

# Epidemiology and Outcomes of Ankle Injuries in the National Football League

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**Background:** Traumatic ankle injuries are commonly complicated by persistent symptoms and the development of chronic ankle instability.

**Purpose:** To describe the epidemiology of ankle injuries in the National Football League (NFL) and investigate the effects that ankle injuries have on performance metrics in the years after injury.

**Study Design:** Descriptive epidemiologic study.

**Methods:** Ankle injuries sustained by NFL players during the 2015-2016, 2016-2017, and 2017-2018 seasons were identified using the Pro Football Reference database. Cumulative incidence was calculated, and demographic identifiers were collected for each injury. The return-to-play (RTP) rate was also recorded. For each player who met inclusion for the performance analysis, power rating (PR) was calculated for the preinjury season (Y-1) and 2 postinjury seasons (Y+1 and Y+2) as follows:  $PR = (\text{offensive yards} / 10) + (\text{total touchdowns} \times 6) + (\text{combined tackles}) + (\text{sacks} \times 2) + (\text{interceptions} \times 2)$ . Mean PRs were calculated for each season as well as the percentage change and mean difference in PR between Y-1 and Y+1 ( $\Delta PR_1\%$ ,  $\Delta PR_1$ ) and between Y-1 and Y+2 ( $\Delta PR_2\%$ ,  $\Delta PR_2$ ). Subgroup analyses of PR were performed by player position, injury type, and years of experience.

**Results:** Overall, 668 ankle injuries were identified, with an average cumulative incidence across the 3 seasons of 11.2% and RTP rate of 91%. Of those injuries, 159 met inclusion criteria for the PR analysis. The mean overall PR (96.95 in Y-1) declined 22% in Y+1 to 76.10 (-20.85 [95% CI, -13.82 to -27.89];  $P < .001$ ) and 27% in Y+2 to 70.93 (-26.02 [95% CI, -18.04 to -34.00];  $P < .001$ ). The mean PR per game played (6.70 in Y-1) decreased 14% in Y+1 to 5.75 (-0.95 [95% CI, -0.56 to -1.34];  $P < .001$ ) and 17% in Y+2 to 5.54 (-1.16 [95% CI, -0.63 to -1.62];  $P < .001$ ).

**Conclusion:** It was found that ankle injuries hampered the performance of NFL players, even multiple years after the injury occurred, despite a relatively high RTP rate. There was a decrease in total games played after ankle injuries as well as a decreased performance output per game played.

**Keywords:** ankle injuries; ankle sprains; National Football League; return to play; power ratings

Ankle injuries are among the most frequently observed musculoskeletal injuries sustained during physical activity.<sup>10-12,19,27</sup> In the National Football League (NFL), lower extremity injuries, including ankle sprains and fractures, account for up to 60% of total injuries during a competitive season.<sup>16</sup> Furthermore, previous literature has demonstrated that ankle injuries are the most common injuries that occur in football players, with only knee injuries found to be more common in certain analyses.<sup>3,4,7,13,17,23</sup> Besides time lost because of injury, traumatic ankle injuries are commonly complicated by persistent pain, chronic instability, and games missed.<sup>2,19,25,26</sup>

Despite the high prevalence of ankle injuries that occur throughout an NFL season, there is currently a paucity of data regarding performance outcomes and return to play (RTP) after ankle injuries. The purpose of this study was to describe the epidemiology of ankle injuries in the NFL and to investigate the effects that ankle injuries have on performance metrics in the years after injury. We hypothesized that ankle injuries would result in a lasting impact on performance in the NFL as evidenced by a decrease in objective performance metrics in the years after injury.

## METHODS

### Data Collection

Ankle injuries sustained by NFL players during the 2015-2016 (2015), 2016-2017 (2016), 2017-2018 (2017)

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seasons were identified using the Pro Football Reference (<https://www.pro-football-reference.com>) database, which utilizes the official statistics partner of the NFL for data collection (Sportradar). The official NFL Injury Report is a league-mandated reporting system of all injuries and player availability statuses each week during the NFL season, and all ankle injury designations on the NFL Injury Report were captured using the aforementioned database.<sup>1</sup> Of 5963 NFL players during the 3 seasons studied, we identified 668 injuries and collected epidemiologic and demographic data on the injured players. Recurrent ankle injuries during each index season were common but not counted as an additional injury (eg, a player on the week 3 injury report who returned on week 5 and was then placed back on the injury report on week 10 of the same index season contributed only 1 ankle injury to the total count).

