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The correlation between the imaging characteristics of hamstring injury and time required before returning to sports: a literature review

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Injuries to the hamstring muscles are common in athletes. Track and field, Australian football, American football and soccer are examples of sports where hamstring injuries are the most common. The purpose of this study was to investigate whether there is a correlation between a hamstring injury prognosis and its characteristics of imaging parameters. The literature search was performed in the databases PubMed and CINAHL, and eleven articles were included. Seven out of the 11 articles showed a correlation between the size of the hamstring injury and length of time required before returning to sports. Different authors have reported contrasting results about length of time required before returning to sports due to location of injury within specific muscle. Majority of the articles found hamstring strain correlated to an extended amount of time required before returning to sports.

Keywords: Athletes, Magnetic resonance imaging, Muscle, Sonography, Sport, Strain

INTRODUCTION

Injuries to the hamstring muscles are common in athletes (Alonso et al., 2009). Track and field (Bennell and Crossley, 1996), Australian football (Orchard et al., 2013) and American football (Feeley et al., 2008) are examples of sports where hamstring injuries are the most common. Soccer, one of the largest sports in the world (Federation Internationale de Football Association [FIFA], 2006), is a sport where hamstring injuries frequently occur. According to Ekstrand et al. (2011b), muscle injuries accounted for 31% of all injuries in football with hamstring injuries being the most common. They also reported that a football team of 25 players usually have about ten muscle injuries per year (Ekstrand et al., 2011a). According to Carling et al. (2011), the risk of a muscle strain in soccer is 4.3/1,000 hr exposure time, with hamstring muscles most often being affected.

A careful review of the injury incident followed by a clinical examination is required in order to diagnose a muscle injury. Clinical examination of a muscle injury consists of inspection, palpation, testing of active and passive range of motion and manual muscle tests of the involved muscle. Minor injuries are more difficult to diagnose than more extensive ones; therefore, ultrasound or magnetic resonance imaging (MRI) have been suggested (Järvinen et al., 2007; Slavotinek, 2010). Ultrasound is considered the first choice of imaging, as it is dynamic, straightforward and rapid compared with MRI and also considerably more inexpensive (Connell et al., 2004; Järvinen et al., 2007; Peetrons, 2002). With ultrasound and MRI, it is possible to detect the location of the damage, fluid retention and discontinuity of muscle fibres. Furthermore, it is possible to measure the size of the injury (Peetrons,

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2002; Slavotinek, 2010). According to Peetrons (2002), a muscle injury can be classified into four different degrees. Grade 0 indicates no visible tissue damage, grade 1 means oedema but without fibre damage, grade 2 fibre damage and grade 3 a total muscle or tendon rupture.

Other parameters to assess the extent of a muscle injury are to measure the size of the total cross-sectional area as well as the length and volume of the hamstring injury. The image that is chosen to determine the cross-sectional area is taken from where the extent of the damage is greatest. The ratio of the extent of damage to the entire muscle bundle cross-sectional area is the percentage cross-sectional area that is damaged. This area is therefore considered to represent the proportion of myofibrils that are destroyed. For this to be assessed, the image should be taken in the transverse plane (Slavotinek, 2010). Thus, it will be possible to measure the extent of damage where it is the largest in both the transverse (T) and anterior-posterior (AP) direction. In longitudinal images, i.e., where the damage is seen from the side, it is possible to measure the length of the injury in cranio-caudal (CC) direction. To calculate the volume, the formula ($[\pi/6] \times AP \times T \times CC$) is used, assuming the damage to form an ellipse (Slavotinek et al., 2002). Sensitivity to fluid retention has been shown to be equal in both MRI and ultrasound (Koulouris and Connell, 2005). The assessment of the volume of fluid in the muscle has even proven to be better using ultrasound than MRI (Thorsson et al., 1993). MRI examination is the most accurate method for assessing a muscle injury (Hayashi et al., 2012), but the sensitivity to detect the healing process is not as high as with ultrasound examination (Connell et al., 2004). However, it is important that the radiologist is experienced in order to make an accurate assessment (Douis et al., 2011). Depending on the muscle group, the images should be taken 2 hr to 5 days after the injury occurs (Peetrons, 2002). Imaging can follow the healing process of a muscle. Retractions of muscle damage, acute effects, the development of scar tissue and detection of complications are parameters that can be assessed (Slavotinek, 2010).

