

Risk and Prognosis of Hamstring Injuries in the National Football League

A 12-Year Review

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Background: Hamstring injuries can have a significant burden on a professional football player's career and performance. One in 4 players will suffer a lower extremity strain in their career, with the hamstring being the most common. These injuries are often fraught with extended periods of recovery and reinjury rates varying between 16% and 38%.

Purpose: To determine the progression and duration of hamstring injury as well as risk factors and probability of reinjury in the National Football League (NFL).

Study Design: Descriptive epidemiology study.

Methods: Data were extracted from the official publicly accessible NFL database of injuries. NFL players suffering a hamstring injury during the study period of 2008-2020 were identified. Injuries were reported weekly as mandated by the NFL. Players were deemed cleared from injury when no longer listed in the injury report (IR). Reinjury was defined as any subsequent hamstring injury after a player's initial injury. The duration of injury and factors associated with injury were analyzed. Secondary objectives included team-specific injury rates and timing of injury.

Results: A total of 2101 hamstring injuries occurred among 1354 players. The mean duration of the IR was 2.4 ± 2.1 weeks. A total of 442 (33%) players suffered subsequent reinjury, 27% of which occurred during the same season. The mean duration on the IR for reinjury was 2.4 ± 1.8 weeks, with no significant difference in duration compared with initial injury (2.4 ± 1.8 vs 2.2 ± 1.7 ; $P = .138$). Defensive skill players were most frequently injured (50.4%) followed by offensive skill players (37.7%). Of the 4812 total IR listings, 1806 (38%) did not participate in practice. A total of 1590 (33.5%) had limited participation in practice, and 1353 (28.5%) had full participation in practice. Injury rates among teams varied and ranged from 0.6% (Baltimore Ravens) to 5.7% (Houston Texans), with a median of 3.1% ($P < .0001$).

Conclusion: Hamstring injuries can have a lasting impact on a player's career with more than a third of players suffering subsequent reinjury. Although suffering a hamstring injury predisposes a player to reinjury, previous injury was not associated with longer recovery times. Rates of injury among organizational teams vary; thus, further research to understand the difference in preventive measures and treatment protocols may be warranted.

Keywords: football (American); hamstring injury; hamstring strain; injury prevention; National Football League; physical therapy/rehabilitation

Professional athletes in the National Football League (NFL) are no strangers to injury. Even at the elite level, hamstring injuries have proven to be a significant burden on player performance and longevity. Up to 41% of NFL players will suffer a lower extremity injury in a single

season, with hamstring injuries being the most common.¹¹ Furthermore, 25% of NFL players suffer a lower extremity strain in a single season, 55% of which are hamstring strains.⁵

Given the significant burden of these injuries, minimizing injury-related risk factors is of importance. Nonmodifiable extrinsic factors are related to game surfaces, timing, and weather, and they have been theorized as risk factors for hamstring injury.⁶ Among the NFL literature, many of these extrinsic factors have been debunked. Playing

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surface, shorter rest in between games, weather, game location—including time zone and altitude, time of the season, and game outcomes—have not been shown to have an association with a hamstring injury.^{6,8}

Modifiable risk factors—such as strength imbalance and flexibility—along with insufficient warmup and player fatigue—have been cited as theoretical risk factors for hamstring strain injury. However, clinical studies remain controversial.⁷ Insufficient warm-up and player fatigue have been theorized as risk factors based on the clinical observation that many hamstring injuries occur during the early and late portion of practices or competitions. Insufficient warm-up has been supported in rabbit models; however, no clinical studies have shown an association with an increased hamstring muscle strain injury rate.⁷ Muscle imbalance and fatigue have been theorized as risk factors because of the role of hamstring flexibility and elongation on the isometric knee flexion angle torque relationship.⁷ Previous literature has established limited flexibility and hamstring weakness as the 2 most significant risk factors for injury; thus, rehabilitation and training regimens largely focus on these as areas of injury prevention.¹⁰

Subsequent reinjury is often fraught with increased severity and prolonged recovery.⁷ Reinjury rates previously reported in the NFL vary, ranging between 16% and 38%.^{3,4} Among other professional sports, such as soccer and rugby, recurrence rates range between 12% and 48%.⁷

Understanding preventable risk factors and rehabilitation for hamstring injury warrants further study and discussion. In this study, we aimed to determine the progression and duration of hamstring injury as assessed by reported practice status and game status. Moreover, position-specific risk factors and probability of reinjury were assessed. Secondary objectives included timing within a single season that hamstring injuries were most likely to occur and team-specific injury rates.

