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Predictors and Prevalence of Postconcussion Depression Symptoms in Collegiate Athletes

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Context: Depression is common after concussion and is associated with functional outcome and quality of life after injury. However, few baseline predictors of postconcussion depressive symptoms (PCDS) have been found.

Objective: To describe the prevalence of depressive symptoms in a collegiate athlete sample at baseline and postconcussion, compare these levels of symptoms and change in symptoms with those of a control group with no reported concussions in the past year, and examine the baseline predictors for PCDS.

Design: Case-control study.

Setting: Undergraduate institution.

Patients or Other Participants: Participants were 84 collegiate athletes (65 men, 19 women) with concussion and 42 individuals (23 men, 21 women) with no history of recent concussion who served as controls.

Main Outcome Measure(s): The Beck Depression Inventory–Fast Screen was administered to the concussion group at baseline and postconcussion and to the control group at 2 time points.

Results: Seventeen athletes (20%) showed a reliable increase in depression, and more athletes reported clinically important depression postconcussion than at baseline. Only 2 participants (5%) in the control group showed a reliable increase in depression. Concussed athletes were more likely to show a reliable increase in depression symptoms than control participants ($\chi^2_1 = 5.2$, $P = .02$). We also found several predictors of PCDS in the athletes, including baseline depression symptoms ($r = 0.37$, $P < .001$), baseline postconcussion symptoms ($r = 0.25$, $P = .03$), estimated premorbid intelligence (full-scale IQ; $r = -0.29$, $P = .009$), and age of first participation in organized sport ($r = 0.34$, $P = .002$). For the control group, predictors of depression symptoms at time 2 were number of previous head injuries ($r = 0.31$, $P = .05$) and baseline depression symptoms ($r = 0.80$, $P < .001$).

Conclusions: A large proportion of athletes showed a reliable increase in depression after concussion, and we identified several baseline predictors. Given that depression affects quality of life and recovery from concussion, more research is necessary to better understand why certain athletes show an increase in PCDS and how these can be better predicted and prevented.

Key Words: concussion, depressive symptoms, sports

Key Points

- The prevalence of clinically important depression symptoms was higher postconcussion than at baseline.
- Postconcussion depression symptoms were related to a higher level of baseline depression symptoms and baseline postconcussion symptoms, lower estimated full-scale IQ, older age at first participation in organized sport, and fewer number of games missed due to concussion.
- Nonwhite ethnicity was associated with increased postconcussion depression symptoms.
- More research is needed to better predict which athletes might have more severe depression symptoms postconcussion.

Depression after concussion has become a particularly salient issue recently given the rise in media coverage of the effects of concussions and of National Football League players committing suicide after careers that likely involved multiple concussions. The terms *concussion* and mild *traumatic brain injury* (TBI) will be used interchangeably in this article. In addition to increasing suicide risk, postconcussion depression symptoms (PCDS) have been associated with worse functional outcome, cognitive performance, and quality of life after injury.[1–5] Furthermore, depression is a mediator between concussion and physical health problems and persistent concussive symptoms after injury.[6]

Whereas some researchers have offered that PCDS are due to functional limitations, anger, frustration, and the experience of loss,[7,8] others have posited that PCDS might be due to functional and microstructural changes in the brain[9] or a combination of these changes. By examining depression symptoms before and after a single injury in younger athletes who underwent baseline testing and comparing them with a control group, the goal of our study was to help identify the individuals who are more at risk for developing depression symptoms after concussion. A better understanding of who is most vulnerable to depression after injury could help to improve both treatment and prevention of this condition.

Researchers have reported that depression is relatively common after brain injury, but most investigators have focused on moderate to severe TBI or have not differentiated among levels of severity.[10] Furthermore, few researchers have examined the effect of preinjury depression levels on postinjury depression symptoms. Busch and Alpern[11] summarized 12 studies on depression after TBI and showed the prevalence of depression after concussion was at least 35%. Rapoport et al[10] found a 15% prevalence of major depression after mild TBI. After all severities of TBI, the prevalence of major depression was 14% to 29%.[10,12,13] Researchers[14–17] examining emotional responses to sport-related concussion also have reported increased levels of depression in athletes after concussive injury.

