Original Article

The Injury Rate in National Football League Players Increased Following Cancellation of Preseason Games Because of COVID-19

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Purpose: To investigate the injury rate in National Football League (NFL) athletes during the first 4 weeks of the 2020 NFL season. **Methods:** This study was a retrospective review of all NFL players who were placed on the injury report during the preseason and the first 4 weeks of the regular season from the 2016-2017 through the 2020-2021 NFL regular seasons. Players' dates of injury were cross-referenced with an absence of statistics from the respective games for which they were ruled out so as to ensure accuracy. Injury rates were calculated per 1,000 athletic exposures. Relative risk with 95% confidence intervals compared injury rates between the 2 cohorts. **Results:** Over the course of the study period of 4 NFL seasons, 3,025 injuries were reported. Of the 3,025 injuries reported, 582 (19%) occurred during weeks 1-4 of the 2020-2021 regular season, whereas 1,292 (53%) occurred during preseason weeks 1-4, and 1,151 (38%) occurred during regular-season weeks 1-4 of NFL seasons 2016-2017, 2018-2019, and 2019-2020. There was a significant increase in the injury rate during weeks 1-4 of the 2020-2021 regular season for all comparisons with the injury rate both during the preseasons and the regular seasons of 3 recent past NFL seasons. **Conclusions:** The rate of injury in NFL players during weeks 1-4 of the 2020-2021 regular seasons was significantly higher than during 3 recent past NFL preseasons and regular seasons. **Level of Evidence:** Level IV, diagnostic case series.

Because of the rising number of positive Covid-19 tests observed in National Football League (NFL) players during the summer of 2020, the NFL suspended the 2020 preseason on July 21, 2020.[1] Suspension of play based on concern regarding rising numbers of cases of Covid-19 in the United States was widespread and not limited to the NFL; similar trends were observed across all sports and levels, including high school, collegiate and professional levels. To mitigate potential exposures to Covid-19, NFL team training camp roster sizes were limited to 80 players.[1] Typically, the NFL preseason serves as the primary time for preparing athletes for the rigors of the upcoming NFL season. However, given this unprecedented stoppage of preseason training and teams' inability to continue with practice and games due to social-distancing precautions, athletes were forced to train and condition on their own. We speculated that in the absence of organized team activities, athletes developed sports deconditioning.

Previous studies have demonstrated that fatigue and deconditioning may place athletes at a higher risk for injury. The International Olympic Committee identified absolute load, calendar congestion and psychological load to be closely associated with injury risk through a variety of mechanisms.[2] Excessive training that exceeds the body's loadbearing capacity causes microtrauma to tendons, muscles and bones and is the cause of overuse injuries.[3-8]

In light of these findings that highlight the association between fatigue and risk of injury, investigating modifiable causes influencing athletes' levels of fatigue is a critical step in reducing risk of injury. The purpose of this study was to investigate the injury rate in NFL athletes during the first 4 weeks of the 2020 NFL

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Table 1. National Football League Injuries During Preseason and Regular Seasons Weeks 1-4 From 2016-2020

	Year			
Week	2016	2018	2019	2020
Preseason week 1	63	176	95	Canceled
Preseason week 2	77	138	228	Canceled
Preseason week 3	112	120	102	Canceled
Preseason week 4	47	97	37	Canceled
Preseason Total	299 (42%)	531 (57%)	462 (58%)	0
Regular season week 1	48	100	76	141
Regular season week 2	177	95	93	159
Regular season week 3	99	94	74	136
Regular season week 4	89	111	95	146
Regular season total	413 (58%)	400 (43%)	338 (42%)	582
Total	712	931	800	582

season. Our hypothesis was that the observed injury rate during the first month of the 2020-2021 NFL season would be significantly higher when compared to past seasons.