The total number of ankle injuries that occurred during each of the 3 index seasons was recorded. The total number of players in the NFL during each index season was calculated by summing the number of players who were a member of the active 53-man roster or practice squad of each team during any given point in the season. We removed duplicate players on different team rosters during our analysis. Cumulative incidence of ankle injury during each season was calculated using this information. Demographic identifiers collected for each injury included player age during the season of injury, years in the league when the injury occurred, experience category (rookie/early, 1-3 years; intermediate, 4-6 years; veteran,  $\geq 7$  years), player position, and ankle injury type (confirmed ankle sprain, confirmed ankle fracture, unspecified ankle injury). RTP was defined as whether the player returned for at least 1 snap of any single game in the NFL after the ankle injury. Position groupings included quarterback (QB); running back (RB); wide receiver and tight end (WR); defensive lineman (DL); linebacker (LB); defensive back (DB); offensive lineman (OL); and kickers, punters, and long snappers (ST). The mean age and years of experience during the season of injury were recorded. Experience category, player position, injury type, and RTP were recorded as counts and percentages.

From the 668 ankle injuries identified, 159 injuries met specific inclusion criteria and resulted in the formation of the 159-player performance analysis cohort. The preindex year was defined as Y-1, and postindex years 1 and 2 were defined as Y+1 and Y+2, respectively. We included injuries

that were sustained by players who started a minimum of 8 games in Y-1, returned to play after injury, and played at least 1 snap in both Y+1 and Y+2 after the ankle injury (ie, players did not retire, were not on injured reserve, or were not an unsigned free agent for the entirety of either season). All OL and ST injuries were excluded from the performance analysis. Finally, injuries occurring in players who already sustained an ankle injury that was included within the analysis from a previous index year were not included (ie, recurrent ankle injuries from distinct index seasons counted toward the total injury count, but only the first injury qualified for inclusion in the final performance analysis).

Data in the performance analysis were analyzed as a case series of NFL players after inclusion and exclusion criteria were applied. Power ratings (PRs) from Y-1, Y+1, and Y+2 were obtained for each player; performance statistics from the season of injury were not collected. Data from Y-1 served as the control sample and were compared with 2 data samples, each collected from a separate season postinjury (Y+1 and Y+2), creating a within-group analysis model to analyze the effects of ankle injury. Mean PRs were calculated for each season ( $PR_{Y-1}$ ,  $PR_{Y+1}$ ,  $PR_{Y+2}$ ), as were the percentage change and mean difference in PR between Y-1 and Y+1 ( $\Delta PR_1\%$ ,  $\Delta PR_1$ ) and between Y-1 and Y+2 ( $\Delta PR_2\%$ ,  $\Delta PR_2$ ). The median PR and interquartile range (IQR) were also calculated. The total number of games played for each player in the analysis was recorded for each season, which then allowed the calculation of PR per game played. PRs were calculated using combined offensive yards (passing, rushing, and receiving) and total touchdowns for offensive players, and total combined tackles, total sacks, and total interceptions for defensive players:

$$PR = (\text{combined offensive yards}/10) \\ + (\text{total touchdowns} \times 6) + (\text{total combined tackles}) \\ + (\text{total sacks} \times 2) + (\text{total interceptions} \times 2)$$

Previous studies have validated and utilized PRs as outcome measurements in NFL players.<sup>5,18,21,24</sup> Subgroup analyses of PR were performed on all offensive players (QB, RB, WR), all defensive players (DL, LB, DB), each individual position group, injury type (confirmed ankle sprains vs all ankle injuries), and experience category (early, intermediate, veteran).

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Ethical approval for this study was waived by Columbia University (protocol No. IRB-AAAT9884).

**TABLE 1**  
Demographics: All NFL Ankle Injuries, 2015-2017 Seasons<sup>a</sup>

Variable	Value
Total ankle injuries, no. of injuries/total no. players	668/5963 (11.2)
Age, y, mean	26.03
Years of experience, mean	3.29
Returned to play	611 (91)
Player position	
QB	11 (2)
RB	61 (9)
WR	129 (19)
OL	144 (22)
DL	102 (15)
LB	90 (13)
DB	127 (19)
ST	4 (1)
Injury type	
Sprain	344 (51)
Fracture	26 (4)
Unspecified	298 (45)
Experience category	
Rookie	113 (17)
Early	300 (45)
Intermediate	156 (23)
Veteran	99 (15)

<sup>a</sup>Values are reported as n (%) unless otherwise indicated. DB, defensive back; DL, defensive lineman; LB, linebacker; NFL, National Football League; OL, offensive lineman; QB, quarterback; RB, running back; ST, kickers, punters, and long snappers; WR, wide receiver and tight end.

