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Days to Return to Participation After a Hamstrings Strain Among American Collegiate Soccer Players

Kevin M. Cross, PhD, PT, ATC*; Susan A. Saliba, PhD, PT, ATC, FNATA*; Mark Conaway, PhD*; Kelly K. Gurka, PhD, MPH†; Jay Hertel, PhD, ATC, FNATA, FACSM*

*University of Virginia, Charlottesville; †Injury Control Research Center, West Virginia University, Morgantown

Context: Among US collegiate soccer players, the incidence rate and the event characteristics of hamstrings strains differ between sexes, but comparisons in the return-to-participation (RTP) time have not been reported.

Objective: To compare the RTP time between male and female collegiate soccer players and analyze the influence of event characteristics on the RTP time for each sex.

Design: Descriptive epidemiology study.

Setting: Data were collected from collegiate teams that voluntarily participated in the National Collegiate Athletic Association Injury Surveillance System.

Patients or Other Participants: Collegiate soccer athletes who sustained 507 hamstrings strains (306 men, 201 women) during the 2004 through 2009 fall seasons.

Main Outcome Measure(s): Nonparametric statistics were used to evaluate RTP time differences between sexes and among categories of each event characteristic (ie, time of season, practice or competition, player position). Negative binomial regression was used to model the RTP time for each sex. All analyses were performed separately for first-time and recurrent strains.

Results: We found no differences in the RTP time between sexes for first-time (median: men = 7.0 days, women = 6.0 days; $P = .07$) or recurrent (median: men = 11 days, women = 5.5 days; $P = .06$) hamstrings strains. For male players with first-time strains, RTP time was increased when the strain occurred during competition or the in-season/postseason and varied depending on the division of play. Among female players with first-time strains, we found no differences in RTP time within characteristics. For male players with recurrent hamstrings strains, the RTP time was longer when the injury occurred during the in-season/postseason. Among female players with recurrent strains, RTP time was longer for forwards than for midfielders or defenders.

Conclusions: Although we found no differences in the RTP time after hamstrings strains in male and female collegiate soccer players, each sex had unique event characteristics that influenced RTP time.

Key Words: sports injuries, muscle injuries, sex differences

Key Points

- Return-to-participation time was not different between male and female collegiate soccer players.
- Each sex had unique characteristics specific to the injury event that influenced the number of days to return to participation after a hamstrings strain.
- Programs for reducing the incidence and severity of hamstrings strains should focus on sport-specific and position-specific training to replicate the demands of competition.

Hamstrings strains are one of the most prevalent injuries in soccer and have a high rate of recurrence.[1–5] The effects of these injuries may be best appreciated by assessing how they influence participation in practices and competitions. Among professional soccer players, the average number of days absent from participation in team-related activities due to a hamstrings strain varied from 14 to 18 days.[4,5] Players have also been found to miss an average of 3 matches per hamstrings strain.[4] In a recent consensus statement on the research methodology of soccer injuries, Fuller et al[6] recommended defining *injury severity* as the number of days from the date of injury to the date of full participation. Unfortunately, the relationship is not pure. The overriding issue in making a return-to-participation (RTP) decision should be to determine if the injured athlete has an acceptable level of risk for reinjury.[7,8] Common factors that may be considered are intrinsic to the injury, such as the involved structure, diagnostic imaging results, strength deficits, and flexibility deficits.[8] Many extrinsic variables unique to the athlete and the situation also characterize the injury event and may influence RTP time. Factors such as the athlete's age; competition situation; social and legal issues; and the approach to injury management by members of the medical staff, coach, parents, and athlete may influence the perception of whether the level of risk is acceptable.[7,8] Researchers[9–16] have investigated the relationship between hamstrings injury characteristics on diagnostic tests, such as magnetic resonance imaging and diagnostic ultrasound, and convalescence time. Generally, as the length or cross-sectional area of the injured tissue increased, or if it involved the central tendon of the biceps femoris, the time for the athlete to RTP also increased.[9–17] Among athletes who were injured during power activities, such as sprinting, involvement of the biceps femoris, specifically the most proximal aspect, also increased the

RTP time.[9,15] In contrast, strains that occurred when the hamstrings moved into an extensively lengthened position, such as when performing a split, commonly had less tissue disruption.[14] When stretch-related injuries to the hamstrings were analyzed separately, the RTP time was independent of the injury size and most commonly involved the semimembranosus. Stretch-related strains generally had a longer RTP time than those that occurred during high-intensity running.[14]

The usefulness of clinical assessments in predicting RTP time has not been studied extensively. Palpation has reported prognostic ability in athletes who stated high-intensity running was the mechanism of injury. As the distance from the most intense area of palpable pain to the ischial tuberosity decreased, the RTP time increased.[15] This relationship did not exist when athletes who reported stretching as the mechanism of injury were assessed.[14] Among Australian football athletes, only the time to walk pain free predicted the RTP time: athletes who required longer than 1 day postinjury took longer to RTP.