Methods

Data Collection

This study was a retrospective review of all NFL players who were placed on the injury report during the preseason and the first 4 weeks of the regular season from the 2016-2017 through the 2020-2021 regular NFL seasons. The data were compiled using publicly available injury reports (Appendix). The sources used publish a weekly injury reports detailing the names of the players injured, their teams and a brief description of each injury. At least 2 different sources were used to cross-reference injury information. To verify each player's date of injury, we confirmed that each player's reported injury date corresponded to an absence of statistics from the respective games for which he was ruled out. These methods are in accordance with previously published protocols.[9-13] When collecting data, we noted that the 2017-2018 records were incomplete, so we excluded them from the study. We thought that data from 3 recent past seasons were adequate to compare data from 2020.

Team records available for individual team websites were used to collect demographic information. Our dataset included each player's name, position, team, pathology, age at injury, date of injury, and season. Data for the 2020 season were collected prospectively, so we were unable to determine games missed due to injury because the 2020 NFL season was ongoing when this study was performed.

Definitions

Reportable injuries were based on the following criteria: that the injury necessitated a team physician's referral or emergent care and that it resulted in missed athletic activity. An athlete-exposure (AE) was defined as 1 athlete's participation in 1 game in which he was exposed to potential injury.

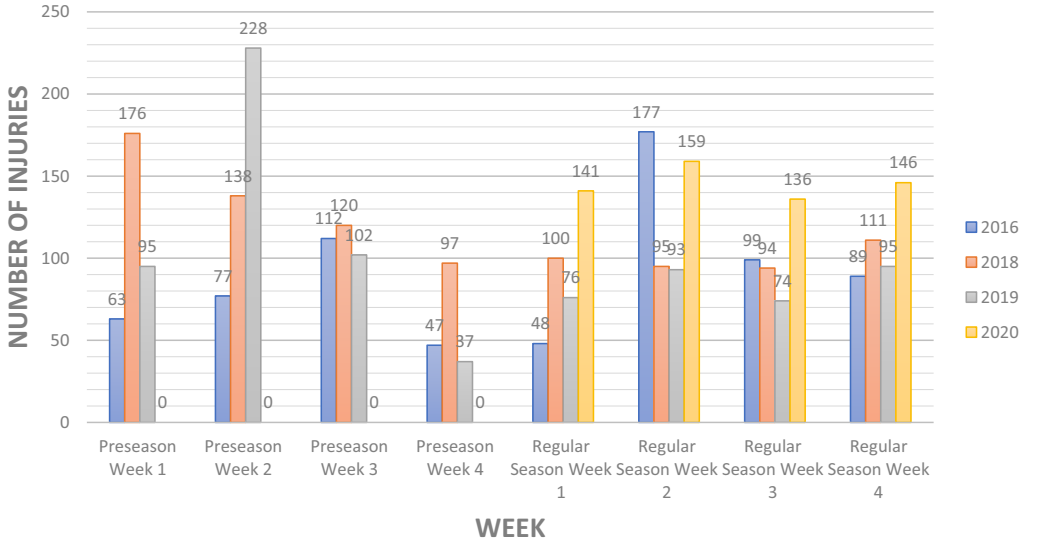

Fig 1. National Football League injures during preseason and regular seasons weeks 1-4 from 2016-2020.

Table 2. National Football League Injuries per Athlete Exposure During Preseason and Regular Seasons Weeks 1-4 From 2016-2020

	Injuries per 1000 Athletic Exposure			
	2016-2019	2020	Relative risk Ratio	*P* Value
Preseason week 1	2.4	Canceled	2.14	0.001
Preseason week 2	3.2	Canceled	1.82	0.001
Preseason week 3	2.4	Canceled	2.07	0.001
Preseason week 4	1.9	Canceled	4.09	0.001
Regular season week 1	2.8	5.2	1.88	0.01
Regular season week 2	4.5	5.9	1.31	0.01
Regular season week 3	3.3	5.0	1.53	0.01
Regular season week 4	3.6	5.4	1.48	0.01