### Statistical Analysis

Paired *t* tests were performed for all continuous outcome variables. Shapiro-Wilk tests were performed to analyze the distribution of continuous data sets, and Wilcoxon signed-rank tests were performed to analyze continuous outcome variables with nonnormal distributions. Chi-square or Fisher exact tests were performed for all categorical data, as appropriate. Two-tailed *P* values <.05 were deemed statistically significant. All analyses were performed with R Version 4.1.0 (R Foundation for Statistical Computation).

## RESULTS

### Epidemiologic Data

The 668 ankle injuries sustained by NFL players were distributed as 290, 172, and 206 in the 2015, 2016, and 2017 seasons, respectively. Analysis of individual team rosters revealed 1965, 2002, and 1996 total NFL players during the 2015, 2016, and 2017 seasons, respectively. Thus, the cumulative incidence of ankle injury from our analysis was 14.8% (290/1965) in 2015, 8.6% (172/2002) in 2016, and 10.3% (206/1996) in 2017, respectively, for an average

**TABLE 2**  
Demographics: Performance Analysis Cohort (N = 159 Players)<sup>a</sup>

Variable	Value
Age, y, mean	26.60
Years of experience, mean	4.16
Player position	
QB	5 (3)
RB	13 (8)
WR	38 (24)
DL	30 (19)
LB	26 (16)
DB	47 (30)
Injury type	
Sprain	100 (63)
Fracture	5 (3)
Unspecified	54 (34)
Experience category	
Early	83 (52)
Intermediate	49 (31)
Veteran	27 (17)

<sup>a</sup>Values are reported as n (%) unless otherwise indicated. 95% confidence interval values are provided in parentheses following each delta value. DB, defensive back; DL, defensive lineman; LB, linebacker; QB, quarterback; RB, running back; WR, wide receiver and tight end.

cumulative incidence of 11.2% (668/5963). In 91% of cases (n = 611 injuries), the athlete was able to RTP.

The mean age of the injured players was 26.03 years, and the mean years of experience was 3.29 years. The number of injuries by player position, experience category, and injury type can be found in Table 1.

The 57 (9%) injuries that resulted in the athlete's being unable to RTP were excluded from the performance analysis cohort. The 148 injuries sustained by OL and ST players were excluded from the performance analysis. Of the remaining 463 injuries, 251 were sustained by players who did not start at least 50% of the team's games in the Y-1 year (including rookies) and were therefore excluded. An additional 37 injuries were sustained by players who retired before Y+1 or Y+2; 3 were sustained by players who spent at least one full post-index season on injured reserve for a non-ankle injury; and 17 injuries were labeled as recurrent, as they involved players who sustained an ankle injury that was already included in the analysis (4 of these occurred in players who also retired during the study period). Thus, a total of 159 injuries sustained by 159 players were included in the final performance analysis group.

### Performance Analysis: Overall

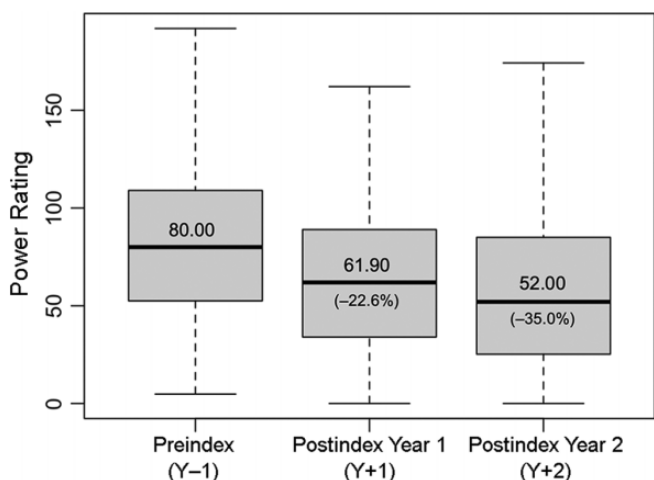
Of the 159 players included in the performance analysis, 56 (35%) were offensive players and 103 (65%) were defensive players. The number of players in the performance analysis by player position, experience category, and injury type can be found in Table 2. The mean PR<sub>Y-1</sub> for the entire performance analysis cohort was 96.95, and the mean