Hamstring muscle injuries account for a large part of the time that an athlete is injured (Ekstrand et al., 2011b). There is often a high priority to return to playing sports as quickly as possible after a muscle injury, which means that the risk for reinjury is high (Ekstrand et al., 2011b). Maybe the injury characteristics could determine the length of time before returning to sports, which is important in order to have accurate prognosis and improve the rehabilitation process.

The purpose of this study was to investigate whether there is a correlation between a hamstring injury prognosis and its characteristics of imaging parameters. The objectives are threefold: to study whether there are any correlations between (a) muscle that is injured, (b) size of the injury, (c) injury location and length of time before being able to return to sports, respectively.

MATERIALS AND METHODS

Systematic literature review was performed. The keywords used were hamstring injury, hamstring strain, return to sports, time to recovery, return to play, imaging, magnetic resonance and sonography. In total, 388 articles were found. First, the abstract of each article was reviewed; second, the whole article was reviewed to determine if it met the inclusion criteria presented below.

Inclusion criteria

- Hamstring injured athletes
- Assessment of injury with MRI or sonography
- Length of time before returning to sports after injury as outcome variable
- Prospective design
- Publications in English in scientific journals from 1990
- Original articles
- Human studies

Exclusion criteria

- Case studies
- Other muscle groups than hamstrings
- Articles where only total hamstring ruptures or avulsion fractures were included

Database search

The literature review search was performed using the databases PubMed and CINAHL with different keyword combinations (Table 1). All searches were carried out until the 28th of November 2015. Eleven articles (Askling et al., 2007a; Askling et al., 2007b; Askling et al., 2008; Comin et al., 2013; Connell et al., 2004; Ekstrand et al., 2012; Gibbs et al., 2004; Hallén and Ekstrand, 2014; Moen et al., 2014; Petersen et al., 2014; Silder et al., 2013) qualified for inclusion. These eleven articles were reviewed according to the aims of the study, and four articles (Comin et al., 2013; Connell et al., 2004; Ekstrand et al., 2012; Hallén and Ekstrand, 2014) addressed the question about the specific muscle injury. All 11 articles addressed the question about the size of the injury, and six articles related to the question about in-

Table 1. Keywords and selected articles in databases

Database	Issue	No. of items	Total selected studies	Study
PubMed	Hamstring injury return to play	130	5	Comin et al. (2013); Ekstrand et al. (2012); Hallén (2014); Moen et al. (2014); Petersen et al. (2014)
PubMed	Hamstring injury return to sport imaging	23	5	Askling et al. (2007a); Askling et al. (2007b); Askling et al. (2008); Connell et al. (2004); Silder et al. (2013)
PubMed	Hamstring injury return to play imaging	36	0	-
PubMed	Hamstring strain return to sport magnetic resonance	7	0	-
PubMed	Hamstring injury time to recovery imaging	29	1	Gibbs et al. (2004)
PubMed	Hamstring strain return to sport sonography	0	0	-
CINAHL	Hamstring injury return to play	28	0	-
CINAHL	Hamstring injury return to sport imaging	81	0	-
CINAHL	Hamstring injury return to play imaging	10	0	-
CINAHL	Hamstring strain return to sport magnetic resonance	11	0	-
CINAHL	Hamstring injury time to recovery imaging	16	0	-
CINAHL	Hamstring strain return to sport sonography	17	0	-