We have found no studies reporting the effect of extrinsic variables on RTP time after a hamstrings strain. However, within professional soccer, researchers[1,4,5,18] have observed that variables such as the athlete's age, ethnicity, hamstrings strain history, playing position, level of play, and time of season influence the incidence of hamstrings strain. Most recently, among US collegiate soccer athletes, disparities in the incidence rate and event characteristics have also been reported between sexes.[19] Specifically, male athletes have a higher frequency of reinjury than female athletes, and if a shorter RTP time in male athletes is confirmed, then this may help explain the difference in reinjury rates. In addition, given that differences exist between sexes in activity intensity during competition and with running[20] and kicking[21] mechanics, injury occurrence during different activities may influence the extent of the injury and, consequently, the RTP time. Therefore, our purpose was to investigate differences in the RTP time after first-time and recurrent hamstrings strains among male and female collegiate soccer players. We also analyzed the distribution of RTP time among the various categories of event characteristics after first-time and recurrent hamstrings strains for male and female athletes. Given the differences in activity patterns between field players and goalkeepers, we analyzed the differences only among the field players. Researchers[22–24] have made this decision for similar studies in which they investigated the activity patterns and results of activities on soccer players.

METHODS

Study Population

In this descriptive epidemiology study, we compared the RTP time after a hamstrings strain between male and female collegiate soccer players and compared the RTP time between the levels of event characteristics for each sex. This study sample consisted of collegiate soccer athletes who sustained 507 hamstrings strains (306 in men, 201 in women). We used data from the National Collegiate Athletic Association (NCAA) Injury Surveillance System (ISS) during the 2004 through 2009 academic years. For the purposes of this study, only the data acquired during the traditional fall collegiate soccer seasons were used for analysis. Number of athletes, age, height, and mass of participants were not recorded. The NCAA ISS collects exposure and injury data from a national volunteer sample of NCAA institutions via a Web-based application. Details of this system, including sampling and data-collection methods, are outlined elsewhere.[25] A sample of Division I, II, and III institutions volunteered to provide data to the NCAA ISS for men's and women's soccer. Data for each injury event, as well as athlete-exposure data, were entered by members of the medical staff at each participating institution.

Definitions

For each injury entered in the NCAA ISS, the injured body part, type of injury, and convalescence time were specified. Per the NCAA ISS definition, an *injury* was defined as one that (1) occurs due to participation in an organized intercollegiate practice or contest, (2) requires attention by certified athletic trainers or physicians, and (3) results in restriction of the athlete's participation for 1 or more days beyond the day of injury. Possible hamstrings diagnoses that the medical staff could select were complete tear, contusion, myositis ossificans, partial tear, spasm, and tendinitis. Only hamstrings injuries classified as complete tears or partial tears by a certified athletic trainer were included in this analysis. Recurrence status was separated into 4 categories: *new*, *recurring*, *recurs from previous year*, and *recurs from before participation at college*. All hamstrings strains not classified as *new* were combined for analysis into a single category of *recurrent strain*. The RTP time was a continuous variable that was calculated as the number of days between the injury date and the date to a full RTP.

The event and athlete characteristics and their respective categories were standardized by the NCAA ISS for all reported injuries during participation in soccer. Specifically, we analyzed the following characteristics: *season*, *event type*, *practice type*, *practice segment*, *time of competition*, *field location*, *player position*, *soccer activity*, and *basic injury mechanism*. Given the low counts of hamstrings strains within certain characteristic categories, 1 or more were combined. The operational definitions for the categories of each characteristic that were used for data analysis are provided in Table 1.

Statistical Analysis

The RTP time data were not normally distributed as demonstrated by the Shapiro-Wilk test for normalcy ($P < .001$). Therefore, we used nonparametric statistics to analyze the data. The Wilcoxon rank sum test was calculated to evaluate the differences in the days to RTP between male and female athletes. For each sex, Wilcoxon rank sum tests or Kruskal-Wallis tests were performed to assess the differences in the days to RTP among categories of event characteristics based on the number of categories for an event characteristic. The α level was set a priori at .05. Participants who did not have the days to RTP recorded or were missing data specific to a given characteristic were omitted from the analyses.

Negative binomial regression was used to model the relationship between each event characteristic and RTP

Table 1. Operational Definitions of Characteristics and Corresponding Categories Used for Data Analysis

Characteristic	Categories
Season	1. Preseason 2. In-season/postseason (in-season and postseason)
Event type	1. Competition 2. Practice
Practice type	1. Regular 2. Scrimmage 3. Walk-through
Practice segment	1. Warm-up 2. Drills (individual drills, team drills) 3. Conditioning
Basic injury mechanism	1. Noncontact 2. Contact (direct with another player or with object or indirect) 3. Overuse/gradual
Soccer activity	1. Shooting/passing (shooting, passing, receiving pass) 2. Ball handling/dribbling 3. General play 4. Conditioning 5. Defending
Time of competition	1. First half (warm-up, first half) 2. Second half (second half, overtime)
Field location (competitions only)	1. Defensive end 2. Offensive end
Player position (competitions only)	1. Forward 2. Midfielder 3. Defender

time (days). Using time in the season as an example, a ratio of 2.0 would translate to an estimated increase of 2 times the number of days to RTP for athletes exposed to the risk factor (injured during the in-season or postseason) relative to the referent category (preseason). This analysis was performed independently for male and female athletes within the *first-time* and *recurrent hamstrings strain* categories. To limit the characteristics included in each model, only those predictors with $P < .10$ during nonparametric testing were entered into the regression analysis. To assess all predictors in 1 model, all participants must be categorized into each predictor. When modeling first-time hamstrings strains among male athletes, we combined 2 variables to allow the inclusion of all

Table 2. Participants Who Had Missing Data for Days Missed and Each Characteristic

