

Playing again after hamstring injury in amateur soccer players: Expert opinions on return to play criteria

Masterthesis

Physiotherapy Science

Program in Clinical Health Sciences

Utrecht University

Name student:	P.A. (Sander) van de Hoef
Student number:	3703533
Date:	4th of July 2014
Internship supervisor(s):	Dr. D.W. Smits, Prof. Dr. F.J.G. Backx
Internship institute:	Department of Rehabilitation, Nursing Science and Sport, Brain Center Rudolf Magnus, University Medical Center Utrecht, Utrecht, The Netherlands
Lecturer/supervisor Utrecht University:	Dr. M.F. Pisters

"ONDERGETEKENDE

Peter Alexander van de Hoef

bevestigt hierbij dat de onderhavige verhandeling mag worden geraadpleegd en vrij mag worden gefotokopieerd. Bij het citeren moet steeds de titel en de auteur van de verhandeling worden vermeld."

Examiner

Dr. M.F. Pisters

Assessors:

Dr. D.W. Smits

Dr. J. van der Net

Masterthesis, Physiotherapy Science, Program in Clinical Health Sciences, Utrecht University,
Utrecht, 2014

SAMENVATTING

Doelstelling Recidiverende hamstringblessures beslaan een groot probleem in de voetbalwereld. Een mogelijke oorzaak hiervoor kan gezocht worden in het te vroeg terugkeren naar volledige groepstraining. Daarom is de doelstelling als volgt: 1. Een lijst met criteria creëren waaraan een amateurvoetballer moet voldoen voordat hij kan terugkeren naar voetbal na een hamstringblessure en 2. onderzoeken hoe deze criteria zouden kunnen worden gemeten volgens experts.

Methode Semi- gestructureerde interviews zijn afgenomen volgens een vooraf opgesteld format bij sportartsen, sportfysiotherapeuten en voetballers die zelf een hamstringblessure hebben gehad. Vervolgens is de kwalitatieve data-analyse uitgevoerd.

Resultaten Er konden 25 criteria en 20 meetinstrumenten geïdentificeerd worden uit de 12 interviews. Deze zijn ondergebracht in 7 thema's. Vier van de thema's betrof de criteria: 1. primaire voorwaarden, 2. Sport specifieke en functionele bewegingen, 3. Gefaseerde opbouw in revalidatie en 4. Overige factoren. De overige drie thema's betrof de meetinstrumenten: 1. Passieve testen, 2. Actieve testen en 3. Sport specifieke testen.

Conclusie Een voetballer mag geen beperkingen hebben in mobiliteit van gewrichten en kracht van de hamstring en moet een goed opgebouwde, gefaseerde revalidatie gericht op sport specifieke handelingen hebben doorlopen. Daarna kan een graduele toename in trainingsactiviteit met de groep starten. Verder onderzoek moet worden gedaan om een toolkit met afkapwaarden voor terugkeer naar volledige groepstraining te ontwikkelen.

Klinische relevantie Deze studie geeft een overzicht van criteria waaraan een amateurvoetballer moet voldoen voordat een volledige groepstraining hervat kan worden. Wanneer een toolkit met afkapwaarden ontwikkeld is, zal een reductie van aantal recidiverende hamstringblessures het resultaat moeten zijn.

ABSTRACT

Aim Recurrent hamstring injuries are a major problem in soccer. One of the reasons for the high recurrent rate could be found in returning to group training too early. Therefore the aim of this study is: 1. To create a list of criteria which should be met by amateur soccer players before they can return to play after a hamstring injury and 2. To explore how these criteria can be measured according to experts in the field of hamstring injuries.

Methods A qualitative approach is chosen. Semi-structured interviews are performed in three categories of participants: sports physicians, sports physical therapists and soccer players who had a hamstring injury in the past season. After interviewing qualitative data-analysis were performed.

Results A list of 25 criteria and 20 measurement tools is conducted from 12 interviews and divided in seven overarching themes. Four themes concern RTP criteria 1. Primary conditions, 2. Sport specific and functional movement, 3. Staged rehabilitation, 4. Other factors. The other three themes concern measurement tools: 1. Passive tests, 2. Active tests and 3. sport specific tests.

Conclusion A soccer player may not have any strength deficits, no joint mobility deficits and must finish a gradually increased rehabilitation protocol which is focused on sport-specific demands. After that, he can gradually increase group training time before participating in a complete group training. Further research needs to be done to develop a toolkit with cut-off points to determine if a player is ready to RTP.

