Return to play criteria after hamstring muscle injury in professional football

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Return to play criteria after hamstring muscle injury in professional football: a Delphi consensus study.

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INTRODUCTION

Hamstring muscle injury (HMI) is the single most common injury in professional football, accounting for 12% of all injuries.[1] Rehabilitation of HMI aims to bring the player back to their pre-injury performance level in the shortest time possible, while minimising the risk of re-injury. Re-injury rate is high (16%) and is linked with significantly longer time to return to play (RTP).[1] Pressure is therefore on medical teams to bring players back onto the field as quickly as possible, but balanced with safe and clinically reasoned RTP decisions in order to avoid re-injury.

RTP decision-making is a complex process, which is based on the evaluation of the relevant health (medical and injury-specific factors) and activity (performance factors) risks, but is also influenced by contextual factors known as decision modifiers (e.g. timing of the season, competitive level, pressure).[2, 3] Despite the relevance of this issue, there is currently no consensus on RTP assessment following HMI in sports. As reported in a recent qualitative systematic review, numerous criteria are used but none of these have been validated.[4] In the absence of scientific evidence, Delvaux et al[5] explored current practice with a survey of physicians from French and Belgian elite football clubs. The authors produced a list of RTP criteria but did not investigate the degree of consensus between responders. The paucity of available evidence on such a relevant topic in football medicine can be explained by the intrinsic limitations that research encounters into this field, such as ethics, players' and clubs' availabilities, and confidentiality.[6, 7] However, there remains the need for validated criteria to facilitate HMI RTP management.

Within the Evidence Based Practice framework, it is established that where no research has been published on a given subject or experimental designs are not feasible due to ethical issues, then expert opinion and expert clinical practice should be considered.[8] This is the case for RTP assessment after HMI in professional football, where the studies available are limited despite a strong need to standardise RTP criteria.[9] Therefore, the aim of this study is to use the Delphi method to reach expert consensus on RTP criteria after HMI in professional football.

METHODS

The Delphi method is an iterative multistage process used to achieve expert consensus on a given subject.[10] In this study, a three-round modified Delphi technique was employed with questionnaires administered anonymously through LimeSurvey (http://www.limesurvey.com); an online secure survey software. The University of Birmingham Ethics Committee (UK) approved the study protocol.

Participants

A key challenge with Delphi studies is the identification of appropriate experts.[11] In this study, physicians and physiotherapists working in professional football clubs in England were assumed to be experts of HMI RTP. With the support of The Football Association (the governing body of football in England), initial contact with the medical departments of all the clubs participating in the English professional football leagues (n=92) was made via e-mail. The invitation included a Participant Information Sheet with the details of the study and its procedures. One expert from each football club was invited to participate in order to avoid sampling bias and duplicate answers by having multiple participants from clubs. Participants were given 1 month to complete the questionnaire in each round, with email reminders sent to non-responders after 1 and 3 weeks. Participants failing to respond in time were still invited to participate in the following round. The whole process lasted from March to July 2016.

Round 1

In Round 1 participants were invited to list all the criteria and assessment methods that they use within the club to inform RTP decisions after HMI. No reference was made to when a test should be performed, be it during or at the end of rehabilitation; rather, RTP criteria were defined as any test or measurement that need to be considered and cleared prior to allowing a player to RTP. An open-ended format with space for free text answers was used to increase the richness of the data collected.[11] Using a content analysis approach,[12] semantically equivalent responses were grouped and categorised under univocal definitions of RTP criteria and assessment methods. In order to reduce categorisation bias, responses were independently coded by 2 researchers, who then collated their analyses through a process of discussion to achieve agreement.[12] At the end of this process, a list of RTP criteria and assessment methods was produced for use in Round 2.

Round 2

In Round 2 participants received the list produced at the end of Round 1 and were informed through feedback on how different responses had been categorised in order to avoid misunderstandings of the terms employed. Participants were asked to rate on a 1-5 Likert scale (Strongly disagree, Disagree, Neutral, Agree, Strongly agree) how much they agreed or disagreed with each RTP criterion and with the appropriateness of the relative assessment methods. Participants were invited to share comments on the process and to give reasons for their rating.

Round 3

In Round 3, participants received feedback on Round 2 results in the form of descriptive statistics, which enabled reflection before expressing their final opinion. Participants were then asked to re-rate (using same Likert scale as Round 2) the criteria that had reached consensus in Round 2, and were given the opportunity to share comments on the reasons behind their rating and on the whole Delphi process.

Data analysis

Following acceptance of assumptions regarding the equality of points on the Likert scale, it was argued as an interval scale.[13] Ratings for each item were analysed and expressed as means with standard deviation. Consensus between participants was measured using coefficient of variation (CV) and percentage agreement (%AGR).[14] CV is a measure of dispersion and %AGR was defined as the percentage of responses falling within the top 2 categories of the 5-point scale (Agree and Strongly agree). Agreement between participants was also evaluated across all items using Kendall's W coefficient of concordance; a non-parametric statistic that can be used to assess strength and changes of agreement between raters.[14] Statistical significance was set at α=0.05. All data were downloaded from LimeSurvey and analyses were performed using IBM SPSS version 21 and Microsoft Office Excel. Table 1 illustrates the requirements for consensus in Rounds 2 and 3. Criteria reaching consensus were retained while those not reaching consensus were removed.

Table 1 Requirements for consensus in Rounds 2 and 3.

Criterion	Round 2	Round 3
Mean rating	≥3.5	≥4.0
CV	≤40%	≤30%
%AGR	≥60%	≥70%
Kendall's W	Significant agreement (p<0.05)	Significant agreement (p<0.05)

RESULTS

Twenty (21.7%) football clubs represented by a member of their medical team accepted the invitation to participate in the study. The response rate across the 3 rounds was 85.0% to 90.0% (Table 2). While participants varied between rounds, n=15 (75.0%) participated to all 3 rounds of the Delphi. Table 2 details the demographic data relating to participants.

Table 2 Details of Delphi participants

Participant data	Round 1 n=18 (90.0%) n, %		Round 2 n=17 (85.0%) n, %		Round 3 n=18 (90.0%) n, %	
Professional background						
Medical Doctor	3	16.7	3	17.6	3	16.7
Physiotherapist	15	83.3	14	82.4	15	83.3
Experience in professional football						
1 - 5 years	4	22.2	3	17.6	3	16.7
6 - 10 years	9	50.0	9	52.9	11	61.1
11 - 15 years	1	5.6	1	5.9	1	5.6
16 - 20 years	3	16.7	3	17.6	2	11.1
21 - 25 years	1	5.6	1	5.9	1	5.6
Level of play						
Premier League (consists of 20 clubs)	8	44.4	7	41.2	8	44.4
Championship (consists of 24 clubs)	6	33.3	6	35.3	7	38.9
League One (consists of 24 clubs)	3	16.7	3	17.6	2	11.1
League Two (consists of 24 clubs)	1	5.6	1	5.9	1	5.6

Round 1

Eighteen participants (90.0%) contributed a total of 108 RTP criteria (mean 6.0, mode 6, range 2-11) with details of how these are assessed. Following the independent coding of the responses performed by 2 researchers, a list of 14 RTP criteria with their assessment methods was approved for Round 2.

