

# Italian consensus statement (2020) on return to play after lower limb muscle injury in football (soccer)

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## ABSTRACT

Return to play (RTP) decisions in football are currently based on expert opinion. No consensus guideline has been published to demonstrate an evidence-based decision-making process in football (soccer). Our aim was to provide a framework for evidence-based decision-making in RTP following lower limb muscle injuries sustained in football. A 1-day consensus meeting was held in Milan, on 31 August 2018, involving 66 national and international experts from various academic backgrounds. A narrative review of the current evidence for RTP decision-making in football was provided to delegates. Assembled experts came to a consensus on the best practice for managing RTP following lower limb muscle injuries via the Delphi process. Consensus was reached on (1) the definitions of 'return to training' and 'return to play' in football. We agreed on 'return to training' and RTP in football, the appropriate use of clinical and imaging assessments, and laboratory and field tests for return to training following lower limb muscle injury, and identified objective criteria for RTP based on global positioning system technology. Level of evidence IV, grade of recommendation D.

## INTRODUCTION

In professional football (soccer), injuries to the hamstring, quadriceps femoris, adductors and soleus-gastrocnemius account for 80%–90% of all muscle injuries.<sup>1–3</sup> Teams

## How might it impact on clinical practice in the future?

- ▶ Our findings represent a reference from Italian experts and may help inform practitioners looking for guidance when making RTT and RTP decisions following lower limb muscle injury in football.
- ▶ Further research is required to determine the reliability and validity of the tests recommended due to a lack of available evidence.
- ▶ We acknowledge that our consensus, despite engaging a large number of experts, provides 'level 4' evidence.
- ▶ We both anticipate and welcome constructive discussion on areas where others may have data we have missed, opinions that diverge from ours and suggestions for new investigations.
- ▶ We appreciate that the overarching goal of sports and exercise medicine research is to improve RTT and RTP for football players and all sportsmen and sportswomen.

that minimise time-loss injuries often achieve greater league success.<sup>4–7</sup> The return to play (RTP) decision-making process in professional football involves multiple stakeholders, including the individual player, the sports medicine team, the coaching staff and the

technical/performance teams. All must combine effectively to facilitate a successful RTP.<sup>8–12</sup>

There is very little research evidence to support RTP decision-making in football, so RTP decision-making process has been based on expert advice (level IV evidence, grade D, using the Grading of Recommendations Assessment, Development and Evaluation [GRADE] framework).<sup>13</sup> Today there is no consensus conference specifically focused only on RTP decision-making for lower limb muscle injuries in football. Muscle injuries represent a heterogeneous group including several muscle groups with varying anatomical location, size and biological responses (eg, healing time).<sup>1 14 15</sup> RTP decision should be based on the specific muscle injured. We propose clinical guidelines, imaging protocols, and laboratory and field tests for clinicians to consider for each muscle group.

### ITALIAN CONSENSUS CONFERENCE ON RTP AFTER LOWER LIMB MUSCLE INJURY IN FOOTBALL

The Italian Consensus Conference (CC) (referred to here as ‘Conference’) on RTP after lower limb muscle injury in football was organised by the Italian Society of Arthroscopy in Milan. The meeting was held on 31 August 2018, with the participation of 66 national and international experts covering several disciplines, including the following:

- ▶ Orthopaedic surgeons (19).
- ▶ Sports physicians (7).
- ▶ Radiologists (5).
- ▶ Rehabilitation physicians (3).
- ▶ Sport physiologists (2).
- ▶ General surgeons (2).
- ▶ Family physicians (2).
- ▶ Physiotherapists (10).
- ▶ Physical trainers (15).
- ▶ Psychologist (1).

The selection of experts was based on pre-eminence in at least one of three criteria: (1) Hirsch Index, (2) number of publications concerning muscle injuries in football, and (3) clinical evaluation, medical treatment and rehabilitation of muscle injuries in football. The experts did not represent any commercial organisations at the time of the consensus meeting. All those who participated in the CC are included as authors of this report. Two authors (KC and ZV), although not present at CC, provided intellectual contributions to the study.

This paper represents the synthesis of the Italian Conference on RTP following lower limb muscle injury in football. The complete document (90 pages in Italian) can be found on the official website of the Italian Society of Arthroscopy ([www.siaonline.net](http://www.siaonline.net)).

### CONSENSUS CONFERENCE NARRATIVE REVIEW PROCESS

Prior to the Conference, two senior authors (GNB and PV) performed a narrative review of RTP decision-making literature in sport and in football specifically. The review process was conducted as follows:

### Box 1 Inclusion and exclusion criteria

#### Inclusion criteria

- ▶ Patient and problem: randomised controlled trials, cases series studies and consensus statement investigating lower muscle injuries in sport.
- ▶ Intervention: conservative treatment of lower muscle injuries.
- ▶ Comparator: comparison between different types of muscle injury classification and different types of conservative treatments.
- ▶ Outcome: time lost to injury, level of return to play, complications and sequelae.