Clinical Relevance This study provides clinicians an overview of which criteria should be met by a soccer player before he is ready to return to play. When a toolkit and cut-off points are developed, a decrease in hamstring injury reoccurrence should be the result.

Keywords: Return to play, hamstring injury, soccer

INTRODUCTION

Thirty-one percent of all injuries in male soccer players are muscle injuries¹. Adductors, quadriceps, calf muscles and hamstrings represent more than ninety percent of these muscle injuries². Hamstring injuries are the most common muscle injuries and account for 12-16% of all injuries in soccer^{2,3,4}.

In addition to the high incidence, hamstring injuries show the highest re-injury rates, the longest absence in matches and training and are the highest burden in muscle injuries in soccer players^{2,5}. Therefore, hamstring injuries represent one of the biggest problems in soccer players⁵.

Several risk factors for hamstring injuries and re-injury have been identified^{1,2,5,6,7}. Intrinsic factors including older age, poor flexibility, taller players, decreased strength, decreased muscle length, strength imbalance and previous hamstring injury indicate high risk on hamstring muscle injury^{5,6,7}. In addition to these intrinsic factors, extrinsic factors such as match play, winter and away matches also appear to indicate high risk on injury⁵.

Although all the above mentioned risk factors have been identified, in 12 – 30 percent of the soccer players a hamstring injury re-occurs^{2,3,4,5}. Hagglund et al. (2013) mention a short-term (i.e. within two months) re-injury rate of 13 percent of all hamstring injuries⁵. This short-term incidence rate may suggest that a player is not completely recovered when he returns to play. Therefore this could be explained by a lack of knowledge about return to play (RTP) criteria.

Currently, therapy after hamstring injury is usually focused on minimizing the risk of getting injured^{8,9}. The main focus of therapy lays on improving hamstring flexibility, muscle strength and core stability^{8,9}. However Tol et al. (2014) found no relation between isokinetic strength and risk of re-injury¹⁰. In addition to this, McCall et al. (2014) stated in their study that all included soccer teams used core stability exercises and 81,8% used stretching exercises to prevent hamstring injury, but no decrease in incidence rates is found yet¹¹. A recent study of Mendigucha et al. (2014) might indicate that functional training is important during therapy¹². They reported that at RTP, players were significantly slower sprinters than two months after RTP¹². Therefore, this might indicate that these players were not fully recovered at the moment of RTP, although they were fit to play according their doctor or physical therapist. That players are not completely recovered at RTP is supported by studies of imaging techniques which found no relation between complete muscle repair and RTP and ultrasonography findings and time to RTP^{13, 14}.

In an attempt to resolve the inconsistencies in the literature, Creighton et al. (2010) developed a decision making model for RTP¹⁵. The above mentioned factors are all mentioned in this decision model, but none of them seem to be valid and eligible for RTP after hamstring injury in soccer players. In addition to this all instruments are static instruments while functional (sport specific) tests provide essential information in the

decision making process of RTP¹⁵. Several studies investigated functional tests such as single leg bridge¹⁶, Gustavson's Hop tests (one leg hop, triple hop, cross-over hop and timed hop)¹⁷,¹⁸, agility t-test¹⁷, active straight leg raise¹⁹, functional movement screen (FMS)¹⁹, inline lunge¹⁹ and peak torque measure²⁰. These tests have been found reliable but not one of these tests is validated for measuring RTP after hamstring injury in soccer players. However, Askling et al. (2010) have developed a hamstring flexibility test that seems to be a reliable and valid test by itself to measure RTP, but no further research has been published on this test since then²¹.

To date, no available evidence exists on criteria and measurement tools for RTP decision making after hamstring injury in amateur soccer players. Despite the lack of evidence about RTP after hamstring injury, it can be assumed that there is relevant knowledge available in the field. Since field knowledge is believed to be an important basis and the ultimate aim is to help clinicians in their decision making by amateur soccer players, there is a need to identify important RTP criteria and measurement tools to measure these criteria via expert opinions. The objective of this study is to develop a list of criteria which should be met by amateur soccer players before they are able to return to play after a hamstring injury. The second objective is to develop a list of measurement tools to measure those criteria. Both lists will be identified by experts (sports physicians, physical therapists and amateur soccer players) in the field of hamstring injuries through interviews.

