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Musculoskeletal Injury History Is Associated With Lower Physical and Mental Health in a Historical Cohort of Former National Football League Players

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Context: Little research has examined health-related quality of life in former National Football League (NFL) players. ***Objective:*** Examine the association of musculoskeletal injury history and current self-reported physical and mental health in former NFL players. ***Setting:*** Cross-sectional questionnaire. ***Patients or Other Participants:*** Historical cohort of 2,103 former NFL players that played at least one season between 1940 and 2001. ***Intervention:*** Players were grouped by self-reported professional career musculoskeletal injury history and whether injuries affected current health: (1) no musculoskeletal injury history; (2) musculoskeletal injury history, currently affected by injuries; and (3) musculoskeletal injury history, not currently affected by injuries. ***Main Outcome Measure:*** The Short Form 36 Measurement Model for Functional Assessment of Health and Well-Being (SF-36) yielded physical and mental health composite scores (PCS and MCS, respectively); higher scores indicated better health. Multivariable linear regression computed mean differences (MD) among injury groups. Covariates included demographics, playing history characteristics, surgical intervention for musculoskeletal injuries, and whether injury resulted in premature end to career. MD with 95% CI excluding 0.00 were deemed significant. ***Results:*** Overall, 90.3% reported at least one musculoskeletal injury during their professional football careers, of which 74.8% reported being affected by their injuries at time of survey completion. Adjusting for covariates, mean PCS in the "injury and affected" group was lower than the "no injury" (MD = −3.2; 95% CI: −4.8, −1.7) and "injury and not affected" groups (MD = −4.3; 95% CI: −5.4, −3.3); mean MCS did not differ. ***Conclusion:*** Many players reported musculoskeletal injuries, highlighting the need for developing and evaluating injury management interventions.

Keywords: epidemiology, health-related quality of life, career-ending injury

As a collision sport, American football has a high risk of serious physical injury.[1] Data from the National Football League (NFL) indicate that up to 68% of NFL players may be injured in a season.[2] Despite research that has focused on mental and physical health outcomes associated with concussions,[3–8] musculoskeletal injuries are also a common occurrence in NFL players that merit empirical attention. It is estimated that most NFL players have experienced 3 or more injuries during their career.[9] Such injuries can be associated with long-term outcomes alongside loss of playing time, such as psychological stress,[10] chronic pain and long-term pain and disability,[3] and an increased prevalence of arthritis and osteoarthritis.[4]

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Former American football players have also been found to have difficulty coping with aging with poor adjustment outcomes, including increased use of prescribed medication, alcohol, or other drugs; trouble sleeping; lack of exercise; and financial problems.[3] Addressing notable limitations of previous research, an investigative focus on the relationship between injury history and the potential long-term effects on self-reported physical and mental health is warranted. With growing evidence to suggest that musculoskeletal injury affects a person beyond the physical presentation of an injury,[11–17] Health-Related Quality of Life (HRQOL) may serve as an important component of patient-centered, holistic health care in this unique former professional athlete population.[18]

The HRQOL is a multidimensional concept that includes aspects of physical, psychological, and social functioning and how these can be affected by experiences, expectations, and individual beliefs.[19] Such measures are important as they can provide beneficial information to clinicians regarding patients' care and existing health-related issues by identifying individuals with poor perceived health. Given the body of research that has highlighted the potential concerns about the health and well-being of former NFL players, additional focus on HRQOL may help to highlight those players at greatest need for additional care. Specifically, gaining insight to how a previous musculoskeletal injury can affect self-reported HRQOL of former NFL players would further support the best lifespan health care management of these individuals provided by clinicians. Furthermore, such data would help to develop intervention programs that assist former players as they transition from sport.

Currently, there is little research regarding self-reported HRQOL in former NFL players, particularly as related to musculoskeletal injury. Given these important gaps in the knowledge base, this study first examined self-reported injury histories of former NFL players. Second, the study examined how injury history was associated with HRQOL outcomes of current physical and mental health status.

Methods

The cross-sectional study was approved by the institutional review board of the University of North Carolina at Chapel Hill and used a historical cohort of former professional football players that had played at least one season in the NFL between 1940 and 2001 and had completed the Retired NFL Players General Health Survey (GHS).[5–7] The measures pertinent to this study that were collected via the GHS are detailed later.

