

Return to Play and Player Performance After Foot Fracture in UEFA Soccer Players

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Background: There is a paucity of information on rate and time to return to play (RTP) in elite-level soccer players who have sustained foot fractures.

Purpose: To (1) determine the rate and timing of RTP after foot fracture (eg, tarsal, metatarsal, or phalangeal), (2) investigate foot fracture reinjury incidence after RTP, and (3) evaluate performance after foot fracture as compared with matched, uninjured controls.

Study Design: Descriptive epidemiology study.

Methods: Athletes sustaining foot fractures were identified across the 5 major European soccer leagues (English Premier League, Bundesliga, La Liga, Ligue 1, and Serie A) between 2000 and 2016. Injured athletes were matched to controls (1:1) using demographic characteristics and performance metrics from 1 season before injury. The authors recorded RTP rate, reinjury incidence, player characteristics associated with RTP within 2 seasons of injury, player availability, field time, and performance metrics during the 4 seasons after injury.

Results: A total of 192 elite soccer players sustaining a foot fracture were identified; 40 players (20.8%) underwent operative treatment. Athletes missed an average of 69.41 ± 59.43 days and 5.15 ± 23.28 games. In the 4 seasons after injury, 80% of players returned to play, with 72% returning to play within 1 season of injury. Nine players (5%) sustained a subsequent foot fracture. Athletes with a foot fracture demonstrated significantly longer league retention compared with uninjured controls ($P < .001$). Elite soccer players older than 30 years of age were less likely to RTP (odds ratio, 0.67; $P = .002$), whereas career experience, field position, and baseline performance showed no significant association with RTP rates. Injured athletes demonstrated similar performance to controls during the 4 years after injury, and there were no position-dependent differences on subgroup analysis. The players who underwent operative treatment had more assists per 90 minutes and more team points per game during the first season after injury compared with athletes treated nonoperatively.

Conclusion: Foot fractures in elite soccer players resulted in moderate loss of play time (69.41 days). RTP rates were high at 80%, although players older than 30 years of age were less likely to RTP. On RTP, athletes who sustained a foot fracture maintained performance similar to preinjury levels and to uninjured controls.

Keywords: soccer; player performance; return to play; foot fracture; metatarsal; phalanges; Union of European Football Associations (UEFA)

Soccer remains the most popular sport worldwide, with increasing participation.¹⁸ More than 265 million people are registered to play soccer, including more than 200,000 professional athletes.^{10,33} Orthopaedic injuries are common in soccer, adversely affecting individual performance and availability, particularly at high levels of competition. In professional soccer players, the rate of injury ranges from 1.4 to 5.8 injuries per 1000 hours of training, with a significant increase to 8.7 to 65.9 injuries per 1000 hours during match play.²⁹ Ten percent of soccer-related injuries are fractures, with one-third of fractures occurring in the lower

extremities.^{8,33} Ankle fractures are the most common (36%) lower extremity fracture, followed by foot fractures (33%) and tibial fractures (22%).²² As such, foot fractures represent an appreciable source of morbidity for soccer players that may adversely affect professionals' ability to compete at high levels.

Fully functional and structurally competent feet are critical to optimal performance in soccer. Several studies have examined lower extremity fractures in soccer players, reporting on mechanisms of injury, injury severity, and injury prevention strategies.^{3,8,11,35,37} Risk factors for foot fracture include common soccer moves such as cutting and lateral shuffling, in addition to bone alignment, high arch structure, and metatarsal length.⁷ Without appropriate rehabilitation after foot fracture, athletes carry significant

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risk of reinjury.³⁵ While investigators have studied return-to-play (RTP) metrics after foot fracture in the National Basketball Association (NBA) and National Football League (NFL), there is a paucity of information on time to RTP and rates of RTP in elite-level soccer players sustaining these injuries.^{1,16} Therefore, a better understanding of RTP rates and timing after foot fractures is essential to establish appropriate expectations.

The purpose of this investigation is to (1) determine the rate and timing of RTP after foot fracture, (2) investigate foot fracture reinjury incidence after RTP, and (3) evaluate performance metrics after foot fracture as compared with matched, uninjured controls.

METHODS

Player Identification

A retrospective review of male soccer athletes playing in the 5 major Union of European Football Associations (UEFA) soccer leagues (English Premier League, Bundesliga, Serie A, La Liga, and Ligue 1) was conducted (Figure 1). Players were identified using publicly available sources as established in previous investigations.^{5,6,19-21,24-26} Inclusion criteria consisted of any soccer player who sustained a foot fracture while signed to a team that competed within 1 of the 5 major European soccer leagues. Athletes who played in at least 1 game before the index injury and who had a minimum follow-up of 1 season after the season of injury were included in the performance analysis. Players were included in the performance analysis for seasons in which they remained active in 1 of the 5 major European soccer leagues. Rookies sustaining foot fractures were excluded from analysis. Athletes with no history of a reported lower extremity injury were included in the control cohort. Soccer players with inconsistent or unclear injury reports were excluded from the injured and control cohorts. Injury reports were cross-referenced with official league reports, official team websites, official team press releases, personal websites, and professional statistical websites by 2 authors (C.C.D. and O.Z.L.-G.). Players undergoing operative treatment of their foot fracture were identified to evaluate impact on RTP rates.