METHODS

Design

This qualitative study was based on interviews with experts. The interviews gave the experts the opportunity to provide their own opinion about decision making factors for RTP after a hamstring injury in soccer players. This study is approved by the Medical Ethics Research Committee of the University Medical Centre of Utrecht (WAG/om/14/009013).

Participants

In the present study, three categories of experts were involved: sports physicians, sports physical therapists and soccer players. For sports physicians, the inclusion criteria were treatment of at least one hamstring injury a month and a minimum of two years of working experience. For sports physical therapists, the inclusion criteria were the same as for sports physicians. For soccer players, the inclusion criteria were experiencing a hamstring injury in the period of April 2013 – April 2014 and playing soccer in second class or higher level. Participants were excluded from this study when they did not speak or understand the Dutch language.

To recruit all participants, a convenience sampling method was used. The recruitment was done in various ways. Sports physicians were introduced to present study during a regional meeting for sports physicians. Sports physical therapists received an introduction via the 'Dutch society of sports physical therapists by email'. Soccer players participating in the Hamstring Injury Prevention Study (HIPS)²² and having a hamstring injury in the period between June 2013 and June 2014 were contacted by email.

The sample size was predetermined on 15 participants (five sports physicians, five sports physical therapists and amateur soccer players). With this sample size, it was expected that saturation was reached and therefore no new criteria and instruments would be mentioned in further interviews.

Data collection

The interviews were based on a topic list. The topics were: 'RTP criteria for completing group training', 'measurement tools to quantify criteria', 'differences in criteria for returning to training or returning to match play', 'other factors that possibly influence the decision of RTP' and 'opinions about three measurement tools for RTP: Gustavson's hop tests^{17,18}, Functional movement screen¹⁹ and active hamstring flexibility test²¹. This topic list is primarily conducted through insight about RTP from the literature, which shows conflicting evidence about which criteria to meet and which instruments to use for RTP. After the primary topic list was developed, a pilot- interview was performed. Following the pilot interview several questions were modified. The topic list for clinicians (sports physicians and sports physical therapists) is available in appendix A.

Procedure

The initial contact between the researcher and the experts was by email. When no response was received, a telephone call followed. After commitment to participate was given, an appointment was scheduled for the interview. The informed consent forms were signed prior the verbal interview in presence of the researcher. The interviews took place at the University Medical Centre in Utrecht, in the work environment of the clinicians or at the soccer club of the soccer players. The twenty-five minute voice- recorded verbal interviews were conducted by one researcher (PA vd H) following the preconceived topic list. At the end of each interview the received information was checked by the participant by summarizing the interview. The participants information and received data was saved anonymously by a numeric code.

Data analysis

Data collection and data analysis were performed in a cyclic process: when an interview was performed, data was immediately transcribed and analyzed before the next interview was conducted. Qualitative data analyses were performed in different steps. First, the interviews were literally transcribed. NVIVO10 (QSR International Pty Ltd. Version 10, 2012) was used to import, process and analyze the literally transcribed interviews. Then, after importing complete transcripts, three steps of coding were taken: open, axial and selective coding²³.

To enhance external validity the first two interviews were coded by a second researcher (EH)²⁴. When there were differences in results from the interviews, the researchers discussed these items until they reached consensus.

Finally, by following this process, two lists of overarching themes, one for criteria and one for measurement tools were presented. These themes cover the criteria and instruments that could be used in clinical practice to decide whether an amateur soccer player can complete a soccer group training. Within these themes the perspectives of sports physicians, sports physical therapists and soccer players were viewed to see if there were differences in decision making. All results are illustrated with quotes from the three perspectives.

RESULTS

Within a 3-month-period (April – June 2014) six sports physicians, eight sports physical therapists and 18 soccer players were contacted to participate in this study. All six sports physicians, three physical therapists and three soccer players (1 midfielder and 2 attackers) signed informed consent and were interviewed. Participants demographics are listed in table 1.

	Sports physicians	Sports physical therapists	Soccer players
Age (Range + Median)	29- 54 + 38	27- 41 +34	26 – 31 + 27
Sex	4 female/ 2 male	3 male	3 male
Years of experience (mean + SD)	12.6 +/- 9.2	11 +/- 4	22.7 +/- 3.3
N hamstring injuries (Mean + SD)	1.9 +/- 1.25 p/month	1.5 p/month	6.5 +/- 3 in career
Specific population	Soccer players	Soccer players	
Work environment	Soccer club (5), hospital (1)	Primary care practice (1), soccer club (2)	

Table 1: Participants demographics

A total of 79 codes, 11 categories and seven overarching themes emerged from the interviews with 12 participants. Four of the seven themes concern RTP criteria and the other three themes concern measurement tools.