Round 2

Seventeen participants (85.0%) completed Round 2, and 13 out of 14 criteria reached consensus (Table 3, full data available in the online supplementary material). Kendall's W was significant at 0.320 ($p<0.0001$). Comments shared by some of the participants in apposite free text spaces alongside their ratings contributed to amendments to the list of RTP criteria. Specifically, 2 participants argued that the Askling H test[6] is a RTP criterion on its own rather than a method to assess hamstring flexibility. The test was initially categorised as a flexibility assessment method in line with its original definition of "active ballistic hamstring flexibility test" from Askling et al.[6] However, "absence of any signs insecurity" while performing this test was the final discriminant to enable football players to RTP in an experimental study conducted by the same authors.[15] Their promising results in terms of recurrence rates justified the inclusion of “Askling H test” as an independent criterion in Round 3, despite no consensus having been achieved with it as a flexibility assessment method in Round 2. Similarly, 3 participants argued that the slump and passive straight leg raise tests not only evaluate muscle flexibility, but also the neurodynamics of the sciatic nerve. Accordingly, although none of the participants in Round 1 mentioned the assessment of peripheral nervous system as a criterion for RTP, a further separate criterion “no signs of sciatic nerve neurodynamic compromise” was included in Round 3. Therefore, a list of 15 criteria was finalised for Round 3.

Table 3 RTP criteria reaching consensus in Round 2

	RTP CRITERIA	MEAN	SD	CV	%AGR
1	Perform maximal sprints	4.88	0.33	6.80	100.00
2	Complete at least one football specific field testing session at maximal performance and under fatigue conditions	4.65	0.49	10.60	100.00
3	Perform a progressive running plan with running performance eventually matching pre-injury levels	4.65	0.49	10.60	100.00
4	No pain in the muscle	4.65	0.79	16.91	94.12
5	Achieve maximal linear speed	4.59	0.51	11.06	100.00
6	Player’s self-reported feeling of confidence and readiness to RTP	4.53	0.62	13.78	94.12
7	Full hamstring muscle strength as compared to the uninjured side and/or to pre-injury benchmark values	4.47	0.62	13.96	94.12
8	Full muscle flexibility, equal to the uninjured side and/or to pre-injury benchmark values	4.41	0.51	11.50	100.00
9	Complete at least two full trainings with the team prior to be available for match selection	4.24	0.83	19.63	88.24
10	Reach GPS-based targets of external load, based on player- or position-specific match markers, which include number of sprints, accelerations, decelerations, changes of direction, maximal speed, high-speed running distance	4.18	0.88	21.14	82.35
11	Good lumbopelvic motor control	4.12	0.78	18.97	76.47
12	No adverse gait patterns on review with video analysis	3.88	0.78	20.12	64.71
13	Recovery of full aerobic and anaerobic fitness performance	3.76	0.44	11.61	76.47

Round 3

Eighteen participants (90.0%) completed Round 3, and 12 out of 15 RTP criteria reached consensus. Kendall’s W was significant at 0.304 ($p<0.0001$). Round 3 definitive RTP criteria are presented in Table 4, with the relative assessment methods for which consensus was established. Notably, the criteria incorporated in Round 3 after analysis of the comments from the previous round (“no signs of sciatic nerve neurodynamic compromise" and "Askling H test") did not reach consensus (mean score 3.83 and 3.78, respectively).

Table 4 RTP criteria with relative assessment methods reaching consensus in Round 3

	RTP CRITERIA	MEAN	SD	CV	%AGR
1	Perform maximal sprints	4.94	0.24	4.77	100.00
	Assessment				
	using wearable GPS technology	4.72	0.57	12.17	94.44
	based on the player's self-reported maximal perceived effort	4.33	0.69	15.83	88.89
	on 10 and 30 meters timed acceleration tests	4.17	0.51	12.35	94.44
2	Achieve maximal linear speed	4.78	0.43	8.95	100.00
	Assessment				
	using wearable GPS technology	4.72	0.46	9.76	100.00
	based on the player's self-reported maximal perceived effort	4.22	0.55	12.99	94.44
3	Complete at least one football specific field testing session at maximal performance and under fatigue conditions	4.78	0.43	8.95	100.00
4	Perform a progressive running plan with running performance eventually matching pre-injury levels	4.78	0.43	8.95	100.00
5	Player's self-reported feeling of confidence and readiness to RTP	4.72	0.46	9.76	100.00
6	Full hamstring muscle strength as compared to the uninjured side and/or to pre-injury benchmark values	4.44	0.51	11.50	100.00
7	Reach GPS-based targets of external load, based on player- or position-specific match markers, which include number of sprints, accelerations, decelerations, changes of direction, maximal speed, high-speed running distance	4.28	0.67	15.64	88.89
8	Recovery of full aerobic and anaerobic fitness performance	4.28	0.75	17.58	83.33
9	No pain in the muscle	4.28	1.27	29.79	83.33
	Assessment				
	on functional activities on the field and in particular during maximal sprinting	4.72	0.96	20.29	94.44
	on maximal voluntary contraction	4.50	0.99	21.89	94.44
	on full range flexibility	4.33	0.97	22.39	94.44
10	Full muscle flexibility, equal to the uninjured side and/or to pre-injury benchmark values	4.22	0.43	10.13	100.00
	Assessment				
	with AKE (Active Knee Extension)	4.33	0.59	13.71	94.44
	with passive SLR (Straight Leg Raise)	4.17	0.62	14.84	88.89
	with active SLR (Straight Leg Raise)	4.06	0.87	21.53	77.78
11	Complete at least two full trainings with the team prior to be available for match selection	4.17	0.79	18.86	88.89
12	Good lumbopelvic motor control	4.00	0.49	12.13	88.89

DISCUSSION

This Delphi is the first study to achieve expert consensus on RTP criteria for HMI in professional football. The strength of the consensus established was reflected by the remarkably low CV for most criteria (mean 13.1, median 10.8, range 4.8-29.8) coupled with high %AGR values (mean 94.4, median 100.0, range 83.3-100.0). The consistency of experts' opinion was supported by Kendall's W demonstrating significant and stable agreement between participants across all items in Rounds 2 and 3. A list of 12 criteria was defined, a number that reflects the complexity of RTP assessment after such a common injury with considerable recurrence rates in football. The criteria reaching consensus in this Delphi study can be grouped into 5 core domains: "functional performance" (criteria 1, 2, 3, 4, 7, 8, 11, 12 in Table 4) "strength" (criterion 6), "flexibility" (criterion 10) , "pain" (criterion 9) and "player's confidence" (criterion 5). Our findings are in agreement with the results of a one-round survey conducted using team physicians from French and Belgian elite football clubs.[5] The 5 criteria that were considered most important ("complete pain relief", "muscle strength performance", "subjective feeling reported by the player", "muscle flexibility" and "specific soccer test performance") are analogous to those reaching consensus in our study, while interestingly, others were not mentioned in this Delphi process ("respect of a theoretical period of competition break", "balance control assessment", "medical imaging", "correction of potential sacroiliac or lumbar joint dysfunction" and "quadriceps - hamstrings EMG analysis").[5] Recent evidence has shown that HMI recurrence rates have not reduced in professional football in the last decade.[16] Therefore, the rationale behind the identified RTP criteria used in clinical practice is critically appraised in light of the limited evidence available, in order to contribute to a more effective management of HMIs.