However, few risk factors, or baseline predictors, of PCDS have been identified. Associated demographic factors include younger age,[1,18] a personal or family history of psychological disorders or substance abuse,[11] and lower levels of education.[1] Rapoport et al[10] reported that the risk of major depression was lower in adults aged more than 60 years than in younger individuals with mild TBI. However, the opposite was observed in a study of mild to moderate TBI.[19] Findings for sex have been mixed in general TBI,[20] but in a study of sex differences in depression after sport-related concussion, rates of depression symptoms among male and female athletes were similar.[15] It is interesting that severity of injury has not been a consistent predictor of PCDS in general TBI,[21,22] but loss of consciousness has been related to the risk of major depression in mild TBI (odds ratio = 3.67).[6]

Therefore, the purposes of our study were to (1) describe the prevalence of depression symptoms in a collegiate athlete sample at baseline and postconcussion, (2) compare these levels of symptoms and change in symptoms with those of a control group with no reported concussions in the year before the study, and (3) examine the baseline predictors for PCDS. Given the mixed literature on predictors of depression in concussion, most of our study was exploratory, with no specific hypotheses generated. However, we did hypothesize that increases in depression after concussion would occur in a greater proportion of our concussed athletes than in the control participants.

METHODS

Procedures

As part of the sport concussion program at a National Collegiate Athletic Association Division I university, 84 college-aged varsity or club athletes were baseline tested when they arrived on campus. We retested these athletes after each was formally diagnosed with a concussion by a team physician or certified athletic trainer. We tested 43% (n = 36) of athletes within 48 hours of the concussion and 71% (n = 60) within 5 days. A total of 23% (n = 19) were tested a week or more after their injury (range, 1 to 41 days). Three athletes (3.6%) reported a history of psychiatric treatment, and none reported a history of substance abuse treatment. Twenty-two (26%) participants had missing data for these variables but we included them in the statistical analyses to maximize the group size because they were not missing other data. All participants who had completed a Beck Depression Inventory–Fast Screen (BDI-FS) at both baseline and postconcussion, including those with a history of psychiatric treatment, were included in the data analysis. Participants were excluded only if they had not completed the BDI-FS.

A control group of 44 undergraduates also was tested at 2 time points. Control participants received research credit toward their introductory psychology courses. We recruited individuals who were involved in "formal, recreational, or pick-up" sports to acquire an athletic control group. Exclusionary criteria consisted of a concussion within the year before the study or a history of inpatient psychiatric or substance-abuse treatment. Two participants missed the BDI-FS at the second time point and so were excluded, leaving 42 control participants. Those participants were tested twice at an interval of 6.0 to 8.4 weeks (average = 6.8 weeks). All participants provided written informed consent, and the study was approved by the Behavioral Committee of the Pennsylvania State University Institutional Review Board.

Self-Report Measures and Other Variables Analyzed

At both time points, athletes were given a 2-hour battery of neuropsychological tests that included the BDI-FS. The BDI-FS was designed as a quick and reliable measure of depression in medical patients and includes 7 items related to sadness, hopelessness, feeling like a failure, anhedonia (loss of pleasure), self-esteem, self-blame, and suicidality. Note the measure does not include vegetative symptoms of depression, such as difficulty concentrating and trouble sleeping, that might be present in a concussed population. A score of 4 or higher on the BDI-FS has been shown[23] to reliably indicate clinically important depression symptoms in a primary care sample, with a sensitivity of 0.97 and a specificity of 0.99.