Data Collection

Each athlete's data, including age, height, field position (eg, attacker, midfielder, defender, or goalkeeper), and playing

experience, were collected. Injury data including time lost after injury (ie, days and games missed), baseline performance and performance on RTP including total time played in the season, games played, average minutes played per game, goals scored, assists, and team points per game up to 4 seasons after injury were also collected. Goals and assists were standardized to 90 minutes of play to account for differences in total field time among athletes. RTP was defined as time from injury to game participation. Teams were awarded 3 points for victories, 1 point for draws, and 0 points for losses.

Case-Control Analysis

A matched-cohort analysis was completed to compare performance metrics of athletes after foot fracture versus control athletes without a reported lower extremity injury. Athletes with foot fractures were matched to the control cohort in a 1:1 ratio using an optimized matching frontier methodology, a technique with concepts derived from *k* nearest-neighbor imputation.^{12-14,17} Soccer players were matched by demographic characteristics and baseline performance metrics. Demographic matching included age, height, playing experience (within 1 year), and position, while performance matching included assists and goals scored per 90 minutes of play recorded 1 season before the year of injury for the foot fracture cohort.²⁴⁻²⁶ The acceptable ranges of matching for goals and assists were selected based on the calculated variability of these features before any data processing. Goalkeepers were included in descriptive analysis but were subsequently excluded from case-control analysis because of the small number of injured athletes, preventing any meaningful analysis with long-term follow-up.^{23,24}

Statistical Analysis

Player characteristics associated with RTP within 2 seasons of injury were investigated through logistic multivariable regression. Player retention in the league between control versus injured cohorts during the follow-up period was evaluated via a log-rank test. Seasonal field time and performance metrics were collected for 3 seasons before the season of injury through the fourth season after injury. Overall differences between control and injured cohorts were assessed for each metric and time point combination, with subsequent subgroup analysis based on player position. Univariate 2-group comparisons were performed using independent 2-group *t* tests and independent Wilcoxon rank-sum

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Ethical approval was not sought for the present study.

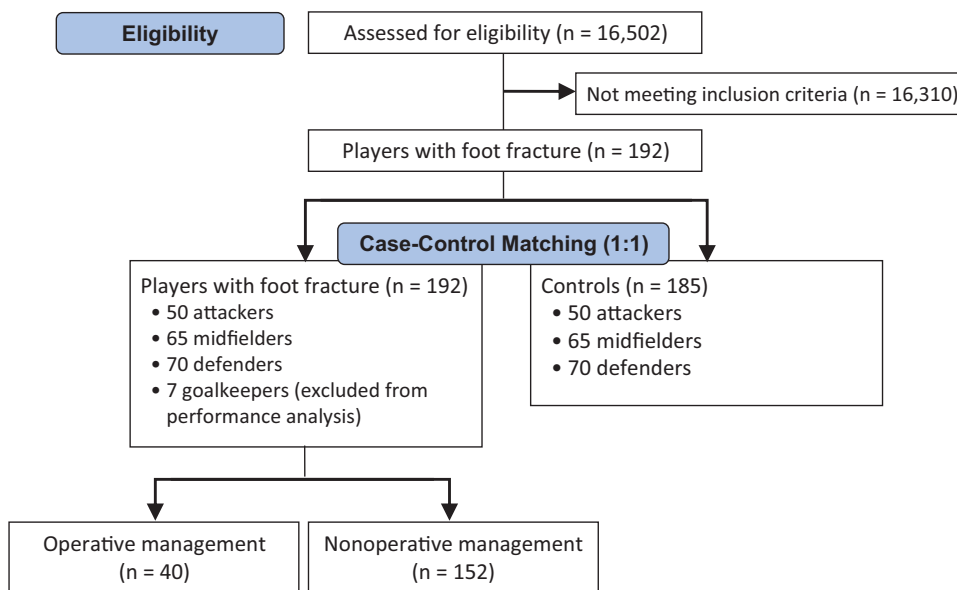


Figure 1. CONSORT (Consolidated Standards of Reporting Trials) diagram for patient enrollment.