Data Collection

The baseline GHS was sent via postal mail to living members of the NFL Retired Players Association (n = 3647) in 2001. Contact information was obtained directly from NFL Retired Players Association administration. Nonrespondents were recontacted by mail, e-mail, and/or telephone follow-up during the subsequent year. In total, 2537 former NFL players (69.6%) responded.

Measures

Professional Career Musculoskeletal Injury History. Respondents were asked in the GHS to provide the number of "serious musculoskeletal injuries (bone, ligament, muscle)" that they sustained while playing professional football. Serious injury was defined as "involving any of the following: a fracture, torn ligament, or ruptured muscle; required surgery; and/or caused you to miss at least 2 games or 2 weeks of practice." The type of musculoskeletal injuries examined were categorized as: (1) head/neck/face injury (eye injury; neck burner/numbness; disc rupture/herniation), (2) upper-extremity injury (shoulder dislocation; biceps/triceps rupture [tear]; elbow dislocation/separation; arm/wrist/hand fracture), (3) upper leg injury (hip dislocation/fracture; thigh/leg fracture; hamstring/quad rupture [tear]), (4) knee injury (knee/patellar [knee cap] dislocation; medial collateral ligament tear; lateral collateral ligament tear; anterior cruciate ligament tear; posterior cruciate ligament tear; meniscus [knee cartilage] tear); and (5) lower leg/ankle/foot injury (calf/Achilles tendon rupture [tear]; ankle ligament rupture [tear]; and ankle/foot fracture). Respondents indicating injury provided information on 3 additional "yes/no" queries: first, whether the injury required surgery; second, whether the injury prematurely ended their professional career; and third, whether their current health was affected by the injury.

Physical and Mental Health Status. The Short Form 36 Measurement Model for Functional Assessment of Health and Well-Being (SF-36) was also included in the GHS and assessed general physical and mental health statuses and was a common measure to assess HRQOL. The SF-36 yielded 2 composite scores: (1) the Physical Health Composite Score (PCS) included scores of physical functioning, role physical, bodily pain, and general health and (2) the Mental Health Composite Score (MCS) included scores of vitality, social functioning, role emotional, and mental health. Higher scores for PCS and MCS suggested better physical and mental health, respectively. Scores were standardized to the general US population data using norm-based scoring, which employed a linear t score transformation with a mean of 50 and an SD of 10. Scores higher than 50.0 suggested better physical or mental health than the general US population.

Demographics, Health History, and Playing History. The GHS acquired self-reported demographical information for age; race/ethnicity; body mass index; exercise, tobacco, and alcohol use in the past year; and use of any medication for any physical and mental ailments. Professional football playing history information was acquired for number of years played professionally, number of years retired, and primary position played, which was recoded using previously established categories[20]: linemen (offensive line and defensive line), skill players (running back, wide receiver, and cornerback/safety), and big skill players (quarterback, tight end, linebacker, and special teams).

Statistical Analyses

Level of significance for all analyses was set a priori at $P < .05$. Analyses were conducted with SAS (version 9.4; SAS Institute Inc, Cary, NC). Data from respondents were included only if they had complete data for outcome measures (ie, SF-36), the main exposure measure (ie, injury history), and covariates (ie, demographics and playing history). This left 2103 (82.9% of respondents) for analysis.

Frequencies were calculated for respondent demographics, health history, playing history, and musculoskeletal injury history during their professional football career. Next, the proportions of respondents endorsing injuries that needed surgery, had their professional careers prematurely ended due to the injury, and were being affected by the injury at the time of survey completion were computed. The proportion of respondents reporting at least one of the specific musculoskeletal injuries (overall musculoskeletal injury history) was also provided.