	Participants, No. (% of Category)			
	First-Time Injury		Recurrent Injury	
Characteristic	Men	Women	Men	Women
Days missed	6 (2.5)	4 (2.3)	2 (3.0)	0 (0.0)
Field location	0 (0.0)	2 (3.4)	0 (0.0)	0 (0.0)
Time of competition	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Player position	2 (2.0)	2 (3.4)	1 (2.9)	0 (0.0)
Season	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Event type	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Practice type	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Basic injury mechanism	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Practice segment	4 (3.0)	4 (3.6)	1 (3.2)	0 (0.0)
Soccer activity	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

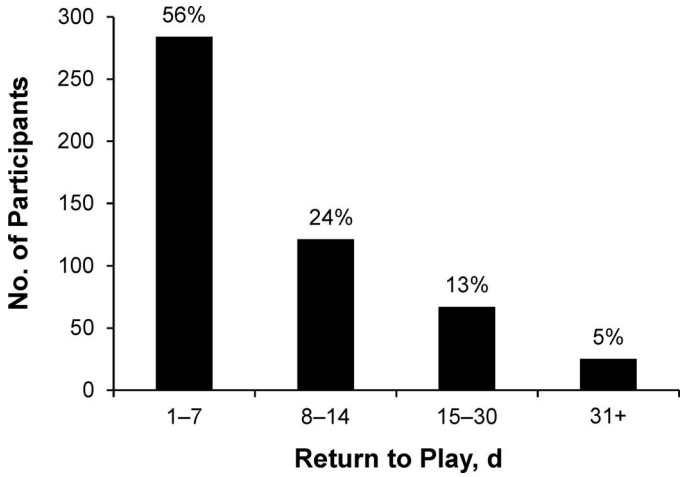

Figure. Distribution of the days to return to participation after hamstrings strain for all soccer athletes.

participants. The NCAA ISS does not record player position during practices. Therefore, athletes injured during practice cannot be categorized within the predictor of player position. To include the influence of all eligible predictors into 1 model, we modified the event-type characteristic by classifying athletes injured during competition by their field positions, and athletes injured during practice were simply classified as *practice*. Participants were coded as *forward during competition*, *midfielder during competition*, *defender during competition*, or *practice injury*. Data analyses were performed using SAS (version 9.1.3; SAS Institute, Inc, Cary, NC).

RESULTS

For male players, 239 strains were first time and 67 strains were recurrent. For female players, 176 strains were first time and 25 strains were recurrent. Days to RTP were provided for 98% (n = 495) of the athletes with hamstrings strains, and similar rates of missing data were reported for the event characteristics (Table 2). The median time to RTP for all athletes was 7 days (range = 1–156 days) with an interquartile range (IQR) of 4 to 12 days. The distribution of the days to RTP is provided in the Figure.

First-Time Hamstrings Strains

We found no difference between sexes in the median time to RTP after a hamstrings strain (men = 7.0 days [IQR = 4.0–12.0 days], women = 6.0 days [IQR = 3.0–9.0 days]; $P = .07$). Male athletes exhibited more median days missed from participation when a player sustained a hamstrings strain during competition rather than during practice (competition = 9.0 days [IQR = 4.0–17.0 days], practice = 6.0 days [IQR = 3.0–10.0 days]; $P = .002$) and more median days missed during the in-season/postseason than during the preseason (in-season/postseason = 7.0 days [IQR = 4.0–14.0 days], preseason = 5.0 days [IQR = 3.0–10.0 days]; $P = .004$). Division I male athletes also had more median days to RTP than Division II and Division III athletes (Division I = 8.0 days [IQR = 4.0–15.0 days], Division II = 6.0 days [IQR = 3.0–10.0 days], Division III = 5.0 days [IQR = 3.0–11.0 days]; $P = .045$). The median

Table 3. Values for Days to Return to Participation After First-Time Hamstrings Strain Among Male Collegiate Soccer Players

	Days to Return to Play			
Event Factor (No.)	Median	Interquartile Range	Wilcoxon Rank Sum or Kruskal-Wallis Test Statistic	*P* Value
Event type			9.67	.002[b]
Competition (99)	9.0	4.0–17.0		
Practice (134)	6.0	3.0–10.0		
Season			8.45	.004[b]
Preseason (97)	5.0	3.0–10.0		
In-season/postseason (137)	7.0	4.0–14.0		
Division			6.21	.045[b]
I (104)	8.0	4.0–15.0		
II (30)	6.0	3.0–10.0		
III (90)	5.0	3.0–11.0		
Player position			5.15	.08
Forward (28)	9.5	5.5–20.5		
Midfielder (40)	10.5	5.0–15.0		
Defender (30)	5.5	4.0–10.0		
Time of competition			0.33	.57
First half (41)	8.0	5.0–17.0		
Second half (47)	9.0	4.0–14.0		
Field location[a]			0.18	.67
Offensive (40)	10.0	4.0–18.0		
Defensive (35)	9.0	4.0–14.0		
Practice segment			0.17	.92
Conditioning (32)	6.0	3.0–9.5		
Drills (83)	6.0	3.0–11.0		
Warm-up (4)	5.5	1.5–14.0		
Practice type			1.52	.47
Regular (122)	6.0	3.0–10.0		
Scrimmage (10)	5.0	5.0–8.0		
Walk-through (2)	11.0	8.0–14.0		
Soccer activity			8.35	.08
Defending (29)	6.0	4.0–11.0		
Ball handling/dribbling (19)	11.0	8.0–18.0		
Conditioning (34)	6.0	3.0–10.0		
General play (126)	7.0	3.0–11.0		
Shooting/passing (24)	7.0	3.0–14.0		
Basic injury mechanism			3.74	.16
Noncontact (212)	7.0	4.0–12.0		
Contact (11)	4.0	2.0–10.0		
Overuse and gradual (10)	5.5	3.0–10.0		

[a] Location during competition only.
[b] Indicates difference ($P < .05$).

days missed and IQR for each characteristic are provided in Table 3.