TABLE 1
Player Characteristics^a

	Foot Fracture (n = 192)	Control (n = 185)	P
Case-control match			
Player position			
Attacker	50	50	.417
Midfielder	65	65	
Defender	70	70	
Goalkeeper	7	0	
Season of play, calendar year	2012 ± 3.15	2013 ± 4.79	.994
Total years played in league	5.45 ± 4.13	3.8 ± 3.04	>.999
Height, m	1.83 ± 0.06	1.81 ± 0.06	.993
Age during season, y	24.76 ± 4.35	23.9 ± 4.04	.444
Baseline metrics ^b			
Games played	25.4 ± 6.9	26.5 ± 11.5	.262
Total time played, min	1883.7 ± 762.3	1881.9 ± 868.8	.113
Goals scored ^c	0.22 ± 0.16	0.21 ± 0.18	.907
Assists recorded ^c	0.19 ± 0.12	0.17 ± 0.14	.636

^aData are reported as No. of players or mean ± SD.

^bMetrics from 1 season before the index time point.

^cStandardized to 90 minutes of play.

tests where appropriate. Chi-square tests were used to compare categorical data. Factors in multivariable regression included athlete characteristics (age, years of player experience in the league, position of play) and performance metrics 1 season before injury (games played, time played, goals per 90 minutes of play, and assists per 90 minutes of play). Statistical significance was set at $P < .05$; all analyses were performed using R Studio software Version 3.6.2 (R Foundation for Statistical Computing).

Post Hoc Analysis of Operative Versus Nonoperative Management

Players undergoing operative intervention for the treatment of a foot fracture were identified, creating a cohort of operatively treated athletes and a cohort of players who were treated nonoperatively. These players were identified by the methods listed above: cross-referencing player injury reports with league reports, team websites, team press releases, personal websites, and statistical-tracking websites. Athletes whose treatment was not described were placed in the nonoperative cohort. Comparative analysis between cohorts examined performance metrics and overall field time.

RESULTS

Athlete Characteristics

A total of 192 elite soccer athletes participating in 1 of the 5 major European soccer leagues who sustained a foot fracture between 2000 and 2016 were identified (Table 1). The mean age at the time of injury was 24.76 ± 4.35 years, with injured athletes having played an average of 5.45 ± 4.13 years in the league at the time of injury. Case-control matching was satisfactory, with no significant differences in athlete characteristics or baseline metrics 1 season before the season of injury (Table 1). The anatomic location of the fractures is presented in Table 2.

Return to Play

A total of 80% (n = 153/192) of elite soccer players with foot fractures were found to RTP at the same level of competition. Of these, 90% (n = 138/153) returned within 1 season

TABLE 2
Injury Characteristics of the Fracture Group (n = 192)^a

Variable	Value
Fracture type	
Phalanx	69 (35.4)
Metatarsal	102 (52.3)
Tarsal	15 (7.7)
Unspecified	6 (3.1)
Primary injury	
Days missed	69.41 ± 59.43
Games missed	5.15 ± 23.28
Return to play	
At any time point	153 (79.7)
By 1 season after injury	138 (71.9)
By 2 seasons after injury	151 (78.7)
By 3 seasons after injury	152 (79.1)
By 4 seasons after injury	153 (79.7)
Secondary injury	
No. of secondary foot fractures	9 (4.7)
Time to secondary fracture, y	2.89 ± 2.62
Days missed	64.22 ± 54.13 ^b
Games missed	8.38 ± 6.05 ^c

^aData are reported as No. of players (%) or mean ± SD.

^bNot significantly different compared with primary injury ($P = .786$).

^cNot significantly different compared with primary injury ($P = .250$).

TABLE 3
Return to Play by Fracture Site^a

	Median Days Missed (IQR)	Median Games Missed (IQR)
Tarsal	73 (35, 99)	6 (4, 12)
Metatarsal	72 (52, 122)	10 (6, 15)
Phalangeal	30 (19, 47)	4 (3, 7)

^aIQR, interquartile range.

of injury. Athletes were absent a median of 59 days (IQR, 31, 91 days) and a median of 7 games (IQR, 4, 13 games). Nine players (5%) sustained a subsequent foot fracture at a median of 2 years (IQR, 1, 4 years) after the primary injury, with no significant difference in days or games missed compared with primary injury (Table 2). Multivariable regression demonstrated age >30 years was associated with a reduced rate of RTP after foot fracture ($P = .002$). No other player characteristics were significantly associated with rate of RTP on multivariable regression (Table 4).

When evaluating anatomic location of foot fracture, time to RTP and games missed differed between tarsal, phalangeal, and metatarsal bones. Soccer players who fractured phalangeal bones returned significantly faster than those who experienced a tarsal and metatarsal fracture, missing a median of 30 days (IQR, 19, 47 days) and 4 games (IQR, 3, 7 games) ($P < .001$). Athletes sustaining fractures to the tarsal bones missed a median of 73 days (IQR, 35, 99 days) and 6 games (IQR, 4, 12 games). Athletes who sustained a

metatarsal fracture were absent a median of 72 days (IQR, 52, 122 days) and 10 games (IQR, 6, 15 games) (Table 3).