Table 2. Study presentation and the issues they address

Study	Title	Responds issue, number		
		1	2	3
Askling et al. (2007a)	Acute first-time hamstring strains during high-speed running: A longitudinal study including clinical and magnetic resonance imaging findings	×		×
Askling et al. (2007b)	Acute first-time hamstring strains during slow-speed stretching: Clinical, magnetic resonance imaging (MRI) and recovery characteristics	×		×
Askling et al. (2008)	Proximal hamstring strains of stretching type in different sports: Injury situations, clinical and magnetic resonance imaging characteristics and return to sport	×		×
Comin et al. (2013)	Return to competitive play after hamstring injuries involving disruption of the central tendon	×	×	×
Connell et al. (2004)	Longitudinal study comparing sonographic and MRI assessments of acute and healing hamstring injuries	×	×	×
Ekstrand et al. (2012)	Hamstring muscle injuries in professional football: The correlation of MRI findings with time required before return to play	×	×	
Gibbs et al. (2004)	The accuracy of MRI in predicting recovery and recurrence of acute grade one hamstring muscle strains within the same season in Australian Rules football players	×		
Hallén and Ekstrand (2014)	Return to play following muscle injuries in professional footballers	×	×	
Moen et al. (2014)	Predicting return to play after hamstring injuries	×		×
Petersen et al. (2014)	The diagnostic and prognostic value of ultrasonography in soccer players with acute hamstring injuries	×		
Silder et al. (2013)	Clinical and morphological changes following 2 rehabilitation programmes for acute hamstring strain injuries: A randomised clinical trial	×		

1, Is there a correlation between size of injury and length of time before returning to sports?; 2, Is there a correlation between the injured muscle bundle and length of time before returning to sports?; 3, Is there a correlation between the injury location within the muscle and length of time required before returning to sports?

jury location within the muscle (Askling et al., 2007a; Askling et al., 2007b; Askling et al., 2008; Comin et al., 2013; Connell et al., 2004; Moen et al., 2014) (Table 2). The purpose of each included article is presented in Table 3.

RESULTS

Item presentation

Table 2 presents the articles that relate to each question. Also, an overview of each item is presented in Table 3.

A summary of the included studies is provided in Table 4. Below is a presentation of the results from the issues.

Is there a correlation between size of injury and length of time before returning to sports?

The answer to the question was based on nine out of the 11 articles (Askling et al., 2007a; Askling et al., 2007b; Askling et al., 2008; Connell et al., 2004; Ekstrand et al., 2012; Gibbs et al.,

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Table 3. Study and their purpose

Study	Purpose or hypothesis
Askling et al. (2007a)	Investigate acute, first-time hamstring strains in sprinters with respect to the occurrence and progression of both clinical and MRI signs of injury during first 6 weeks after injury, as well as the extent of correlation between clinical and magnetic resonance imaging (MRI) findings and their association with time required before return to preinjury level
Askling et al. (2007b)	Investigate acute, first-time hamstring strains in dancers with respect to injury mechanism, location, and extent of the injury as well as possible relationships with clinical and MRI findings and time required before return to preinjury level
Askling et al. (2008)	Investigate the generalisability of our earlier findings (Askling et al., 2007b) of specific injury location and long recovery times for stretching-type hamstring injuries in dancers
Comin et al. (2013)	Evaluate the use of a novel qualitative MRI parameter, the presence of disruption of central tendon fibres, for prognostication of hamstring injuries in a group of elite athletes
Connell et al. (2004)	Compare the characteristics of sonography with MRI in assessing both the acute and healing phases of hamstring injuries. Also, to investigate whether MRI and sonography characteristics identified at baseline could serve as clinically useful prognostic factors to determine whether professional football players can return to full competition (Australian football)
Ekstrand et al. (2012)	Evaluate the use of MRI as a prognostic tool for lay-off time after hamstring injuries in professional football players. A further aim was to investigate use of MRI in hamstring injuries in elite level football teams and to study the association between MRI findings and injury circumstances
Gibbs et al. (2004)	Comparing the estimated time of return to sport based on clinical diagnostics or MRI with the actual recovery time as well as to find out the degree of agreement between clinical diagnosis and MRI examination for the presence or absence of injury
Hallén and Ekstrand (2014)	Hypothesis; imaging would provide detailed data that would assist the persons working on the football field in answering the common question, 'When can the player return to ordinary training and matches?'
Moen et al. (2014)	Assess the prognostic value of clinical and MRI parameters for length of time required before returning to play after acute hamstring injury
Petersen et al. (2014)	(1) Investigate the characteristic sonographic findings of acute hamstring injuries in soccer players, (2) compare the mean injury severity (time required before return to play) in injured players with and without sonographically verified abnormalities, and (3) correlate the length of the injured area and absence from soccer play (time required before return to play) to investigate if ultrasonography can be used as a prognostic indicator of length of time required before return to play
Silder et al. (2013)	Assess differences between a progressive agility and trunk stabilisation rehabilitation programme and a progressive running and eccentric strengthening rehabilitation programme in recovery characteristics following an acute hamstring injury, as measured via physical examination and MRI

