The role of family and personal psychiatric history in postconcussion syndrome following sport-related concussion: a story of compounding risk

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OBJECTIVE Sport-related concussion (SRC) has become a major public health concern. Prolonged recovery after SRC, named postconcussion syndrome (PCS), has been associated with several biopsychosocial factors, yet the role of both family and personal psychiatric histories requires investigation. In a cohort of concussed high school athletes, the authors examined the role(s) of family and personal psychiatric histories in the risk of developing PCS.

METHODS A retrospective cohort study of 154 high school athletes with complete documentation of postconcussion symptom resolution or persistence at 6 weeks was conducted. PCS was defined as 3 or more symptoms present 6 weeks after SRC. Three groups were defined: 1) positive family psychiatric history and personal psychiatric history (FPH/PPH), 2) positive FPH only, and 3) negative family and personal psychiatric histories (controls). Three bivariate regression analyses were conducted: FPH/PPH to controls, FPH only to controls, and FPH/PPH to FPH. Post hoc bivariate regression analyses examined specific FPH pathologies and PCS.

RESULTS Athletes with FPH/PPH compared with controls had an increased risk of PCS ($\chi^2 = 8.90$, $p = 0.018$; OR 5.06, 95% CI 1.71–14.99). Athletes with FPH only compared with controls also had an increased risk of PCS ($\chi^2 = 6.04$, $p = 0.03$; OR 2.52, 95% CI 1.20–5.30). Comparing athletes with FPH/PPH to athletes with FPH only, no added PCS risk was noted ($\chi^2 = 1.64$, $p = 0.247$; OR 2.01, 95% CI 0.68–5.94). Among various FPH diagnoses, anxiety ($\chi^2 = 7.48$, $p = 0.021$; OR 2.99, 95% CI 1.36–6.49) and bipolar disorder ($\chi^2 = 5.13$, $p = 0.036$; OR 2.74, 95% CI 1.14–6.67) were significantly associated with the presence of PCS.

CONCLUSIONS Concussed high school athletes with FPH/PPH were greater than 5 times more likely to develop PCS than controls. Athletes with only FPH were over 2.5 times more likely to develop PCS than controls. Those with an FPH of anxiety or bipolar disorder are specifically at increased risk of PCS. These results suggest that not only are athletes with FPH/PPH at risk for slower recovery after SRC, but those with an FPH only—especially anxiety or bipolar disorder—may also be at risk. Overall, this study supports taking a detailed FPH and PPH in the management of SRC.

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KEYWORDS family psychiatric history; postconcussion syndrome; personal psychiatric history; sport-related concussion; trauma

SPORT-RELATED concussions (SRCs) have proven to be a major public health concern in young athletes. From the 1.6 to 3.8 million SRCs that occur each year, approximately 136,000 involve a high school athlete.^{28,42} While research in this area has increased in recent years, identification of biopsychosocial factors that may be important for clinical recovery, such as age, sex, and devel-

opmental disabilities, has been mixed.¹⁵ Both heterogeneity and nonspecificity of symptoms used to diagnose SRCs contribute to discrepant results.¹²

For SRCs that occur in high school athletes, greater than 90% will have symptom resolution within 4 weeks.^{27,28} Athletes with persistent symptoms beyond 4 weeks are classified as having postconcussion syndrome (PCS). PCS

ABBREVIATIONS FPH = family psychiatric history; ICD-10 = *International Statistical Classification of Diseases and Related Health Problems, 10th Revision*; PCS = postconcussion syndrome; PPH = personal psychiatric history; SRC = sport-related concussion.

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includes symptoms that affect somatic, cognitive, sleep, and emotional functioning.⁷ The prolonged symptoms following SRC can adversely affect the athlete's academic performance,³⁶ neurocognitive functioning,⁹ and exercise tolerance.¹⁸ Often, athletes with PCS suffer both personally and socially from their ongoing symptoms. At present, a consensus definition of PCS does not exist.³⁷ PCS is defined in the *Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV)*¹ as 3 or more symptoms lasting longer than 3 months, while the *International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10)*⁴¹ defines PCS as 3 or more symptoms, without specifying a length of symptom duration. The diagnosis of PCS has been omitted from the DSM-V.² Perhaps more clinically relevant, a study of more than 500 sports medicine physicians concluded that the relative majority (33%) diagnosed PCS at 1 month, yet no true majority was found.³⁷