Player Availability After RTP

Long-term player availability during the 4-year follow-up period was significantly higher in athletes sustaining foot fracture compared with controls ($P < .001$) (Figure 2). There was no significant difference in total years played in either injured or control cohorts with case-control matching (Table 1). No significant difference in league retention was found between players sustaining phalanx, metatarsal, and tarsal fractures ($P = .892$).

Player Performance

Injured players demonstrated comparable performance metrics, contributing similar total minutes per season, minutes per game, goals per 90 minutes, and assists per 90 minutes compared with control athletes over the 4 seasons after injury (Figure 3). There were no significant differences in game time and performance metrics by field position or anatomic location of foot fracture. Athletes sustaining a foot fracture contributed to teams scoring 0.19 more team points per game ($P < .01$) when compared with control athletes' teams during the year of injury (Figure 3).

Field Time by Position

Three seasons after injury, midfielders who sustained foot fractures played 7.21 more games per season ($P < .05$) and 606.82 more total minutes per season ($P < .05$) compared with controls (Figure 4). Attackers contributed 9.71 more minutes per game in the season of injury ($P < .05$). No significant differences in field time were appreciated between injured and control defenders (Figure 4).

Player Performance by Position

Midfielders contributed 0.08 more assists per game in the season of injury ($P < .01$) and 0.07 more assists per game in the 2 subsequent seasons after injury ($P < .05$). Midfielders who sustained a foot fracture played for teams scoring 0.24 more points per game in the season of injury ($P < .05$) and 0.44 more points per game in the third season after injury ($P < .05$) relative to matched controls. Attackers demonstrated no significant difference in goals, assists per game, and team points, as compared with control athletes based on position at any time point after injury (Figure 5).

Post Hoc Analysis of Operative Versus Nonoperative Management

A total of 40 elite soccer players (20.8%) who sustained a foot fracture underwent operative intervention. Players

TABLE 4
Multivariable Regression for RTP at the Same League Level Within 2 Seasons of Injury^a

Factor	OR (95% CI)	P	Factor	OR (95% CI)	P
Age, y			Games played ^b		
<21	Reference		<10	Reference	
21-25	1.06 (0.89-1.26)	.50	10-19	0.81 (0.57-1.16)	.26
26-30	0.89 (0.74-1.07)	.22	20-29	0.86 (0.43-1.71)	.67
>30	0.67 (0.52-0.86)	.002	>30	0.74 (0.34-1.60)	.44
Time in League, y			Time played, min ^b		
<3	Reference		<1000	Reference	
3-5	1.07 (0.91-1.25)	.42	1000-1999	1.54 (0.80-2.98)	.20
6-8	1.02 (0.84-1.25)	.84	2000-2500	1.64 (0.77-3.49)	.20
>8	1.11 (0.90-1.36)	.33	>2500	1.67 (0.76-3.69)	.20
Player position			Goals ^b		
Attacker	Reference		<3	Reference	
Midfielder	0.98 (0.83-1.15)	.78	3-6	1.02 (0.82-1.26)	.88
Defender	1.06 (0.90-1.25)	.50	>7	1.03 (0.66-1.60)	.91
Fracture type			Assists ^b		
Phalanx	Reference		0-3	Reference	
Metatarsal	0.95 (0.83-1.07)	.39	>9	0.84 (0.58-1.22)	.36
Tarsal	1.06 (0.83-1.36)	.62	>3	1.00 (0.81-1.23)	.99
Unspecified	1.17 (0.83-1.65)	.37			

^aBolded P value indicates statistical significance (P < .05). OR, odds ratio; RTP, return to play.

^bOverall metrics for 1 season before the index time point.

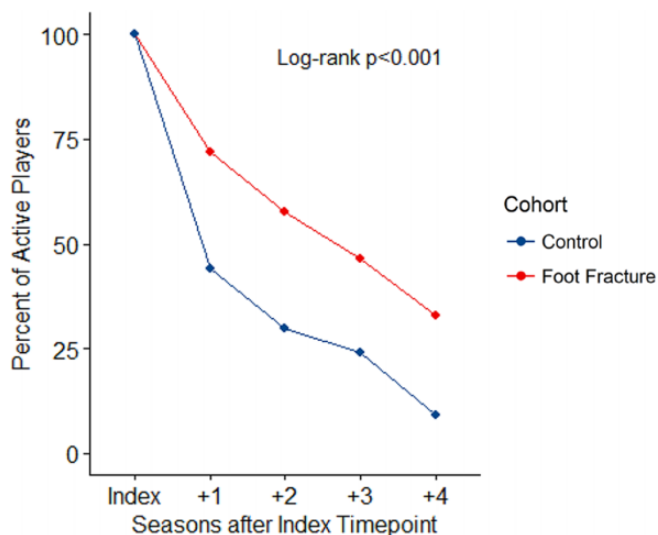


Figure 2. Player retention in the leagues by injury status during the study follow-up period.