#### Exclusion criteria

- ▶ Patient and problem: randomised controlled trials, case series and consensus statements that investigated lower muscle injuries in a non-sporting population.
- ▶ Intervention: surgical treatment of lower muscle injuries.
- ▶ Comparison: comparison between conservative and surgical treatments.
- ▶ Outcome: unspecified outcome of time lost to injury, level of return to play, complications and sequelae.

- ▶ An independent search was performed by both authors, with no language limitation applied.
- ▶ The databases searched were Medline, EMBASE, Excerpta Medica, Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews. Grey literature (ie, conferences, abstracts, thesis and unpublished reports) was not considered.
- ▶ Studies that did not meet our inclusion criteria were excluded. The inclusion and exclusion criteria are shown in **box 1**.

The authors provided a summary document divided into two sections:

1. RTP decision general principles (in sport, not only in football; see inclusion criteria in **box 1**).
2. RTT and RTP decision-making following lower limb muscle injuries in football.

The document was presented to each expert a week ahead of the Conference and was considered the starting point for our discussion. The two senior authors facilitated (GNB) and chaired (PV) the Conference.

### CONSENSUS CONFERENCE STATEMENT

Having outlined the background to the consensus statement and the methods, we now share our key findings in two sections.

Section 1 of our consensus reports the general principles of RTP decision under five subheadings:

- ▶ Terminology relating to RTP.
- ▶ Return to training (RTT): decision-making process.
- ▶ RTP: decision-making process.
- ▶ Imaging: what role should it play when clinicians make RTT and RTP decisions.
- ▶ The biopsychosocial model and RTP decisions.

**Table 1** Mean (SD) of voting rounds for section 1 (RTP decisions general principles)

	Voting 1	Voting 2	Voting 3	Voting 4	Voting 5
Average score	9.76	9.76	9.80	9.72	9.96
SD	0.33	0.33	0.30	0.35	0.32

RTP, return to play.

Our consensus ‘decision-making process’ refers to the evidence-based criteria outlined to support decisions on both RTT and RTP.<sup>16 17</sup>

Section 2 of our consensus provides guidance on RTT and RTP decision following four specific lower limb muscle injuries in football. We cover decisions on both RTT and RTP following:

- ▶ Hamstring injuries.
- ▶ Quadriceps injuries.
- ▶ Adductor injuries.
- ▶ Soleus-gastrocnemius injuries.

The agreements and guidance presented were the result of a Delphi process. A written outline for each section was presented by the facilitator (GNB), followed by a plenary discussion conducted by the chairman (PV). Acceptance of a consensus statement was approved by a majority vote.

The Conference participants voted using a Likert scale of 0–10, where 0 reflected complete disagreement, 5 neither agreement nor disagreement, and 10 complete agreement. Clarification and debate continued until a mean score of >7.5 was reached.<sup>15 18–20</sup> For section 1, we required five rounds of votes, while for section 2 four rounds to reach consensus. Amendments were made between each voting round following discussion among the Conference group. Consensus was reached in all cases (ie, for each voting round, a mean score of >7.5 was reached). The voting results are shown in tables 1 and 2.

## SECTION 1: RTP DECISION GENERAL PRINCIPLES

### Terminology of RTP

The term RTP was defined by the consensus statement developed by the American Academy of Orthopaedic Surgeons and the American College of Sports Medicine as follows:

The decision-making process of returning an injured or ill athlete to practice or competition. This ultimately leads to medical clearance of an athlete for full participation in sports.<sup>21–23</sup>

This definition implicitly means a return to ‘full training and competition availability’. However, in football, RTP is complex and often involves a period of progressive reintegration, where a player is not necessarily a full participant in all team activities. This period varies on factors such as the type of injury and the overall amount of time out of full training. During the reintegration period, the player

**Table 2** Mean (SD) of voting rounds for section 2 (RTT and RTP decision-making following lower limb muscle injuries in football)

	Voting 1	Voting 2	Voting 3	Voting 4
Average score	9.24	9.64	9.54	9.72
SD	0.49	0.39	0.43	0.35

RTP, return to play; RTT, return to training.

may be subjected to constraints concerning both the intensity and amount of training load performed.<sup>24 25</sup>

The CC considered it necessary to introduce a clarification, in accordance with the 2016 consensus statement on the return to sport.<sup>8</sup> We define the term ‘*return-to-training*’ as beginning when the player is partially reintegrated into the team, and define the term ‘*return to play*’ as beginning when a player has made a full return to unrestricted availability in training and competition.