**TABLE 3**  
Overall Power Rating Analysis in Preindex Versus Postindex Seasons (N = 159 Players)<sup>a</sup>

	Preindex Year 1 (Y-1)	Postindex Year 1 (Y+1)	$\Delta PR1^b$	<i>P</i>	Postindex Year 2 (Y+2)	$\Delta PR2^b$	<i>P</i>
Power rating, overall							
Mean	96.95	76.10	-20.85 (-13.82 to -27.89)	<.001	70.93	-26.02 (95% CI, -18.04 to -34.00)	<.001
Median [IQR]	80.0 [52.5 to 109.0]	61.90 [34.0 to 89.0]			52.00 [25.25 to 85.00]		
Games played, mean	14.76	13.19	-1.57 (-0.93 to -2.20)	<.001	12.50	-2.26 (-1.51 to -3.02)	<.001
Power rating per game							
Mean	6.70	5.75	-0.95 (-0.56 to -1.34)	<.001	5.54	-1.16 (-0.63 to -1.62)	<.001
Median [IQR]	5.67 [3.60 to 7.45]	4.5 [2.82 to 6.46]			4.2 [2.40 to 5.48]		

<sup>a</sup>Bold *P* values indicate a statistically significant difference compared with Y-1 (*P* < .05). IQR, interquartile range.

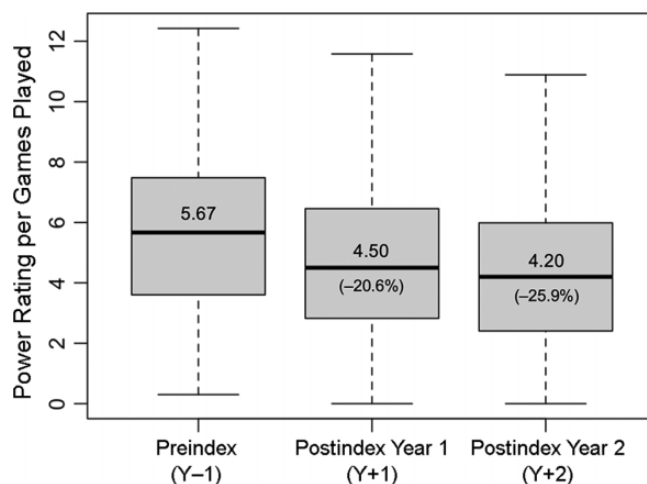
<sup>b</sup> $\Delta PR1$  represents the change in mean power rating from Y-1 to Y+1, and  $\Delta PR2$  represents the change in mean power rating from Y-1 to Y+2.



**Figure 1.** Overall power rating in the preindex year (Y-1), postindex year 1 (Y+1), and postindex year 2 (Y+2) for all National Football League players who sustained an ankle injury between the 2015 and 2017 seasons. The centerline of each box plot represents the median, with the upper and lower margins of the box defining the interquartile range. The whiskers represent the threshold for outlier values, and were set at a distance above and below the median value equal to 1.5 multiplied by the interquartile range. Percentage change from Y-1 is depicted in the Y+1 and Y+2 box plots.

$PR_{Y+1}$  and  $PR_{Y+2}$  for all players were 76.10 and 70.93, respectively. This represented a statistically significant decrease from  $PR_{Y-1}$  to  $PR_{Y+1}$  (-20.85 [95% CI, -13.82 to -27.89]; *P* < .001) as well as from  $PR_{Y-1}$  to  $PR_{Y+2}$  (-26.02 [95% CI, -18.04 to -34.00]; *P* < .001) (Table 3). Median values are shown in Figure 1.

The mean numbers of games played for all players were 14.76 for Y-1, 13.19 (-1.57; *P* < .001) for Y+1, and 12.50 (-2.26; *P* < .001) for Y+2. The mean PR per game played was 6.70 in Y-1; this decreased to 5.75 in Y+1 (-0.95 [95% CI, -0.56 to -1.34]; *P* < .001). There was also a statistically significant decrease between Y-1 and Y+2, with a



**Figure 2.** Power rating per game played in the preindex year (Y-1), postindex year 1 (Y+1), and postindex year 2 (Y+2) for all National Football League players who sustained an ankle injury between the 2015 and 2017 seasons. The centerline of each box plot represents the median, with the upper and lower margins of the box defining the interquartile range. The whiskers represent the threshold for outlier values, and were set at a distance above and below the median value equal to 1.5 multiplied by the interquartile range. Percentage change from Y-1 is depicted in the Y+1 and Y+2 box plots.

mean PR per game played of 5.54 in Y+2 (-1.16 [95% CI, -0.63 to -1.62]; *P* < .001) (Table 3). Median values are shown in Figure 2.