Criteria

Four overarching themes concerning criteria were identified: 1. Primary conditions, 2. Sport specific and functional movement, 3. Staged rehabilitation and 4. Other factors. Table 2 gives an overview of each of these four themes illustrated by quotations of participants from different perspectives.

Primary conditions

Illustrative quotes in this theme were *"A player may not have any pain during physical examination"* and *"No deficits may occur in joint mobility of all joints from ankle to lower back"*. All three perspectives (sports physicians, sports physical therapists and soccer players) agreed that before RTP can be considered, all criteria for normal movement of the total body must be met. This means a player cannot have any pain in ADL, concentric or eccentric muscle contraction and in full muscle stretch. Besides not experiencing any pain, there can be no deficits in strength, mobility or coordination. Two soccer players mentioned that when they did not feel strong enough, they would not participate in the group training. This accounted for having enough strength, but also for confidence in their own body.

	Sports physicians	Sports physical therapists	Soccer players
Primary conditions	"Strength must be equal in both legs"	"At least he may not have pain in ADL"	"When I feel pain during stretching, I could not train with the group"
Sport specific and functional movement	"He has to do a long run of at least 30 minutes"	"He has to show me that he can perform plyometric exercises"	"I have to be able to sprint on maximum speed, at a sudden moment"
Staged rehabilitation	"A soccer player is gradually participating in more parts of the training. At first only warm-up and passing, than warm-up, passing and short games and in the end complete training"	"When I train him individually he is participating partly in group training. I increase his training load according to phases of wound repair"	"Running laps is the first thing I do on the field, than running with the bal, passing, than running and passing, etc. Every time I can do more".
Other factors	"The trainer plays a key role in this issue. He has to decide if the player is fit enough to complete his training".	"the feeling of the player"	"When it does not feel good, I sometimes still wanted to train. Afterwards I mostly regret it"

Table 2: An overview of the themes for criteria illustrated with citations

Sport specific and functional movements

Sport specific movements as shooting, sprinting, jumping and turning must be performed before group training can be completed (RTP). In this theme the level of competition plays an important role. *"The higher the level of competition, the higher the intensity of which sport specific movements must be performed"*. Within the criteria, it might be useful to create gradations for the levels of competition in soccer, because a player on third class level, does not have to be able to perform on the same intensity as a player in first class competition.

Staged rehabilitation

Most sports physicians, sports physical therapists and soccer players mentioned that they gradually increase training load. This also means that they gradually increase the training participation time. *"Before a player can complete a group training for a 100 percent, he must have proved that all loose parts of a group training can be completed without any pain"*. *"I start with running laps when I feel no pain in physical examination, when that goes well I start with small sprints, dribbling and kicking the ball over 5meters."* These quotes describe that gradually participating longer in group training is part of the rehabilitation and therefore a key role in the clinical decision making process of RTP for a complete group training. It is even mentioned by a sports physical therapists that when 10 players are rehabilitated in a different way, they can all score good on the tests, but that does not mean that they are all ready to complete a group training. That depends on what they have done during rehabilitation.

Within staged rehabilitation, injury severity appeared to play an important role. It is mentioned that *"The more severe the injury, the more repetitions must be done per sport specific movement before group training can be resumed"*.

The injury severity was mentioned to be determined by part of the hamstring muscle, tendon

or muscle and size of the defect. When a grade 2 hamstring injury occurred, the stages in the gradually increase of training intensity were believed to be shorter than when a more severe grade 3 injury occurred.

Other factors

This theme includes criteria as the player's confidence, the player's feelings, timing in competition including demotion or championship match and trainer's pressure. *"When there are only three matches left to play and the team needs to win all three, pressure rises and risks of re-injury are taken by letting not fully recovered players participate in those matches."* This theme shows that at least three perspectives are involved in the decision making process: the clinician, the player himself and the trainer. Appendix B shows the complete list of criteria mentioned by the participants.