Functional performance

The ability to perform maximal sprints and reach maximal linear velocity were consistently considered essential by all participants. These activities require forceful contraction of the hamstrings[17] and constitute the most prevalent mechanism of HMI in professional football.[18] In line with this, participants also agreed that the player must complete a progressive running plan with total high-speed running distance equivalent to match requirements. While contributing to the restoration of the player's physical condition,[19] high-volume running training and high-speed running also place a considerable eccentric load on the hamstrings that is essential in order to restore full hamstring function.[17] Another reason to support the completion of a structured running plan encompassing high-speed running is that maximal horizontal force and power while sprinting are reduced at RTP, possibly playing a role in recurrences.[20]

Furthermore, recovery of full aerobic and anaerobic fitness as well as achievement of match-based targets of external load also reached consensus. Together with completion of a testing session at maximal effort and under fatigue conditions, these criteria reinforce the need to restore pre-injury physical condition before RTP.[19, 21]. The player has to train enough prior to RTP, as sudden peaks in their workload have been demonstrated to increase the risk of re-injury.[22] Moreover, the unfit player is more vulnerable to fatigue, which is perceived as one of the most important risk factors for non-contact injuries[7] and is considered the primary reason for the rise of HMI at the end of each half.[23]

Lastly, good lumbopelvic motor control is explained in light of the proposed association of lumbopelvic pathology with HMI.[24] However this has not been prospectively proven, although lumbopelvic stability exercises are widely used as a prevention strategy in professional football.[7] Sherry and Best advocated a role for lumbopelvic stability exercises in preventing re-injury,[25] but in their study no actual measurement of lumbopelvic stability was made. Furthermore, the authors used a multimodal rehabilitation protocol that also included eccentric hamstring exercises, which are known to induce changes in muscle strength and architecture.[26] Therefore, it is difficult to support their conclusions regarding the effect of lumbopelvic stability exercises. Moreover, the role of lumbopelvic motor control in HMI remains difficult to establish due to the lack of standardised assessment methods.

Strength and flexibility

All the participants agreed that full hamstring strength and flexibility are necessary for a safe RTP. A significant increased risk of re-injury within 12 months has been documented for incomplete recovery of hamstring muscle strength (Adjusted Odds Ratio (AOR) 1.04 per deficit in Newton measured with hand-held dynamometry) and flexibility (AOR 1.13 per deficit in degree measured on the active knee extension test) in a cohort consisting of mostly football players.[27] Conversely, another study reported that 35 out of 52 football players with clinically-recovered HMI have residual isokinetic strength deficits when cleared for RTP; no association with re-injury was found but the follow-up only lasted 2 months.[21] Evidence from sufficiently large cohort studies supports the consensus achieved in this Delphi, as lower isokinetic strength[28, 29] and lower passive straight leg raise flexibility[30] were showed to be associated with HMI in professional football players. It should be noted that most isokinetic strength imbalances were revealed in the eccentric contraction phase.[29] This finding is supported by an emerging body of evidence that demonstrates a more significant role of eccentric rather than concentric or isometric strength in HMI, and particularly that the risk of re-injury is reduced with high levels of eccentric strength.[31, 32] Future research will need to determine how to assess hamstring strength and flexibility at the point of RTP after HMI. In particular, different types of muscle contraction would need to be considered separately and more emphasis should be given to eccentric over concentric or isometric strength.

Pain

Although reaching consensus, surprisingly not all the participants agreed that the player must not feel pain in the muscle. Notably, this criterion scored the greatest CV (29.8) revealing considerable divergences in participants' opinion. The strict rule of "no pain" has been recommended by a large number of authors[4] and considered the most important criterion in a previous survey of football club physicians.[5] For these reasons, it is difficult to interpret the only partial agreement and high CV on this criterion. Further investigations are required to understand whether pain can be accepted at RTP without an increased risk of re-injury.

Player's confidence

All participants agreed that the player must feel ready and confident to RTP. In line with this, it is important to understand that the player's confidence before RTP is essential; negative emotions such as anxiety and apprehension not only are detrimental to performance but are also associated with increased risk of re-injury.[33] With this in mind, the successful fulfilment of all functional performance criteria presented in this study can help the player regain full confidence before RTP.

Criteria not reaching consensus

One test that specifically evaluates the player's apprehension is the Askling H test,[6] which has been proposed as a promising tool to assess readiness to RTP as only 1 recurrence among 75 HMIs was reported when used on football players.[15] Surprisingly, the Askling H test did not reach consensus in this study. Consensus was not achieved on neural function either, although its compromise has been proposed to have a connection with HMI[24] and Brukner et al[19] recommended to include neurodynamic assessment in the management of HMI. It is recognised that the amendments made between rounds 2 and 3 might have impaired the building of consensus for these 2 criteria. However it remains difficult to explain the reasons behind their low scoring; particularly for the Askling H test given the supporting data previously published[15] and that the test is easy to perform in clinical practice and therefore to implement in RTP assessment.[6] For these reasons, future researchers may want to investigate the validity of these RTP criteria despite consensus was not achieved in this study.

While the focus of this study is to present criteria reaching consensus, the knowledge of the items excluded during the Delphi may be of equal interest for future research and clinical decisions. A complete report of the whole process is available in the online supplementary material. For instance, the value of medical images in the assessment of HMI has been extensively investigated. However, it is noteworthy that in line with the reported poor significance of MRI findings at RTP,[34, 35] none of the participants stated they use medical images to inform their RTP decisions.