2004; Hallén and Ekstrand, 2014; Petersen et al., 2014; Silder et al., 2013). In five of these (Askling et al., 2007a; Connell et al., 2004; Ekstrand et al., 2012; Gibbs et al., 2004; Hallén and Ekstrand, 2014), there was a correlation in that the more extensive the injury, the longer the time required before returning to sports. Askling et al. (2007a) reported clear links between volume ($r = 0.608$) and cross-sectional area ($r = 0.695$), as measured by MRI four days after the injury, and a longer time required before returning to sports ($P < 0.05$). Connell et al. (2004) showed that at baseline, the longitudinal length of the hamstring tear on MRI had the highest correlation with recovery ($r = 0.58$, $P < 0.0001$) and was the best radiologic predictor of amount of time required before returning to sports. Multivariate analysis of MRI showed that the injury incidence of the biceps femoris and the length of the injury were factors resulting in an extended amount of time required before returning to sports ($r = 0.62$). An analysis of ultrasound images showed that the incidence of an injury to the biceps femoris, percent of cross-sectional area and presence of hematomas were predictors of length of time required before returning to sports ($r = 0.58$, $P < 0.05$). Ekstrand et al. (2012) reported that the greater the extent of the injury, using Peetrons (2002) classification, the longer the time required before returning to sports ($P < 0.001$). Gibbs et al. (2004) found that an increased length ($r = 0.84$) and per cent of the cross sectional area ($r = 0.78$) of the lesion increased the amount of time required before returning to sports. Silder et al. (2013) found that a greater cranio-caudal length of the injury was positively correlated with longer time required before returning to sports ($r = 0.41$, $P = 0.04$). Hallén and Ekstrand (2014) observed a significant association between lay-off days and MRI grading ($P < 0.001$) (grades 1–3 according to Peetrons (2002). In another two studies by Askling et al. (2007b; 2008), they did not find any correlation between the extent of the injury and an extended amount of time required before returning to sports ($r = 0.008$ to 0.625, $P = 0.055$ to 0.981, respectively). Furthermore, Petersen et al. (2014) reported that there was no correlation between the length of the injured area and extended time required before returning to sports ($r = 0.19$, $P = 0.29$). Moen et al. (2014) found no correlation between MRI parameters in grades 1 and 2 of the hamstring injuries and amount of time required before returning to sports ($P = 0.54$, $P > 0.83$, respectively).

Is there a correlation between the injured muscle bundle and length of time before returning to sports?

In four out of the 11 articles (Comin et al., 2013; Connell et al., 2004; Ekstrand et al., 2012; Hallén and Ekstrand, 2014), it was possible to find an answer to this question. Using univariate anal-