METHODS

This descriptive epidemiology study was completed by identifying NFL players suffering a hamstring injury during the 2008-2009 to 2019-2020 seasons, for a total of 12 seasons. Data were extracted from the official publicly accessible NFL database of injuries.¹¹ All reported hamstring injuries were collected and organized according to the week of the 16-game regular season and postseason playoffs. Preseason injuries were not reported in the NFL database of injuries. Each team has a 1-week break during the regular season known as a bye week. Bye weeks were cross-referenced and accounted for as an extra week of

injury if one occurred during the time that the athlete was reported as injured for a hamstring injury.

Athletes' on-field position, team, duration of injury, return to play, evidence of newly reported hamstring injury within the same season or subsequent seasons, and reported practice status and reported game status were collected. "Skilled" and "unskilled" were defined using conventional groupings described in a previous study.¹³ Per NFL policy, teams are mandated to list a player's game status the day before the upcoming game and are required to list the practice status during the 3 days prior.¹⁰ The most recent practice status before the upcoming game was collected. Players were deemed cleared from injury when no longer listed in the injury report (IR). Practice status was collected based on the NFL's definition of participation. Definitions were based on participation compared with the normal volume of practice repetition. It was defined as the following: Did not participate in practice—0% of a player's normal repetitions; limited participation in practice—<100% of a player's normal repetitions; and full participation in practice—100% of a player's normal repetitions. Games status was defined as follows: Out—will not play; doubtful—unlikely to play; questionable—uncertain if a player will play; and probable—likely to play.

Reinjury was defined as any subsequent hamstring injury after a player's initial injury. Reinjury was further classified as a same-season event or a subsequent-season event. The duration of reinjury was determined for each listing.

Variables were presented as the mean and standard deviation and compared using the Student *t* test and the chi-square goodness-of-fit test or as a median and interquartile range (IQR). The duration of injury and factors associated with injury were analyzed. Secondary objectives included team-specific injury rates and timing of injury within the season. The 2008-2009 season was excluded when calculating rates of injury per scheduled game week because of incomplete data. The analysis was performed with R statistical software with $\alpha = .05$. (Version 4.1.2; R Foundation for Statistical Computing).

RESULTS

A total of 4812 weekly IR listings for hamstring injuries were documented on the NFL IR list between the 2008 season and the 2019 season, resulting in a total of 2101 individual injuries (Figure 1). A total of 1354 different players suffered a hamstring injury. The mean number of consecutive weeks on the IR for a hamstring injury was 2.4 ± 2.1 weeks. The mean number of consecutive weeks before full or upgraded practice status was 2.2 ± 1.6 weeks.

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Ethical approval was not sought for the present study.

TABLE 1
Injury by Position^a

Offensive Skill		Defensive Skill		Linemen		Kickers	
	1815 (37.7)		2426 (50.4)		533 (10.9)		38 (0.8)
QB	40 (0.8)	S	558 (11.6)	C	21 (0.4)	K	29 (0.6)
TE	280 (5.8)	CB	900 (18.7)	G	69 (1.4)	P	9 (0.2)
RB	537 (11.2)	LB	968 (20.1)	T	112 (2.3)		
WR	958 (19.9)			DT	55 (1.1)		
				DE	276 (5.7)		

^aData are presented as total (%). C, center; CB, cornerback; DE, defensive end; DT, defensive tackle; G, guard; K, kicker; LB, linebacker; P, punter; QB, quarterback; RB, running back; S, safety; T, tackle; TE, tight end; WR, wide receiver.

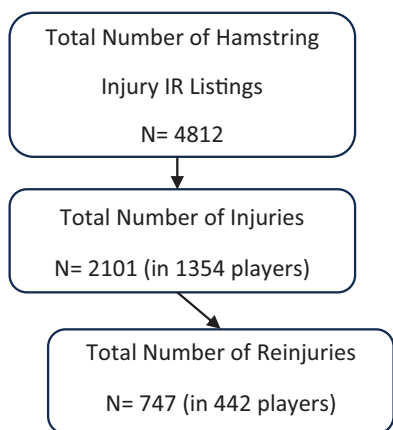


Figure 1. Flowchart describing the ascertainment of players with hamstring injury. IR, injury report.