Athletes also were administered the Previous Head Injury Questionnaire (PHIQ), the Wechsler Test of Adult Reading (WTAR), and the Post-Concussion Symptom Scale (PCSS). The PHIQ is a detailed self-report measure that was developed by 1 of the authors (P.A.A.) and instructs athletes to report on previous concussions sustained. Most investigators simply ask athletes how many concussions they have had and rely on them to know the proper definition of *concussion*. However, this measure aims for more accurate reporting by defining *concussions* in detail before instructing athletes to list how many concussions they have had and the details surrounding them. History of concussion was analyzed due to the mixed findings for the relationship between multiple concussions and depression.[24] We also administered the WTAR as an estimate of premorbid intelligence. The PCSS, a self-report measure, instructs the individual to rate the extent to which he or she is currently experiencing a series of 21 common postconcussive symptoms on a Likert scale (range, 0–6). This scale has excellent internal consistency, ranging from 0.88 in healthy, uninjured participants to 0.94 in recently concussed individuals.[25] We included the PCSS because previous research[6] has demonstrated a relationship between depression symptoms and increased postconcussive symptoms.

In addition to the baseline self-report measures listed, we analyzed demographics, including age, sex, and ethnicity, to characterize demographically related risk factors, given

Table 1. Participants' Demographics

Variable	Group		Statistical Comparison
Age at baseline testing, y	Concussed 18.4 ± 0.8	Control 18.9 ± 0.9	$t_{124} = 3.17$, $P = .002$
Sex			$\chi^2 = 8.47$, $P = .003$
Male	65	23	
Female	19	21	
Ethnicity	52 white, 25 African American, 6 multiracial, 1 other	34 white, 2 African American, 3 Asian American, 1 Latin American, 2 multiracial[a]	$\chi^2 = 4.68$, $P = .03$
Time between baseline and postconcussion testing, y (range)	1.5 ± 1.2 (0.2–4.0)	0.14 ± 0.0 (0.12–0.16)	$t_{114} = 7.33$, $P < .001$
Previous concussions, n (range)	0.92 ± 1.8 (0–15)	0.57 ± 0.9 (0–3)	$t_{124} = 1.19$, $P = .24$
Time since concussion at postconcussion testing, d	6.6 ± 8.7	Not applicable	Not applicable
Sport	37 football, 18 lacrosse, 11 basketball, 8 soccer, 7 ice hockey, and 3 wrestling	Not applicable	Not applicable

[a] Two participants missed the Beck Depression Inventory-Fast Screen at the second time point and were excluded.

previous findings on the relationship of these 3 variables to depression and outcome after TBI. Information on the participants' sports and concussion histories (ie, number of previous concussions, age when individuals started participating in organized sports, number of years participating in collegiate sport, number of games missed due to concussion) was also included in data analysis to examine whether these factors were related to PCDS. This information was obtained from in-house–designed self-report forms; the PHIQ; or Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT), a widely used computerized neurocognitive assessment measure. Sport-specific histories were not obtained from control participants. Finally, information on baseline alcohol and substance abuse was also analyzed.

Statistical Analysis

Overall depression symptoms were compared between the baseline and postconcussion time points. Participants were divided into high and low depression-symptom groups based on the 4 or higher score on the BDI-FS. We performed the McNemar test to determine whether a difference existed in baseline and postconcussion frequencies of high and low levels of depression symptoms. The SPSS software (version 21; IBM Corporation, Armonk, NY) was used to determine differences with the McNemar test, and the McNemar χ^2 statistic was calculated by hand with the Yates correction applied for continuity. We performed correlations or independent-samples t tests for continuous or categorical variables, respectively, to determine whether baseline variables were related to PCDS. Follow-up analysis was conducted for predictors of PCDS, controlling for history of psychiatric treatment. Last, we conducted reliable change analyses with 95% confidence intervals using the Edwards-Nunnally corrected reliable change index,[26] which adjusts pretreatment scores for regression to the mean, to determine which factors were correlated with a reliable increase in depression from baseline to postconcussion. We performed the χ^2 analysis comparing the proportion of participants who showed a reliable increase in depression between the concussed athletes and the control group. The α level was set at .05.