Based upon overall musculoskeletal injury history and whether respondents were affected by reported injuries at time of survey completion, a 3-category injury variable was created: (1) "No injury" (reported no musculoskeletal injuries during professional football career), (2) "Injury and not affected" (reported at least one musculoskeletal injury during professional football career, but did not report being affected by any of those injuries at time of survey completion), and (3) "Injury and affected" (reported at least one musculoskeletal injury during professional football career and reported being affected by at least one of those injuries at time of survey completion). Linear regression models estimated mean differences (MDs) and 95% confidence intervals (CIs) for PCS and MCS among the 3 overall musculoskeletal injury groups. Five additional models were run utilizing these musculoskeletal injury groups with each model focused on specific body part groups (head/neck/face injury, upper-extremity injury, upper leg injury, knee injury, and lower leg/ankle/foot injury).

These models were run first with solely the 3-category injury variable (ie, univariable models) and second with the addition of covariates (ie, multivariable models). Covariates included demographics, playing history characteristics, whether surgery was required for any musculoskeletal injuries, and whether injury resulted in premature end to career. Years since retirement was not included due to high correlation with current age ($r = .96$). To probe multicollinearity, variance inflation factors were examined to ensure no model values were above the recommended cutoff point of 10.[21] To satisfy assumptions of linear regression, models originally utilized transformed variables. However, these transformations did not change the direction or the significance of

effect estimates. Thus, effect estimates from models with untransformed variables were reported for ease of interpretation.[22]

Results

Sample Characteristics

The mean age of respondents was 53.1 (13.0) years with the majority being white/non-Hispanic (71.3%; Table 1). Most self-reported exercising regularly (74.5%); respondents' average body mass index (based on self-report) was 30.6 (4.2). The largest proportion of respondents primarily played as linemen (35.8%). Respondents had played for an average 6.8 (3.5) years professionally and had been retired from football for 23.9 (13.2) years.

Musculoskeletal Injury History

Overall, 90.3% of the sample reported at least one type of musculoskeletal injury during their professional football career (Table 2). The most prevalent musculoskeletal injuries reported were neck burner/numbness (41.7%), meniscus (knee cartilage) tear (33.6%), and arm/wrist/hand fracture (32.9%).

Among those reporting at least one musculoskeletal injury, 60.7% reported having surgery, 40.3% reported an injury prematurely ending their professional career, and 74.8% reported still being affected by the injury at time of survey completion (Table 2). The injuries with the largest proportions of respondents noting surgery were to the knee, ranging from 53.5% for knee/Patellar (knee cap) dislocation to 76.2% for Meniscus (knee cartilage) tear. The injuries with the largest proportions of respondents noting their professional career ending due to the injury were posterior cruciate ligament tear (44.4%), anterior cruciate ligament tear (42.9%), and disc rupture/herniation (42.2%). The injuries with the largest proportions of respondents noting they were still affected by the injury at time of survey completion were disc rupture/herniation (79.4%) and injuries to the knee, ranging from 61.1% for lateral collateral ligament tear to 73.2% for anterior cruciate ligament tear. Among those reporting at least one musculoskeletal injury, respondents reporting that they were still affected by injury at time of survey completion were more likely to report sustaining an injury requiring surgery (69.6% vs 34.7%, $P < .001$) and an injury that prematurely ended their career (49.6% vs 12.7%, $P < .001$).

Physical and Mental Health

The average PCS was 45.8 (10.6), which was lower than the US population norm of 50.0 (10.0) (Table 3). The average MCS was

Table 1 Demographics, Health History, and Playing History of Historical Cohort of Former National Football League Players (n = 2103)

Categories	n	%	Categories	n	%
Age (at reporting), y			Currently on medication		
40 and under	425	20.2	Yes	1224	58.2
41–50	477	22.7	No	879	41.8
51–60	598	28.4	Primary position played		
61–70	376	17.9	Linemen	753	35.8
71–80	191	9.1	Offensive line	515	24.5
Over 80	36	1.7	Defensive line	238	11.3
Race/ethnicity			Skill players	743	35.3
White/non-Hispanic	1499	71.3	Running back	259	12.3
Nonwhite	604	28.7	Wide receiver	193	9.2
Black/non-Hispanic	544	25.9	Cornerback/safety	291	13.8
Mixed race	42	2.0	Big skill players	607	28.9
Other	18	0.9	Quarterback	109	5.2
Current body mass index			Tight end	109	5.2
Under 25.0	107	5.1	Linebacker	279	13.3
25.0–29.9	951	45.2	Special teams	110	5.2
30.0–34.9	764	36.3	Number of years retired (at reporting)		
35.0–39.9	214	10.2	10 and under	390	18.5
40.0 and over	67	3.2	11–20	471	22.4
Exercise regularly			21–30	575	27.3
Yes	1567	74.5	31–40	416	19.8
No	536	25.5	41–50	195	9.3
Smoked within the past year			Over 50	56	2.7
Yes	189	9.0	Number of years played professionally		
No	1914	91.0	5 and under	832	39.6
Drank alcohol within the past year			6–10	949	45.1
Yes	1506	71.6	11–15	299	14.2
No	597	28.4	Over 15	23	1.1