Assessment methods

Participants were also asked to rate their agreement to the RTP criteria assessment methods that were collated after analysis of Round 1 responses. The appraisal of the literature supporting the validity of each assessment method is beyond the scope of this work, but those reaching consensus have been reported in Table 4 as a reference for clinical practice and future studies. In general, the measurement properties of the assessment methods either are poor or have never been investigated, therefore the validity of RTP assessment is often questionable.[4] Future research should evaluate this validity in order to standardise RTP assessment.[3]

Study generalisability

Out of the 92 invited football clubs only 20 (participation rate 21.7%) agreed to participate in this research. It is difficult to recruit and retain participants in Delphi studies conducted in sports, possibly due to the high competing interests and unwillingness to disclose details of own internal protocols. Previous studies have been published despite a limited size of the expert panel[36] and low engagement rate.[37] Low retention rate throughout the different rounds is also common in Delphi studies,[37] while by contrast this remained high in our work (85.0 to 90.0%). It is acknowledged that the external validity of our results is challenged by the participation rate,[10] although it has been shown that if experts have consistent training and knowledge, then relatively small samples can be selected.[38] Interestingly, most of the responses (77.7%, 76.5% and 83.3% in the three rounds, respectively) came from clubs participating in the top two divisions of the English football pyramid (40.0%, 35.0% and 40.0% of Premier League clubs and 25.0%, 25.0 and 29.2% of Championship clubs participated in the three rounds, respectively). It can be speculated that the medical teams working at the top levels represent the state of the art in HMI management, which would support the validity of this study.

CONCLUSION

This Delphi study defined expert consensus on RTP criteria for HMI in professional football, which will support RTP decisions in clinical practice. However, it is important to note that the existence of a consensus does not mean that the correct answer has been found[10] and the criteria hereby identified are not always well supported by the available literature. Accordingly, our results should be intended as a first step to streamline future investigations in order to develop an evidence-based decision-making framework for RTP after HMI in professional football.

What are the new findings?
➡This study defined a list of RTP criteria for HMI reaching consensus among physiotherapists and physicians working in elite football in England.
➡We identified 5 main RTP criteria domains: “functional performance”, “strength”, “flexibility”, “pain” and “player’s confidence”.

How might it impact on clinical practice in the near future?
➡Our findings set a new reference for practitioners to support their RTP decisions after HMI in professional football.
➡Consensually agreed RTP criteria and relative assessment methods are not always well supported by the available literature and therefore further research is required to determine their validity.

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INTRODUCTION

Hamstring muscle injury (HMI) is the single most common injury in professional football, accounting for 12% of all injuries.[1] Rehabilitation of HMI aims to bring the player back to their pre-injury performance level in the shortest time possible, while minimising the risk of re-injury. Re-injury rate is high (16%) and is linked with significantly longer time to return to play (RTP).[1] Pressure is therefore on medical teams to bring players back onto the field as quickly as possible, but balanced with safe and clinically reasoned RTP decisions in order to avoid re-injury.

RTP decision-making is a complex process, which is based on the evaluation of the relevant health (medical and injury-specific factors) and activity (performance factors) risks, but is also influenced by contextual factors known as decision modifiers (e.g. timing of the season, competitive level, pressure).[2, 3] Despite the relevance of this issue, there is currently no consensus on RTP assessment following HMI in sports. As reported in a recent qualitative systematic review, numerous criteria are used but none of these have been validated.[4] In the absence of scientific evidence, Delvaux et al[5] explored current practice with a survey of physicians from French and Belgian elite football clubs. The authors produced a list of RTP criteria but did not investigate the degree of consensus between responders. The paucity of available evidence on such a relevant topic in football medicine can be explained by the intrinsic limitations that research encounters into this field, such as ethics, players' and clubs' availabilities, and confidentiality.[6, 7] However, there remains the need for validated criteria to facilitate HMI RTP management.

Within the Evidence Based Practice framework, it is established that where no research has been published on a given subject or experimental designs are not feasible due to ethical issues, then expert opinion and expert clinical practice should be considered.[8] This is the case for RTP assessment after HMI in professional football, where the studies available are limited despite a strong need to standardise RTP criteria.[9] Therefore, the aim of this study is to use the Delphi method to reach expert consensus on RTP criteria after HMI in professional football.

METHODS

The Delphi method is an iterative multistage process used to achieve expert consensus on a given subject.[10] In this study, a three-round modified Delphi technique was employed with questionnaires administered anonymously through LimeSurvey (http://www.limesurvey.com); an online secure survey software. The University of Birmingham Ethics Committee (UK) approved the study protocol.

Participants

A key challenge with Delphi studies is the identification of appropriate experts.[11] In this study, physicians and physiotherapists working in professional football clubs in England were assumed to be experts of HMI RTP. With the support of The Football Association (the governing body of football in England), initial contact with the medical departments of all the clubs participating in the English professional football leagues (n=92) was made via e-mail. The invitation included a Participant Information Sheet with the details of the study and its procedures. One expert from each football club was invited to participate in order to avoid sampling bias and duplicate answers by having multiple participants from clubs. Participants were given 1 month to complete the questionnaire in each round, with email reminders sent to non-responders after 1 and 3 weeks. Participants failing to respond in time were still invited to participate in the following round. The whole process lasted from March to July 2016.

Round 1

In Round 1 participants were invited to list all the criteria and assessment methods that they use within the club to inform RTP decisions after HMI. No reference was made to when a test should be performed, be it during or at the end of rehabilitation; rather, RTP criteria were defined as any test or measurement that need to be considered and cleared prior to allowing a player to RTP. An open-ended format with space for free text answers was used to increase the richness of the data collected.[11] Using a content analysis approach,[12] semantically equivalent responses were grouped and categorised under univocal definitions of RTP criteria and assessment methods. In order to reduce categorisation bias, responses were independently coded by 2 researchers, who then collated their analyses through a process of discussion to achieve agreement.[12] At the end of this process, a list of RTP criteria and assessment methods was produced for use in Round 2.

Round 2

In Round 2 participants received the list produced at the end of Round 1 and were informed through feedback on how different responses had been categorised in order to avoid misunderstandings of the terms employed. Participants were asked to rate on a 1-5 Likert scale (Strongly disagree, Disagree, Neutral, Agree, Strongly agree) how much they agreed or disagreed with each RTP criterion and with the appropriateness of the relative assessment methods. Participants were invited to share comments on the process and to give reasons for their rating.

Round 3

In Round 3, participants received feedback on Round 2 results in the form of descriptive statistics, which enabled reflection before expressing their final opinion. Participants were then asked to re-rate (using same Likert scale as Round 2) the criteria that had reached consensus in Round 2, and were given the opportunity to share comments on the reasons behind their rating and on the whole Delphi process.