#### Performance Analysis: By Player Position

The performance analysis by player position can be found in Table 4. When evaluating only the offensive players, the mean decrease between  $PR_{Y-1}$  and  $PR_{Y+1}$  was -31.22 (22%; *P* < .001), and the mean decrease between  $PR_{Y-1}$  and  $PR_{Y+2}$  was -35.31 (25%; *P* < .001). The mean decreases observed within the defensive player subgroup were -15.21 (21%;

TABLE 4  
Subgroup Power Rating Analysis in Preindex Versus Postindex Seasons<sup>a</sup>

	Preindex (Y-1)	Postindex Year 1 (Y+1)	$\Delta$ PR1 <sup>b</sup> (95% CI)	P	Postindex Year 2 (Y+2)	$\Delta$ PR2 <sup>b</sup> (95% CI)	P
Power rating by position							
Offense (n = 56)	143.66	112.44	-31.22 (-14.51 to -47.93)	<.001	108.35	-35.31 (-16.64 to -53.99)	<.001
QB (n = 5)	503.76	427.86	-75.90 (45.53 to -197.33)	.158	472.42	-31.34 (138.74 to -201.42)	.636
RB (n = 13)	136.67	94.21	-42.46 (0.83 to -85.75)	.054	73.10	-63.57 (-23.91 to -103.23)	.004
WR (n = 38)	98.67	77.17	-21.5 (-4.49 to -38.51)	.015	72.50	-26.17 (-6.91 to -45.43)	.009
Defense (n = 103)	71.55	56.34	-15.21 (-9.24 to -21.18)	<.001	50.58	-20.97 (-13.86 to -28.08)	<.001
DL (n = 30)	45.37	37.63	-7.73 (-0.40 to -15.07)	.040	37.07	-8.30 (0.00 to -16.60)	.050
LB (n = 26)	95.88	65.12	-30.77 (-13.23 to -48.31)	.001	63.42	-32.46 (-14.26 to -50.67)	.001
DB (n = 47)	74.81	63.42	-11.38 (-4.13 to -18.64)	.003	52.70	-22.70 (-11.96 to -33.44)	<.001
Power rating by injury type							
Sprain (n = 100)	101.43	75.84	-25.59 (-16.08 to -35.10)	<.001	74.47	-26.95 (-15.89 to -38.02)	<.001
Fracture (n = 5)	272.70	232.34	-40.36 (59.91 to -140.63)	.326	206.58	-66.12 (-15.48 to -116.76)	.022
Unspecified (n = 54)	72.38	62.11	-10.27 (-1.50 to -19.05)	.023	51.80	-20.59 (-9.61 to -31.56)	<.001
Power rating by experience category							
Early (n = 83)	93.53	70.95	-22.58 (-12.36 to 32.80)	<.001	68.40	-25.13 (-14.44 to -35.82)	<.001
Intermediate (n = 49)	78.76	65.09	-13.67 (-3.9 to -23.45)	.007	54.28	-24.48 (-12.36 to -36.60)	<.001
Veteran (n = 27)	140.46	111.90	-28.56 (-6.76 to -50.37)	.012	108.91	-31.55 (-3.93 to -59.18)	.027

<sup>a</sup>Bold P values indicate a statistically significant difference compared with Y-1 (P < .05). DB, defensive back; DL, defensive lineman; LB, linebacker; QB, quarterback; RB, running back; WR, wide receiver and tight end.

<sup>b</sup> $\Delta$ PR1 represents the change in mean power rating from Y-1 to Y+1, and  $\Delta$ PR2 represents the change in mean power rating from Y-1 to Y+2.

P < .001) between PR<sub>Y-1</sub> and PR<sub>Y+1</sub> and -20.97 (29%; P < .001) between PR<sub>Y-1</sub> and PR<sub>Y+2</sub>.

A comparison of preindex and postindex year performance between each player position was also performed (Table 4). Statistical significance was not reached in the QB cohort when comparing the mean decrease between PR<sub>Y-1</sub> and PR<sub>Y+1</sub> (-75.90; 15%; P = .158) or between PR<sub>Y-1</sub> and PR<sub>Y+2</sub> (-31.34; 6%; P = .636). All other positions revealed statistically significant decreases in PR between the preindex and at least 1 of the postindex seasons, with only the changes in the RB cohort from Y-1 to Y+1 (PR<sub>Y-1</sub> = 136.67, PR<sub>Y+1</sub> = 94.21; P = .054) and the DL from Y-1 to Y+2 (PR<sub>Y-1</sub> = 45.37, PR<sub>Y+2</sub> = 37.07; P = .050) falling short of statistical significance.

### Performance Analysis: By Injury Type

PR was also analyzed by injury type (Table 4). In the 100 confirmed ankle sprains, PR<sub>Y-1</sub> was 101.43, with a 25% decrease to 75.84 (-25.59; P < .001) in Y+1 and a 27% decrease to 74.47 (-26.95; P < .001) in Y+2. When evaluating the 5 confirmed ankle fractures, the PR<sub>Y-1</sub> of 272.70 decreased 15% to 232.34 (-40.36; P = .326) in Y+1 and decreased 24% to 206.58 (-66.12; P = .022) in Y+2. Finally, the unspecified ankle injury group had a PR<sub>Y-1</sub> of 72.38, which decreased 14% to 62.11 (-10.27; P = .023) in Y+1 and decreased 28% to 51.80 (-20.59; P < .001) in Y+2.