To perform the regression analysis for male athletes, division of play, player position, soccer activity at the time of injury, event type, and season qualified as eligible predictors (Table 4). The regression analysis revealed that athletes playing the forward position during competitions took 1.52 (95% confidence interval [CI] = 1.01, 2.29) times longer to RTP than those who were injured during practice.

Table 4. Negative Binomial Regression Analyses of First-Time Hamstrings Strains Among Male Collegiate Soccer Players

Variable	Ratio of Days to Return to Play to Referent	95% Confidence Interval	$P > (\chi^2)$
Position/event type			.061
Defender during competition	0.82	0.55, 1.23	.357
Midfielder during competition	1.13	0.78, 1.64	.502
Forward during competition	1.52	1.01, 2.29	.042[a]
All positions during practice	1.00	NA	NA
Division			.199
I	1.25	0.97, 1.61	.086
II	1.03	0.72, 1.48	.876
III (referent)	1.00	NA	NA
Season			
In-season/postseason	1.18	0.88, 1.61	.263
Preseason (referent)	1.00	NA	NA
Soccer activities			.346
Defending	0.99	0.61, 1.62	.989
Ball handling/dribbling	1.34	0.81, 2.23	.254
General play	1.06	0.75, 1.53	.711
Shooting/passing	1.48	0.92, 2.36	.105
Conditioning (referent)	1.00	NA	NA

Abbreviation: NA, not applicable.
[a] Indicates difference ($P < .05$).

For female athletes, we found no differences in the days missed within any characteristic (Table 5). The regression analysis also did not identify characteristics that explained the RTP time (Table 6).

Recurrent Hamstrings Strains

The median days to RTP after a recurrent hamstrings strain were not different between the sexes (men = 11.0 days [IQR = 5.0–16.0 days], women = 5.5 days [IQR = 4.0–12.0 days]; $P = .06$). Male athletes required a longer convalescence time if they were injured during the in-season/postseason than during the preseason (in-season/postseason = 11.0 days [IQR = 6.0–17.0 days], preseason = 7.5 days [IQR = 3.0–12.0 days]; $P = .048$). No other event characteristics were different (Table 7). The negative binomial regression did not reveal any characteristics that explained the differences in RTP time (Table 8). The only event characteristic that influenced days missed for female athletes was player position during competition (forward = 11.0 days [IQR = 9.0–14.0 days], midfielder = 2.0 days [IQR = 2.0–4.0 days], defender = 4.0 days [IQR = 3.0–5.0 days]; $P = .02$). No other characteristics were different (Table 9). The regression estimated that forwards required 4.22 (95% CI = 2.03, 8.78) times longer to RTP than midfielders and 2.83 (95% CI = 1.36, 5.88) times longer than defenders (Table 10).

DISCUSSION

In the literature, risk factors and predictors of hamstrings strain severity have predominantly been based on observations in professional male soccer players. Given the variability of the intrinsic characteristics of the athletes and the differences in the extrinsic characteristics of the sport, the generalizability of the literature to the collegiate athlete is questionable. This is especially true among

Table 5. Values for Days to Return to Participation After First-Time Hamstrings Strain Among Female Collegiate Soccer Players

	Days to Return to Participation			
Event Factor (No.)	Median	Interquartile Range	Wilcoxon Rank Sum or Kruskal-Wallis Test Statistic	*P* Value
Event type			2.01	.16
Competition (59)	6.0	4.0–11.0		
Practice (113)	5.0	3.0–9.0		
Season			0.09	.76
Preseason (85)	6.0	4.0–9.0		
In-season/postseason (87)	6.0	3.0–9.0		
Division			0.18	.91
I (79)	6.0	3.0–9.0		
II (19)	6.0	4.0–12.0		
III (74)	5.0	3.0–9.0		
Player position			3.17	.21
Forward (22)	6.5	2.0–9.0		
Midfielder (18)	7.0	5.0–17.0		
Defender (17)	6.0	4.0–11.0		
Time of competition			0.15	.71
First half (28)	7.0	5.0–11.0		
Second half (18)	6.0	5.0–12.5		
Field location[a]			3.80	.053
Offensive (16)	9.0	7.0–13.5		
Defensive (20)	6.0	4.0–10.0		
Practice segment			2.17	.34
Conditioning (25)	6.0	4.0–11.0		
Drills (60)	5.0	3.0–7.5		
Warm-up (5)	3.0	2.0–11.0		
Practice type			0.37	.83
Regular (104)	5.0	3.0–9.0		
Scrimmage (7)	4.0	4.0–6.0		
Walk-through (2)	6.0	6.0–6.0		
Soccer activity			0.39	.98
Defending (14)	5.0	4.0–11.0		
Ball handling/dribbling (16)	7.0	4.0–9.0		
Conditioning (27)	6.0	4.0–11.0		
General play (94)	6.0	3.0–9.0		
Shooting/passing (20)	5.0	2.0–11.5		
Basic injury mechanism			2.55	.28
Noncontact (141)	5.0	3.0–9.0		
Contact (19)	6.0	4.0–9.0		
Overuse and gradual (11)	8.0	5.0–14.0		

[a] Location during competition only.