Table 4. Summary of the included studies

Study	Investigation method and measured variables	No. of included injuries	Sport	When a participant was considered to have returned to sport	Standardized rehabilitation protocol	Question No. 1	Question No. 2	Question No. 3	Time before return to sport
Askling et al. (2007a)	MRI. Muscle bundle, distance to tuber ischiadicum, location, length, width, depth, area	18	Sprint	Perform at a similar level as before the injury	No	The greater the extent of the injury, the longer time required before return to sports	-	The closer to the ischial tuberosity the injury was located, the longer the time required before return to sports. Location in the proximal tendon meant more time required before return to sports	Median: 16 weeks (range, 6–50 weeks)
Askling et al. (2007b)	MRI. Muscle bundle, distance to ischial tuberosity, location, length, width, depth	15	Dance	Perform at a similar level as before the injury	No	No association between extent of injury and length of time before return to sports	-	No correlation between distance from ischial tuberosity to injury and length of time before return to sports. All injuries in semimembranosus were involved with proximal tendon	Median: 50 weeks (range, 30–76 weeks)
Askling et al. (2008)	MRI. Muscle bundle, distance to ischial tuberosity, length	30	Twenty-one different sports	Perform at a similar level as before the injury	No	No correlation between the length and time of the injury and amount of time required before return to sports	-	No association between distance from the ischial tuberosity to injury and length of time before return to sports	Median: 31 weeks (range, 9–104 weeks)
Comin et al. (2013)	MRI. Muscle bundle, central tendon, presence of absence of disruption.	62	Australian football	Return to play arbitrary and varies on different factors	No	Positive correlation between central tendon disruption and length of time before return to sports	No significant differences in recovery time for the different hamstrings muscles	Positive correlation between central tendon disruption and length of time before return to sports	Median recovery time: 21 days (range, 14–42 days)
Connell et al. (2004)	MRI & sonography. Muscle bundle, location, area, length, prevalence of hematoma	60	Australian football	Match completed	No	Positive correlation between injury length and % cross-sectional area and longer time required before return to sports	Positive correlation between injuries in biceps femoris and longer time required before return to sports	Positive correlation if the injury was not located at the junction between muscle and tendon, and longer time required before return to sports	Median: 21 days (range, 4–56 days)
Ekstrand et al. (2012)	MRI & US Muscle bundle, extent (Peetrons, 2002)	207	Soccer	The medical team allowed full participation in training, availability for matches	No	The greater the injury (Peetrons, 2002), the longer the time required before return to sports	No difference in time to return to sport in respect of which muscles are effected	-	Average, 19 days
Gibbs et al. (2004)	MRI. Muscle bundle, length, area	17	Australian football	Full participation in training	Yes	Positive correlation between injury length and % cross-sectional area and longer time required before return to sports	-	-	Average, 20.2 days
Hallén and Ekstrand (2014)	MRI. Muscle bundle, location, severity classification and location	249	Soccer	The team´s medical staff allowed full training and declared available for match selection	No	Significant association between lay-off days and MRI grading	No difference in lay-off days was detected between the hamstring muscles	-	Average, 21 ± 19 days

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Table 4. Continued

Study	Investigation method and measured variables	No. of included injuries	Sport	When a participant was considered to have returned to sport	Standardized rehabilitation protocol	Question No. 1	Question No. 2	Question No. 3	Time before return to sport
Moen et al. (2014)	MRI. Muscle bundle, location, distance ischial origin to fibula, tibia, cross-sectional area	74	Six different sports	The physiotherapist allowed after full rehabilitation program included sport specific testing	Yes	MRI parameters in grades 1 and 2 hamstring injuries are not associated with length of time required before return to sports	-	No association between distance to ischial tuberosity and length of time before return to sports	Average, 44 ± 18 days
Petersen et al. (2014)	US. Muscle bundle, location, area, length, intramuscular, prevalence of hematoma	51	Soccer	The medical team allowed full participation in training, availability for matches	No	No correlation between the length of time required before return to play and the injured area	-	-	Average, 25.4 ± 15.7 days
Silder et al. (2013)	MRI. Muscle bundle, tendon, location, cross-sectional area	25	High-speed sports	Normal physical strength and function after rehabilitation programmes	Yes	Positive correlation between cranio-caudal length of injury and longer time required before return to sports	-	-	Median, 23 days (range, 13–28 days)

MRI, magnetic resonance imaging; US, ultrasound.