In summary, the concept of RTT is linked to ‘*return to sports practice/training with possible restrictions*’, while RTP is linked to the concept of ‘*return to training and competition without restriction*’. We underline that RTT and RTP are based on different decision-making criteria. RTT is based on clinical-functional criteria, whereas RTP is based on functional-performance criteria. The RTP criteria have an added layer of complexity as decision-making crosses from the responsibility of medical team to the performance team.<sup>24</sup>

### The RTT decision-making process

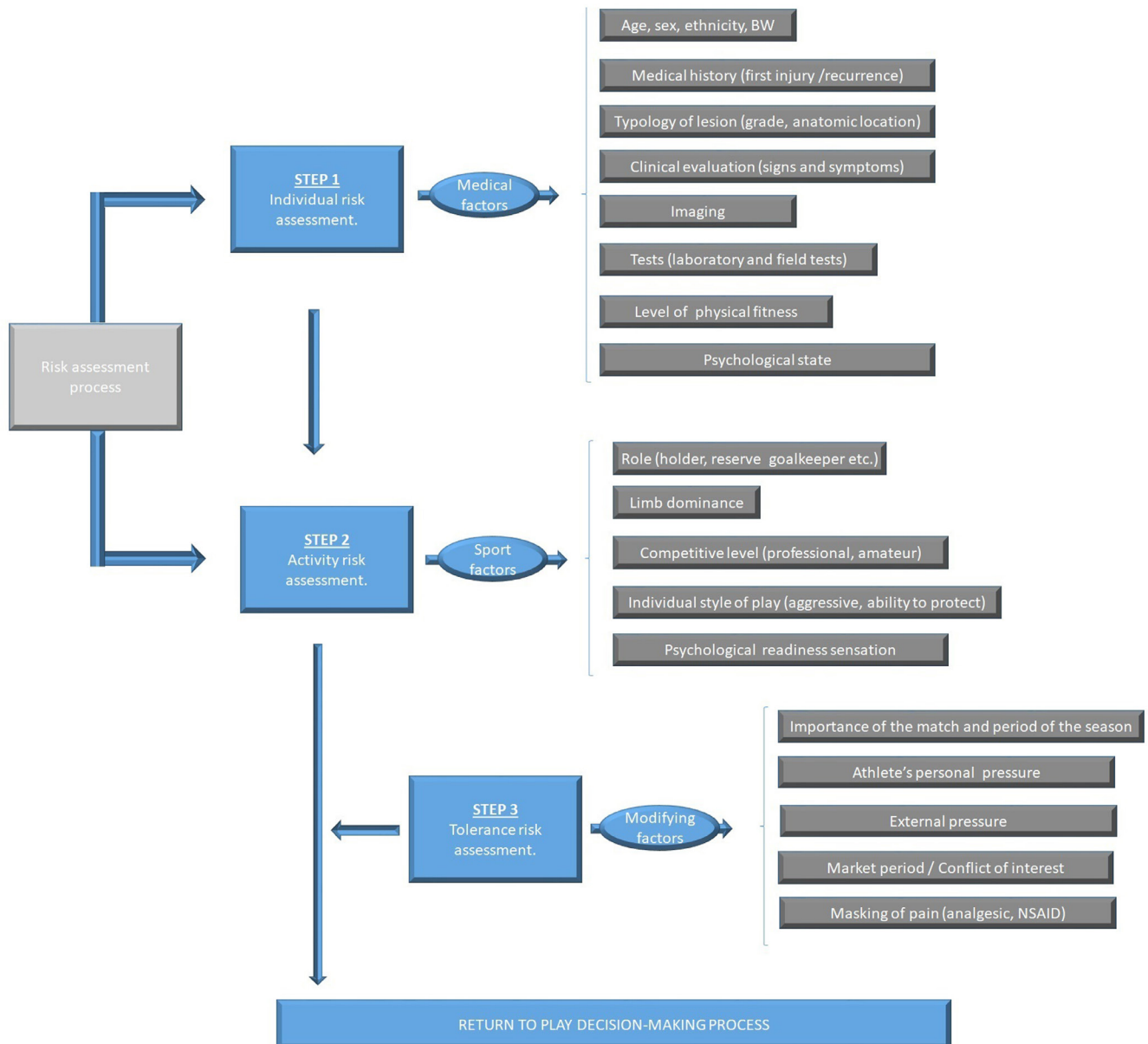
RTT decisions must be supported by clinical assessment and imaging and functional tests based on ‘injury-dependent criteria’. The following points must be identified and followed for each type of muscle injury:

- ▶ Identification of appropriate clinical tests dependent on the type of muscle injury.<sup>8</sup>
- ▶ Identification of appropriate imaging protocols dependent on the type of muscle injury.<sup>15 24 25</sup>
- ▶ Identification of appropriate laboratory tests specific to the functional deficit for the type of muscle injury.<sup>26 27</sup>
- ▶ Identification of appropriate field tests specific to the functional deficit for the type of muscle injury.<sup>26 27</sup>

The test battery must account for the performance and related physiological demands of each player’s field position. RTT decision-making process may need to be altered for primary time-loss or recurrent time-loss injury.<sup>8–10 16 17</sup>

### The concept of ‘tolerable risk’ in RTT decision-making process

Tolerable risk (TR) represents the maximum level of risk acceptable for different short-term and long-term outcomes associated with RTT.<sup>8–10 28 29</sup> TR is attributed equally to medical and technical staff, team management, and the player. TR is shared except in life-threatening situations (eg, concussion in which the player has a reduced level of consciousness/decision-making ability). Under such circumstances, the



