Categorization of Hamstring Strain Injuries by MRI and Playing Time Lost in Professional football Players

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Hamstring muscle injuries are prevalent in many sports that require high-speed running, acceleration, deceleration and quick changes in direction[1,3,7]. Recently, authors have reported the occurrence of hamstring injuries in Australian Rules football (16%), soccer (12%), rugby (6%-15%), and basketball (6%) [3].

It's not just the initial hamstring injury that causes concern. It's the risk of re-injury. The recurrence rate for hamstring strains can be as high as 30% in Aussie Rules, 12% in professional soccer [7].

Hamstring muscle injuries can be disabling for any athlete, but potentially devastating for the professional football player who relies on his ability to perform in order to earn a living.

How Does it Happen?

Documented mechanisms of hamstring injury include sprinting, jumping, waterskiing and dancing [5,8,11]. In sports such as football, running or sprinting accounts for most of the hamstring injuries [8,15]. Studies suggest that hamstring strains often occur during the terminal part of the swing phase as the hamstrings are contracting eccentrically to slow the forward swing of the leg to prevent hyperextension of the knee and flexion of the hips [2].

Risky Behaviors

Many people have theorized about the exact etiology of hamstring strains. Potential risk factors previously reported for hamstring injuries include muscle weakness, lack of flexibility, increased muscle stiffness, poor lumbo-pelvic posture, inadequate warm-up, and muscle fatigue[14]. Strength imbalance between the hamstrings and quadriceps muscles and previous hamstring and other lower limb muscle injuries have also been suggested as possible risk factors [3].

Recently, intrinsic factors such as age, height, body mass or body mass index have not been found to be significant factors in the incidence of hamstring muscle injuries [3]. The literature does support the fact that previous history of hamstring injury is a reliable risk factor for recurrence [2,7,14].

Imaging

Magnetic resonance imaging is often the preferred modality to assess muscle injuries in the professional football player. MRI provides the physician with the ability to quantify the extent of the hamstring injury by measuring the size of the hyperintense signal within the muscle(s) in question.

Studies have been conducted to determine the classification and location of muscle injuries by their appearance on MRI. Speer et al[13] evaluated 50 athletes and determined that muscle injuries predictably occurred at the myotendinous junction. De Smet et al[4] evaluated 15 collegiate athletes who sustained hamstring injuries and determined the biceps femoris muscle was the most commonly injured, followed by the semitendinosis. Askling et al[1] correlated the location of the highest point of hamstring pain during palpation and time to recover to pre-injury level for sprinters with first-time strains. Magnetic resonance imaging was used to determine location and size of the injury. Palpation (proximity to the ischial tuberosity) and MRI results (involvement of the proximal free tendon) together were found to be associated with longer time to return to pre-injury level.

The purpose of this study was to determine the time to return to play for NFL football players based on the severity of hamstring injury as determined by MRI as well as the reported occurrences and recurrences.

Setting the Stage

All NFL teams received study packets to enroll eligible players who sustained hamstring injuries prospectively during the season. Upon player completion of treatment and return to full football activity, all physician documentation, treatment and rehabilitation notes, and MRI copies were sent to our clinic. The clinical notes were reviewed to determine demographic information, the position of the player, injury occurrence (practice or game), mechanism of injury, hamstring injury location and muscle involvement, length of recovery, and injury recurrence.

Over the course of the 2001-02 season, this study grew to include 21 professional players from six NFL teams. All had suffered hamstring injuries, although not chronic. About 71% of the men were starting players.

Imaging

All MRIs were reviewed by an experienced musculoskeletal radiologist who interpreted the pathologic characteristics of the hamstring injuries according to a grading system that was developed by natural breaks among the tear sizes. The protocol included recording the

length of injury as observed on the coronal and sagittal views in centimeters.

Grade I injuries were defined as edema within the muscle belly that measured <8cm (Figure 1).

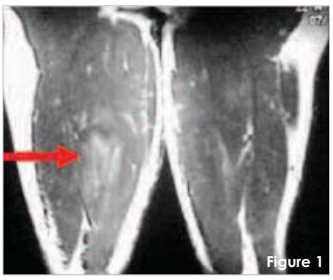

Figure 1: MR image of professional football player with a grade I hamstring injury.

Grade II injuries had edema of > 8cm with a vertical split in the muscle with hemorrhage and fluid in the fascial planes (Figure 2).

Tendon separation at the musculotendinous junction defined the grade III injuries (Figure 3).