Table 7. Values for Days to Return to Participation After Recurrent Hamstrings Strain Among Male Collegiate Soccer Players

	Days to Return to Participation			
Event Factor (No.)	Median	Interquartile Range	Wilcoxon Rank Sum or Kruskal-Wallis Test Statistic	*P* Value
Event type			2.37	.13
Competition (35)	11.0	6.0–16.0		
Practice (30)	7.5	4.0–17.0		
Season			4.08	.048[b]
Preseason (22)	7.5	3.0–12.0		
In-season/postseason (43)	11.0	6.0–17.0		
Division			3.29	.19
I (37)	11.0	6.0–17.0		
II (7)	8.0	4.0–11.0		
III (21)	10.0	3.0–14.0		
Player position			3.89	.14
Forward (17)	13.0	8.0–23.0		
Midfielder (7)	11.0	4.0–14.0		
Defender (10)	6.5	4.0–12.0		
Time of competition			1.88	.18
First half (14)	13.0	11.0–23.0		
Second half (19)	10.0	5.0–14.0		
Field location[a]			0.62	.43
Offensive (10)	12.5	8.0–23.0		
Defensive (14)	10.5	4.0–21.0		
Practice segment			3.87	.14
Conditioning (7)	11.0	9.0–29.0		
Drills (19)	7.0	3.0–12.0		
Warm-up (1)	4.0	4.0–4.0		
Practice type			0.17	.92
Regular (27)	7.0	4.0–17.0		
Scrimmage (2)	7.5	3.0–12.0		
Walk-through (1)	8.0	8.0–8.0		
Soccer activity			2.32	.68
Defending (7)	8.0	5.0–12.0		
Ball handling/dribbling (2)	13.0	12.0–14.0		
Conditioning (6)	14.5	9.0–29.0		
General play (48)	11.0	4.5–16.5		
Shooting/passing (2)	12.0	3.0–21.0		
Basic injury mechanism			3.75	.15
Noncontact (57)	11.0	6.0–17.0		
Contact (3)	11.0	8.0–12.0		
Overuse and gradual (5)	4.0	4.0–5.0		

[a] Location during competition only.
[b] Indicates difference ($P < .05$).

Table 6. Negative Binomial Regression Analyses of First-Time Hamstrings Strains Among Female Collegiate Soccer Players

Field Location	Ratio of Days to Return to Play to Referent	95% Confidence Interval	$P > (\chi^2)$
Offensive field	1.33	1.08, 1.68	.118
Defensive field (referent)	1.00	Not applicable	Not applicable

Table 8. Negative Binomial Regression Analyses of Recurrent Hamstrings Strains Among Male Collegiate Soccer Players

Season	Ratio of Days to Return to Play to Referent	95% Confidence Interval	$P > (\chi^2)$
In-season/postseason	1.41	1.21, 1.66	.113
Preseason (referent)	1.00	Not applicable	Not applicable

Table 9. Values for Days to Return to Participation After Recurrent Hamstrings Strains Among Female Collegiate Soccer Players

	Days to Return to Participation			
Event Factor (No.)	Median	Interquartile Range	Wilcoxon Rank Sum or Kruskal-Wallis Test Statistic	*P* Value
Event type			0.08	.79
Competition (11)	5.0	3.0–12.0		
Practice (13)	6.0	4.0–12.0		
Season			0.32	.59
Preseason (9)	6.0	4.0–13.0		
In-season/postseason (15)	5.0	3.0–12.0		
Division			4.44	.11
I (17)	8.0	5.0–12.0		
II (1)	2.0	2.0–2.0		
III (6)	4.5	2.0–5.0		
Player position			7.47	.02[b]
Forward (6)	11.0	9.0–14.0		
Midfielder (3)	2.0	2.0–4.0		
Defender (2)	4.0	3.0–5.0		
Time of competition			0.32	.57
First half (4)	9.5	6.0–11.0		
Second half (7)	5.0	2.0–14.0		
Field location[a]			0.79	.38
Offensive (3)	9.0	2.0–14.0		
Defensive (4)	3.5	2.5–4.5		
Practice segment			3.14	.21
Conditioning (4)	4.5	3–17.5		
Drills (7)	8.0	6.0–13.0		
Warm-up (1)	2.0	2.0–2.0		
Practice type				NA
Regular (13)	6.0	4.0–12.0		
Scrimmage (0)	NA	NA		
Walk-through (0)	NA	NA		
Soccer activity			2.55	.47
Defending (3)	5.0	2.0–13.0		
Ball handling/dribbling (0)	NA	NA		
Conditioning (7)	4.0	2.0–12.0		
General play (12)	8.5	5.0–13.0		
Shooting/passing (2)	4.5	3.0–6.0		
Basic injury mechanism			0.01	.99
Noncontact (20)	5.5	4.0–11.0		
Contact (2)	8.5	3.0–14.0		
Overuse and gradual (2)	14.5	2.0–27.0		

Abbreviation: NA, not applicable.

[a] Location during competition only.

[b] Indicates difference ($P < .05$).