**Figure 1** Tolerance risk flow chart. The first step is the ‘individual risk assessment’, while the second step is the ‘activity risk factors’. The first and second steps represent the ‘risk assessment process’. The third step (tolerance risk assessment) influences the risk assessment process in the return to play decision-making process. BW, body weight.

sole and final decision of RTT depends entirely on the medical team assessment. TR is variable and dependent on the presenting situation. For example, TR may be considered greater in a cup final than in a friendly match. Furthermore, TR can be influenced by several factors, such as whether an injury is acute or an overuse injury; a first time injury or recurrence; by its degree of severity and anatomical location; by its type (ie, monoarticular muscle, biarticular muscle, myotendinous junction, in proximity to the central tendon and so on); and by biological, endocrine-metabolic and gender-related factors. TR may also need to take into account for economic evaluations; a typical example is when the player is directly involved in a market negotiation

(ie, transfer). The tolerance risk flow chart is shown in [figure 1](#). In any case, it is important to underline that the medical staff has the responsibility to act in the best interests of the player’s long-term health regardless of any contractual negotiation.

For player suffering from a muscle injury, TR is represented by the objective quantification of the maximum mechanical load that can be tolerated by the injured muscular tissues. TR must be based on the following:

- ▶ Clinical examination.
- ▶ Imaging.
- ▶ Functional tests.

The clinical examination is illustrated in section 2.

## The basic principles of functional tests used in the RTT decision-making process

Functional tests must attempt to simulate real-time game situations that replicate the following<sup>28</sup>:

- ▶ Forces required during muscle contraction.
- ▶ Speed required during movement.
- ▶ Power expressed during movement.
- ▶ Type of movement required (ie, specific or non-specific to the football model; eg, straight line running is a non-specific movement, while cutting during a run is a specific movement).
- ▶ Specificity of the required movement (ie, specific or non-specific in comparison with the movement/movements that can cause a reinjury in the previously injured muscles; eg, a sprint is a specific risk movement for biceps femoris muscle injury, and kicking is a specific risk movement for rectus femoris muscle injury).

## Objective criteria in the RTP decision-making process

Decisions for RTT and RTP should be based on objective criteria. The only subjective criteria that may be taken into account are the individual profiles (ie, the psychological state) of players. Clinical and functional investigations that are numerically quantifiable are preferred when making decision. In this context, a reported pain value, such as the Visual Analogue Scale, is acceptable. Indeed, pain is an essential parameter in the decision-making process.<sup>30-48</sup> The presence of pain in the injured tissue area strongly suggests that healing is incomplete. For this reason, many authors underline the notion that RTT should be granted only on complete resolution of the presenting symptoms.<sup>36 48-54</sup>

## The RTP decision-making process

The RTP decision-making process is a judgement of whether the athlete is fit enough to resume full training without restriction, as well as ready to take part in competition. The decision-making process for RTP, which follows that of RTT, is an assessment based on a judgement of 'functionality' and 'performance capacity' rather than 'clinical-functional suitability'.

We considered the use of global positioning system (GPS) technology<sup>55 56</sup> sufficient to inform objective criteria. Therefore, these recommendations are limited to teams who have access to GPS information. We encourage all professional teams to adopt GPS data collection.

We subdivided the fundamental points of the RTP decision into three evaluation categories:

- ▶ Quantitative evaluation (QNE).
- ▶ Qualitative evaluation (QLE).
- ▶ Parameter analysis (PA).

## Quantitative evaluation

QNE<sup>25 57-59</sup> requires the analysis of speed (divided into six progressively increasing speed categories) recorded in the last period of preinjury training versus the same

parameters recorded in the postinjury period to make an RTP judgement.

For each of the six categories of speed listed, the recorded data should account for the time spent and distance covered at the indicated velocity. Recordings should be taken in similar training environments (ie, do not compare possession-based play with shuttle runs). The categories are presented below.

- ▶ Walking (range 0–<5.4 km/hour).
- ▶ Jogging (range 5.5–<10.8 km/hour).
- ▶ Low speed running (range 10.9–<14.4 km/hour).
- ▶ Intermediate speed running (range 14.5–<19.8 km/hour).
- ▶ High-speed running (range 19.9–<25.2 km/hour).
- ▶ Maximum speed running (≥25.2 km/hour).

## Qualitative evaluation

QLE is based on the analysis of metabolic power (MP) calculated with GPS technology. MP (expressed in W/kg<sup>-1</sup>) represents the product of speed and acceleration in determining the intensity of running.<sup>57-59</sup>

The MP value can be calculated using the following formula<sup>57</sup>:

$$MP = CE \cdot v$$

where CE represents the energy cost of running at a constant speed (equal to 1 kcal/kg/km)<sup>59</sup> and *v* is the athlete's instantaneous speed. Below is the division of MP into six progressively greater categories. MP is calculated by quantifying time spent in each MP category.