Figure 2: MR image of professional football player with a grade II hamstring injury.

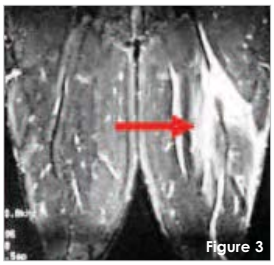

Figure 3: MR image of professional football player with a grade III injury, showing tendon separation at the M-T junction.

The associated MRIs had been read by team radiologists. Our radiologist was blinded to the MRI interpretations made by those physicians and to the outcomes of the injured players.

Results

As you can see in Tables 1 and 2, 32 hamstring injuries in 21 players were reported during the study period.

Players who suffered a grade I injury took an average of 16 days to recover; grade II injuries recovered in an average of 21.5 days; and players with a grade III injury recovered in an average of 28.5 days.

There was a significant difference in total recovery days between those who had been reinjured versus those who hurt their hamstrings for the first time: an average of 56 days compared to 16.5 days before getting back on the field.

In fact, the study showed that hamstring injuries recurred at a rate of 31%, usually within one week of coming back from initial injury. Further, we found that when players returned from the first recurrence, they averaged 11 days before suffering a third hamstring injury (which

TABLE 1 Injury Occurrence and Mechanism by Player Position and Level

Position N=21	Level N=17	Occurrence N=19	Mechanism N=18
Corner Back (1)	Starters (12)	Game (6)	Tackle (1)
Def. Back (6)	Backup (5)	Tr Camp (6)	Running (16)
Def. Line (1)		Practice (3)	Rushing (1)
Off.Tackle (1)		Preseas P (2)	
Running Back (2)		Preseas G (2)	
Free Safety (2)			
Full Back (1)			
Safety (1)			
Wide Rec. (3)			
Tackle (1)			
2 Positions (3)			

TABLE 2 Specific Areas of Injury and Size

Location	Muscle Injured	Grade	Mean Tear Size by Grade (cm)
Distal (9)	Biceps Femoris (10)	I (7)	6.93
Middle (3)	Semitendinosis (1)	II (10)	18.80
Proximal (9)	Semimembranosus (2)	III (4)	23.25
	Combined (8)		

took an additional 33 days to rehabilitate). Interestingly, all subjects who experienced a second recurrence sustained a grade II muscle injury.

Discussion

To our knowledge, this is the first look at hamstring muscle injuries in athletes of the NFL with subsequent breakdown into player position, seasonal time of injury, mechanism of injury, involved hamstring location and muscle(s), grade by MRI, playing time missed, and recurrence.

Hamstring muscle injuries are common in sports that require sprinting and acceleration, and the NFL certainly places those demands on its athletes. The myotendinous junction of the hamstrings is the most common site of injury, and this is related to the eccentrically loaded contractions of the muscle group.

When a football player sustains a hamstring injury it is important to assess the extent of the injury and to attempt to predict a time of return to play so that the player, coach and other interested parties may be informed. In

TABLE 3 Reinjured Players and Recovery

Reinjured only 1X N=4				Reinjured 2X N=3				
Grade	Mean Size (cm)	Recovery Days Initial Inj	Recovery Days Recurrence	Grade	Size	Recovery Days Initial Inj	Recovery Days Recurrence 1	Recovery Days Recurrence 2
I	8	35	21	II	59	2	11	45
II	20	18	3	II	92	32	16	44
III	30	19	13	II	22	5	7	10
III	15	36	39					

the past, clinical data such as the history and physical examination, as well as the player's perception of the severity of the injury, provided the basis for return to play decisions.

In recent years, imaging studies such as MRI have emerged as an additional diagnostic tool to not only assess the extent of these injuries, but also to help determine a time frame in which the athlete can return to the field with an acceptable risk of recurrence.

A pilot study of nine NFL players was performed previously to assess the accuracy of predicting return to play on the basis of MRI alone. Players with Grade I and II injuries returned to play within two weeks, whereas players with Grade III injuries required an average of five weeks to return.

Our study demonstrated that the average rehabilitation and recovery time is variable and cannot be determined on the basis of MRI alone. Schneider-Kolsky et al[12] compared clinical assessment to MRI as a predictor of the duration of rehabilitation required after acute hamstring injury. It was concluded that, compared with clinical assessment, a positive MRI result was useful as a predictor for duration of rehabilitation only in cases of moderate or severe injuries.