52.7 (9.8), which was higher than the US population norm of 50.0 (10.0). Musculoskeletal injury group averages for both PCS and MCS had similar findings in comparison with US population norms other than the "injury and affected" group, which had a mean PCS of 44.2 (5.8 points lower than the US population norm).

In the simple and multivariable linear regression models predicting PCS, MDs were found (Table 4). Controlling for covariates (ie, demographics, playing history, surgery, career-ending injury) in the multivariable model, the mean of PCS in the "injury and affected" group was lower than the "no injury" group (MD = –3.2; 95% CI, –4.8 to –1.7) and the "injury and not affected" group (MD = –4.3; 95% CI, –5.4 to –3.3). No MD was found between the "injury and affected" and "no injury" groups in the multivariable model (MD = 1.1; 95% CI, –0.4 to 2.6). Of note,

Table 2 Musculoskeletal Injury History During Professional Football Career of Historical Cohort of Former National Football League Players (n = 2103)

Type of injury	n (%) among full sample reporting at least one injury	n (%) among those with injury		
		Required surgery	Ended professional career due to injury	Currently affected by injury (at time of survey completion)
Head/neck/face injury				
Eye injury	238 (11.3)	36 (15.1)	13 (5.5)	63 (26.5)
Neck burner/numbness	876 (41.7)	17 (1.9)	51 (5.8)	447 (51.0)
Disc rupture/herniation	218 (10.4)	87 (39.9)	92 (42.2)	173 (79.4)
Upper-extremity injury				
Shoulder dislocation	563 (26.8)	164 (29.1)	73 (13.0)	338 (60.0)
Biceps/triceps rupture (tear)	131 (6.2)	31 (23.7)	9 (6.9)	58 (44.3)
Elbow dislocation/separation	181 (8.6)	62 (34.3)	11 (6.1)	93 (51.4)
Arm/wrist/hand fracture	692 (32.9)	170 (24.6)	21 (3.0)	299 (43.2)
Upper leg injury				
Hip dislocation/fracture	61 (2.9)	15 (24.6)	10 (16.4)	34 (55.7)
Thigh/leg fracture	148 (7.0)	45 (30.4)	27 (18.2)	49 (33.1)
Hamstring/quad rupture (tear)	569 (27.1)	11 (1.9)	54 (9.5)	149 (26.2)
Knee injury				
Knee/patellar (knee cap) dislocation	157 (7.5)	84 (53.5)	39 (24.8)	99 (63.1)
MCL tear	493 (23.4)	309 (62.7)	134 (27.2)	309 (62.7)
LCL tear	185 (8.8)	101 (54.6)	61 (33.0)	113 (61.1)
ACL tear	406 (19.3)	306 (75.4)	174 (42.9)	297 (73.2)
PCL tear	160 (7.6)	112 (70.0)	71 (44.4)	113 (70.6)
Meniscus (knee cartilage) tear	706 (33.6)	538 (76.2)	213 (30.2)	487 (69.0)
Lower leg/ankle/foot injury				
Calf/Achilles tendon rupture (tear)	144 (6.8)	41 (28.5)	43 (29.9)	63 (43.8)
Ankle ligament rupture (tear)	384 (18.3)	77 (20.1)	43 (11.2)	174 (45.3)
Ankle/foot fracture	324 (15.4)	86 (26.5)	42 (13.0)	151 (46.6)
Overall musculoskeletal injuries[a]	1898 (90.3)	1153 (60.7)	765 (40.3)	1419 (74.8)

Abbreviations: ACL, anterior cruciate ligament; LCL, lateral collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament. [a]Composite measures in which respondents reported at least one of the specific musculoskeletal injuries and, for follow-up questions, at least one of the specific musculoskeletal injuries had the characteristic in question (eg, at least one of the injuries required surgery).