### Performance Analysis: By Experience Category

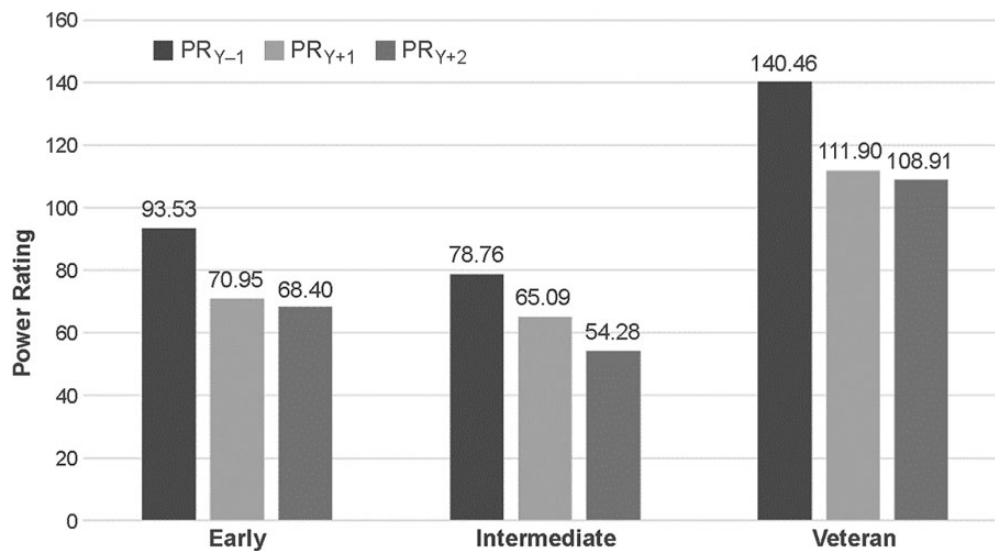
Statistically significant decreases in PR were seen across all experience categories (Table 4 and Figure 3). In the

early group, PR<sub>Y-1</sub> (93.53) decreased 24% to 70.95 by Y+1 (-22.58; P < .001) and decreased 27% to 68.40 by Y+2 (-25.13; P < .001). Among the players in the intermediate group, PR<sub>Y-1</sub> (78.76) decreased 17% to 65.09 by Y+1 (-13.67; P = .007) and 31% to 54.28 by Y+2 (-24.48; P < .001). The same effect was also seen in the veteran group, with PR<sub>Y-1</sub> (140.46) decreasing 20% to 111.90 by Y+1 (-28.56; P = .012) and 22% to 108.91 by Y+2 (-31.55; P = .027).

## DISCUSSION

In our analysis, the average cumulative incidence of ankle injury in all NFL players was 11.2% over the 3 seasons. Mack et al<sup>16</sup> showed an average incidence rate of 13.6% ankle injuries per player-season. This is expectedly higher than the cumulative incidence identified in the present study, as cumulative incidence does not increase with recurrent injuries sustained by the same player. However, incidence rate does. An analysis of NFL Injury Reports performed by Bedard et al<sup>3</sup> determined that 1485 (14%) of the 10,934 injuries that occurred in the NFL between 2012 and 2016 were ankle injuries. Ultimately, it is evident that ankle injuries afflict a significant proportion of NFL players each year. The true prevalence and incidence of ankle injuries is likely even higher when taking into account the underreported nature of any injury in the NFL.

A recent epidemiological study by DeFroda et al<sup>8</sup> demonstrated an RTP percentage of 89.7% for all NFL players who sustained a high ankle sprain from the 2009-2010 season to the 2019-2020 season. The mean time to RTP was 80.5 ±



**Figure 3.** Mean power rating (PR) per game played in the preindex year (Y-1), postindex year 1 (Y+1), and postindex year 2 (Y+2), stratified by experience category: early (1-3 years), intermediate (4-6 years), and veteran ( $\geq 7$  years).

132.9 days. When analyzing only players who were treated nonoperatively, Osbahr et al<sup>20</sup> reported RTP in 15.4 days and 6.5 days after syndesmotic and lateral ankle sprains, respectively. Recurrent ankle sprains or improper rehabilitation can lead to long-term ankle instability in up to 70% of individuals.<sup>6,11</sup> Players with recurrent instability may eventually be forced to retire from the NFL, despite initially returning to play after injury.