In our study, we were able to determine the average time for return to play for both acute and recurrent hamstring injuries, also taking into account the severity of the injury according to our MRI grading scale. Although the ranges of time for return to play were broad, there was a trend between severity of injury and actual time to return to competition.

One of the most striking results centers on re-injury, particularly the average time to return to play following a second recurrence. The average time to return to the playing field following a first recurrence was a modest 13 days. However, the average time to return following a second recurrence was 33 days, which is a significant amount of time for professional football players. Loss of playing time could result in the loss of a starting position and possibly a roster position.

Word of Caution

There are limitations to this study. Our prospective study undertaken during the NFL season may have resulted in the limited number of research subjects. At the time of this study, the only previous study involving professional NFL athletes and hamstring injuries had been done retrospectively utilizing information from an injury database. The authors felt prospectively collected data may portray these injuries, their treatment and recovery more accurately. We also allowed the team physicians to treat their athletes according to their own protocols and did not specify criteria for ordering or interpreting MRIs, or specific rehabilitative protocols. The authors felt this was necessary so that too many restrictions were not imposed on the medical team during an already hectic time. Certainly, future randomized studies are needed that include specific criteria for MRI evaluation and treatment protocols.

Conclusion

In conclusion, we feel this study provides valuable information pertaining to the recovery of professional football players with graded hamstring injuries as well as injury occurrences and recurrences.

We were able to see a trend among the categorization of tears classified by MRI and the number of days, based on severity, for return to play.

With this information in mind and the recurrent injury rates presented, the medical team may have a basis from which to assist in making their return to play decisions. In addition, repeat MRIs may be beneficial to assess healing to possibly avoid recurrent injury.

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References

1. Askling CM, Tengvar M, Saartok T, Thorstensson A. Acute first-time hamstring strains during high-speed running: A longitudinal study including clinical and magnetic resonance imaging findings. *Am J Sports Med.* 2006;35:197-206.
2. Brockett CL, Morgan DL, Proske U. Predicting hamstring strain injury in elite athletes. *Med Sci Sports Exerc.* 2004;36:79-387.
3. Brooks JHM, Fuller CW, Kemp SPT, Redding DB. Incidence, risk, and prevention of hamstring muscle injuries in professional rugby union. *Am J Sports Med.* 2006;34:1297-1306.
4. De Smet AA, Best TM: MR imaging of the distribution and location of acute hamstring injuries in athletes. *AJR.* 2000;174:393-399.
5. Garrett WE Jr. Muscle strain injuries. *Am J Sports Med.* 1996;24:S2-8.
6. Levine WN, Bergfeld JA, Tessendorf W, Moorman CT 3rd: Intramuscular corticosteroid injection for hamstring injuries. A 13-year experience in the National Football League. *Am J Sports Med.* 2000;3:297-300.
7. Orchard J, Best TM, Verrall GM. Return to play following muscle strains. *Clin J Sports Med.* 2005;15:436-441.
8. Peterson J, Hölmich P. Evidence based prevention of hamstring injuries in sport. *Br J Sports Med.* 2005;39:319-323.
9. Pomeranz SJ, Heidt RS Jr: MR imaging in the prognostication of hamstring injury. Work in progress. *Radiology.* 1993;189:897-900.
10. Rettig AC. Hamstring injuries in the national football league: Correlation between MRI findings and return to play. *PFATS.* 2001;19:7.
11. Sallay PI, Friedman RL, Coogan PG, et al. Hamstring muscle injuries among water skiers. Functional outcome and prevention. *Am J Sports Med.* 1996;24:130-136.
12. Schneider-Kolsky ME, Hoving JL, Warren P, Connell DA. A comparison between clinical assessment and magnetic resonance imaging of acute hamstring injuries. *Am J Sports Med.* 2006;34:1008-1015.
13. Speer KP, Lohnes J, Garrett WE Jr: Radiographic imaging of muscle strain injury. *Am J Sports Med.* 1993;21:89-95.
14. Verrall GM, Slavotinek JP, Barnes PG, Fon GT, Spriggins AJ. Clinical risk factors for hamstring muscle strain injury: A prospective study with correlation of injury by magnetic resonance imaging. *Br J Sports Med.* 2001;35:435-440.
15. Woods C, Hawkins RD, Maltby S, et al. The football association medical research programme: An audit of injuries in professional football: A analysis of hamsting injuries. *Br J Sports Med.* 2004;38:36-41.
16. Zarins B: Epidemiology of Hamstring Injuries in the NFL, 2002 NFL Combines Scientific Meeting.