treated operatively demonstrated superior performance in the season after injury, contributing to more team points per game (+0.31) and assists per 90 minutes (+0.09) when compared with players treated nonoperatively (P < .05). Of note, those treated nonoperatively participated in significantly more games in the first season after foot fracture (+4.3). Three seasons after injury, athletes undergoing operative treatment outperformed players treated nonoperatively by scoring more goals per 90 minutes (+0.22) (P < .05).

DISCUSSION

The principal findings from this study were that 80% of elite European soccer players RTP at the same league level after foot fracture, missing a mean of 69.41 days and 5.15 games. Athletes older than 30 years of age were significantly less likely to RTP (OR, 0.67; P = .002), while career experience, field position, and baseline performance showed no significant association with RTP rates. Elite soccer players, regardless of field position, contributed comparable or superior performance when compared with control athletes for 4 years after injury. Foot fracture reinjury rates were low (5%), with RTP metrics similar to those of athletes with primary foot fractures. These findings suggest that most professional European soccer players are able to RTP at elite levels while maintaining or improving performance after foot fractures.

The majority of foot fractures included in this investigation (52.3%) occurred in the metatarsals. Jones fractures are injuries to the fifth metatarsal and represent the most common fracture to the metatarsals, particularly in athletes.²⁸ Previous investigations of Jones fractures in high-level contact sport athletes have reported similar RTP rates of 85% to 100%.^{1,16,38} Ekstrand and van Dijk's⁴ previous epidemiologic investigation on fifth metatarsal fractures in elite European soccer players reported 38 cases from 2001 to 2012. These players are likely captured in our study. Because of poor blood supply, Jones fractures are often treated with operative management in active populations to mitigate risk of nonunion and accelerate RTP.^{31,34} While the timing of RTP after a Jones fracture remains controversial, rehabilitation recommendations consist of 7- to 10-week programs.³⁰ Of note, NFL player performance