Table 3 Short-Form 36-Item Health Survey PCS and MCS Values, by Injury History Group, in a Historical Cohort of Former National Football League Players (n = 2103)

Health score	Overall sample, mean (SD)	Musculoskeletal injury group, mean (SD)		
		No injury[a]	Injury and not affected[b]	Injury and affected[c]
PCS	45.8 (10.6)	48.5 (10.6)	49.6 (10.5)	44.2 (10.3)
MCS	52.7 (9.8)	53.7 (9.1)	54.1 (8.7)	52.1 (10.2)

Abbreviations: MCS, mental composite score; PCS, physical composite score.
[a]Reported no musculoskeletal injuries during professional football career. [b]Reported at least one musculoskeletal injury during professional football career but did not report being affected by any of those injuries at time of survey completion. [c]Reported at least one musculoskeletal injury during professional football career and reported being affected by at least one of those injuries at time of survey completion.

Table 4 Crude and Adjusted Mean Differences in PCS and MCS Values, by Injury History Group, in a Historical Cohort of Former National Football League Players

	Mean difference in PCS		Mean difference in MCS	
Comparisons	**Crude**	**Adjusted[a]**	**Crude**	**Adjusted[a]**
Injury and not affected[b] vs no injury[c]	1.0 (–0.7 to 2.7)	1.1 (–0.4 to 2.6)	0.3 (–1.2 to 1.9)	0.4 (–1.2 to 2.0)
Injury and affected[d] vs no injury	–4.3 (–5.9 to –2.8)*	–3.2 (–4.8 to –1.7)*	–1.6 (–3.0 to –0.2)*	–0.5 (–2.1 to 1.1)
Injury and affected vs injury and not affected	–5.4 (–6.5 to –4.3)*	–4.3 (–5.4 to –3.3)*	–2.0 (–3.0 to –1.0)*	–0.9 (–2.0 to 0.2)

Abbreviations: CI, confidence interval; MCS, mental composite score; PCS, physical composite score.

[a]Adjusted controls for age, race/ethnicity, body mass index, exercised regularly, smoked in past year, drank alcohol in past year, currently on medication, primary position played, years played professionally, whether surgery was required for any musculoskeletal injuries, and whether injury resulted in premature end to career; years retired was not included due to high correlation with current age ($r = .96$). [b]Reported at least one musculoskeletal injury during professional football career but did not report being affected by any of those injuries at time of survey completion. [c]Reported no musculoskeletal injuries during professional football career. [d]Reported at least one musculoskeletal injury during professional football career and reported being affected by at least one of those injuries at time of survey completion.

*Statistical significance (ie, 95% CI does not include 0.0).

Table 5 Crude and Adjusted Mean Differences in PCS and MCS Values, by Injury History Group and Body Part Group, in a Historical Cohort of Former National Football League Players