Data and Statistical Analysis

Data analysis was conducted using SPSS 25 (SPSS, Chicago, IL). Injury rates were calculated per 1,000 AEs using the following calculations: for the first 3 preseason games where NFL teams carry 90 players on the roster (total number of injuries × 1,000/total number of AEs (AEs = 90 players * 32 NFL teams * number of games)); for the fourth preseason game, where NFL teams cut the roster to 75 players (total number of injuries × 1,000/total number of AEs (AEs = 75 players * 32 NFL teams * number of games)); and for the regular-season games (total number of injuries × 1,000/total number of AEs (AEs = 53 players * 32 NFL teams * number of games)). Risk ratio with 95% confidence intervals (CIs) compared injury rates between the 2 cohorts. Risk ratios were calculated by comparing both weeks 1-4 from the preseason and the regular NFL seasons in 2016-2017, 2018-2019 and 2019-2020 to the 2020-2021 season. Week 1 of the 2020-2021 NFL season was compared to both past preseason and regular-season week 1; this method of comparison was continued for weeks 2-4. Continuous variables were statistically compared using a 2-tailed *t* test, whereas categorical variables were compared using the χ^2 test. Statistical significance was set at $p \leq 0.05$.

Results

Over the course of the study period of 4 NFL seasons, 3,025 injuries were reported. Of those, 582 (19%) occurred during weeks 1-4 of the 2020-2021 regular season, while 1,292 (53%) occurred during preseason weeks 1-4, and 1,151 (38%) occurred during regular-season weeks 1-4 of NFL seasons 2016-2017, 2018-2019 and 2019-2020 (Table 1) (Fig 1). There was a significant increase in the injury rate during weeks 1-4 of the 2020-2021 regular season for all comparisons with the injury rate, both during the preseason and the regular season of the 3 recently past NFL seasons (Table 2).

Positional breakdowns demonstrated that wide receivers, safeties and linebackers sustained the most injuries during the study period (Table 3). Most of the reported injuries were to the knee 473 (16%), hip/groin 347 (11%) or ankle 316 (10%) (Table 4). The majority of injuries occurred secondary to player contact: 2,151 (71%). Undisclosed injuries identified numbered 343 (11%).

Discussion

The most important finding of this study was that the injury rate during weeks 1-4 of the 2020-2021 NFL season was significantly higher than the injury rates during weeks 1-4 of the 2016-2017, 2018-2019 and 2019-2020 NFL preseasons and regular seasons. The findings of our study confirmed our hypothesis that players were at a higher risk of injury during the early 2020-2021 regular season following cancellation of preseason games due to Covid-19. Our findings highlight the importance of the NFL training camp in preparing NFL athletes for the rigors of the NFL regular season and its influence on injury prevention.

Similar to the findings of Feeley et al.[14] and Elliott et al.,[15] we observed that more injuries occurred during the first 2 weeks of the NFL preseason (777) (60%)

Table 3. Positional Breakdown of Injuries

Positional Breakdown					
Offense (quarterback)	2016	2018	2019	2020	Total
Quarterback	22	20	22	9	73
Runningback	65	97	88	45	295
Wide receiver	97	138	102	95	432
Tight end	62	64	66	34	226
Center	14	20	14	9	57
Offensive tackle	41	83	62	52	238
Guard	29	43	28	30	130
Fullback	0	2	5	3	10
Defense	2016	2018	2019	2020	Total
Defensive tackle	90	54	95	39	278
Defensive end	23	63	40	47	173
Linebacker	103	119	102	79	403
Cornerback	44	77	62	77	260
Safety	117	139	108	56	420
Special teams	2016	2018	2019	2020	Total
Kicker	4	12	5	6	27
Long snapper	0	0	1	1	2

Table 4. Injuries in National Football League Games by Season, Anatomic Site and Injury Mechanism