Data analysis

Following acceptance of assumptions regarding the equality of points on the Likert scale, it was argued as an interval scale.[13] Ratings for each item were analysed and expressed as means with standard deviation. Consensus between participants was measured using coefficient of variation (CV) and percentage agreement (%AGR).[14] CV is a measure of dispersion and %AGR was defined as the percentage of responses falling within the top 2 categories of the 5-point scale (Agree and Strongly agree). Agreement between participants was also evaluated across all items using Kendall's W coefficient of concordance; a non-parametric statistic that can be used to assess strength and changes of agreement between raters.[14] Statistical significance was set at α=0.05. All data were downloaded from LimeSurvey and analyses were performed using IBM SPSS version 21 and Microsoft Office Excel. Table 1 illustrates the requirements for consensus in Rounds 2 and 3. Criteria reaching consensus were retained while those not reaching consensus were removed.

Table 1 Requirements for consensus in Rounds 2 and 3.

Criterion	Round 2	Round 3
Mean rating	≥3.5	≥4.0
CV	≤40%	≤30%
%AGR	≥60%	≥70%
Kendall's W	Significant agreement ($p<0.05$)	Significant agreement ($p<0.05$)

RESULTS

Twenty (21.7%) football clubs represented by a member of their medical team accepted the invitation to participate in the study. The response rate across the 3 rounds was 85.0% to 90.0% (Table 2). While participants varied between rounds, n=15 (75.0%) participated to all 3 rounds of the Delphi. Table 2 details the demographic data relating to participants.

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Table 2 Details of Delphi participants

Participant data	Round 1 n=18 (90.0%) n, %		Round 2 n=17 (85.0%) n, %		Round 3 n=18 (90.0%) n, %	
Professional background						
Medical Doctor	3	16.7	3	17.6	3	16.7
Physiotherapist	15	83.3	14	82.4	15	83.3
Experience in professional football						
1 - 5 years	4	22.2	3	17.6	3	16.7
6 - 10 years	9	50.0	9	52.9	11	61.1
11 - 15 years	1	5.6	1	5.9	1	5.6
16 - 20 years	3	16.7	3	17.6	2	11.1
21 - 25 years	1	5.6	1	5.9	1	5.6
Level of play						
Premier League (consists of 20 clubs)	8	44.4	7	41.2	8	44.4
Championship (consists of 24 clubs)	6	33.3	6	35.3	7	38.9
League One (consists of 24 clubs)	3	16.7	3	17.6	2	11.1
League Two (consists of 24 clubs)	1	5.6	1	5.9	1	5.6

Round 1

Eighteen participants (90.0%) contributed a total of 108 RTP criteria (mean 6.0, mode 6, range 2-11) with details of how these are assessed. Following the independent coding of the responses performed by 2 researchers, a list of 14 RTP criteria with their assessment methods was approved for Round 2.

Round 2

Seventeen participants (85.0%) completed Round 2, and 13 out of 14 criteria reached consensus (Table 3, full data available in the online supplementary material). Kendall's W was significant at 0.320 ($p<0.0001$). Comments shared by some of the participants in apposite free text spaces alongside their ratings contributed to amendments to the list of RTP criteria. Specifically, 2 participants argued that the Askling H test[6] is a RTP criterion on its own rather than a method to assess hamstring flexibility. The test was initially categorised as a flexibility assessment method in line with its original definition of "active ballistic hamstring flexibility test" from Askling et al.[6] However, "absence of any signs insecurity" while performing this test was the final discriminant to enable football players to RTP in an experimental study conducted by the same authors.[15] Their promising results in terms of recurrence rates justified the inclusion of "Askling H test" as an independent criterion in Round 3, despite no consensus having been achieved with it as a flexibility assessment method in Round 2. Similarly, 3 participants argued that the slump and passive straight leg raise tests not only evaluate muscle flexibility, but also the neurodynamics of the sciatic nerve. Accordingly, although none of the participants in Round 1 mentioned the assessment of peripheral nervous system as a criterion for RTP, a further separate criterion "no signs of sciatic nerve neurodynamic compromise" was included in Round 3. Therefore, a list of 15 criteria was finalised for Round 3.

Table 3 RTP criteria reaching consensus in Round 2

	RTP CRITERIA	MEAN	SD	CV	%AGR
1	Perform maximal sprints	4.88	0.33	6.80	100.00
2	Complete at least one football specific field testing session at maximal performance and under fatigue conditions	4.65	0.49	10.60	100.00
3	Perform a progressive running plan with running performance eventually matching pre-injury levels	4.65	0.49	10.60	100.00
4	No pain in the muscle	4.65	0.79	16.91	94.12
5	Achieve maximal linear speed	4.59	0.51	11.06	100.00
6	Player's self-reported feeling of confidence and readiness to RTP	4.53	0.62	13.78	94.12
7	Full hamstring muscle strength as compared to the uninjured side and/or to pre-injury benchmark values	4.47	0.62	13.96	94.12
8	Full muscle flexibility, equal to the uninjured side and/or to pre-injury benchmark values	4.41	0.51	11.50	100.00
9	Complete at least two full trainings with the team prior to be available for match selection	4.24	0.83	19.63	88.24
10	Reach GPS-based targets of external load, based on player- or position-specific match markers, which include number of sprints, accelerations, decelerations, changes of direction, maximal speed, high-speed running distance	4.18	0.88	21.14	82.35
11	Good lumbopelvic motor control	4.12	0.78	18.97	76.47
12	No adverse gait patterns on review with video analysis	3.88	0.78	20.12	64.71
13	Recovery of full aerobic and anaerobic fitness performance	3.76	0.44	11.61	76.47

Round 3

Eighteen participants (90.0%) completed Round 3, and 12 out of 15 RTP criteria reached consensus. Kendall's W was significant at 0.304 ($p<0.0001$). Round 3 definitive RTP criteria are presented in Table 4, with the relative assessment methods for which consensus was established. Notably, the criteria incorporated in Round 3 after analysis of the comments from the previous round ("no signs of sciatic nerve neurodynamic compromise" and "Askling H test") did not reach consensus (mean score 3.83 and 3.78, respectively).

Table 4 RTP criteria with relative assessment methods reaching consensus in Round 3