	Mean difference in PCS		Mean difference in MCS	
Comparisons	**Crude**	**Adjusted[a]**	**Crude**	**Adjusted[a]**
Head/neck/face injury				
Injury and not affected[b] vs no injury[c]	0.5 (–0.6 to 1.7)	0.1 (–0.9 to 1.2)	0.5 (–0.6 to 1.5)	0.5 (–0.6 to 1.6)
Injury and affected[d] vs no injury	–4.3 (–5.3 to –3.2)*	–3.4 (–4.5 to –2.3)*	–2.1 (–3.1 to –1.2)*	–1.9 (–3.0 to –0.8)*
Injury and affected vs injury and not affected	–4.8 (–6.1 to –3.5)*	–3.5 (–4.7 to –2.4)*	–2.6 (–3.8 to –1.4)*	–2.4 (–3.6 to –1.2)*
Upper-extremity injury				
Injury and not affected[b] vs no injury[c]	0.2 (–0.9 to 1.4)	0.0 (–1.1 to 1.1)	0.4 (–0.7 to 1.4)	0.6 (–0.5 to 1.7)
Injury and affected[d] vs no injury	–3.6 (–4.7 to –2.6)*	–3.6 (–4.7 to –2.5)*	–1.5 (–2.5 to –0.5)*	–0.4 (–1.5 to 0.7)
Injury and affected vs injury and not affected	–3.9 (–5.1 to –2.6)*	–3.6 (–4.8 to –2.5)*	–1.9 (–3.0 to –0.7)*	–1.0 (–2.2 to 0.2)
Upper leg injury				
Injury and not affected[b] vs no injury[c]	–1.1 (–2.2 to –0.01)*	–1.5 (–2.5 to –0.5)*	–0.9 (–1.9 to 0.2)	–0.9 (–1.9 to 0.1)
Injury and affected[d] vs no injury	–2.2 (–3.7 to –0.7)*	–2.7 (–4.2 to –1.1)*	–1.8 (–3.2 to –0.4)*	–1.9 (–3.5 to –0.3)*
Injury and affected vs injury and not affected	–1.1 (–2.8 to 0.6)	–1.2 (–2.7 to 0.5)	–0.9 (–2.5 to 0.6)	–1.0 (–2.6 to 0.7)
Knee injury				
Injury and not affected[b] vs no injury[c]	–0.2 (–1.5 to 1.1)	–0.4 (–1.7 to 1.0)	–0.8 (–2.0 to 0.4)	–0.6 (–2.0 to 0.8)
Injury and affected[d] vs no injury	–5.3 (–6.3 to –4.3)*	–4.8 (–6.2 to –3.5)*	–1.3 (–2.2 to –0.4)*	–0.3 (–1.7 to 1.1)
Injury and affected vs injury and not affected	–5.1 (–6.4 to –3.8)*	–4.5 (–5.7 to –3.2)*	–0.5 (–1.8 to 0.7)	0.3 (–1.0 to 1.6)
Lower leg/ankle/foot injury				
Injury and not affected[b] vs no injury[c]	0.3 (–0.9 to 1.5)	0.6 (–0.5 to 1.7)	–0.2 (–1.3 to 0.9)	–0.3 (–1.4 to 0.8)
Injury and affected[d] vs no injury	–2.4 (–3.7 to –1.1)*	–2.5 (–3.8 to –1.1)*	–2.3 (–3.5 to –1.1)*	–2.3 (–3.6 to –0.9)*
Injury and affected vs injury and not affected	–2.7 (–4.3 to –1.2)*	–3.0 (–4.5 to –1.6)*	–2.1 (–3.5 to –0.6)*	–2.0 (–3.4 to –0.5)*

Abbreviations: CI, confidence interval; MCS, mental composite score; PCS, physical composite score.

*Statistical significance (ie, 95% CI does not include 0.0).

[a]Adjusted controls for age, race/ethnicity, body mass index, exercised regularly, smoked in past year, drank alcohol in past year, currently on medication, primary position played, years played professionally, whether surgery was required for any musculoskeletal injuries, and whether injury resulted in premature end to career; years retired was not included due to high correlation with current age ($r = .96$). [b]Reported at least one musculoskeletal injury during professional football career but did not report being affected by any of those injuries at time of survey completion. [c]Reported no musculoskeletal injuries during professional football career. [d]Reported at least one musculoskeletal injury during professional football career and reported being affected by at least one of those injuries at time of survey completion.

having a career-ending injury was associated with lower PCS (MD = –2.0; 95% CI, –2.9 to –1.1).

In the simple linear regression models predicting MCS, MDs were found (Table 4). However, in the multivariable model, no differences in mean MCS were found among groups. Furthermore, having a career-ending injury was not associated with MCS.

Results were mostly similar for the multivariable models focused on specific body part groups, with a few exceptions (Table 5). First, among upper leg injuries, mean PCS was lower in the "injury and not affected" group than the "no injury" group. Second, mean MCS in the "injury and affected" group were lower than the other 2 groups among head/neck/face injuries and lower leg/ankle/foot injuries. Also, among lower leg injuries, mean MCS

was lower in the "injury and affected" group than the "no injury" group.