Among numerous biopsychosocial factors related to PCS, including age,⁶ sex,^{14,32} early/initial symptom burden,^{17,29} and various acute and subacute symptoms,^{17,33} the importance of a psychiatric history has also been investigated. In terms of a positive personal psychiatric history (PPH), Ellis et al. found that a personal preinjury history of depression was an independent predictor of PCS in a pediatric SRC population,¹⁰ and Morgan et al. reported that young athletes with PCS were more likely to have a PPH.³³ In contrast, Terwilliger et al. studied a group of young athletes with and without a recurrent head impact 24 hours after SRC and did not find a difference in length of recovery based on PPH.³⁹ Regarding family psychiatric history (FPH), Morgan et al.³³ identified a positive FPH as more common in young athletes with PCS. In a study examining development of psychiatric illness after SRC in a pediatric population, Ellis et al.¹¹ reported that patients with SRC who developed a postinjury psychiatric illness were more likely to have an FPH. More than 90% of patients who developed a postinjury psychiatric outcome met ICD-10 criteria for PCS. No studies have reported an absent association between FPH and recovery after SRC.¹⁵

While these studies have reported that FPH and PPH are independently associated with PCS, these factors have been studied in the context of multiple candidate variables, and their specific importance has yet to be confirmed in a dedicated study. Moreover, the role of a combined FPH and PPH (FPH/PPH) has yet to be investigated as a predictor of PCS.¹⁵ The aim of the current study was threefold: 1) to examine and replicate the previously demonstrated association between FPH and development of PCS, 2) to examine the influence of FPH/PPH on the development of PCS, and 3) to examine specific FPH pathologies in developing PCS in a high school athlete population.

Methods

Study Design

Institutional review board approval was obtained prior to initiation of this retrospective cohort study. Participants were high school athletes from various high schools in middle Tennessee presenting to the Vanderbilt University Sports Concussion Center for postconcussion evaluation

during the years 2013–2017. Study data were collected and managed using the REDCap (Research Electronic Data Capture) electronic data capture tools hosted at Vanderbilt University.¹³ REDCap is a secure, web-based application designed to support data capture for research studies.

Participants

For all athletes who sustained an SRC, demographic variables and pre- and postinjury characteristics were collected using a secure electronic medical record. A suspected diagnosis of SRC was identified by a certified athletic trainer on site at the time of injury and later confirmed by a team physician in accordance with the Concussion In Sport Group guidelines.²⁴ Study inclusion criteria were 1) age 13–18 years, 2) concussion sustained during sport, 3) presentation to the Sports Concussion Center between June 1, 2013, and May 31, 2017, with evaluation by a sports neuropsychologist (G.S.S.), 4) complete documentation of symptom resolution or persistence at 6 weeks, and 5) explicit documentation of presence or absence of FPH. The exclusion criterion was absent documentation of presence or absence of PPH. A total of 168 patients met study inclusion criteria, and 14 were excluded due to missing PPH data.

Data Collection

Symptoms were collected from 2 sources: 1) a self-reported 22-item postconcussion symptom scale²⁰ administered at each clinic visit, and 2) clinical evaluation/medical record notes. PCS was defined based on the ICD-10 definition, which includes the presence of 3 or more symptoms without a defined time period. For the current study, a symptom duration of 6 weeks was chosen 1) to clearly demarcate each group, 2) to ensure that clinic scheduling and clinician availability were not factors in group assignment, and 3) because children and adolescents have been shown to take more time to recovery than adults.^{8,43} The 6-week operational definition of symptom duration required for assignment to the PCS group is similar to that reported in other studies,^{19,38} but it differs slightly from the typically used 4-week duration.³⁷ Control patients required documentation of an absence of 3 or more symptoms and/or a diagnostic impression indicating absence of residual SRC-related symptoms.