Measurement tools

In total 20 measurement tools were mentioned, but *"It might even be impossible to design one test to decide if a player is ready to RTP"* Three themes concerning measurement tools were identified: 1. Passive tests, 2. Active tests and 3. Sport specific tests. Table 3 gives an overview of each of these three themes illustrated by quotations of participants from different perspectives.

	Sports physicians	Sports physical therapists	Soccer players
Passive tests	"Tests for joint mobility and hamstring flexibility I do in the examination room. I use the pop angle and the straight leg raise"	"Tests for strength and joint mobility I do primarily manually in the examination room"	"The physical therapist did feel my hamstring if the rupture was gone. Then I could start running laps"
Active tests	"I use the Nordic curls to test the eccentric strength"	"In addition to the manual tests I would do lunges and goodmornings to see how the muscle is doing"	"When I could run laps I had to do jumping exercises like skate jumps"
Sport specific tests	"The test is if a player can complete exercises in group training. That is the ultimate test to see if he is ready to RTP"	"The agility T-test if there is room to perform it. That is a sprint test"	"When sprinting with the ball goes well, I had the feeling it was getting better and I could start doing exercises with the group training. Then I just saw how long I could continue doing that".

Table 3. An overview of the themes for measurement tools illustrated with citations

Passive tests

Mostly primary conditions were tested with passive tests. Primary conditions included no pain, no deficits in strength, mobility of several joints and coordination. *"I will test strength manually to see if the injured part can deliver an equal amount of force as the uninjured leg"* is one of the mentioned test for strength. Other tests that are being used are the straight leg

raise and pop- angle for hamstring flexibility and palpation for pain detection. Besides these passive tests the Visual Analog Scale (VAS) for pain is used to objectify the amount of pain a player experiences.

Active tests

The active tests are used to see if the player can use his body in a functional way and tests are scored both quantitative as well as qualitative. Most active tests are exercises that are being used as tests. *"I use tests as the Nordic curl and the player has to be able to perform deadlifts and lunges"*. Other tests that are being used are exercises as box jumps for functional strength, long run of at least 30 minutes for strength and endurance and single leg bridge for core stability.

Sport specific tests

Sport specific tests are tests that measure all movements that are necessary to play soccer. Mostly running, sprinting and jumping are involved in those tests. *"At the end of my individual training I have to be able to sprint on maximum speed over a longer distance than 10meters"*. Several participants mentioned that a player passed the test when no compensatory movements could be seen during the tests. Other tests mentioned than sprinting in a straight line are the agility T-test and completing parts of group training.

Not all mentioned criteria are measured separately. Some criteria (i.e. exercise capacity), are being measured secondary in one of the measurement tools. Appendix C shows the complete list of all mentioned measurement tools separated in the three themes.

DISCUSSION

The aim of this study was to investigate which criteria should be met by amateur soccer players before they are ready to return to play after a hamstring injury and to explore how these criteria can be measured properly.

Based on expert opinions in present study, it has been found that soccer players must meet all criteria of normal movement patterns and must have completed a staged rehabilitation programme before RTP can be considered. In addition to this, experts indicated that another criteria for RTP is that soccer players must be able to perform sport specific movements during a certain time and intensity depending on what level of competition they play.

To measure those criteria passive, active and sport specific tests were mentioned by the experts. Twenty measurement tools have been mentioned, but there is not yet one instrument that can be used to decide if a player is ready to RTP. There is a need for a toolkit with cut-off points which can determine if a player is ready to return to play.

Criteria

According to sports physicians and sports physical therapists, soccer players must meet all primary conditions for normal movement patterns. This means that the player cannot have any pain and no deficits in joint mobility, muscle length and strength of the hamstring muscle. The result of the criteria strength is in contrast with earlier findings which indicated that there is no relation in isokinetic strength and risk of re-injury¹⁰. This may suggest that solely a deficit in isokinetic strength is not an indication for a higher risk of re-injury but in combination with other deficits it might account for a part of the risk. This supports the fact that this study indicates that the RTP decision depends on many criteria, while previous studies focused on single criteria^{10,12,13,15}. A recent study involved a seven point treatment program which also indicates that more than one criterion influences the RTP decision in hamstring injury²⁵.

Possibly more important than meeting primary conditions, considering it is frequently mentioned, is the fact that all participants mentioned that the functional aspects and sport specific movements must be optimally trained. Prior et al (2009) also concluded that functional rehabilitation established preventive effects and earlier RTP, but further research needed to be done in this area⁸.