	RTP CRITERIA	MEAN	SD	CV	%AGR
1	Perform maximal sprints	4.94	0.24	4.77	100.00
	Assessment				
	using wearable GPS technology	4.72	0.57	12.17	94.44
	based on the player's self-reported maximal perceived effort	4.33	0.69	15.83	88.89
	on 10 and 30 meters timed acceleration tests	4.17	0.51	12.35	94.44
2	Achieve maximal linear speed	4.78	0.43	8.95	100.00
	Assessment				
	using wearable GPS technology	4.72	0.46	9.76	100.00
	based on the player's self-reported maximal perceived effort	4.22	0.55	12.99	94.44
3	Complete at least one football specific field testing session at maximal performance and under fatigue conditions	4.78	0.43	8.95	100.00
4	Perform a progressive running plan with running performance eventually matching pre-injury levels	4.78	0.43	8.95	100.00
5	Player's self-reported feeling of confidence and readiness to RTP	4.72	0.46	9.76	100.00
6	Full hamstring muscle strength as compared to the uninjured side and/or to pre-injury benchmark values	4.44	0.51	11.50	100.00
7	Reach GPS-based targets of external load, based on player- or position-specific match markers, which include number of sprints, accelerations, decelerations, changes of direction, maximal speed, high-speed running distance	4.28	0.67	15.64	88.89
8	Recovery of full aerobic and anaerobic fitness performance	4.28	0.75	17.58	83.33
9	No pain in the muscle	4.28	1.27	29.79	83.33
	Assessment				
	on functional activities on the field and in particular during maximal sprinting	4.72	0.96	20.29	94.44
	on maximal voluntary contraction	4.50	0.99	21.89	94.44
	on full range flexibility	4.33	0.97	22.39	94.44
10	Full muscle flexibility, equal to the uninjured side and/or to pre-injury benchmark values	4.22	0.43	10.13	100.00
	Assessment				
	with AKE (Active Knee Extension)	4.33	0.59	13.71	94.44
	with passive SLR (Straight Leg Raise)	4.17	0.62	14.84	88.89
	with active SLR (Straight Leg Raise)	4.06	0.87	21.53	77.78
11	Complete at least two full trainings with the team prior to be available for match selection	4.17	0.79	18.86	88.89
12	Good lumbopelvic motor control	4.00	0.49	12.13	88.89

DISCUSSION

This Delphi is the first study to achieve expert consensus on RTP criteria for HMI in professional football. The strength of the consensus established was reflected by the remarkably low CV for most criteria (mean 13.1, median 10.8, range 4.8-29.8) coupled with high %AGR values (mean 94.4, median 100.0, range 83.3-100.0). The consistency of experts' opinion was supported by Kendall's W demonstrating significant and stable agreement between participants across all items in Rounds 2 and 3. A list of 12 criteria was defined, a number that reflects the complexity of RTP assessment after such a common injury with considerable recurrence rates in football. The criteria reaching consensus in this Delphi study can be grouped into 5 core domains: "functional performance" (criteria 1, 2, 3, 4, 7, 8, 11, 12 in Table 4) "strength" (criterion 6), "flexibility" (criterion 10) , "pain" (criterion 9) and "player's confidence" (criterion 5). Our findings are in agreement with the results of a one-round survey conducted using team physicians from French and Belgian elite football clubs.[5] The 5 criteria that were considered most important ("complete pain relief", "muscle strength performance", "subjective feeling reported by the player", "muscle flexibility" and "specific soccer test performance") are analogous to those reaching consensus in our study, while interestingly, others were not mentioned in this Delphi process ("respect of a theoretical period of competition break", "balance control assessment", "medical imaging", "correction of potential sacroiliac or lumbar joint dysfunction" and "quadriceps - hamstrings EMG analysis").[5] Recent evidence has shown that HMI recurrence rates have not reduced in professional football in the last decade.[16] Therefore, the rationale behind the identified RTP criteria used in clinical practice is critically appraised in light of the limited evidence available, in order to contribute to a more effective management of HMIs.

Functional performance

The ability to perform maximal sprints and reach maximal linear velocity were consistently considered essential by all participants. These activities require forceful contraction of the hamstrings[~~16~~17] and constitute the most prevalent mechanism of HMI in professional football.[~~17~~18] In line with this, participants also agreed that the player must complete a progressive running plan with total high-speed running distance equivalent to match requirements. While contributing to the restoration of the player's physical condition,[~~18~~19] high-volume running training and high-speed running also place a considerable eccentric load on the hamstrings that is essential in order to restore full hamstring function.[~~16~~17] Another reason to support the completion of a structured running plan encompassing high-speed running is that maximal horizontal force and power while sprinting are reduced at RTP, possibly playing a role in recurrences.[~~19~~20]

Furthermore, recovery of full aerobic and anaerobic fitness as well as achievement of match-based targets of external load also reached consensus. Together with completion of a testing session at maximal effort and under fatigue conditions, these criteria reinforce the need to restore pre-injury physical condition before RTP.[~~18~~19, ~~20~~21]. The player has to train enough prior to RTP, as sudden peaks in their workload have been demonstrated to increase the risk of re-injury.[~~21~~22] Moreover, the unfit player is more vulnerable to fatigue, which is perceived as one of the most important risk factors for non-contact injuries[7] and is considered the primary reason for the rise of HMI at the end of each half.[~~22~~23]

Lastly, good lumbopelvic motor control is explained in light of the proposed association of lumbopelvic pathology with HMI.[~~23~~24] ~~Although~~ However this has not been prospectively proven, although lumbopelvic stability exercises are widely used as a prevention strategy in professional football.~~,~~[7] Sherry and Best advocated a role for lumbopelvic stability exercises in preventing re-injury,[25] but in their study no actual measurement of lumbopelvic stability was made. Furthermore, the authors used a multimodal rehabilitation protocol that also included eccentric hamstring exercises, which are known to induce changes in muscle strength and architecture.[26] Therefore, it is difficult to support their conclusions regarding the effect of lumbopelvic stability exercises. Moreover, the role of lumbopelvic motor control in HMI remains difficult to establish due to the lack of standardised assessment methods.~~and were included in a HMI rehabilitation protocol which resulted superior than a stretching and strengthening programme in terms of re-injury rate.[24] However, evaluation of lumbopelvic motor control lacks standardisation, therefore it remains difficult to ascertain its role in HMI.~~

Strength and flexibility

All the participants agreed that full hamstring strength and flexibility are necessary for a safe RTP. A significant increased risk of re-injury within 12 months has been documented for incomplete recovery of hamstring muscle strength (Adjusted Odds Ratio (AOR) 1.04 per deficit in Newton measured with hand-held dynamometry) and flexibility (AOR 1.13 per deficit in degree measured on the active knee extension test) in a cohort consisting of mostly football players.[~~25~~27] Conversely, another study reported that 35 out of 52 football players with clinically-recovered HMI have residual isokinetic strength deficits when cleared for RTP; no association with re-injury was found but the follow-up only lasted 2 months.[~~20~~21] Evidence from sufficiently large cohort studies supports the consensus achieved in this Delphi, as lower isokinetic strength[~~26~~28, ~~27~~29] and lower passive straight leg raise flexibility[~~28~~30] were showed to be associated with HMI in professional football players. It should be noted that most isokinetic strength imbalances were revealed in the eccentric contraction phase.[29] This finding is supported by an emerging body of evidence that demonstrates a more significant role of eccentric rather than concentric or isometric strength in HMI, and particularly that the risk of re-injury is reduced with high levels of eccentric strength.[31, 32] Future research will need to determine how to assess hamstring strength and flexibility at the point of RTP after HMI. In particular, different types of muscle contraction would need to be considered separately and more emphasis should be given to eccentric over concentric or isometric strength.