Presence of family and personal psychiatric histories was assessed during the postinjury clinical interview by a sports neuropsychologist (G.S.S.) and recorded as binary (present or absent). All PPHs were preexisting and not newly diagnosed at the time of concussion evaluation. Given that this was a retrospective study, the treating clinician was blinded to the purpose of the study. The parent/guardian of each high school athlete was queried, "Do you know of any blood relative, alive or deceased, who has been diagnosed with a psychiatric disorder (anxiety, depression, bipolar disorder, schizophrenia) and treated with medicine by a doctor?" When present, known, and corroborated by an adult family member accompanying the student-athlete to the clinic, the specific psychiatric diagnosis was recorded. Family psychiatric history was considered positive in up to second-degree family members to the athlete and

TABLE 1. Demographic characteristics of patients with an FPH/PPH, FPH only, and control groups

Characteristic	FPH/PPH (n = 18)	FPH Only (n = 59)	Control (n = 77)	F Statistic*	χ^2	p Value
Demographic						
Mean age, yrs (SD)	15.28 (1.02)	14.92 (1.04)	14.73 (1.31)	1.67		0.19
No. of males	6 (33.3%)	38 (64.4%)	42 (54.5%)		5.51	0.06
Medical history						
PCS diagnosis	11 (61.1%)	25 (43.9%)	18 (23.7%)			
Prior concussion	8 (44.4%)	18 (30.5%)	26 (33.8%)		1.2	0.55
ADHD/LD	6 (42.9%)	6 (10.3%)	6 (7.8%)		13.98	<0.01
Psychiatric history						
Anxiety	14 (77.8%)	22 (37.3%)				
Bipolar disorder	7 (38.9%)	18 (30.5%)				
Depression	11 (61.1%)	26 (44.1%)				
Other	4 (22.2%)	17 (28.8%)				

ADHD = attention-deficit/hyperactivity disorder; LD = learning disability.

Values represent the number of patients (%), unless otherwise indicated.

* ANOVA.

included aunts, uncles, and grandparents. Common FPH pathologies included anxiety, bipolar disorder, depression, and schizophrenia.

Statistical Analysis

The sample was divided into the following 3 groups: 1) positive FPH/PPH, 2) positive FPH only, and 3) negative family and personal psychiatric histories (controls). One-way ANOVA tests of continuous demographic variable differences and a chi-square test of categorical demographic variables were performed to examine data differences across the 3 groups. Continuous variables are presented as the mean and standard deviation. Binary variables are presented as percentages.

Three bivariate regression analyses were conducted: 1) FPH/PPH to controls, 2) FPH only to controls, and 3) FPH/PPH to FPH only. Post hoc bivariate regression analyses examined specific FPH pathologies in all participants. Odds ratios and 95% confidence intervals were calculated using bivariate regression. In order to control for inflated type I bivariate regressions and multiple comparisons, significance levels were adjusted for multiple comparisons using the false discovery rate Benjamini-Hochberg procedure with significance set at $p < 0.05$.⁵ Statistical analyses were performed using IBM SPSS Statistics (version 24, IBM Corp.).

Results

Demographic characteristics of the 3 study groups are presented in Table 1. Of the 154 total patients included in the final analysis, 18 had a positive FPH/PPH, 59 had a positive FPH only, and 77 served as controls. Analysis of continuous demographic variables revealed no significant differences among the groups, with the exception of attention-deficit/hyperactivity disorder/learning disability (ADHD/LD), $F = 13.98$, $p < 0.01$, which was significantly higher in the FPH/PPH group. However, this variable was not utilized as a covariate, as it did not have a significant influence on the outcome of PCS ($\chi^2 = 0.48$, $p = 0.50$). Elev-

en (61.1%) FPH/PPH athletes developed PCS, 25 (43.9%) FPH-only athletes developed PCS, and 18 (23.7%) controls developed PCS. Prior concussion history was present in 8 (44.4%) FPH/PPH cases, 18 (30.5%) FPH-only cases, and 26 (33.8%) controls. The three most commonly reported family psychiatric history pathologies were anxiety (77.8% FPH/PPH cases, 37.3% FPH-only cases), bipolar disorder (38.9% FPH/PPH cases, 30.5% FPH-only cases), and depression (61.1% FPH/PPH cases, 44.1% FPH-only cases).