Discussion

Among this historical cohort of former NFL players, over 90% reported sustaining at least one musculoskeletal injury during their professional careers. Respondents self-reported that many of these injuries required surgery, resulted in their professional playing careers prematurely ending, and still affected them. Although the majority of research on the long-term health and well-being of former football players has focused on concussions,[5–7,23] this study highlights the breadth of musculoskeletal injuries that players sustain and their associations with self-report HRQOL outcomes.

These data from a historical data set and may not be as generalizable to today's health care system. Nonetheless, they highlight the incidence of injuries that are self-reported by former NFL players as well as the impact of these injuries on their short-term outcomes, such as surgical needs and retiring due to injury, and long-term outcomes, such as still believing they are impacted by these injuries and HRQOL. Moreover, although study replication is needed with newer cohorts, these data highlight the need for health care systems to appropriately treat serious injuries in this population and mitigate the potential negative impacts on HRQOL.

Estimates of Musculoskeletal Injury History and HRQOL

The current study's estimate of reporting at least one musculoskeletal injury (90.3%) exceeds the number of respondents from the same cohort that had noted a concussion history (60.7%).[6] The current study's estimate is also higher than that of a previous study (68%),[2] although the current study's timeframe was one's entire NFL career compared with one season. The current study's injury definition also included only those that were considered potentially serious (eg, fractures, torn ligaments, and ruptured muscles; injuries requiring surgery or resulting in missing at least 2 games or 2 wk of practice); the previous estimate was based upon NFL weekly injury reports. Despite these differences, both findings highlight the high prevalence of injured athletes within the NFL.

The additional findings that highlight the large percentages of NFL players reporting surgery (60.7%), a premature end to their professional football career (40.3%), and still being affected by injury (74.8%) further augment the concern about the effects from musculoskeletal injuries on overall functioning across the lifespan. As a recent systematic review identified both involuntary retirement and pain as potential risk factors for worse HRQOL,[24] clinicians working with former athletes should be aware of such factors to help inform long-term management and treatment plans. For example, such plans could benefit from assessments of HRQOL in addition to the detailed injury histories and physical exams consistent with best practice for lifespan health maintenance.

Compared with US population normative scores, PCS and MCS in the sample of former NFL players were lower and higher, respectively. However, it is important to note that these were both within 1 SD of the US population normative scores, which may indicate a lack of clinical meaningfulness. Nonetheless, clinicians working with former athlete populations such as former NFL players should acquire information about competitive sports participation and injury history to better attend to their current and future health needs.

Differences in Physical and Mental Health by Injury History

There has been little research done on the impact of a previous musculoskeletal injury on self-reported HRQOL, particularly in former NFL players. Former NFL players that had a professional football musculoskeletal injury history and noted still being affected by the injury reported lower PCS scores compared with the those without a history and those with an injury history but not still affected; MCS was lower in the "no injury" group but only in univariable models. The current study's findings are similar to previous research examining long-term musculoskeletal outcomes of former college athletes. In such studies, those that sustained a severe or career-ending musculoskeletal injury had lower levels of physical health (physical functioning, role physical, bodily pain, and general health) compared with those without severe or career-ending injuries.[25,26] Interestingly, no differences were found in mean PCS and MCS scores between respondents in the "no injury" and "injury and not affected" groups. Although this finding may suggest that long-term consequences may be diminished when appropriate postinjury management and treatment are done efficiently in former professional athlete populations, additional research is needed to further validate this interpretation in additional samples including former NFL players who have retired more recently. Such research is important given recent findings that although athletes with severe injuries may return to play, they may face reduced performance[27,28] and the onset of other adverse outcomes, such as osteoarthritis.[29,30]

When results were stratified by specific body part group, there were some variations in findings, the most prominent being the statistically significant lower MCS found in the "injury and affected" group compared with the other groups in the multivariable head/neck/face injuries and lower leg/ankle/foot injuries models. Previous research on injuries to specific body parts and HRQOL is limited, although one study with former college athletes found that knee injury history was associated with lower HRQOL, specifically in role emotional and physical functioning subscales.[31] Agreement with our study's knee injury-specific findings were mixed in that an association was found with PCS but not with MCS. Given the limited prior research, coupled with the mixed findings in comparison with what research exists, additional research HRQOL in former athlete populations is needed to better understand the potential long-term effects of sports participation and specific musculoskeletal injuries and the factors that may potentially facilitate and mitigate better outcomes. Such work may benefit from the establishment of multidisciplinary research teams (ie, sport scientists, sports medicine clinicians, epidemiologists) designed to disentangle potentially complex links between injury onset, rehabilitation, and lifespan HRQOL across multiple injuries.