In addition to all physical factors, players have to cope with psychosocial or psychological stressors as fear of re-injury, pressure from trainer and feeling unfit. These findings also correspond with other studies^{26,27,28}.

Measurement tools

This study states that there is not one instrument that can be used to determine whether a player is ready to RTP and a toolkit to measure RTP is indicated.

Measurements of maximum sprint speed and maximum force of the hamstring muscle could be useful tools to get an indication if a player is ready to RTP. This corresponds with findings of Mendigucha et al. (2014)¹² who found an increase in sprint speed in the period from RTP

till six months after RTP.

Besides these physical factors, also psychological factors should be measured. All clinicians asked the player if he felt confident about his hamstring, but not one clinician used an instrument to measure this. In future the Injury- Psychological Readiness to Return to sport Scale (I-PRRS) might be a helpful instrument to determine if a player is mentally ready to return to complete group training²⁷.

In addition to these criteria, a staged rehabilitation is mentioned as an important criterion. It could be useful to design criteria to decide when a player can move to the next stage in rehabilitation. The test that is used at this moment is to see if a player can perform the exercises in the stage without any pain or compensatory movements. Seven out of nine clinicians mentioned that injury severity plays an important role in time to increase training intensity in the staged rehabilitation program. The more severe the injury, the more hours of training are necessary before a player can RTP. Therefore an MRI or ultrasonography could be a useful instrument to determine injury severity at the moment of getting injured. This is in contrast with earlier findings which indicated that there is no relation between ultrasonography findings and RTP time^{13,14}.

Strengths and weaknesses

At first, this study investigated three perspectives in the decision making process of return to play after a hamstring injury, namely the sports physician, the sports physical therapist and the injured player himself. It is assumable that up to date knowledge about this subject is available by these experts in the field. Second, this design and method of data collection was chosen because of the conflicting evidence in literature. This made it necessary to go back to basics and investigate the knowledge and ideas of the experts in the field about RTP. Third, several steps were taken to maintain high validity, including full transcription of the interviews, audit trail and member checking.

This study had also several methodological issues. First, a suggestion for further research is to involve trainers of soccer teams, because in several interviews the role of the trainer is pointed out as an essential factor in the decision making process. Especially in the final phase of the competition. Second, because of a low response, a small number of soccer players and sports physical therapists participated in this study. The last point for improvement of this study was the interview itself. Unfortunately limited cut- off points for instruments for criteria were mentioned during the interviews. The reason for this result could be due to the questions that were asked or due to not being available of cut-of points. Further research should be performed to confirm or reject these results.

Interpretations and mechanisms

This study was the primary step in developing a measurement tool to determine whether an amateur soccer player is ready to RTP. The next step is to develop a toolkit and investigate whether this is a valid instrument for these criteria. This toolkit should at least measure several primary conditions, sport specific movements and other factors as psychological state.

Other further research might focus on rehabilitation protocols. Suggestion could be made to divide the rehabilitation in phases and develop a protocolled rehabilitation program per phase. This staged rehabilitation program also corresponds with Taylor's model used in sports psychology²⁸.

In summary, a list of RTP criteria is conducted, but in future research a toolkit should be developed including cut-off points on the measurements in that toolkit.

Clinical relevance

This study provides clinicians an overview of which criteria should be met by a soccer player before he is ready to return to play. When a toolkit and cut-off points are developed a decrease in hamstring injury reoccurrence should be the result.

CONCLUSION

RTP after hamstring injuries in amateur soccer players is a widespread problem in this type of sports. In present study, 25 criteria and 20 measurement tools were mentioned by the 12 participants. The main conclusion is that a soccer player may not have any strength deficits, no joint mobility deficits and must finish a gradually increased rehabilitation protocol which is focused on sport- specific demands. After that, he can gradually increase group training time before participating in a complete group training. Further research needs to be done to develop a toolkit with cut-off points to determine if a player is ready to RTP.