yses, Connell et al. (2004) found an injury to the biceps femoris to be correlated with an extended time before returning to sports (r = not reported). Multivariate analysis of MRI showed that an injury to the biceps femoris and the length of the injury were factors requiring an extended amount of time before returning to sports (r = 0.62), while an analysis of ultrasound images showed that the incidence of injury to the biceps femoris, per cent of cross sectional area and the presence of hematoma were predictors of length of time required before returning to sports (r = 0.58) ($P < 0.05$). This is in contrast with the findings of Comin et al. (2013), who did not find any difference in terms of recovery time for the different hamstring muscles ($P = 0.33$). In a study by Ekstrand et al. (2012) and Hallén and Ekstrand (2014), no correlation could be seen between any of the three injured hamstring muscles and an extended amount of time before returning to sports ($P = 0.79$, $P = 0.83$, respectively).

Is there a correlation between the injury location within the muscle and length of time required before returning to sports?

Six out of the 11 articles (Askling et al., 2007a; Askling et al., 2007b; Askling et al., 2008; Comin et al., 2013; Connell et al., 2004; Moen et al., 2014) contributed to an answer to this question. Askling et al. (2007a) reported that the closer the injury to the ischial tuberosity, the longer the time needed before returning to sports ($r = 0.5440$ to 0.705; $P = 0.005$ to 0.044). In cases where the proximal tendon was involved, it took 35 weeks (median) before being able to return to the sport, while it took 13 weeks (median) if the proximal tendon was not involved (Askling et al., 2007a). Askling et al. (2007b) did not find any correlation between the distance of the injury from the ischial tuberosity and extended time before returning to sports (r = 0.008 to 0.625, $P = 0.055$ to 0.981). In contrast, when the whole injury was located close to the proximal tendon of the semimembranosus, the time required before returning to sports was the longest compared to all studied articles (median, 50 weeks). Askling et al. (2008) did not find any correlation between the distance of the injury from the ischial tuberosity and extended amount of time before returning to sports (r = -0.198). Connell et al. (2004) reported that an injury located in the junction between the muscle and tendon was not linked to an extended amount of time before return to sport (r = not shown). Comin et al. (2013) reported that hamstring injuries involving disruption of the central tendon at any point along its length have a significantly worse prognosis than injuries in other parts of the muscle. Specifically, median 21 days (interquartile range [IQR]), 9–28) recovery time for those without central tendon disruption and 72 days (IQR, 42–109), respectively ($P < 0.1$). Moen et al. (2014) did not find any correlation between the distance of the injury from the ischial tuberosity and length of time before returning to sports (95% confidence interval, -1.2 to 0.06; $P = 0.075$).

DISCUSSION

The results show that there is a correlation between the size of the injury and an extended amount of time required before returning to sports. Data suggest that the closer to the ischial tuberosity the hamstring injury is located, the longer the amount of time required before returning to sports. However, the results are contradictory. It seems doubtful whether the same relationship exists in terms of the specific muscle bundle that has been injured, with the conflicting results shown in the included studies.

The study by Comin et al. (2013) highlighted the difference in amount of time required before being able to return to competitive play, if the central tendon of the biceps femoris was ruptured, which required significantly longer time for recovery. In their study, it took four times longer to return to play when the central tendon was injured.

The outcome variable for length of time required before being able to return to sports was much larger in studies by Askling et al. (2007a; 2007b; 2008) and Comin et al. (2013) than in the other studied articles. Time required before being able to return to sports varied from 19 days to 50 weeks. One explanation may be that the reporting of length of time required before returning to sports differed from the way it was done by Askling et al. (2007a; 2007b; 2008), where the patients themselves reported when they were able to perform sporting activities at a similar level as before they were injured. Another explanation could be that Comin et al. (2013) collected data retrospectively from the club medical records. In Askling et al. (2007b), the subjects performed similar sprint times in order to return to playing sports, while in the other two studies by Askling et al. (2007b; 2008) the performance was reported based on the patient's own opinion. In the studies by Ekstrand et al. (2012), Hallén and Ekstrand (2014) and Petersen et al. (2014), the medical teams, in consultation with the injured players, decided when the players could return to play. Another explanation for the varying time lengths before return to play could be different requirements for the hamstring muscles in the different sports. A further explanation could be that the characteristics of the injury may differ between studies, although this has not been studied in the present investigation. However, for example, 70% of MRI examinations in a study by Ekstrand et al. (2012) were normal. This particular study from 2012 was also the one with the shortest amount of time before the player could return to sports, and the subjects had an average return after 19 days.