Table 10. Negative Binomial Regression Analyses of Recurrent Hamstrings Strains Among Female Collegiate Soccer Players

Player Position During Competition	Ratio of Days to Return to Participation to Referent	95% Confidence Interval	$P > (\chi^2)$
Defender	0.35	0.17, 0.72	.008[a]
Midfielder	0.24	0.11, 0.49	<.001[a]
Forward (referent)	1.00	Not applicable	Not applicable

[a] Indicates difference ($P < .05$).

female athletes because of the recent reports that male athletes have larger incidence rates of hamstrings strains.[19,26] We are the first to compare the RTP time after hamstrings strain between male and female soccer players and to investigate the effect of event characteristics on the RTP time in this population.

Our findings indicated that the RTP time was not different among male and female athletes who sustained a first-time or recurrent hamstrings strains; however, each sex had unique characteristics that affected the number of days missed from participation. Specifically, regarding male athletes, differences in RTP time after a first-time strain existed within the event type, division of play, and specific season. Forward was the only position in which players injured during competition required a longer RTP time than players injured during practice. The RTP time after recurrent strains was different only between preseason and in-season/postseason injuries. For female athletes, RTP time did not differ for any of the characteristics. The actual player's position during competition resulted in different RTP times for recurrent strains.

We found that after a first-time hamstrings strain for male and female athletes, the median RTP times were 7 days and 6 days, respectively. Similarly, female athletes with recurrent strains had a median RTP time of 5 days, and male athletes with recurrent strains had a median RTP time of 11 days. All values were substantially less than the RTP time reported in the literature, which averages 2 to 3 weeks and longer for more extensive injuries.[4,5,16,27] Unfortunately, most investigators in the soccer literature have reported the RTP data as an average, which may not represent the RTP time because it does not account for the potentially skewed distribution of data. Several factors other than the impairments and consequent functional limitations may influence the RTP time. Among professional soccer players, factors inherent to the different levels of the sport, such as faster play, increased volume of high-intensity soccer activities, and playing style, have been discussed.[28,29] Other factors, such as the intrinsic motivation of the athletes, sociocultural influences, and the values and beliefs of everyone involved in decision making, may also affect the duration of time missed.[7]

Few researchers have attempted to prognosticate the RTP time after hamstrings strains among soccer athletes. Among 207 men's professional soccer athletes, Ekstrand et al[16] reported that the only characteristic to influence the RTP time was the relative degree of visible injury on magnetic resonance imaging. The average time missed was 8 days if the tissue did not have visible injury but 17 days or more if architectural disruption was present. Similar results have been reported among Australian football players and elite sprinters.[15,17,30] Objective data recorded during the clinical examination may also be useful in predicting the RTP time. The clinical examination addresses strength, flexibility, and neuromobility[30]; the area of palpable tenderness[15,31]; and ambulatory status,[31] all of which have been deemed effective in qualitatively determining RTP time. Unfortunately, in our study, the data were collected by a centralized ISS, so accompanying clinical and diagnostic examination data could not be linked to the individual athlete and event

characteristics. Therefore, causation between the characteristics that were present and hamstrings strain occurrence cannot be determined because of the lack of specific information regarding important confounding factors, such as history, strength, and flexibility.

Our observations suggested that after a first-time hamstrings strain, Division I male soccer players took more days to RTP. One of the primary influential differences among the divisions may be an increase in the intensity and speed of activity in Division I. Mohr et al[32] reported that among European professional soccer players, top-class players performed more high-intensity activities during competitions than moderate-class players did. These qualitative changes in activity would require higher-class athletes to be at an elevated level of function before RTP because of the fatiguing effects of soccer activity on the hamstrings muscles.[33–35]

Similarly, differences in the intensity of activity may explain the difference in RTP time between event type and season for first-time and recurrent hamstrings strains among male athletes. Professional soccer players have a greater volume of high-intensity runs and a higher work-to-rest ratio during competitions than during practices.[22,23] The larger volume of high-intensity activities may lead to relatively greater hamstrings fatigue, which results in an increased injury risk, especially when decelerating from a sprint.[33] In addition, practices are more controlled, and as players fatigue, they may regulate the intensity and volume of high-intensity activity, which would reduce the strain on the hamstrings. Therefore, the extent of muscle damage may be greater when a player injures the hamstrings during a competition, thus requiring an increase in the RTP time.

For male athletes, the difference in the RTP time between the preseason and the in-season/postseason reflects the relationship between practices and competitions because very few competitions occur during the preseason. Among players with first-time and recurrent hamstrings strains, the median days to RTP were greater during the in-season/postseason than during the preseason. Furthermore, the RTP time for recurrent strains appeared prolonged compared with first-time strains. Researchers[36–39] have suggested that athletes with previous hamstrings strains have unresolved impairments that exist for an indeterminate time after RTP. The lower baseline of flexibility and strength may negatively influence the extent of muscle injury and function after a reinjury, thereby increasing the days missed after a strain. Furthermore, athletes are required to perform activities at a higher intensity during the in-season to participate in competitions.[22,40] Thus, longer RTP times may be expected during the in-season, especially among players with recurrent strains.

Among collegiate soccer players, field position appears to influence RTP time. Male professionals who play the forward position participate in a larger volume of sprinting activity than athletes at other field positions except fullback.[22,32] In comparison, female forwards and midfielders perform an equivalent high volume of high-intensity and sprinting activities.[24] Before returning to full participation, both groups must be able to perform repeated sprinting activities to fulfill the unique requirements of soccer. Male forwards, therefore, have a longer RTP time than players at other positions. The specific player position was more pronounced among female athletes with recurrent injuries, as the forwards required a longer time to RTP than midfielders and defenders.