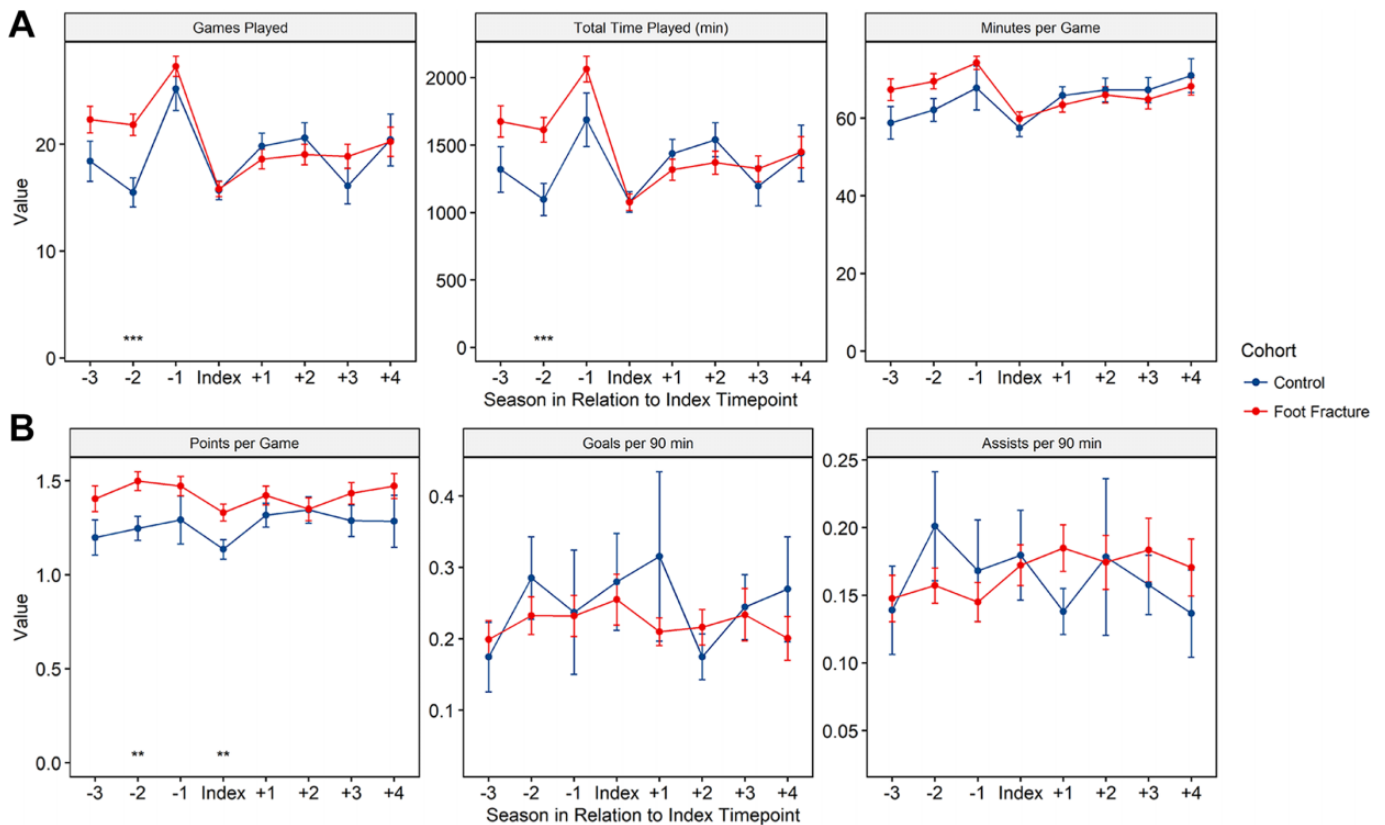


Figure 3. Comparison between groups of player performance and field time: (A) games played, total time played in minutes, and minutes per game; and (B) points per game, goals per 90 minutes, and assists per 90 minutes. Statistically significant differences between study groups: * $P < .05$, ** $P < .01$, *** $P < .001$.

was inferior in athletes who returned to play in less than 10 weeks after a Jones fracture compared with athletes returning after 10 weeks.²⁷ Begly et al¹ found that NBA players matched preinjury performance when returning to play after a Jones fracture, but timing of RTP was not reported. The present investigation found a median time to RTP of 72 days, or 10.2 weeks, after metatarsal fracture with no difference in performance of elite UEFA soccer players.

Phalangeal fractures represented 35.4% of injuries included in this investigation. Digital fractures most often result from direct trauma.^{15,36} Nonoperative treatment of phalangeal fractures yields satisfactory results, although professional athletes may opt for surgical intervention (internal fixation) to accelerate recovery.^{15,32} Current guidelines recommend 4 weeks of immobilization via buddy strapping or forefoot offloading, followed by a gradual return to activities.² A minimum of 4 weeks of rehabilitation before RTP is necessary to optimize healing and prevent chronic disability.³² These recommendations appear to be consistent with time to RTP in elite soccer players (30 days after phalangeal fracture). The strong performance metrics on RTP after foot fracture in the present study suggest that phalangeal fractures are associated with good outcomes in these professional athletes.

Although RTP rates were high in athletes sustaining a foot fracture, 20% of professional soccer players were unable to return to the same league level. While this is a significant proportion, it is imperative to note that RTP in this study was defined as players returning to play in the same league level who were selected for official games. As such, there is likely a proportion of players within this 20% that returned to play in lower-tiered leagues. Of note, career experience, field position, and baseline performance showed no significant association with RTP rates in this study, although players older than 30 years of age were less likely to return. The exact reason these athletes did not RTP is beyond the scope of this work; however, players older than 30 years may have been approaching the end of their careers before injury and chose to forgo a lengthy rehabilitation. Grassi et al's⁹ study of RTP after Achilles tendon rupture similarly identified age older than 30 years as a risk factor for reduced RTP rate in male professional soccer athletes. Similar to the present study, Grassi et al⁹ also found no differences in RTP based on field position.

Given increased league retention after foot fracture relative to uninjured controls ($P < .001$) and similar performance metrics on RTP, this investigation provides encouraging results for professional soccer players sustaining foot fractures. There are several possible explanations