Season and Anatomic site	Number of Injuries (per 1000 AEs)				Injuries per 1000 AEs
	Contact	Noncontact	Overuse	Total	
Weeks 1-4 of 2016-2017 Preseason and Regular Season					
Hip/groin	19	2	110	131	0.46
Upper Leg/thigh	21	1	2	22	0.08
Knee	117	0	0	117	0.41
Lower leg/Achilles	11	9	24	44	0.15
Ankle	83	0	0	83	0.29
Foot/toes	28	0	0	28	0.10
Back	28	0	0	28	0.10
Biceps	0	0	0	0	0.00
Rib Fracture	11	0	0	11	0.04
Collarbone	1	0	0	1	0.00
Concussion	61	0	0	61	0.21
Elbow	15	0	0	15	0.05
Finger	1	0	0	1	0.00
Hand	22	0	0	22	0.08
Illness	0	6	0	6	0.02
Neck	9	0	0	9	0.03
Pectoralis Major	2	7	0	9	0.03
Toe	9	0	0	9	0.03
Shoulder	60	0	0	60	0.21
Sports Hernia	0	0	0	0	0.00
Triceps	3	0	0	3	0.01
Undisclosed	50	0	0	50	0.18
Total	551	25	136	712	2.50

Season and Anatomic site	Number of Injuries (Injuries per 1000 AEs)				Injuries per 1000 AEs
	Contact	Noncontact	Overuse	Total	
Weeks 1-4 of 2018-2019 preseason and regular season					
Hip/groin	24	50	9	83	0.29
Upper leg/thigh	0	12	109	121	0.42
Knee	159	0	0	159	0.56
Lower leg/Achilles	23	6	18	47	0.16
Ankle	94	0	0	94	0.33
Foot/toes	46	0	0	46	0.16
Back	0	21	0	21	0.07
Biceps	0	2	0	2	0.01
Rib fracture	13	0	0	13	0.05
Collarbone	0	0	0	0	0.00
Concussion	63	0	0	63	0.22
Elbow	14	0	0	14	0.05
Finger	6	5	0	11	0.04
Hand	16	0	0	16	0.06
Illness	0	16	0	16	0.06
Neck	7	0	0	7	0.02
Pectoralis major	6	0	0	6	0.02
Toe	10	0	0	10	0.04
Shoulder	63	0	0	63	0.22
Sports hernia	0	0	0	0	0.00
Triceps	0	3	0	3	0.01
Forearm	4	0	0	4	0.01
Undisclosed	132	0	0	132	0.46
Total	680	115	136	931	3.26

Season and Anatomic site	Number of Injuries (Injuries per 1000 AEs)				Injuries per 1000 AEs
	Contact	Noncontact	Overuse	Total	
Weeks 1-4 of 2019-2020 preseason and regular season					
Hip/groin	20	22	22	64	0.22
Upper leg/thigh	13	39	40	92	0.32
Knee	108	0	0	108	0.38

(continued)

Table 4. Continued

Season and Anatomic site	Number of Injuries (Injuries per 1000 AEs)				Injuries per 1000 AEs
	Contact	Noncontact	Overuse	Total	
Lower leg/Achilles	21	26	0	47	0.16
Ankle	81	0	0	81	0.28
Foot/toes	37	0	0	37	0.13
Back	0	23	0	23	0.08
Biceps	0	3	0	3	0.01
Rib fracture	6	0	0	6	0.02
Collarbone	9	0	0	9	0.03
Concussion	65	0	0	65	0.23
Elbow	11	0	0	11	0.04
Finger	13	0	0	13	0.05
Hand	15	8	0	23	0.08
Illness	0	6	0	6	0.02
Neck	17	0	0	17	0.06
Pectoralis major	6	0	0	6	0.02
Toe	6	0	0	6	0.02
Shoulder	54	0	0	54	0.19
Sports hernia	0	0	0	0	0.00
Triceps	0	0	0	0	0.00
Forearm	0	0	0	0	0.00
Undisclosed	129	0	0	129	0.45
Total	611	127	62	800	2.81