FPH/PPH and FPH Only as Predictors of PCS

Athletes with FPH/PPH had an increased risk of PCS ($\chi^2 = 8.90$, $p = 0.018$; OR 5.06, 95% CI 1.71–14.99), compared to controls (Table 2). Athletes with FPH only also had an increased risk of PCS ($\chi^2 = 6.04$, $p = 0.03$; OR 2.52, 95% CI 1.20–5.30), compared with controls. The presence of FPH/PPH did not increase athletes' risks of developing PCS above and beyond FPH only ($\chi^2 = 1.64$, $p = 0.247$; OR 2.01, 95% CI 0.68–5.94). Among pathologies in our entire FPH sample, anxiety ($\chi^2 = 7.48$, $p < 0.021$; OR 2.99, 95% CI 1.36–6.49) and bipolar disorder ($\chi^2 = 5.13$, $p = 0.036$; OR 2.74, 95% CI 1.14–6.67) were significantly associated with presence of PCS (Table 3).

Discussion

In this retrospective cohort study of high school athletes evaluated after SRC, we found that athletes with a history of both family and personal psychiatric illness (FPH/PPH) were over 5 times more likely to develop PCS. Athletes without a personal history of psychiatric illness, yet only a family history of psychiatric illness, were over 2.5 times more likely to develop PCS. Furthermore, athletes with a family history of anxiety and bipolar disorder were at greater risk for developing PCS. To our knowledge, this is the first reported study demonstrating that athletes with FPH/PPH have a compounded risk of developing PCS following SRC. The results from this study extend previous findings identifying predictors of PCS in the young athlete population^{14,17,22,32,33} and work investigating

TABLE 2. Bivariate regression of PCS comparing FPH/PPH, FPH only, and control groups

	B	SE	Wald	p Value	Adjusted p Value*	OR	95% CI	
							Lower Bound	Upper Bound
FPH/PPH & controls†	1.62	0.55	8.58	<0.01	0.018	5.06	1.71	14.99
FPH only & controls‡	0.92	0.38	5.92	0.02	0.03	2.52	1.20	5.30
FPH/PPH & FPH only§	0.70	0.55	1.60	0.21	0.247	2.01	0.68	5.94

Boldface type indicates statistical significance.

* Adjusted p values for multiple comparisons using the false discovery rate Benjamini-Hochberg procedure.

† Bivariate regression of overall model, $\chi^2 = 8.90$, $p < 0.01$, Nagelkerke $R^2 = 0.13$.

‡ Bivariate regression of overall model, $\chi^2 = 6.04$, $p = 0.02$, Nagelkerke $R^2 = 0.06$.

§ Bivariate regression of overall model, $\chi^2 = 1.64$, $p = 0.21$, Nagelkerke $R^2 = 0.03$.

the role of psychiatric history in prolonged recovery after an SRC.^{3,10,11,21,33}

This study provides additional evidence of FPH only as a predictor of PCS and identifies high school athletes with FPH/PPH as also having an increased risk of PCS. Both of these findings are consistent with literature identifying FPH³³ and PPH¹⁰ as independent predictors of PCS. While routine SRC management includes an assessment of PPH, FPH is less commonly obtained. These results provide support for FPH to be part of routine SRC assessment and management, even in athletes with no personal history of any psychological or psychiatric diagnosis. In areas with limited access to a concussion specialist, primary care providers may be less likely to record a family or personal psychiatric history. In a survey of 367 primary care providers, over 30% stated that they did not routinely use published guidelines in concussion management, with unawareness of the guidelines cited as the most common reason for lack of use.³⁵ In addition, only 16% of these providers had access to neuropsychological testing within 1 week of injury.³⁵ This further suggests that concussion management, in particular by nonspecialists, does not include documentation of psychiatric histories as part of routine assessment and care. However, its potential relevance is underscored, given the 5-times and 2.5-times increased odds in PCS diagnosis in compounded FPH/PPH and FPH-only cases, respectively.

In the FPH pathologies that were recorded in both the FPH-only and FPH/PPH groups (all FPH pathologies), anxiety and bipolar disorder were significantly associated with the development of PCS. These two conditions are particularly important because of their high heritability. For example, one study estimated that children of parents with a diagnosed anxiety disorder have a greater than 7 times risk of personally developing an anxiety disorder.⁴⁰ Similarly for bipolar disorder, studies have estimated its heritability in excess of 80%.²⁵ Moreover, the prevalence of these disorders in high school students is approximately 32% for anxiety and 4% for bipolar disorder.³⁰ In the context of the high heritability of these two disorders, family histories of psychiatric illness with a particular emphasis on anxiety and bipolar disorder may further identify athletes at risk of prolonged recovery post-SRC.