RESULTS

Characteristics of the sample are detailed in Table 1. The concussed and control groups differed on age, sex, ethnicity, and duration of test-retest interval. However, the age difference between groups was very small, and age was not associated with depression symptoms at either time point for concussed participants (baseline: $r = 0.03$, $P = .82$; postconcussion: $r = 0.10$, $P = .38$) or control participants (time 1: $r = 0.12$, $P = .44$; time 2: $r = 0.07$, $P = .65$). In addition, sex was not related to depression symptoms at either time point in concussed participants (baseline: $t_{82} = 1.08$, $P = .28$; postconcussion: $t_{82} = 1.02$, $P = .31$) or control participants (time 1: $t_{40} = 1.21$, $P = .23$; time 2: $t_{34.39} = 1.69$, $P = .10$). Regarding ethnicity, participants who were not white had more depression symptoms postconcussion ($t_{82} = -2.74$, $P = .01$), but ethnicity groups otherwise did not differ on baseline depression symptoms ($t_{82} = -1.43$, $P = .16$) or change in depression symptoms ($t_{82} = -1.06$, $P = .29$) for concussed athletes. In the control group, those who were white had a greater change in depression symptoms than nonwhite participants ($t_{33} = 2.39$, $P = .02$) but did not differ on depression levels at baseline ($t_{40} = -0.71$, $P = .49$) or postconcussion ($t_{40} = -0.32$, $P = .75$). Last, the test-retest interval was not related to PCDS ($r = -0.12$, $P = .29$) or to a change in depression symptoms from baseline to postconcussion ($r = 0.17$, $P = .16$) in the concussed group. The test-retest interval was not related to depression symptoms for the control group at time 1 ($r = -0.06$, $P = .69$) or time 2 ($r = -0.07$, $P = .66$).

Overall, depression levels in the concussed sample were mild, and the means were not different between time points ($t_{83} = -1.59$, $P = .12$). However, based on the cutoff score of 4 or higher on the BDI-FS, more athletes reported clinically important depression symptoms after concussion than at baseline. A total of 9 of 84 athletes (11%) at baseline and 19 of 84 athletes (23%) postconcussion scored 4 or higher on the BDI-FS (McNemar test; χ^2_1 [N = 84] = 5.64, $P = .02$). For the control group, depression symptoms were marginally higher at baseline than at time 2 ($t_{41} = 1.90$, $P = .06$); yet the mean at baseline was still very low (1.3 ± 1.6). Three of 42 control participants (7%) at time 1 and 4 of 42 control participants (10%) at time 2 scored a 4

Table 2. Baseline Predictors of Postconcussion Depression Symptoms

Predictor	Statistical Value	*P*
Ethnicity	$F_{3,80} = 2.70$	.05
Beck Depression Inventory-Fast Screen	$r = 0.37$	<.001
Baseline postconcussion symptoms (Post-Concussion Symptom Scale)	$r = 0.25$	.03
Wechsler Test of Adult Reading estimated full-scale IQ	$r = -0.29$	.009
Age at first organized sport	$r = 0.34$	.002
Years playing main sport	$r = -0.20$	.08
Number of games missed due to concussions	$r = -0.23$	.04
Number of previous concussions (Previous Head Injury Questionnaire)	$r = -0.16$	.15
Age	$r = 0.10$	.38
Sex	$t_{82} = 1.03$	.31
Average number of drinks per week	$r = -0.15$	.19
Number of times used marijuana	$r = -0.10$	.38

or higher on the BDI-FS (McNemar test; χ^2_1 [n = 42] = 0.25, $P > .99$).