Of the 1354 individual players who suffered a hamstring injury, 442 players (33%) suffered subsequent reinjury. A total of 747 subsequent reinjuries occurred. A total of 27% of reinjuries occurred during the same season. The mean length on the IR for reinjury was 2.4 ± 1.8 weeks, with a median of 2 weeks (IQR, 1-3 weeks). No significant difference was observed in duration on the IR for reinjury compared with initial injury (2.4 ± 1.8 vs 2.2 ± 1.7 weeks; *P* = .138). Also, 36% of reinjuries had a longer duration than the initial injury. Conversely, 36% of reinjuries were less than the duration of the initial injury.

Defensive skill players—safeties (S), cornerbacks (CB), and linebackers (LB)—made up most injuries (50.4%) followed by offensive skill players—quarterbacks (QB), running backs, wide receivers (WR), and tight ends (TE) (37.7%) (Table 1). Offensive and defensive linemen combined—centers (C), guards, tackles, and defensive ends—only made up 10.9% of hamstring injuries. LBs were most likely to be injured, making up 20.1%, followed by WR at 19.9% and CB at 18.7%.

Of the 4812 total IR listings, 4749 had listed practice statuses and 1806 (38%) did not participate in practice. A total of 1590 (33.5%) had limited participation in practice and 1353 (28.5%) had full participation in practice. 4808 had listed game statuses. 1214 (25.3%) were listed as out.

TABLE 2
Injury by Week

Week	n (%)	Week	n (%)
1	211 (4.5)	10	264 (5.7)
2	255 (5.5)	11	246 (5.3)
3	300 (6.4)	12	263 (5.6)
4	320 (6.9)	13	258 (5.5)
5	344 (7.4)	14	259 (5.6)
6	332 (7.1)	15	248 (5.3)
7	295 (6.3)	16	247 (5.3)
8	295 (6.3)	17	219 (4.7)
9	238 (5.1)	Playoffs	69 (1)

400 (8.3%) were listed as doubtful and 1845 (38.4%) were listed as questionable. 1349 (28.1%) were listed as probable.

Weeks 1 and 17 had the least hamstring injuries reported (4.5% and 4.7%, respectively), while weeks 5 and 6 had the most hamstring injuries reported (7.5% and 7.1%, respectively) (*P* < .001) (Table 2). Only 1% of injuries occurred in the playoffs. The 2011-2012 season had the most hamstring injuries with 587 (12.2%) injuries. The 2017-2018 season had the smallest number of injuries with 294 (6.1%) injuries. There was a significant difference in the distribution of hamstring injuries across NFL teams (*P* < .0001). Among the 32 teams, the Houston Texans had the most injuries with 276 (5.7%) injuries, while the Baltimore Ravens had the least injuries, with only 28 (0.6%) (Table 3). The average among teams was 150 (3.1%). The median number of injuries was 13.5 per team per season.

DISCUSSION

In our study, hamstring injuries proved to be a significant burden for NFL players. A total of 1354 players suffered hamstring injuries, with a total of 2101 injuries during the study period. The mean duration on the IR was 2 weeks, with 38% of players not practicing at all and 33.5% having limited participation. Most players injured were skilled position players, primarily LBs, WRs, and CBs. Rates of injury among organizational teams varied with rates ranging between 0.6% and 5.7%. More than

TABLE 3
Injury by Team

Team	n (%)	Team	n (%)
49ers	110 (2.3)	Jaguars	175 (3.6)
Bears	118 (2.5)	Jets	198 (4.1)
Bengals	162 (3.4)	Lions	119 (2.5)
Bills	119 (2.5)	Packers	208 (4.3)
Broncos	112 (2.3)	Panthers	78 (1.6)
Browns	137 (2.9)	Patriots	162 (3.4)
Buccaneers	183 (3.8)	Raiders	155 (3.2)
Cardinals	194 (4)	Rams	64 (1.3)
Chargers	177 (3.7)	Ravens	28 (0.6)
Chiefs	95 (2)	Redskins	177 (3.7)
Colts	165 (3.4)	Saints	149 (3.1)
Cowboys	178 (3.7)	Seahawks	184 (3.8)
Dolphins	163 (3.4)	Steelers	113 (2.4)
Eagles	205 (4.3)	Texans	276 (5.7)
Falcons	133 (2.8)	Titans	161 (3.4)
Giants	173 (3.6)	Vikings	141 (2.9)

a third of players suffered subsequent reinjury, 27% of which occurred during the same season. Interestingly, previous injury did not predispose to longer durations of recovery.