- ▶ Low power (0–<5 W.kg<sup>-1</sup>).
- ▶ Intermediate power (5.1–<10 W.kg<sup>-1</sup>).
- ▶ High power (10.1–<20 W.kg<sup>-1</sup>).
- ▶ Higher power (20.1–<25 W.kg<sup>-1</sup>).
- ▶ Very high power (25.1–<50 W.kg<sup>-1</sup>).
- ▶ Maximum power (≥50 W.kg<sup>-1</sup>).

MP time values recorded in the last period of preinjury training are compared with the same parameters recorded postinjury to formulate the RTP judgement.

## Parameter analysis

PA is based on a number of parameters recorded preinjury, including the following<sup>57-59</sup>:

- ▶ Total distance covered during training (regardless of the run speed).
- ▶ Equivalent distance (ED). In football, energy expenditure is influenced by the accelerating and decelerating components of the activity.<sup>58</sup> ED corresponds to the distance that the athlete could theoretically cover if he ran, at constant speed, using the same total energy expenditure as that used during the game. The ED value can be calculated using the following formula<sup>57</sup>:

$$ED = W / Ecc$$

where  $W$  represents the energy cost expressed in J/kg, and  $E_{cc}$  is the energy cost of running in a straight line at constant speed on compact grassland (ie, 4.6J/kg).

- ▶ Equivalent distance index (EDI). EDI represents the ratio between the value of ED and the distance actually covered by the player (RD) according to the following formula<sup>57</sup>:

$$EDI = ED / RD$$

- ▶ Anaerobic index (AI). AI represents the ratio between the energy cost beyond a certain metabolic threshold (ie, anaerobic threshold value or maximal aerobic speed value) and is calculated as follows<sup>57</sup>:

$$AI = W_{tp} / W$$

where  $W_{tp}$  represents the energy consumed beyond the metabolic threshold considered (anaerobic threshold or maximal aerobic speed) expressed in J/kg, and  $W$  is the total energy expenditure, also expressed in J/kg.

#### The evaluation of aerobic fitness in RTP decision-making process

Many studies suggest a correlation between low aerobic fitness and increased risk of muscle injury.<sup>60–66</sup> Injuries with greater time loss characterised by low-intensity physical activity are accompanied by a decrease in aerobic fitness.<sup>6</sup> Suspension of high-intensity aerobic activity for 20 days or greater results in a significant decrease in  $VO_{2max}$ .<sup>67 68</sup> Therefore, 20 days or greater of reduced aerobic activity should include an evaluation of  $VO_{2max}$  and/or the corresponding aerobic speed value<sup>69</sup> assessed by an incremental speed run test. We suggest evaluating aerobic fitness during the RTP period by a valid test for determining  $VO_{2max}$ .<sup>70–74</sup>

#### The monitoring of acute and chronic load in the RTP decision-making process

The over-riding priority of RTP period is to avoid reinjury.<sup>8–10</sup> Monitoring of the training load, that is, the ‘acute load’, in relation to the preceding four training loads, that is, the so-called ‘chronic load’, allows the ‘acute versus chronic workload’ ratio (ACWR) to be calculated.<sup>75</sup> Use of ACWR is still debated and therefore it may be necessary to update load calculations based on future best practice guidelines.<sup>76 77</sup> However, we consider the calculation of ACWR useful in managing progressive increases in training load, which may reduce the risk of reinjury. We strongly advise that ACWR assessment becomes an integral part of RTP decisions.

#### The role of imaging in the RTT and RTP decision-making process

The value of imaging during decision to return a player to sport is debated.<sup>16 78–83</sup> In RTP cases 29–49 days after a muscle injury, between 50% and 90% of athletes still show an abnormal MRI signal (ie, hyperintensity of the injured area).<sup>84–86</sup> Furthermore, an abnormal ultrasound

(US) signal may be obtained in 32% of examinations.<sup>84</sup> On average, the area under the anomalous MRI signal, at the time of RTP, ranged from 20% to 28% of the area measured at the baseline, that is, at the time of the injury.<sup>86</sup> Both the MRI and the US signals normalised after an average of 6 months.<sup>84–86</sup> Several studies of postlesion tissue at the time of RTP demonstrate that 34% of athletes exhibit a low-intensity MRI signal, indicative of the formation of fibrotic scar tissue.<sup>84 87 88</sup> Despite persistent alteration, the percentage of reinjuries was less than 2%.<sup>84–86</sup> The presence of abnormalities on MRI and US during this period may be explained by the greater number of the ionic interactions of immature collagen formed during the early stage of muscle healing. The conversion of these weaker bonds to stronger covalent bonds, during post-translational modifications of the constituent amino acids, may require longer periods of up to 6 months depending on the extent of the injury.<sup>84</sup>

Therefore, in respect of imaging, this consensus specifies the following:

- ▶ RTT decision-making process does not necessarily require a total resolution of MRI and US area of signal alteration.<sup>84–86</sup>
- ▶ In MRI, a signal alteration (hyperintensity zone in fluid-sensitive sequences) decreased by at least 70% in comparison with the baseline signal alteration is acceptable for RTT.<sup>85 86 89</sup>
- ▶ The presence of an extensive area of low signal intensity, indicative of fibrotic scar tissue, must be interpreted as a risk factor for reinjury.<sup>83 86 87</sup> However, attention must be paid to the fact that a haemosiderin deposition, following haemorrhage, can mimic the formation of fibrotic tissue.<sup>89</sup>
- ▶ Given its greater sensitivity and the greater tissue contrast gradient, MRI is preferable to US when making RTT decisions.<sup>84 89</sup>

#### The biopsychosocial model

RTT and RTP decision-making processes are heavily influenced by the psychosocial context within which they occur.<sup>80–93</sup> Not taking psychosocial factors into account can lead to the loss of valuable objective information being missed. Psychological factors include apprehension, fear or anxiety. In addition to negatively interfering with performance, these parameters represent a risk factor for reinjury.<sup>37 54 94–97</sup> Therefore, we specified the following:

- ▶ During RTT and RTP decisions should take into account the psychological state of the athlete.<sup>37 94–96</sup>
- ▶ Individuals such as the coach, technical staff and others may exert pressure on the RTT and RTP decision-making process.<sup>29 43 44 94 98–103</sup> A potential conflict of interest exists between the athlete’s needs and wishes of the coach, technical staff and/or the management team of the club.<sup>100 104 105</sup> We recommend all stakeholders avoid external pressures to maintain maximum objectivity during RTT and RTP decisions.

- ▶ The decision-making process must be based on a continual exchange of information, between all stakeholders. This should allow for reformulation/revision of the rehabilitation plan where necessary.<sup>8–10</sup>
- ▶ The RTT and RTP decision-making process must be based on a continuum that runs parallel to the rehabilitation process. Isolated decisions regarding RTT and RTP that are not part of the rehabilitation process are to be avoided.<sup>8–10</sup>
- ▶ The RTT and RTP decision-making process must be player-centred. The central role of the player/patient is to be respected by taking the following into account:
  1. The short-term, medium-term and long-term health risks associated with RTT and RTP.
  2. The role of player/patient as an active ‘decision maker’ when deciding whether to RTT or RTP.

## SECTION 2: RTT AND RTP DECISION-MAKING FOLLOWING LOWER LIMB MUSCLE INJURIES IN FOOTBALL

Hamstrings, quadriceps, adductors and soleus-gastrocnemius muscles account for 80%–90% of all football muscle injuries.<sup>1–3</sup> Each muscle group was reviewed and reported under five subheadings:

- ▶ Epidemiology.
- ▶ Clinical and imaging assessments for RTT.
- ▶ Laboratory tests for RTT.
- ▶ Field tests for RTT.
- ▶ RTP tests.

### RTT and RTP decisions following hamstring injuries

#### Epidemiology

Hamstring injuries are the most frequent injury in football and represent about 17% of all football injuries.<sup>106</sup> A professional football team incurs an average of 10 hamstring injuries per season.<sup>67</sup> This results in an average of 90 days of time lost to injury, and on average between 15 and 21 matches lost per team per season. The incidence of hamstring injuries ranges from 0.87 to 0.96 per 1000 hours of exposure (training and match).<sup>6</sup>

#### Clinical and imaging assessments for RTT

The following are our recommendations for clinical and imaging assessments for RTT following hamstring injury:

#### General assessment

- ▶ Absence of clinical symptoms.<sup>49 53 54</sup>
- ▶ Absence of pain or tenderness during muscle palpation.<sup>15 49 54 86 107</sup>
- ▶ Absence of pain on passive and active stretching.<sup>15 108</sup>
- ▶ Absence of pain on isometric, concentric and eccentric contraction.<sup>15</sup>
- ▶ Completion of the prescribed rehabilitation programme.<sup>86</sup>
- ▶ MRI and US imaging assessment respecting points specified in ‘The role of imaging in the RTT and RTP decision-making process’ section.<sup>84–89</sup>

- ▶ Subjective feelings of the player taken into account (ie, assess levels of anxiety, apprehension, fear of failure and/or fear of reinjury).<sup>37 54 94–97</sup>

#### Specific assessment

- ▶ Passive straight leg raise test.<sup>54 108–110</sup>
- ▶ Dynamic flexibility H test.<sup>111</sup>

#### Laboratory tests for RTT

The following are the laboratory tests recommended prior to RTT:

- ▶ Evaluation of hamstring muscle strength by dynamometric tests (isometric, isotonic and isokinetic tests).<sup>54 85 112 113</sup> The basic principles for the administration of dynamometric tests are shown in [table 3](#).