Season and Anatomic site	Number of Injuries				Injuries per 1000 AEs
	Contact	Noncontact	Overuse	Total	
2020-2021					
Hip/groin	21	10	38	69	0.64
Upper leg/thigh	0	13	78	91	0.84
Knee	26	63	0	89	0.82
Lower leg/Achilles	10	26	0	36	0.33
Ankle	57	1	0	58	0.53
Foot/toes	20	0	0	20	0.18
Back	1	8	0	9	0.08
Biceps	3	0	0	3	0.03
Rib fracture	18	0	0	18	0.17
Collarbone	2	0	0	2	0.02
Concussion	22	0	0	22	0.2
Elbow	9	0	0	9	0.08
Finger	15	0	0	15	0.14
Hand	5	0	0	5	0.05
Illness	0	33	0	33	0.3
Neck	8	0	0	8	0.07
Pectoralis major	8	0	0	8	0.07
Toe	11	0	0	11	0.1
Shoulder	41	0	0	41	0.38
Sports hernia	0	2	0	2	0.02
Triceps	0	1	0	1	0.01
Undisclosed	32	0	0	32	0.3
Total	309	157	116	582	5.4

AE, athlete exposure.

when compared with the second 2 weeks (515) (40%). This trend was noted to continue, although less dramatically, during the 2020-2021 regular season; 300 (52%) injuries occurred during the first 2 weeks, whereas 282 (48%) occurred during the second 2 weeks. The results of our study suggest that in the absence of an NFL preseason, injuries are more common during the early regular season, similar to the injury trend noted by Feeley et al.[14] during training camp. However, given the unprecedented nature of the Covid-19 pandemic and its effect on the 2020-2021 NFL season, such a finding should be interpreted with this limitation in mind.

We speculate that factors similar to those proposed to account for the increased injury rate noted in the early NFL preseason also contributed to the increased injury rate noted in NFL players during weeks 1-4 of the 2020-2021 regular season. These factors include the relative

deconditioning and muscle weakness that occurs during the offseason,[16,17] as well as fatigue, which suggests that fatigued muscles are more vulnerable to injury.[18,19] It is likely that the deconditioning of players during the early 2020 NFL regular season was similar to that of past NFL preseasons; however, during the 2020 season players were asked to play for more time and at a higher level than they would typically be expected to play during the early preseason, specifically, starters. Thus, increased time and intensity of play in the context of baseline deconditioning likely explains why the injury rate during the early 2020 NFL season was higher than the injury rate during past NFL preseasons. Our findings contribute to growing body of evidence that fatigue and deconditioning may place athletes at a higher risk for injury.

Saw et al., in their systematic review of subjective measures used to monitor athletes' responses to training, noted subjective measures, including mood disturbance, perceived stress and recovery and symptoms of stress, to be highly sensitive to an athlete's well-being in response to acute and chronic exercise loads.[20] In light of these findings, the NFL may consider implementing athletes' self-reported questionnaires in order to monitor athletes' levels of exhaustion. The benefits of monitoring fatigue and athletes' well-being include revealing the need for recovery in order to prevent injury, guiding training and competition scheduling, and understanding changes in athletic performance related to fatigue.[2,21] To our knowledge, no such measures have been practiced in attempt to reduce injury risk in professional football players. Future investigations may be useful in evaluation of these subjective measurement techniques and their efficacy in injury reduction in the NFL.

Limitations

This study, as well as other similar publications using the well-established multistep protocol to identify injuries in professional athletes through review of public records, is associated with several limitations. This is a database study, and incomplete data entry and inaccurate reporting of injuries could confound the season-to-season injury differences. Details regarding injury diagnosis and management, including injury severity, exact pathology, imaging reports, and exact medical clearance, were not available for all players. Because injured players were identified using public records, the possibility of reporting errors and omissions exist. We did not assess the rate of injuries over the entire season to see whether the injury rates normalized as the season went on. Our study also lacks objective measures of deconditioning to correlate with injury rates during COVID-19. Finally, there remains the possibility of selection bias in the injured group in which only "newsworthy" players injured were reported on. We attempted to minimize this bias by corroborating reported injuries with 2 additional resources, but the data are limited by what is publicly available.

Conclusion

The rate of injury in NFL players during weeks 1-4 of the 2020-2021 regular seasons was significantly higher than that of the 3 recent past NFL preseasons and regular seasons.

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Appendix

Data sources used: http://www.nfl.com/injuries, https://www.espn.com/nfl/injuries, https://www.cbssports.com/nfl/injuries/, https://www.pro-football-reference.com/players/injuries.htm, https://bleacherreport.com/nfl-injuries