Pain

Although reaching consensus, surprisingly not all the participants agreed that the player must not feel pain in the muscle. Notably, this criterion scored the greatest CV (29.8) revealing considerable divergences in participants' opinion. The strict rule of "no pain" has been recommended by a large number of authors[4] and considered the most important criterion in a previous survey of football club physicians.[5] For these reasons, it is difficult to interpret the only partial agreement and high CV on this criterion. Further investigations are required to understand whether pain can be accepted at RTP without an increased risk of re-injury.

Player's confidence

All participants agreed that the player must feel ready and confident to RTP. In line with this, it is important to understand that the player's confidence before RTP is essential; negative emotions such as anxiety and apprehension not only are detrimental to performance but are also associated with increased risk of re-injury.[~~29~~33] With this in mind, the successful fulfilment of all functional performance criteria presented in this study can help the player regain full confidence before RTP.

Criteria not reaching consensus

One test that specifically evaluates the player's apprehension is the Askling H test,[6] which has been proposed as a promising tool to assess readiness to RTP as only 1 recurrence among 75 HMIs was reported when used on football players.[15] Surprisingly, the Askling H test did not reach consensus in this study. Consensus was not achieved on neural function either, although its compromise has been proposed to have a connection with HMI[~~23~~24] and Brukner et al[~~18~~19] recommended to include neurodynamic assessment in the management of HMI. It is recognised that the amendments made between rounds 2 and 3 might have impaired the building of consensus for these 2 criteria. However it remains difficult to explain the reasons behind their low scoring; particularly for the Askling H test given the supporting data previously published[15] and that the test is easy to perform in clinical practice and therefore to implement in RTP assessment.[6] For these reasons, future researchers may want to investigate the validity of these RTP criteria despite consensus was not achieved in this study.

While the focus of this study is to present criteria reaching consensus, the knowledge of the items excluded during the Delphi may be of equal interest for future research and clinical decisions. A complete report of the whole process is available in the online supplementary material. For instance, the value of medical images in the assessment of HMI has been extensively investigated. However, it is noteworthy that in line with the reported poor significance of MRI findings at RTP,[~~30~~34, ~~31~~35] none of the participants stated they use medical images to inform their RTP decisions.

Assessment methods

Participants were also asked to rate their agreement to the RTP criteria assessment methods that were collated after analysis of Round 1 responses. The appraisal of the literature supporting the validity of each assessment method is beyond the scope of this work, but those reaching consensus have been reported in Table 4 as a reference for clinical practice and future studies. In general, the measurement properties of the assessment methods either are poor or have never been investigated, therefore the validity of RTP assessment is often questionable.[4] Future research should evaluate this validity in order to standardise RTP assessment.[3]

Study generalisability

Out of the 92 invited football clubs only 20 (participation rate 21.7%) agreed to participate in this research. It is difficult to recruit and retain participants in Delphi studies conducted in sports, possibly due to the high competing interests and unwillingness to disclose details of own internal protocols. Previous studies have been published despite a limited size of the expert panel[~~32~~36] and low engagement rate.[~~33~~37] Low retention rate throughout the different rounds is also common in Delphi studies,[~~33~~37] while by contrast this remained high in our work (85.0 to 90.0%). It is acknowledged that the external validity of our results is challenged by the participation rate,[10] although it has been shown that if experts have consistent training and knowledge, then relatively small samples can be selected.[~~34~~38] Interestingly, most of the responses (77.7%, 76.5% and 83.3% in the three rounds, respectively) came from clubs participating in the top two divisions of the English football pyramid (40.0%, 35.0% and 40.0% of Premier League clubs and 25.0%, 25.0 and 29.2% of Championship clubs participated in the three rounds, respectively). It can be speculated that the medical teams working at the top levels represent the state of the art in HMI management, which would support the validity of this study.

CONCLUSION

This Delphi study defined expert consensus on RTP criteria for HMI in professional football, which will support RTP decisions in clinical practice. However, it is important to note that the existence of a consensus does not mean that the correct answer has been found[10] and the criteria hereby identified are not always well supported by the available literature. Accordingly, our results should be intended as a first step to streamline future investigations in order to develop an evidence-based decision-making framework for RTP after HMI in professional football.

What are the new findings?
➡This study defined a list of RTP criteria for HMI reaching consensus among physiotherapists and physicians working in elite football in England.
➡We identified 5 main RTP criteria domains: “functional performance”, “strength”, “flexibility”, “pain” and “player’s confidence”.

How might it impact on clinical practice in the near future?
➡Our findings set a new reference for practitioners to support their RTP decisions after HMI in professional football.
➡Consensually agreed RTP criteria and relative assessment methods are not always well supported by the available literature and therefore further research is required to determine their validity.

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APPENDIX 1 - ONLINE SUPPLEMENTARY MATERIAL

Table 5 Complete report of the results of Round 2

	RTP CRITERIA	MEAN	SD	CV	%AGR	CONSENSUS
1	Perform maximal sprints	4.88	0.33	6.80	100.00	YES
	Assessment					
	using wearable GPS technology	4.47	0.72	16.05	88.24	YES
	on 10 and 30 meters timed acceleration tests	4.29	0.69	15.98	88.24	YES
	based on the player's self-reported maximal perceived effort	4.24	1.03	24.38	82.35	YES
2	Complete at least one football specific field testing session at maximal performance and under fatigue conditions	4.65	0.49	10.60	100.00	YES
	Assessment					
	using agility t-test compared to pre-injury benchmark values	4.00	0.61	15.31	82.35	YES
	using multidirectional arrowhead test compared to pre-injury benchmark values	3.82	0.73	19.03	64.71	YES
	using multidirectional arrowhead test comparing injured to uninjured side	3.71	0.85	22.91	58.82	NO
3	Perform a progressive running plan with running performance eventually matching pre-injury levels	4.65	0.49	10.60	100.00	YES
4	No pain in the muscle	4.65	0.79	16.91	94.12	YES
	Assessment					
	on functional activities on the field and in particular during maximal sprinting	4.88	0.33	6.80	100.00	YES
	on maximal voluntary contraction	4.71	0.99	20.94	94.12	YES
	on full range flexibility	4.24	1.15	27.09	88.24	YES
	on muscle palpation	4.06	1.03	25.35	76.47	YES
5	Achieve maximal linear speed	4.59	0.51	11.06	100.00	YES
	Assessment					
	using wearable GPS technology	4.65	0.49	10.60	100.00	YES
	based on the player's self-reported maximal perceived effort	4.12	0.99	24.11	82.35	YES
6	Player's self-reported feeling of confidence and readiness to RTP	4.53	0.62	13.78	94.12	YES
7	Full hamstring muscle strength as compared to the uninjured side and/or to pre-injury benchmark values	4.47	0.62	13.96	94.12	YES
	Assessment					
	with manual muscle testing	3.94	0.90	22.82	82.35	YES
	with isokinetic dinamometry, concentric and eccentric	3.76	0.75	19.99	70.59	YES
	with Nordbord eccentric strength testing	3.65	0.93	25.54	64.71	YES
	with ability to lift weights to pre-injury level	3.59	0.71	19.85	58.82	NO
	with hand-held dynamometry, isometrics	3.47	0.80	23.05	52.94	NO
	with leg curl, 3RM (3 repetitions maximum)	3.24	0.83	25.70	41.18	NO
8	Full muscle flexibility, equal to the uninjured side and/or to pre-injury benchmark values	4.41	0.51	11.50	100.00	YES
	Assessment					
	with passive SLR (Straight Leg Raise)	4.35	0.70	16.12	88.24	YES
	with AKE (Active Knee Extension)	4.24	1.03	24.38	88.24	YES
	with active SLR (Straight Leg Raise)	4.06	0.97	23.81	70.59	YES
	with Askling H test	3.82	0.95	24.87	58.82	NO
	with slump test	3.35	1.06	31.53	58.82	NO
	with toe touch	2.65	0.79	29.60	11.76	NO