Our analysis demonstrated a 91% RTP for all ankle injuries, with the definition of playing at least 1 snap in any 1 subsequent NFL game. This number exceeds RTP statistics for many other common lower extremity injuries in the NFL. Regarding other injuries, anterior cruciate ligament injuries in RBs and wide receivers resulted in a 79% RTP, at an average of 55.8 weeks after injury.<sup>5</sup> Tran et al<sup>24</sup> investigated 24 NFL players who sustained a turf-toe injury between 2010 and 2015, demonstrating that 75% returned to play during the same season at a median time of 28 days; the overall RTP by our definition was not reported. Achilles ruptures in NFL players were examined by Parekh et al,<sup>21</sup> who identified 31 Achilles tendon ruptures from 1997 to 2002, with only 68% achieving RTP at an average of 11 months postinjury. Thus, the current literature, along with the present study, suggests that ankle injuries are relatively less debilitating than other lower extremity injuries with regard to RTP rates.

Paramount to the success of many players in the NFL are speed and agility, attributes that can be directly affected by ankle pain, weakness, and instability after an ankle injury.<sup>22</sup> The detriment that ankle injuries have on performance may be exaggerated in today's NFL as players continue to become faster and more agile as a collective. In a study evaluating NFL Combine results from 1999-2000 to 2015-2016, Fitzgerald and Jensen<sup>9</sup> found significant improvements in the 40-yard dash ( $P = .002$ ), vertical jump ( $P = .028$ ), broad jump ( $P < .001$ ), and 3-cone drill

( $P < .001$ ). Furthermore, an article by Krause<sup>15</sup> demonstrated that the 40-yard dash was a direct predictor of draft success for NFL players, with wide receivers who ran faster than 1 SD below the mean being drafted 93% of the time, while wide receivers 1 SD above were only drafted 25% of the time. This trend was also seen in the RB position group, with 85% of players drafted versus 30% of players drafted at 1 SD below the mean and 1 SD above the mean, respectively.

When compared with the preinjury season, there was a mean decrease in PR of 22% during the first postinjury season, and a mean decrease of 27% during the second postinjury season in all NFL players, demonstrating a significant and lasting decline in performance after ankle injuries. Furthermore, negative effect sizes in PR were identified in each subgroup, with PR decreases seen in each individual player group, each injury type, and each experience category. Several highlights from these data are worth noting regarding player position. When evaluating all offensive players and all defensive players separately, a comparable decline in performance was seen in both groups in both postinjury seasons. Some specific positions, however, seemed to be more heavily affected by ankle injuries than others. RBs showed the greatest decrease in PR after ankle injuries, with  $\Delta PR_1\% = -31\%$  and  $\Delta PR_2\% = -47\%$ . LBs, WRs, and DBs also showed large decreases, while DL ( $\Delta PR_1\% = -17\%$ ,  $\Delta PR_2\% = -18\%$ ) and QB ( $\Delta PR_1\% = -15\%$ ,  $\Delta PR_2\% = -6\%$ ) showed more modest decreases (Table 4).

The relative effect sizes demonstrated by these data may be the result of the differing values of attributes such as speed and agility on each position group. RBs, for example, rely heavily on the ability to elude tacklers and sprint through running lanes in order to be successful in the NFL. WRs benefit from speed and agility to create separation from defenders while running routes and, similar to RBs, evading tacklers after making receptions. LBs and DBs also

must possess elite speed and agility to match the athleticism of the players they are defending against. It is thus unsurprising that these 4 position groups showed the largest declines in PR after sustaining ankle injuries. DLs also certainly benefit from elite speed and agility, but these players also rely heavily on strength to overpower offensive blockers, which is likely less directly affected by ankle injuries. While the lack of speed and agility can still hamper the play of a QB because of decreased pocket mobility and decreased efficacy in advancing the ball as a rusher, these attributes are less critical to the success of a QB than to an offensive skills player (RB, WR) or defensive player. Furthermore, QBs rely heavily on throwing velocity, accuracy, and decision making for elite performance, which are less likely to be overtly affected by ankle injuries. This was the only position group to have no statistically significant decline in PR in either of the postinjury seasons despite still showing a negative effect size ( $\Delta PR_1 = -75.9$ ,  $P = .158$ ;  $\Delta PR_2 = -31.34$ ,  $P = .636$ ). The lack of statistical significance may also have been because this subgroup is underpowered, with only 5 QBs in the analysis.