When investigating baseline variables relating to PCDS in the athletes, we found several important predictors, including baseline BDI-FS score, baseline postconcussion symptoms, WTAR-estimated full-scale IQ (FSIQ), and age of first participation in organized sport (Table 2). Ethnicity was also related marginally, with multiracial athletes reporting the highest level of PCDS, followed by African American athletes and then white athletes. When compared as groups, nonwhite athletes reported more PCDS than white athletes ($t_{82} = -2.70$, $P = .01$). These groups did not differ on depression symptoms at baseline ($t_{82} = -1.43$, $P = .16$). Age of first participation in organized sport was also correlated with PCDS ($r = 0.34$, $P = .002$). Paradoxically, athletes with fewer years of experience in organized sports reported more PCDS. The number of years playing the main sport was also marginally negatively related to PCDS: a greater number of years participating in the current sport was related to fewer reported PCDS. Last, whereas the number of previous concussions was not related to PCDS, the total number of games missed due to previous concussions was negatively related to PCDS; therefore, more games missed was associated with lower rates of PCDS. It is interesting that we observed no sex differences in depression at either time point ($t_{82} = 1.03$, $P = .31$). Age and alcohol or substance use at baseline were also not related to PCDS (Table 2).

We conducted a follow-up analysis, controlling for history of psychiatric treatment. With this variable entered as a covariate, baseline depression symptoms ($R^2 = 0.11$, $F_{1,59} = 5.32$, $P = .03$), postconcussion symptoms ($R^2 = 0.11$, $F_{1,59} = 5.42$, $P = .02$), and age at first organized sport participation ($R^2 = 0.15$, $F_{1,58} = 8.35$, $P = .005$) remained predictors of PCDS. The number of years playing the main sport ($R^2 = 0.09$, $F_{1,53} = 3.58$, $P = .06$), estimated FSIQ ($R^2 = 0.08$, $F_{1,55} = 3.29$, $P = .08$), and the number of games missed due to concussion ($R^2 = 0.08$, $F_{1,59} = 3.22$, $P = .08$) were marginal predictors of PCDS. Ethnicity was no longer a predictor of PCDS ($R^2 = 0.04$, $F_{1,59} = .78$, $P = .38$).

In the control group, predictors of depression symptoms at time 2 were also examined. The only predictors of time 2 depression symptoms were the number of previous head injuries ($r = 0.31$, $P = .05$) and baseline depression symptoms ($r = 0.80$, $P < .001$). Age, sex, ethnicity, and age of first participation in organized sport were not correlated. The WTAR FSIQ estimate was not available for these participants.

To evaluate the change in depression within an individual over time, we conducted reliable change analyses and found that concussed athletes were more likely to show a reliable increase in depression symptoms than nonconcussed control participants ($\chi^2_1 = 5.2$, $P = .02$). Seventeen athletes (20%) showed a reliable increase in BDI-FS score, 8 athletes (10%) had a reliable decrease, and 59 athletes (70%) had no reliable change. In the control group, 2 participants (5%) showed a reliable increase in BDI-FS score, 3 (7%) had a reliable decrease, and 37 (88%) showed no reliable change.

Concussed athletes with reliable increases in BDI-FS scores after concussion had missed fewer games due to concussion ($t_{64} = 3.35$, $P = .001$), had marginally lower WTAR-estimated FSIQ ($t_{78} = 1.83$, $P = .07$), and were marginally older when they started participating in organized sports ($t_{16.5} = -1.75$, $P = .10$) than athletes with stable or decreased depression symptoms. Note that athletes with a reliable increase in depression did not have more depression at baseline ($t_{82} = 0.67$, $P = .50$).

DISCUSSION

We observed a higher prevalence of clinically important depression symptoms postconcussion than at baseline. We found that PCDS was related to more baseline depression symptoms and baseline postconcussion symptoms, lower estimated FSIQ, older age at first participation in organized sport, and fewer number of games missed due to concussion. In reliable change analyses, athletes with a reliable increase in PCDS had a marginally lower estimated FSIQ, were marginally older when they started participating in organized sports, and had missed fewer games due to concussion. Athletes with a reliable increase in depression did not have more depression at baseline.