Clinical implications for preventive and rehabilitation programs after hamstrings strains may be developed by considering the findings of our study. Most strains resulted from noncontact mechanisms, specifically during the general play of competitions and practice. This is consistent with the literature, in which authors[4,19] have stated that most hamstrings strains occur during running activities. Our results indicated that noncontact mechanisms result in RTP times that are similar to those for contact or overuse or gradual mechanisms. However, the circumstances during which the injury mechanism occurs appear to influence the days to RTP. Clinicians should consider the event characteristics that result in longer RTP times and determine the potential consequences of these findings. Preventive and rehabilitative programs should be managed accordingly.

For male and female athletes, the influence of player position is different or may be implied for first-time and recurrent hamstrings strains. Given the increased RTP time and the unique soccer activities that occur during competitions among forwards and midfielders, training should emphasize repeated high-intensity and sprinting activities with high work-to-rest ratios. Activity intensity during competition should be replicated in training, because the injuries result in more days missed when they occur during competition. Athletic trainers must ensure that athletes have been rehabilitated properly, especially in the end stages of functional progression, to reduce the level of clinical impairments and to target appropriate fitness standards that mimic competition activities.

Our study had limitations. As discussed, various psychosocial and sociocultural factors have been suggested to influence the decision of when to RTP.[7] Determining when an athlete should RTP was not standardized across all participating institutions, so various factors extrinsic to the actual injury may have influenced the days missed. Given that the data came from a preexisting database, we only considered the difference in the RTP time within soccer-specific event characteristics, so the potential confounding effects of these factors were not measured or controlled. However, given this lack of standardization, the results are more representative of actual RTP decisions. In addition, a formal definition of *hamstrings strain* was not provided, and injured athletes may have been misclassified relative to the actual diagnosis of a hamstrings strain. Participation in the NCAA ISS is voluntary, so although adjustments were made to account for differences among NCAA divisions, the results may not represent all collegiate soccer athletes.

Given that the days to RTP are count data and, consequently, not normally distributed, standard linear regression analysis was not appropriate. A negative binomial regression analysis was the most accurate analysis because of the highly skewed distribution of the days to RTP. Participants who had missing data were omitted from the specific analysis. However, only 2% of RTP data were missing, and less than 4% of data for any given characteristic were missing. Therefore, the influence should be considered minimal. In addition, relatively few recurrent injuries were available for data analysis. Because of the distribution of RTP time and the multiple levels within

certain characteristics, the power of the analysis on recurrent strains was limited.

CONCLUSIONS

Multiple factors may influence the RTP time after an injury. We focused on identifying the event characteristics that resulted in differences in the RTP time among male and female collegiate soccer players. Our finding of no differences in the RTP time between sexes indicated that factors intrinsic to specific athletes and the sport of soccer may be more influential in determining the days to RTP. The differences in the RTP time among player positions, event type, and time of the season were explained by inferring from the literature that more days were missed when athletes were required to perform high volumes of high-intensity activities. Preventive programs to reduce the incidence and severity of hamstrings strains should focus on sport-specific and position-specific training to replicate the demands of competitions.