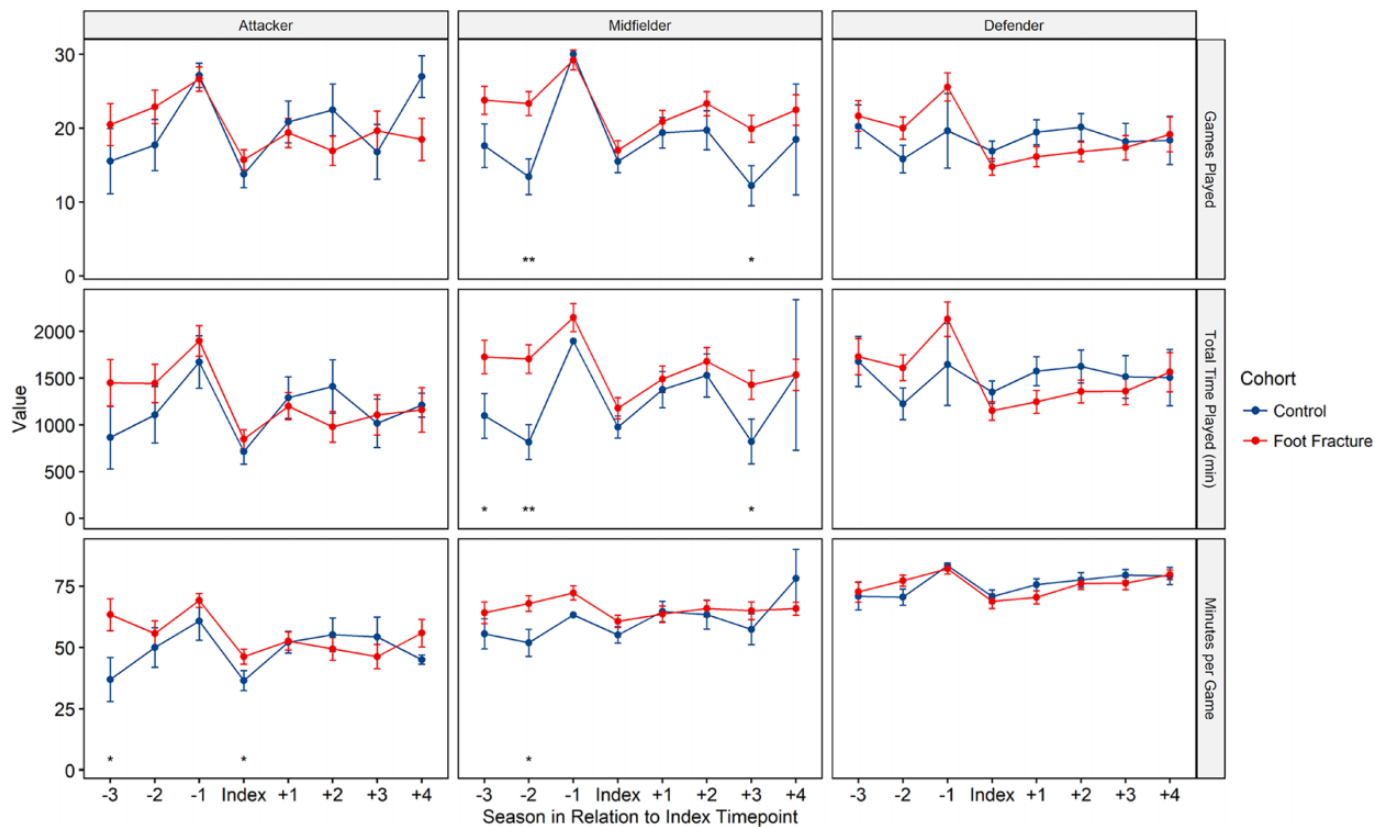


Figure 4. Comparison between groups of field time by player position. Statistically significant differences between study groups: * $P < .05$, ** $P < .01$, *** $P < .001$.

for greater career longevity in the foot fracture group compared with the control group, but this observation may be because of higher skill level, suggested by more playing time before injury. Ultimately, elite European soccer players demonstrated the ability to maintain career performance and continue skill development on RTP after foot fracture. Given the many demands on soccer players' feet, including running, tackling, dribbling, passing, and shooting, this study suggests that athletes heal well after foot fracture with rare reinjury.

Limitations

This study is not without limitations. Public data sources were used to generate the foot fracture player cohort. This lends the possibility of a selection bias toward players with publicly reported injuries while not fully capturing information on injuries that remain undisclosed to the public. This limitation is minimized in the context of investigating foot fractures because of the prolonged rehabilitation necessary after injury and thus low likelihood of a player's reason for absence remaining undisclosed to the public. Additionally, it was not possible to determine differences in treatment and rehabilitation between individual players without access to official medical record documentation. As such, players treated operatively likely sustained different fractures when compared with players treated

nonoperatively. Moreover, the presence of concurrent injuries was infrequently reported, prohibiting any meaningful analysis based on the presence of associated injuries. The fate of athletes who did not return to the same level of competition, along with the associated reasons for being unable to RTP, was also rarely reported. The impact of additional athlete-related and team-based variables on time lost, return-to-sport timing, and performance metrics in athletes sustaining foot fractures was not recorded and cannot be inferred based on the current data. The publicly available data were not specific enough to determine precise fracture location or origin (trauma vs stress) in every case, emphasizing the need for a centralized injury database for professional European soccer athletes to identify injuries and optimize their treatment more accurately.