Two additional analyses provide further insights into the impact of ankle injuries on NFL players. The first is evaluating PR by experience category. Many players experience age-related decline in speed, agility, strength, and other important attributes that are unrelated to injury. Thus, it is possible that the decline in performance seen in Y+1 and Y+2 occurred as a result of aging rather than the ankle injury itself. To examine this, we evaluated the PR changes in 3 experience categories (early, intermediate, and veteran) and found statistically significant declines in performance in all 3 groups for each of the postinjury seasons. In fact, the percentage PR decreases in the early group ( $\Delta PR_1\% = -24\%$ ;  $\% \Delta PR_2 = -27\%$ ) were slightly larger than those in the veteran group ( $\Delta PR_1\% = -20\%$ ;  $\Delta PR_2\% = -22\%$ ). Of note, the  $PR_{Y-1}$  in the veteran group (140.46) was much higher than the overall  $PR_{Y-1}$  (96.95) or the early-group  $PR_{Y-1}$  (93.53). This improved baseline performance may be explained primarily by the fact that the majority of the QB group (60%), which had a  $PR_{Y-1}$  of 503.76, fell within the veteran experience category. This also may have been due to an increased relative level of success achieved by this group to have surpassed the mean NFL career length of 3.3 years.<sup>14</sup>

The final relevant analysis of these data was to evaluate PR per game played. A significant proportion of the injury burden of any injury results from the games missed because of injury. There was a statistically significant decline in the mean number of games played from Y-1 (14.76) to the mean numbers of games played in both Y+1 (13.19;  $P < .001$ ) and Y+2 (12.50;  $P < .001$ ), which likely contributed significantly to the decline in PR. We aimed to understand whether NFL players, even if they were able to continue participating in games, also had a lower performance output *within* each game. To examine this question, we calculated PR per game played. The mean PR per game played in Y-1 was 6.70, while the mean PRs per game played in Y+1 and Y+2 were 5.75 and 5.54, respectively. This represented statistically significant decreases in PR per game played in both the Y+1 ( $-14\%$ ;  $-0.95$ ;  $P < .001$ ) and Y+2 ( $-17\%$ ;  $-1.16$ ;

$P < .001$ ) seasons. Thus, not only did players play in fewer games as a result of their ankle injuries, but they also contributed a decreased statistical performance on average in each game they played in both postinjury seasons. This may be explained by the deleterious effects that ankle injuries have on key attributes, such as speed and agility, preventing maximal performance output. It also may be explained by decreased playing time awarded within each game because of the perceived or actual inability to perform at as high a level as other players on the roster. Of note, this decline was not as severe as the 34% decline in PR identified after anterior cruciate ligament injury (mean PR per game played in preinjury seasons, 9.9; mean PR per game played in postinjury seasons, 6.5).<sup>5</sup>

### Limitations

One limitation of this study was that all injuries of the ankle, except Achilles tendon injuries, were included in this study and primarily analyzed as a single group. While some injuries were specified as ankle sprains or ankle fractures, many were unspecified. Use of the NFL electronic health record may allow more detailed identification of each specific ankle injury pattern in addition to allowing comparisons to be made regarding performance and RTP rates between operative and nonoperative management of these injuries. The data nonetheless were sourced from official NFL injury reports and thus provided reliable answers to our clinical questions. Further, the subgroup analysis of the 100 confirmed ankle sprains in the present study provides strong data regarding the deleterious effects of this specific category of injury.

Another possible limitation is that additional nonankle injuries may have affected performance in the postindex seasons. While other injuries may have occurred in the index year or subsequent years and affected subsequent performance, the same may have occurred in Y-1 and the years prior. Thus, it is unlikely that this resulted in a significant effect on the comparisons drawn in this analysis with a relatively large cohort.

Additionally, data were not reported on the number of games missed because of the injury. Viewing the number of missed games as a surrogate for injury severity may be misleading, however, because the severity of an injury occurring closer to the end of the index season, with fewer games available to miss, may be underestimated. Additionally, it is not feasible to identify the specific cause of each individual game missed over a multiple-year span with a cohort of this size. The authors believe that PR effectively encapsulates the burden of injury.

Finally, the use of NFL injury reports for this analysis may have resulted in an overall underestimation of ankle injury cumulative incidence. League-mandated NFL injury reports are intended to promote credible and timely reporting of injury by each team, and failure to do so is punishable by fine, suspension of personnel, or loss of rights to draft picks in future seasons.<sup>1</sup> Nonetheless, athletes are apt to play through injury, and as a result, it is likely that some proportion of ankle injuries are not captured on the injury report or in this analysis.

## CONCLUSION

Ankle injuries hamper the performance of NFL players, even multiple years after the injury occurs, despite a relatively high RTP rate. We identified a decrease in total games played after ankle injuries as well as a decreased performance output per game played.

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