REFERENCES

1. Arnason A, Gudmundsson A, Dahl HA, Johannsson E. Soccer injuries in Iceland. *Scand J Med Sci Sports*. 1996;6(1):40–45.
2. Hawkins RD, Hulse MA, Wilkinson C, Hodson A, Gibson M. The association football medical research programme: an audit of injuries in professional football. *Br J Sports Med*. 2001;35(1):43–47.
3. Orchard J, Seward H. Epidemiology of injuries in the Australian Football League, seasons 1997–2000. *Br J Sports Med*. 2002;36(1): 39–44.
4. Woods C, Hawkins RD, 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(1):36–41.
5. Ekstrand J, Hagglund M, Walden M. Epidemiology of muscle injuries in professional football (soccer). *Am J Sports Med*. 2011; 39(6):1226–1232.
6. Fuller CW, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med*. 2006;40(3):193–201.
7. Shrier I, Charland L, Mohtadi NG, Meeuwisse WH, Matheson GO. The sociology of return-to-play decision making: a clinical perspective. *Clin J Sport Med*. 2010;20(5):333–335.
8. Orchard J, Best TM, Verrall GM. Return to play following muscle strains. *Clin J Sport Med*. 2005;15(6):436–441.
9. Connell DA, Schneider-Kolsky ME, Hoving JL, et al. Longitudinal study comparing sonographic and MRI assessments of acute and healing hamstring injuries. *AJR Am J Roentgenol*. 2004;183(4):975–984.
10. 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(6):435–440.
11. Slavotinek JP, Verrall GM, Fon GT. Hamstring injury in athletes: using MR imaging measurements to compare extent of muscle injury with amount of time lost from competition. *AJR Am J Roentgenol*. 2002;179(6):1621–1628.
12. Pomeranz SJ, Heidt RS Jr. MR imaging in the prognostication of hamstring injury: work in progress. *Radiology*. 1993;189(3):897–900.
13. Gibbs NJ, Cross TM, Cameron M, Houang M. 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. *J Sci Med Sport*. 2004;7(2):248–258.
14. Askling CM, Tengvar M, Saartok T, Thorstensson A. Proximal hamstring strains of stretching type in different sports: injury situations, clinical and magnetic resonance imaging characteristics, and return to sport. *Am J Sports Med*. 2008;36(9):1799–1804.
15. 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*. 2007;35(2):197–206.
16. Ekstrand J, Healy JC, Walden M, Lee JC, English B, Hagglund M. Hamstring muscle injuries in professional football: the correlation of MRI findings with return to play. *Br J Sports Med*. 2012;46(2):112–117.
17. Comin J, Malliaras P, Baquie P, Barbour T, Connell D. Return to competitive play after hamstring injuries involving disruption of the central tendon. *Am J Sports Med*. 2013;41(1):111–115.
18. Hawkins RD, Fuller CW. A prospective epidemiological study of injuries in four English professional football clubs. *Br J Sports Med*. 1999;33(3):196–203.
19. Cross KM, Gurka KK, Saliba S, Conaway M, Hertel J. Comparison of hamstring strain injury rates between male and female intercollegiate soccer athletes. *Am J Sports Med*. 2013;41(4):742–748.
20. Chumanov ES, Heiderscheit BC, Thelen DG. The effect of speed and influence of individual muscles on hamstring mechanics during the swing phase of sprinting. *J Biomech*. 2007;40(16):3555–3562.
21. Brophy RH, Backus S, Kraszewski AP, et al. Differences between sexes in lower extremity alignment and muscle activation during soccer kick. *J Bone Joint Surg Am*. 2010;92(11):2050–2058.
22. Gabbett TJ, Mulvey MJ. Time-motion analysis of small-sided training games and competition in elite women soccer players. *J Strength Cond Res*. 2008;22(2):543–552.
23. Casamichana D, Castellano J, Castagna C. Comparing the physical demands of friendly matches and small-sided games in semiprofessional soccer players. *J Strength Cond Res*. 2012;26(3):837–843.
24. Mohr M, Krustrup P, Andersson H, Kirkendal D, Bangsbo J. Match activities of elite women soccer players at different performance levels. *J Strength Cond Res*. 2008;22(2):341–349.
25. Marshall S, Corlette J. *Fall Sports Qualifying Report: 2004–2009 Academic Year*. Indianapolis, IN: Datalys Center for Sports Injury and Prevention; 2009:65–76.
26. Cross KM, Gurka KK, Conaway M, Ingersoll CD. Hamstring strain incidence between genders and sports in NCAA athletics. *Athl Train Sports Health Care*. 2010;2(3):124–130.
27. Walden M, Hagglund M, Orchard J, Kristenson K, Ekstrand J. Regional differences in injury incidence in European professional football. *Scand J Med Sci Sports*. 2013;23(4):424–430.
28. Walden M, Hagglund M, Ekstrand J. UEFA Champions League study: a prospective study of injuries in professional football during the 2001–2002 season. *Br J Sports Med*. 2005;39(8):542–546.
29. Volpi P, Melegati G, Tornese D, Bandi M. Muscle strains in soccer: a 5-year survey of an Italian major league team. *Knee Surg Sports Traumatol Arthrosc*. 2004;12(5):482–485.
30. 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(6): 1008–1015.
31. Warren P, Gabbe BJ, Schneider-Kolsky M, Bennell KL. Clinical predictors of time to return to competition and of recurrence following hamstring strain in elite Australian footballers. *Br J Sports Med*. 2010;44(6):415–419.
32. Mohr M, Krustrup P, Bangsbo J. Match performance of high-standard soccer players with special reference to development of fatigue. *J Sports Sci*. 2003;21(7):519–528.
33. Small K, McNaughton LR, Greig M, Lohkamp M, Lovell R. Soccer fatigue, sprinting, and hamstring injury risk. *Int J Sports Med*. 2009; 30(8):573–578.

34. Small K, McNaughton L, Greig M, Lovell R. Effect of timing of eccentric hamstring strengthening exercises during soccer training: implications for muscle fatigability. *J Strength Cond Res*. 2009; 23(4):1077–1083.
35. Small K, McNaughton L, Greig M, Lovell R. The effects of multidirectional soccer-specific fatigue on markers of hamstring injury risk. *J Sci Med Sport*. 2010;13(1):120–125.
36. Worrell TW, Perrin DH, Gansneder BM, Gieck JH. Comparison of isokinetic strength and flexibility measures between hamstring injured and noninjured athletes. *J Orthop Sports Phys Ther*. 1991; 13(3):118–125.
37. Croisier JL. Factors associated with recurrent hamstring injuries. *Sports Med*. 2004;34(10):681–695.
38. Croisier JL, Forthomme B, Namurois MH, Vanderthommen M, Crielaard JM. Hamstring muscle strain recurrence and strength performance disorders. *Am J Sports Med*. 2002;30(2):199–203.
39. Jonhagen S, Nemeth G, Eriksson E. Hamstring injuries in sprinters: the role of concentric and eccentric hamstring muscle strength and flexibility. *Am J Sports Med*. 1994;22(2):262–266.
40. Dawson B, Hopkinson R, Appleby B, Stewart G, Roberts C. Comparison of training activities and game demands in the Australian Football League. *J Sci Med Sport*. 2004;7(3):292–301.

Address correspondence to Kevin M. Cross, PhD, PT, ATC, University of Virginia, HealthSouth, 545 Ray C Hunt Drive, Box 801005–22908, Charlottesville, VA 22908. Address e-mail to kevin.cross@healthsouth.com.