A limitation of the present literature review was that in the articles included in this review, besides the one by Gibbs et al. (2004) and Silder et al. (2013), the training programmes of the athletes were not described in detail. This could be a confounder since it has been reported that various rehabilitation protocols influence the time required before returning to sports (Askling et al., 2013b; Sherry and Best, 2004).

Another problem is that the authors of the different articles have used different methods for assessing when the player is ready to return to sports. Today, there is no golden standard for how to assess when the player can return to sports (Orchard et al., 2005), which may be due to the fact that different sports require different demands of the muscles, for instance. It is impossible to know for sure if the athletes returned to their sport at the right time. The injured athletes were deemed able to return to sports when they were able to participate in sporting activities at a similar level as before their injury (Askling et al., 2007a; Askling et al., 2007b: Askling et al., 2008). Suggestions for this differ between studies according to the following: when a match was completed (Connell et al., 2004), when the medical team allowed full participation (Ekstrand et al., 2012; Hallén and Ekstrand, 2014; Petersen et al., 2014), when the physiotherapist allowed participation (Moen et al., 2014) or when the athlete was back to full training (Gibbs et al., 2004; Silder et al., 2013). According to Orchard and Best (2002), the risk of suffering a reinjury is high and could therefore be a problem when an athlete returns to sports. The analysis of the reinjury rate was not the scope of the present study; therefore, it has not been mentioned in the included studies. This is important to take into consideration since reinjury rate is an equally important outcome measure as the recovery time. More research is thus desired within this area. Askling et al. (2010) have developed a specific clinical test in order to assess when it is appropriate to return to sports after a hamstring rupture. In supine position, the athlete performs a hip flexion as fast and as high as possible while maintaining the knee joint fully extended. Thereafter, the athlete value recorded on a visual analogue scale. If this estimation is different from zero, the athlete is not allowed to return to their sport. The test has shown good results in terms of a reduced risk of reinjury in soccer players (Askling et al., 2013a). The test needs, however, to be further evaluated.

Another factor that may influence the timing of when the player can return to sport is the support that the athlete receives from the medical team, both in acute care but also during rehabilitation. Regarding the four studies with the shortest amount of time before returning to the sport, it is tempting to think that the athletes received better care when it came to sports performed at a high level with large financial resources unlike the other seven studies.

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When the length of the injury is important for amount of time required before returning to sports, it is positive from the point of view that it is easier and less time-consuming to measure the length of injury instead of the cross-sectional area (Gibbs et al., 2004). According to the present study, there was a correlation between the size of injury and an extended amount of time before returning to sports. However, it is unclear whether the same relationship exists for length of time required before to returning to sports and the cross-sectional area.

Moreover, according to Askling et al. (2013b) and Comin et al. (2013), the amount of time required before returning to sports might be extended, if the injuries involve the proximal muscle tendon unit and the central tendon. The reason may be that the blood flow in a tendon is much less extensive than in the muscle, which could mean fewer opportunities for healing. However, it should be pointed out that this argument is quite weak for this issue, since a correlation between the size of injury and an extended amount of time before being able to return to sports is not known. There may also be other influencing factors not investigated in this study. Among other things, the impact of the injury mechanism at the time of returning to sports is not clear (Askling et al., 2013a). Further research is needed to better understand the most optimal way of evaluating athletes with hamstring injuries before considering a safe return to the sport.

Majority of cases with hamstring rupture is associated with an extended amount of time before being able to return to sports. More controlled research, including improvements in the rehabilitation protocol and methods for evaluations before returning to sports are needed.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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