#### Field tests for RTT

The following are the field tests we recommended to determine readiness to RTT after hamstring strain:

- ▶ Illinois Agility Test.<sup>24 25 114–116</sup>
- ▶ Braking test.<sup>24 25</sup>
- ▶ Backward running.<sup>117</sup>

No previous validation studies were identified on the use of field tests to inform RTT and RTP. However, we considered an RTP test checklist for athletes who suffered a lower extremity injury set out in a 2013 Delphi study.<sup>118</sup> The tests were recommended based on expert opinions (GRADE evidence level V). Furthermore, the Illinois Agility Test is an asymmetric test<sup>24 25 114–116</sup>; thus, we recommend execution in its modified format formulated by Rouissi *et al.*<sup>119</sup>

#### RTP tests

The RTP decisions are based on performance evaluation, and therefore chronologically follow the RTT decision-making process. We recommend the following RTP specific guidelines:

- ▶ The data acquisition period must start from the first day of RTT and include a period of at least 7–10 days.
- ▶ During this period, the training sessions should be systematically recorded via GPS technology.
- ▶ It is necessary to identify several ‘typical’ sessions from the last preinjury week and from the period following the RTT on which to base a return to normal function.

The three evaluation categories are mentioned in the ‘The RTP decision-making process’ section.<sup>57–59</sup>

The reference value, below which the positive judgement for RTP is postponed, is arbitrarily set at a maximum difference of 10% between preinjury data and the data recorded during the acquisition period following RTT.

Furthermore, regarding aerobic fitness, we advise the player regains a  $VO_{2max}$  value equal to at least 90% of their preinjury level.

### RTT and RTP decisions following quadriceps injuries

#### Epidemiology

In soccer, the majority (~88%) of quadriceps femoris injuries involve the rectus femoris.<sup>67</sup> The risk of suffering from this type of injury is higher during competition than

**Table 3** Basic principles for the administration of dynamometric (isometric, isotonic and isokinetic) tests

Isometric tests <sup>147–149</sup>	Isotonic tests <sup>147 150–152</sup>	Isokinetic tests <sup>42 85 112 113 153</sup>
Operate a proper warm-up. Biomechanically isolate the muscle group to be tested.	Operate a proper warm-up. Biomechanically isolate the muscle group to be tested.	Operate a proper warm-up. Biomechanically isolate the muscle group to be tested.
Standardise the lever arm.	Standardise the lever arm and ROM.	Standardise the lever arm and ROM.
Begin the test with the healthy limb.	Begin the test with the healthy limb.	Begin the test with the healthy limb.
Apply an isometric contraction of progressive intensity for a duration of between 3 sec and 5 sec.	Apply the maximal speed during the movement.	Align the centre of rotation of the joint with that of the mechanical device.
Encourage the patient during the test.	Encourage the patient during the test.	Encourage the patient during the test.
Perform at least three trials with an adequate recovery between each trial (around 1 min 30 sec).	Perform at least one set of 6–10 repetitions.	Subtract the weight of the limb from the calculation of the force moment (usually done automatically by the device).
Consider the peak value.	Consider both average and peak value.	Consider the average value, avoiding the so-called ‘peak artifact’.
Check for any pain symptoms with VAS.	Check for any pain symptoms with VAS.	Check for any pain symptoms with VAS.
Stop the test in the presence of severe pain (VAS >3).	Stop the test in the presence of severe pain (VAS >3).	Stop the test in the presence of severe pain (VAS >3).
The dynamometric values must be ≥90% of the prelesion values or ≥90% of the contralateral limb values.	The dynamometric values must be ≥90% of the prelesion values or ≥90% of the contralateral limb values.	Perform one set of 6–10 repetitions at low speed (30°/s–60°/s) and one set at high speed (>300°/s).  Perform at least one eccentric test at 60°/s or 30°/s. Consider the value of the joint angle corresponding to the peak force production. Consider the values of the mechanical work. Consider the shape of the force curve. Consider the value of the ratio of HS (concentric modality) to Q (concentric modality), and the value of the ratio HS (eccentric modality) to Q (concentric modality). Perform the tests observing an adequate recovery between the sets (~2–3 min). The dynamometric values must be >>90% of the pre-lesion values or >>90% of the contralateral limb values

ROM, range of motion; VAS, Visual Analogue Scale.

training (1.1 vs 0.3 per 1000 hours of exposure)<sup>6–120</sup>; 62% of rectus femoris lesions are recorded during the first half of the match, and the peak risk is observed between the 16th and 45th minutes of play.<sup>6 120</sup> The most common mechanism of injury is during the kicking motion (~28% of injuries). The rate of reinjury is approximately 13%,<sup>121–123</sup> and a team of 25 players should expect on average three lesions of the rectus femoris per season, resulting in a total time loss of around 50 days.<sup>6 7</sup>

#### Clinical and imaging assessments for RTT

We recommend the following clinical and imaging assessments for RTT following quadriceps injury:

#### General assessment

- ▶ The same conditions specified for hamstring lesions hold true.