It is important to interpret these findings with caution, as the GHS was unable to specify how each injury affected each former NFL player. Potential historical/cultural changes in injury diagnosing and/or reporting also merit exploration as a potential moderator of these associations. Specifically, increased knowledge/awareness (eg, education campaigns, social media portrayals of injury) and treatment of injuries may be impactful, as definitions of injuries and treatments provided have increased over the years. Obtaining further detail about these effects may help to better identify the underlying mechanisms of the potential associations among demographics, playing history, and HRQOL. Practical implications also involve insight into targeted behavioral health programming designed to address modifiable health risk factors in former athlete populations (eg, nutrition, exercise, sleep).

Furthermore, it is difficult to gauge the clinical meaningfulness of the group differences, as minimal clinically important differences (MCID)[32] (ie, the smallest differences that would be deemed important by clinicians) are typically used at the individual level (eg, change in an individual prerehab and postrehab). Given the cross-sectional nature of our study, this was not feasible. Furthermore, one aspect related to musculoskeletal injuries that has not been widely explored is the assessment of HRQOL prior to football participation. Traditionally, HRQOL has been examined in the context of the end result of care postinjury. Measuring this at the beginning of each season (and professional career) can help establish a prospective baseline that can help guide treatment and return to play decisions for subsequent injuries and potentially mitigate the long-term consequences of sustaining future musculoskeletal injuries. This can be especially important for individuals who have injury history but are otherwise healthy and can be an integral component to the delivery of patient-centered health care both during and after an athletic career.[18,33] Although this study used the SF-36, a number of tools are available, such as the abridged SF-12 or the PROMIS® toolbox. It is important for clinicians to review these available options and select the tool that is the most feasible for use with their populations of interest.

Limitations

Despite the study's high response rate, the historical nature of this study may not be generalizable to current NFL players and more recent retirees. Rule changes may have potentially changed injury risk and improved medical care for the diagnosis and treatment of musculoskeletal injuries. Our sample is also majority white/non-Hispanic, which does not equate to the large percentage of black players currently playing the NFL. Still, the findings highlight the need to provide adequate care for the increasing number of former professional football players and to continue efforts to mitigate injury incidence and severity in professional football. To help address some of these needs, the NFL Players' Association has joined with many universities and medical programs to create The Trust (http://playerstrust.com/) in which former players can receive comprehensive medical and rehabilitation assessments with physicians who are familiar with the needs of this unique population. Former players can also receive physical therapy and exercise training at reputable facilities and in partnership with community organizations. However, research is needed to evaluate the use of these and resources from other agencies (ie, NFL, nonleague affiliated nonprofits) on their effectiveness in aiding the physical health and well-being of former athletes.

Given the retrospective nature of the study, it is also difficult to assess causality. Furthermore, changes in players' memory or the management and treatment of injury were not assessed in the current study's analyses. The accuracy of recall could also not be validated, although previous research has found that individuals generally have good recall of their own medical history.[34–36] The study was also unable to specify how each injury affected each former NFL player. Also, the GHS focused solely on injury history during one's professional football career and not during other levels of football (eg, youth, high school, college).

Conclusion

Despite these limitations, this study highlights the need for more research on a wide range of care for both former and current NFL players. These findings may suggest that positive physical and mental functioning outcomes (key markers of HRQOL) postcareer can, nonetheless, be obtained despite injury history. However, additional research is needed to better examine this in the context of other life events that may also contribute to adverse health outcomes. Efforts exist from governing bodies to expand into this area to assess the needs of former players as they transition out of active play, particularly as related to the areas of exercise/physical therapy and body composition/nutrition, both of which are aspects central to long-term injury management. In addition, it is recommended that clinicians working with former NFL players further explore how programs such as The Trust may assist. However, all efforts to assist former NFL players should be empirically evaluated to ensure that they provide the intended benefits.

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