Because of the inclusion criteria and the inherent limitations in utilizing public data sources, a relatively small cohort size of athletes was identified, potentially exposing the results reported in this investigation to beta error and emphasizing the need for further prospective study in professional European soccer athletes to identify correlations between athlete performance and foot fractures more accurately. Moreover, the findings from this investigation cannot be generalized to include nonelite soccer athletes. Last, the relatively small number of players competing in the 5 leagues included in the present study limited matching techniques to experience, year of play, height, and age, but

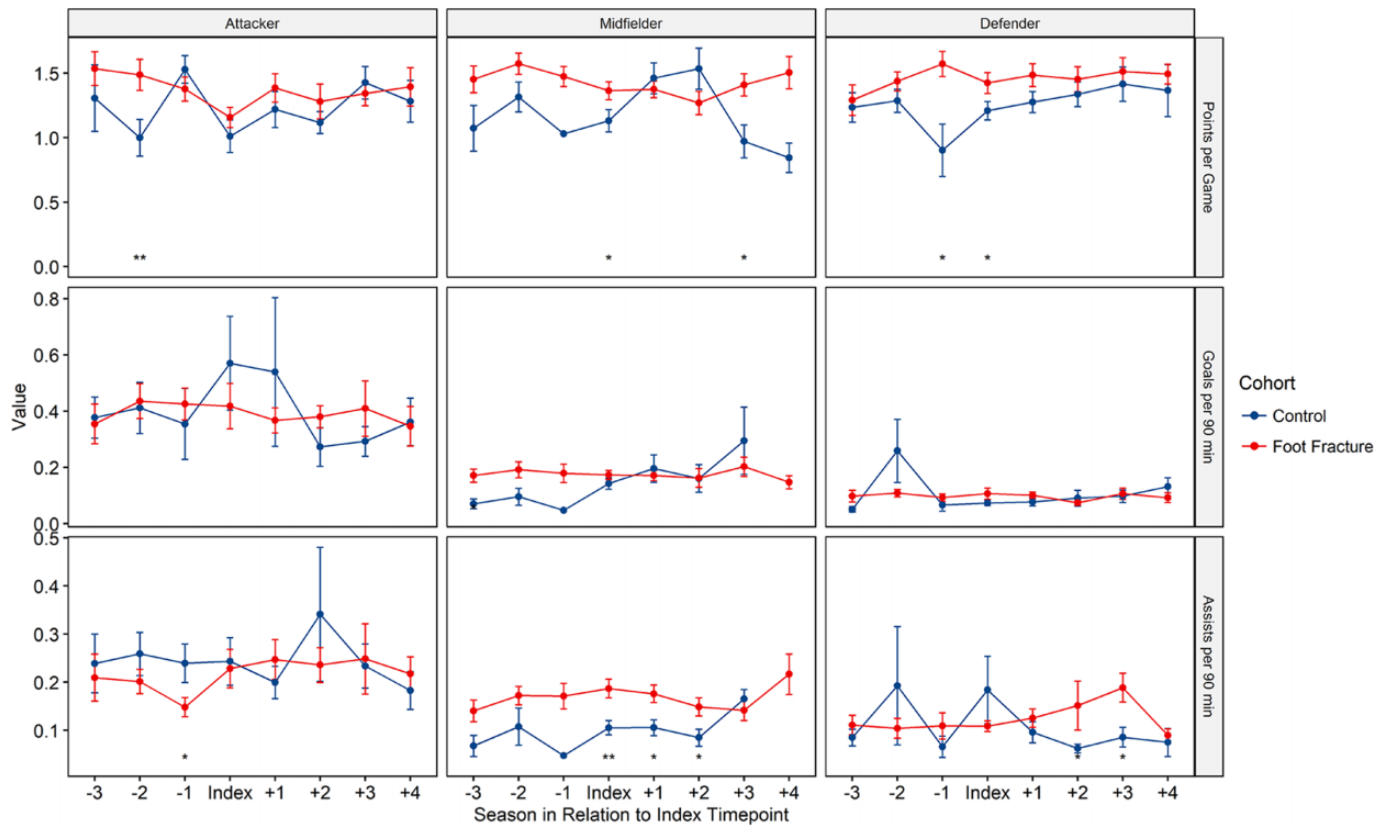


Figure 5. Comparison between groups of performance metrics by position. Statistically significant differences between study groups: * $P < .05$, ** $P < .01$, *** $P < .001$.

RTP and performance may be affected by contract status, fan popularity, and many other variables. Although uninjured controls played fewer minutes, which did not reach statistical significance, the difference may have limited players' opportunity to record goals, assists, and team points.

CONCLUSION

The study findings indicated that foot fractures in elite soccer players resulted in moderate loss of play time (69.41 days). RTP rates were high at 80%, although players aged older than 30 years were less likely to RTP. On RTP, athletes who sustained a foot fracture maintained performance similar to preinjury levels and uninjured controls.

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