On average, a player remained on the IR with a hamstring injury for 2.4 weeks and upgraded their practice status shortly before that time in 2.2 weeks. Game status was most listed as “questionable,” almost 40% of the time. A listing of “questionable” has strategic advantages allowing players and team to make a “game-time decision” and offering a competitive edge against opponents scouting. Interestingly, players were considered “out” from games 25% of the time. Furthermore, players were not practicing at all 38% of the time and had limited participation 33.5% of the time, demonstrating how debilitating these injuries can be on player performance.

Our study further supports previous literature demonstrating that skilled positions are most at risk of injury.^{2,3,5,6} Defensive skill players—which include S, CBs, and LBs—were found to be most at risk. Specifically, LBs were at the highest risk of injury followed by WRs and CBs, respectively. These results may be related to the amount of time that each player position is on the field at one time, as there is only 1 C and 1 QB while there may be as many as 4 LBs and 5 WRs on the field for any given play. The difference in the requirements of the player positions likely plays a stronger role in determining the risk of hamstring injury, rather than the number of players on the field alone. These “high-risk” position players are more likely to have higher agility and perform more changes in speed and direction during play. In the literature and other professional sports, most hamstring strains occur in sports that require high-speed running, as it is reported that 60% to 80% of hamstring injuries occur during the running sequence of the sport.⁷ Another mechanism in which hamstring injury frequently occurs is kicking, with rates of 10% to 19% attributed to kicking in rugby and Australian football.⁷ Although kicking is a mechanism prone to injury in other sports, NFL kickers made up only 0.8% of injuries. This may be due to kickers having

time to warm up, no sprinting while kicking, and a limited number of kicking attempts during a game, which might account for the low injury rate in NFL kickers.

The rate of reinjury was 33% among NFL players in our study. Reinjury rates in the literature and different sports vary, ranging between 12% and 48%.^{7,9} The most significant reported risk factor for hamstring injury is a previous injury, with an increased risk of reinjury by 2 to 6 times.¹ It is theorized that a hamstring injury leads to the formation of stiffer and weaker scar tissue, thus altering the muscle-tendon contractile mechanics, leading to a lower threshold for injury.^{1,4} In NFL data, risk factors for reinjury include shorter time to return to play, more recent year of injury, in-game injury, lower body mass index, skilled position, and longer playing experience.² The greatest risk factor for recurrence was return to play within 2 weeks; thus, a longer time of rehabilitation and recovery is potentially a modifiable modality to minimize recurrence. Although previous injury is a risk factor for reinjury, it did not predispose to a longer duration of recovery in our study. No significant difference was observed in time spent on IR for initial injury compared with reinjury with both averaging 2 weeks on the IR.

Interestingly, rates of injury were not equal among NFL organizations, with some having ≥ 100 more injuries than other organizations. Thus, differing organizational strength and conditioning programs, along with preventive measures, may play a large role in injury prevention. Numerous preventative and treatment programs have been published based on eliminating risk factors of injury, with the main emphasis on strength imbalances, flexibility, and fatigue. Eccentric strengthening has been shown to reduce injury incidence while improving risk factors of injury such as hamstring strength, fascicle length, hamstring/quadriceps ratio, and limb asymmetry.¹² Stretching-based interventions can be implemented to improve flexibility, together minimizing known risk factors of injury.

Limitations

There are several limitations to this study. First, our study period was limited to only in-season play; thus, shorter durations of injury may be reported if injury duration lasted longer than in-season play. Furthermore, the study period did not include the preseason because of the lack of reporting in the injury database; thus, a cohort of injured players was potentially excluded. Factors unrelated to physiological recovery—such as organizational/team preferences, finances, and motivation—may affect return to play. Moreover, extrinsic and player-specific factors—such as playing surface, ambient temperature, and age—were not assessed and may affect injury rates and duration. Data regarding hamstring tear severity, classification, diagnostic imaging, and treatment are lacking because of limited reporting in the NFL injury reporting database. Our study was limited to elite-level athletes with dedicated rehabilitation personnel; thus, the generalizability of our findings may be limited in the application to athletes at lower levels of competition. However, although a limitation, this also offers a unique

representation of how early athletes can return to a high level of play after a hamstring injury.

CONCLUSION

Hamstring injuries in the NFL are common and can have a lasting impact on a player's career with more than a third of players suffering subsequent reinjury. Although suffering a hamstring injury predisposes a player to reinjury, previous injury was not associated with longer recovery times. Players most at risk of injury are those skill players with higher speed and agility demands. Rates of injury among organizational teams vary; thus, further research to understand the difference in preventive measures and treatment protocols among organizations may be an area of interest.

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