REFERENCES

1. Ekstrand J, Hagglund M, Walden M. Injury incidence and injury pattern in professional football—the UEFA injury study. *Br J Sports Med.* 2011;45(7):553-558.
2. Ekstrand J, Hagglund M, Walden M. Epidemiology of muscle injuries in professional football (soccer). *Am J Sports Med.* 2011;39(6):1226-1232.
3. Woods C , Hawkins R D , Maltby S , Hulse M , Thomas A , Hodson A . The Football Association Medical Research Programme: an audit of injuries in professional football – analysis of hamstring injuries . *Br J Sports Med* 2004;38:36- 41
4. Croisier J.L. Factors associated with recurrent hamstring injuries. *Sports Med* 2004;34:681–695
5. Hagglund, M., Walden, M., Ekstrand J. Risk Factors for Lower Extremity Muscle Injury in Professional Soccer. *Am J Sports Med* 2013 41: 327 – 335.
6. Van Beijsterveldt, A.M., van de Port, I.G., Vereijken, A.J., Backx, F.J. Risk factors for hamstring injuries in male soccer players: a systematic review of prospective studies. *Scand J Med Sci Sports* 2013 Jun;23(3):253-62
7. Kumazaki, T., Ehara, Y., Saka, T. Anatomy and physiology of hamstring injury. *Int J Sports med* 2012 Dec;33(12):950-954
8. Prior, M., Guerin, M., Grimmer, K. An evidence- based approach to hamstring strain injury: a systematic review of the literature. *Sports health* 2009 Mar;1(2):154-64.
9. Mendiguchia, J., Brughelli, M. A return-to-sport algorithm for acute hamstring injuries. *Phys Ther Sport.* 2011 Feb;12(1):2-14
10. Tol, J.L., Hamilton, B., Eirale, C., Muxart, P., Jacobsen, P., Whiteley, R. At return to play following hamstring injury the majority of professional football players have residual isokinetic deficits. *Br J sports Med.* 2014 Feb 3
11. McCall, A., Carling, C., Nedelec, M., Davison, M., Le Gall, F., Berthoin, S., Dupont, G. Risk factors, testing and preventative strategies for non-contact injuries in professional football: current perceptions and practices of 44 teams from various premier leagues. *Br J Sports Med.* 2014 May 16. Epub ahead of print
12. Mendigucha, J., Samozini, P., Martinez-Ruiz, E., Brughelli, M., Schmikli, S., Morin, J.B., Mendez-Villanueva, A. Progression of Mechanical Properties during On-field Sprint Running after Returning to Sports from a Hamstring Muscle Injury in Soccer Players. *Int J Sports Med.* 2014 Jan 14
13. Sanfilippo, J.L., Silder, A., Sherra, M.A., Tuite, M.J., Heiderscheit, B.C. Hamstring strength and morphology progression after return to sport from injury. *Med Sci Sports Exerc.* 2013 Mar;45(3):448-54
14. Petersen, J., Thorborg, K., Nielsen, M.B., Skjodt, T., Bolvig, L., Bang, N., Holmich, P. The Diagnostic and Prognostic Value of Ultrasonography in Soccer Players With Acute Hamstring. *Am J Sports Med.* 2014 Feb;42(2):399-404
15. Creighton, D.W., Shrier, I., Shultz, R., Meeuwisse, W.H. and Matheson, G.O. Return- to-play in sport: A decision based model. *Clin J Sport med.* 2010. Vol. 20. No. 5. P. 379 –

385.

16. Freckleton, G., Cook, J., Pizzari, T. The predictive validity of a single leg bridge test for hamstring injuries in Australian Rules Football. *Br. J. Sports med.* (2013). Epub ahead of print.
17. Munro, A.G., Herrington, L.C. Between session reliability of four hop tests and the agility T-test. *Journal of strength and conditioning research.* (2011). Vol. 25. No. 5. P. 1470 – 1477.
18. Skaara, H. E., Moksnes, H., Frihagen, F., Stuge, B. Self- reported and performance-based functional outcomes after surgical repair of proximal hamstring avulsions. *The American journal of sports medicine.* (2013) (Epub ahead of print)
19. Cook, G., Burton, L., Hoogenboom, B. Pre-participation screening: the use of fundamental movements as an assessment of function – part 1. *N Am J Sports Phys Ther.* 2006. Vol. 1. No 2. P. 62- 72
20. Brockett, C.L., Morgan, D.L., Proske, U. Human hamstring muscles adapt to eccentric exercise by changing optimum length. *Med Sci Sports Exerc* 2001;33:783–90.
21. Askling, C.M., Nilsson, J., Thorstensson, A. A new hamstring test to complement the common clinical examination before return to sport after injury. *Knee Surg sports traumatol arthrosc.* 2010. Vol. 18. P. 1798/ 1803
22. van der Horst N, Smits DW, Petersen J, Goedhart EA, Backx FJ. The preventive effect of the Nordic hamstring exercise on hamstring injuries in amateur soccer players: study protocol for a randomised controlled trial. *Inj Prev.* 2013 Dec 13
23. Strauss, A.L., Corbin, J. (1998) *Basics of qualitative research: techniques and procedures for developing grounded theory.* Thousand Oaks, sage.
24. Boeije, H. (2008) *Analysis in qualitative research. Data collection.* First edition. Nederland: Boom onderwijs Page 144- 156
25. Brukner, P., Nealon, A., Morgan, C., Burgess, D., Dunn, A. Recurrent hamstring muscle injury: applying the limited evidence in the professional football setting with a seven-point programme. *Br J sports med* 2014 Jun; 48(11): 929-938
26. Podlog, L., Dimmock, J., Miller, J. A review of return to sport concerns following injury rehabilitation: Practitioner strategies for enhancing recovery outcomes. *Phys Ther Sport.* 2011 Feb;12(1):36-42
27. Glazer, D.D. Development and Preliminary Validation of the Injury- Psychological Readiness to Return to Sport (I-PRRS) Scale. *Journal of athletic training.* 2009;44(2): 185-189
28. Taylor J, Taylor S. *Psychological Approaches to Sports Injury Rehabilitation.* Gaithersburg, Maryland: Aspen; 1999.

