'post-rehabilitation phase' based on the severity of the index injury and improve the development of injury specific monitoring strategies for both reinjury, and possible subsequent injuries, to alternative sites.[122] Furthermore, mechanism of subsequent injury is a further factor to investigate. Establishing a potential pattern of mechanisms may be beneficial to guide injury prevention programming. Previous injury and subsequent injury associations are rarely considered, despite previous injury modifying the complex interactions between determinants of injury.[158] Further studies are required into current practices within subsequent injury surveillance and specific athlete support post-RTT.

Player Perceptions of Rehabilitation Processes

The role of multiple stakeholders within rehabilitation has been widely acknowledged,[81, 183] however, despite being part of the decision-making process,[92, 95] player perception and role within rehabilitation is not thoroughly discussed. A lack of consensus between players and coaches regarding the RTP decision has been previously noted.[184] Players are a key stakeholder in rehabilitation and anxiety, the need for a plan, evaluating the risk of early return, demonstrating progress and social support are important factors in the process.[32, 35] Furthermore, establishing athlete satisfaction post-injury requires further research.[43] Feedback of GPS training data within professional football has been shown to support the coaching process and understanding player feedback preference is key to elicit engagement.[185] However, little exists around RTP procedures and player perceptions regarding the use of specific GPS targets within the rehabilitation setting and feedback of this data.

Injury Specific Metrics

Different load metrics may have varying relationships to injury risk[126, 186-188] and the specific stress/strain capacity, resilience and adaptation of different tissues.[46, 165, 189] In a survey of practitioners, "GPS metrics for certain injuries" was referred to as a useful future development in RTP protocols.[36] Quantifying the success of a rehabilitation process is an important consideration[36] and a continuum of importance for injury specific targets for different injury sites could be developed. These insights could give practitioners greater understanding of key injury specific metrics for load management during rehabilitation and post-RTT, although this should be acknowledged within the complex nature of injury.

Limitations and Perspectives

An acknowledged limitation of the article is the use of a narrative review and, therefore, a clear, systematic search methodology was not utilised resulting in potential bias.[186] The limitations of narrative reviews are documented,[190] however, using this method allowed for a wider search strategy exploring interdisciplinary topics and to reflect the complex nature of applied rehabilitation and decision-making for practitioners.

The review focuses on literature within the domain of male professional football, however, the frameworks presented may be further applicable to female professional football and developmental players. Research understanding the gender specific differences in injury and rehabilitation is growing,[191, 192] however, more is warranted specific to female football players and to academy players investigating the potential impact on long-term athlete development programming if an injury occurs. This may help to reduce disparity and improve understanding and application of the frameworks presented. Ultimately, a long-term objective of developing bespoke models for different sports, injury pathologies, age groups and genders, with multidisciplinary inputs, is crucial in future research and applied practices.

Conclusion

The purpose of this review was to give an overview of existing aetiological models, decision-making frameworks and RTS approaches within the current literature and evaluate the role of criteria-based progressions in rehabilitation frameworks and their application within male professional football. General sporting, and football specific models and frameworks are presented to demonstrate approaches and different interpretations of RTP and

RTS terminology. Further consensus in terminology used to define phases, and subphases (i.e., RTT subphases), within the rehabilitation procedure is required to help guide intention and impact phase specific monitoring, and performance markers to inform safe return. By understanding injury type, mechanism, severity and location, the demands of the sport and multiple interacting risk factors, evidence based RTP criteria can be used to guide decisions alongside practitioner intuitions and experiences. However, research of subsequent injury risk, and inter-injury relationships, is lacking in male professional football with current RTP frameworks using a stepwise progression through different rehabilitation phases and objective exit criteria to inform decision making. Development of flexible, bespoke frameworks, using validated objective criteria, is required and further research is needed to ensure effective rehabilitation procedures, with successful RTP outcomes, to guide programming, and decision-making, that minimises subsequent injury risk. Through improved practitioner knowledge and understanding of aetiological models, decision-making and rehabilitation frameworks, and the future development of these topic areas, the support of injured athletes can be enhanced during, and following, the rehabilitation process.

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Acknowledgements

Not applicable.

Author Contributions

BD was responsible for the conception and writing of the review. DH and JA contributed and provided supervision and feedback throughout. All authors critically reviewed the manuscript and approved the final version.

Statements and Declarations

Ethics Considerations

Not applicable.

Consent to Participate

Not applicable.

Consent for Publication

Not applicable.

Conflicts of Interest

The authors declare no competing interests.

Funding

No funding was received for this research.

Data Availability

Not applicable.