Table 5 Complete report of the results of Round 2

	RTP CRITERIA	MEAN	SD	CV	%AGR	CONSENSUS
9	Complete at least two full trainings with the team prior to be available for match selection	4.24	0.83	19.63	88.24	YES
10	Reach GPS-based targets of external load, based on player- or position-specific match markers, which include number of sprints, accelerations, decelerations, changes of direction, maximal speed, high-speed running distance	4.18	0.88	21.14	82.35	YES
11	Good lumbopelvic motor control	4.12	0.78	18.97	76.47	YES
	Assessment performed by checking for abnormal movement patterns (e.g. uncontrolled movement, lumbar shift or rotation, etc) while					
	performing functional drills such as squats, lunges and step-ups	4.12	0.70	16.92	82.35	YES
	performing single- and double-leg long lever bridge	3.59	0.80	22.16	52.94	NO
	performing knee extension from an upright sitting position (hamstring upright sitting length test)	3.41	0.62	18.12	47.06	NO
	performing the Functional Movement Screen tests	3.12	0.93	29.75	35.29	NO
12	No adverse gait patterns on review with video analysis	3.88	0.78	20.12	64.71	YES
13	Recovery of full aerobic and anaerobic fitness performance	3.76	0.44	11.61	76.47	YES
14	Vertical jump performance comparable to pre-injury benchmark values	3.35	0.86	25.70	35.29	NO

Table 6 Complete report of the results of Round 3

	RTP CRITERIA	MEAN	SD	CV	%AGR	CONSENSUS
1	Perform maximal sprints	4.94	0.24	4.77	100.00	YES
	Assessment					
	using wearable GPS technology	4.72	0.57	12.17	94.44	YES
	based on the player's self-reported maximal perceived effort	4.33	0.69	15.83	88.89	YES
	on 10 and 30 meters timed acceleration tests	4.17	0.51	12.35	94.44	YES
2	Achieve maximal linear speed	4.78	0.43	8.95	100.00	YES
	Assessment					
	using wearable GPS technology	4.72	0.46	9.76	100.00	YES
	based on the player's self-reported maximal perceived effort	4.22	0.55	12.99	94.44	YES
3	Complete at least one football specific field testing session at maximal performance and under fatigue conditions	4.78	0.43	8.95	100.00	YES
	Assessment					
	using agility t-test compared to pre-injury benchmark values	3.94	0.54	13.67	83.33	NO
	using multidirectional arrowhead test compared to pre-injury benchmark values	3.78	0.55	14.51	72.22	NO
4	Perform a progressive running plan with running performance eventually matching pre-injury levels	4.78	0.43	8.95	100.00	YES
5	Player's self-reported feeling of confidence and readiness to RTP	4.72	0.46	9.76	100.00	YES
6	Full hamstring muscle strength as compared to the uninjured side and/or to pre-injury benchmark values	4.44	0.51	11.50	100.00	YES
	Assessment					
	with manual muscle testing	3.83	0.38	10.00	83.33	NO
	with isokinetic dinamometry, concentric and eccentric	3.83	0.79	20.50	88.89	NO
	with Nordbord eccentric strength testing	3.78	0.88	23.25	77.78	NO
7	Reach GPS-based targets of external load, based on player- or position-specific match markers, which include number of sprints, accelerations, decelerations, changes of direction, maximal speed, high-speed running distance	4.28	0.67	15.64	88.89	YES
8	Recovery of full aerobic and anaerobic fitness performance	4.28	0.75	17.58	83.33	YES
9	No pain in the muscle	4.28	1.27	29.79	83.33	YES
	Assessment					
	on functional activities on the field and in particular during maximal sprinting	4.72	0.96	20.29	94.44	YES
	on maximal voluntary contraction	4.50	0.99	21.89	94.44	YES
	on full range flexibility	4.33	0.97	22.39	94.44	YES
	on muscle palpation	3.67	1.19	32.40	72.22	NO
10	Full muscle flexibility, equal to the uninjured side and/or to pre-injury benchmark values	4.22	0.43	10.13	100.00	YES
	Assessment					
	with AKE (Active Knee Extension)	4.33	0.59	13.71	94.44	YES
	with passive SLR (Straight Leg Raise)	4.17	0.62	14.84	88.89	YES
	with active SLR (Straight Leg Raise)	4.06	0.87	21.53	77.78	YES

Table 6 Complete report of the results of Round 3

	RTP CRITERIA	MEAN	SD	CV	%AGR	CONSENSUS
11	Complete at least two full trainings with the team prior to be available for match selection	4.17	0.79	18.86	88.89	YES
12	Good lumbopelvic motor control	4.00	0.49	12.13	88.89	YES
	Assessment performed by checking for abnormal movement patterns (e.g. uncontrolled movement, lumbar shift or rotation, etc) while performing functional drills such as squats, lunges and step-ups	3.83	0.51	13.42	88.89	NO
13	No adverse gait patterns on review with video analysis	3.83	0.62	16.13	72.22	NO
14	No signs of sciatic nerve neurodynamic compromise	3.83	0.86	22.37	66.67	NO
	Assessment					
	with slump test	4.22	0.55	12.99	94.44	YES*
	with passive SLR (Straight Leg Raise)	4.06	0.54	13.30	88.89	YES*
15	Perform the Askling H test i.e. a straight leg raise as fast as possible to the highest point with no insecurity reported (Askling et al., BJSM 2013 and 2010)	3.78	1.17	30.86	61.11	NO

* Conversely, there was no consensus on neural function as a criterion for RTP, but both the slump and the passive SLR tests were agreed to be appropriate to assess sciatic nerve neurodynamic compromise. It is important to note that the consensus achieved on the appropriateness of an assessment method is not related to the agreement existing on the relative criterion.