The relationship between PCDS and FSIQ suggested that a higher baseline IQ might protect an individual from some of the mood effects of a concussion, representing a type of "mood reserve." In other words, cognitive reserve might not only protect against head injury and dementia, as has consistently been shown, but also against psychopathology, such as depression, a concept that has been proposed.[27–29] This finding fits with previous observations[1] that depression after TBI is associated with a lower level of education (by the nature of our sample, all participants were enrolled in college).

Nonwhite ethnicity was also associated with increased PCDS. This fits with previous observations[30] that people of color tend to have worse outcomes after TBI, although the findings have been mixed. We observed that PCDS was also correlated with older age at the athlete's first participation in organized sport and fewer years participating in the athlete's main sport. This finding was somewhat surprising because it seemed intuitive that those participating in sports for a longer period would have a greater chance of sustaining concussions and subconcussive blows and that these injuries would be related to increased levels of depression. However, Guskiewicz et al[24] reported mixed

results for a history of TBI as a predictor of post-TBI depression. In addition, perhaps athletes with shorter histories of sports participation are less accustomed to, and possibly less desensitized to, concussions. Moreover, athletes who have been participating in sports longer are possibly more invested in their athletic careers and more likely to minimize symptoms.

The observed increase in depression from baseline to postconcussion testing in 20% of the sample could be due to many factors, including physiologic changes, being held out of participation, and coping with and adjusting to concussion-related symptoms. It could also be due to other changes occurring between baseline and postconcussion because most athletes had not started college or were freshmen when they were first tested. Over a year or more, many other life changes can occur, including increasing school stress, adjustment to college, and other psychosocial changes. Therefore, it is difficult to determine whether the increase in depression was necessarily due to the athletes' concussions. However, compared with baseline rates, more athletes postconcussion did show clinically important levels of depression, and 20% of athletes showed a reliable increase in depression from baseline. Furthermore, only 5% of the control group showed a reliable increase in depression, although their test-retest intervals were shorter. Considering that these athletes will likely have multiple concussions in their careers and that a large percentage already displayed clinically significant depression after 1 isolated concussion, our results are concerning.

Limitations and Future Directions

Our study had several limitations, including the self-reported depression symptoms. Although we were interested in depression symptoms rather than clinically diagnosed major depressive disorder and the BDI-FS is widely used and shown to be consistently related to clinically important depression, a more thorough interview-based measure would be ideal. This population might have an increased tendency to minimize symptoms due to desires to return to sports participation. Furthermore, these findings might not be generalizable to individuals experiencing major depressive disorders postconcussion. In addition, the time since injury and the procedures for referrals across different sports teams were not consistent; this inconsistency could have introduced biases into which athletes were tested (eg, whether all athletes were sent for testing postconcussion or only those who were not recovering as expected). The control group was tested over a shorter period than the injured participants, and controls differed in terms of sex and ethnicity from the concussed group. Researchers should test control participants matched on test-retest intervals and other demographic factors or otherwise control for these variables. Last, given that we focused only on sport-related concussions, readers should be cautious in generalizing to other causes of concussion, such as blast exposure.

Depression affects quality of life and may delay recovery from concussion, so more research is necessary to better predict which individuals might experience depression symptoms after concussion. Specifically, further study is needed on the effects of multiple concussions and subconcussive blows, as well as more reliable previous head-injury data. In addition, longitudinal data are required to establish the relationship between PCDS and later-life depression. Follow-up analyses on the association of ethnicity with depression postconcussion also will be useful.

Individuals who work with athletes are encouraged to be mindful that athletes who have higher baseline levels of depression, are not white, have lower estimated FSIQs, and have been participating in sports for shorter periods of time might be at higher risk for developing depression symptoms after a concussion. Counseling after concussions might help athletes better cope with their symptoms, a possible lack of participation time, and other concerns.

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