#### Specific assessment

- ▶ Passive quadriceps stretch test.<sup>108 124</sup>

#### Laboratory tests for RTT

After quadriceps injury, the following are the laboratory tests for RTT recommended by CC:

- ▶ Quadriceps muscles strength assessed by dynamometric tests.<sup>54 85 112 113</sup>
- ▶ Synchro plates test.<sup>113</sup>



### Field tests for RTT

The following are the field tests recommended prior to RTT following quadriceps injury:

- ▶ Illinois Agility Test.<sup>24 25 114 115</sup>
- ▶ Braking test.<sup>24 25</sup>
- ▶ Kicking test.<sup>24 25</sup>

### RTP tests

- ▶ The same conditions specified for hamstring lesions hold true.

## RTT and RTP decisions following adductor injuries

### Epidemiology

Adductor injuries account for 23% of all muscle injuries in soccer.<sup>125 126</sup> They occur most frequently in the 22–30 years age group and reinjury rates are reported to be as high as 18%.<sup>125 126</sup> Previous injury and a history of reduced adductor muscle strength have been identified as risk factors for adductor injury.<sup>127</sup> Amateur soccer players with adductor weakness are four times more prone to adductor injury.<sup>126</sup>

### Clinical and imaging assessments for RTT

The following are the clinical and imaging assessments prior to RTT recommended by CC following adductor injury:

#### General assessment

- ▶ The same conditions specified for hamstrings and quadriceps lesions hold true.

#### Specific assessment

- ▶ Pubic stress test.<sup>113 128 129</sup>
- ▶ Resisted hip adduction test.<sup>112 127 128</sup>
- ▶ Squeeze test.<sup>113 130–133</sup>
- ▶ Adductor passive stretching test.<sup>108 134</sup>

### Laboratory tests for RTT

The following are the recommended laboratory tests for RTT following adductor injury:

- ▶ Adductor muscles strength assessed by dynamometric tests.<sup>54 85 112 113</sup>

### Field tests for RTT

The following are the field tests for RTT recommended by CC following adductor injury:

- ▶ Kicking test.<sup>113</sup>
- ▶ Carioca test.<sup>135 136</sup>

### RTP tests

- ▶ The same conditions outlined for hamstrings and quadriceps lesions hold true.

## RTT and RTP decisions following soleus-gastrocnemius injuries

### Epidemiology

Soleus-gastrocnemius (calf) injuries are common across sports involving high-speed running, high total running loads and high number of accelerations/decelerations. Calf injuries are observed frequently when a player is

fatigued. Football match play incidences of 0.84 per 1000 hours of exposure have been recorded.<sup>137 138</sup> Calf injuries cause greater time loss per incident<sup>138</sup> and are more likely to occur during critical periods of competition (eg, end of the season in soccer).<sup>139</sup> Older soccer players (above 25.8±4.5 years) demonstrate an almost twofold increase in the rate of calf injury (HR, 1.93; 95% CI 1.38 to 2.71).<sup>6</sup> Age and a history of calf strain are the strongest risk factors for suffering future calf injury.<sup>6 7</sup>

### Clinical and imaging assessments for RTT

The following are the clinical and imaging assessments prior to RTT recommended by CC following calf injury:

#### General assessment

- ▶ The same conditions specified for the hamstrings, quadriceps and adductor lesions hold true.

#### Specific assessment

- ▶ Heel-raise test.<sup>140 141</sup>
- ▶ Ankle flexibility test.<sup>142 143</sup>

### Laboratory tests for RTT

The following are the laboratory tests prior to RTT recommended by CC following calf injury:

- ▶ Soleus-gastrocnemius muscles strength assessed by dynamometric tests.<sup>53 84 111 112</sup>
- ▶ Synchro plates test.<sup>113</sup>
- ▶ Drop jump test.<sup>144–146</sup>

### Field tests for RTT

The following is the field test for RTT recommended by CC following calf injury:

- ▶ Illinois Agility Test.<sup>24 25 114–116</sup>

### RTP tests

- ▶ The same conditions specified for the hamstrings, quadriceps and adductor lesions hold true.

## SUMMARY AND CONCLUSION

The Italian CC incorporated a cross-professional group of established clinician and academics from various backgrounds. The diversity of the group provided a large number of experiential-based viewpoints to be taken into account. The CC recommendations are summarised as follows:

1. The appropriateness of the term RTP and the concepts of RTT were reformulated as RTT signifying a return to sports practice with possible restrictions, and RTP a return to training and competition without restriction.
2. The general and specific criteria concerning RTT and RTP decision were identified, discussed and approved.
3. The four main muscle groups (hamstrings, quadriceps, adductors and soleus-gastrocnemius) involved in lower limb football muscle injuries were identified and discussed. The CC approved recommendations on the following areas:
  - a. Clinical and imaging assessment for RTT.
  - b. Laboratory tests for RTT.
  - c. Field tests for RTT.

## d. RTP tests.

**FUTURE OBJECTIVES**

The CC recommends the future development and research into efficacy of the following:

- ▶ Field and laboratory tests to objectively inform RTT and RTT decisions.
- ▶ The role of imaging in the decision-making processes for RTT and RTP.

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