Appendix A – Topic list of the interviews with clinicians : Nog te vertalen?

Mondeling Interview Opzet Behandelaars van hamstringblessures

- Korte samenvatting over het onderzoek:
 - o voorstellen
 - o Doelstelling
 - o Beoogd resultaat van het interview: opinie verkrijgen van de geïnterviewde, kennis vergaring over het onderwerp vanuit de praktijk

- Demografische gegevens:
 - o Naam
 - o Leeftijd
 - o Geslacht
 - o Beroep
 - o Specialisaties/ aandachtsgebied
 - o Aantal jaren werkervaring
 - o Specifieke populatie (specifieke sport, blessure/klachten)
 - o Werksetting
 - o Gemiddeld aantal hamstringblessures per maand

- Return-to-play
 - o Stel: een amateurvoetballer komt bij u met een hamstringblessure; die gaat u behandelen en uiteindelijk komt er een moment dat u (in samenspraak met de patiënt) tot een besluit komt dat de patiënt de veldtraining met de groep weer volledig kan hervatten.
Ik zou graag willen weten wat uw overwegingen zijn bij dat besluit.
Vervolgvrage: welke meetinstrumenten gebruikt u daarvoor?

- o Wat zijn je overwegingen voor een wedstrijd?

- *Zijn er nog andere factoren die van invloed kunnen zijn op het besluit?*

-

Kent u de

- *Functional Movement Screen?* Ja/Nee
- *Active hamstring flexibility test?* Ja/ Nee
- *Gustavson Hop testen?* Ja/ Nee

- o *Zo ja, wat is uw mening over de eventuele bruikbaarheid van deze testen om tot een RTP beslissing te komen?*

- Samenvatting
- Conclusie interview (in 2 zinnen)
- Bedanken voor de medewerking **en vragen of men het eindverslag/artikel wil ontvangen (emailadres ondervraagde bij je bekend)?**

APPENDIX B - Complete list of criteria mentioned by the participants

Criteria
No pain in ADL
No pain in Range of motion
No pain in strength
No pain in muscle tone
No pain in eccentric strength
Full strength
full eccentric strength
explosive max strength
coordination and technic
endurance
Full range of motion
No restriction in any joint
core stability
Maximum speed sprints
Maximum force shooting
No Pain in sportspecific movements
Players feeling
no fear of re-injury
History of injury
snow or wet field
degradation/ demotion
Trainers opinion
specific exercise capacity for soccer
sport specific exercises
Staged intensity build up in rehabilitation

Appendix C - Complete list of measurement tools mentioned by the participants divided in three themes

Category	Measurement tool
Passive tests	Visual analog scale Player's feeling Manual test range of motion Straight leg raise Laseque Pop angle Isolated hamstring strength manually tested
Active tests	Long run > 30minutes Balance error score Single leg bridge Nordic Curl Lunges Deadlifts Biodex – H:Q ratio + < 30% difference injured/ uninjured leg Sit and reach test
Sport specific tests	Gustavson Hop tests Box jumps Agility T-test 30m + maximum speed sprints Shuttle run