Armed with this information, how can athletes with FPH/PPH or FPH only be treated to minimize the risk of PCS? One possibility involves specialized educational, athletic, and medical accommodations for these athletes.

Although findings have been mixed in evaluating the effectiveness of complete rest,²⁶ 1 week of full cognitive and physical rest in athletes who were slow to recover demonstrated substantial improvement in 62% of the cohort studied.³⁴ It remains to be seen whether extended rest immediately postinjury is protective against the development of PCS in athletes with a positive FPH/PPH or FPH only. A second possibility for more specialized treatment of PCS in FPH/PPH or FPH-only athletes is for more frequent and multidisciplinary clinical follow-up after SRC. One study²¹ demonstrated a benefit of using a collaborative care approach involving cognitive-behavioral therapy, psychopharmacological treatment, and care coordination among a multidisciplinary team of health care providers and school officials. After 6 months of treatment, high postconcussive symptom levels were reported in 13% of the collaborative care group compared with 40% of controls. A final possible treatment strategy may be pharmacological management; however, there is a lack of clear guidelines for use of medications in managing recovery after SRC, and limited evidence exists for their effectiveness.²³ Although we did not examine the pharmacological and/or counseling treatments for athletes with psychiatric illness, further study is warranted to understand how FPH/PPH and FPH-only athletes may benefit from pharmacological and/or counseling interventions. Additionally, these studies may describe the relationship between treated and untreated psychiatric illness and an association with development of PCS.

Lastly, the importance of psychiatric history may be relevant to the discussion of “brain reserve” and outcomes after concussion. Bernard et al. found that in a non-SRC population of concussed children 2–12 years of age, preexisting noninjury factors had an increasingly strong association with PCS after a mild traumatic brain injury over time.⁶ Prior arguments for brain reserve as a modifying factor in outcomes after cerebral insult have centered around poorer outcomes for children with preexisting learning difficulties.⁶ In the current study, we found that learning disabilities were significantly more common in the combined FPH/PPH group, suggesting that a relationship may exist among learning disability, FPH/PPH, and PCS. It is possible the concept of brain reserve is intertwined with a genetic component underlying the development of PCS in a similar manner to APOE $\epsilon 4$ -positive athletes reporting greater symptomatology postconcussion than APOE $\epsilon 4$ -negative athletes.³¹ Overall, it is unclear how psychiatric illness and learning disabilities interact to modify an

TABLE 3. Bivariate regression of PCS comparing specific FPH diagnoses and controls

FPH	B	SE	Wald	p Value	Adjusted p Value*	OR	95% CI	
							Lower Bound	Upper Bound
Anxiety†	1.09	0.40	7.39	<0.01	0.021	2.99	1.36	6.49
Bipolar disorder‡	1.01	0.44	5.09	0.02	0.036	2.74	1.14	6.67
Depression§	0.42	0.39	1.17	0.28	0.276	1.52	0.71	3.25

Boldface type indicates statistical significance.

* Adjusted p values for multiple comparisons using the false discovery rate Benjamini-Hochberg procedure.

† Bivariate regression of overall model, $\chi^2 = 7.48$, $p < 0.01$, Nagelkerke $R^2 = 0.06$.

‡ Bivariate regression of overall model, $\chi^2 = 5.13$, $p = 0.02$, Nagelkerke $R^2 = 0.05$.

§ Bivariate regression of overall model, $\chi^2 = 1.17$, $p = 0.28$, Nagelkerke $R^2 = 0.01$.

individual student-athlete's response to SRC, yet brain reserve may be decreased in both conditions, thus inhibiting recovery.

Limitations

We acknowledge several limitations to the results of our study. Utilization of ICD-10 criteria for PCS diagnosis can be limited by a 40% false-positive rate.¹⁶ In addition, individuals with medical illnesses, orthopedic injuries, alcohol use, and exercise exertion may report PCS-like symptoms.⁴ It may be difficult for high school student-athletes to differentiate symptoms specific to the SRC versus the symptoms of daily life. Moreover, our selection of participants may be at risk of selection bias. We chose a convenience sample referred to a specialty sports concussion clinic, and this could limit the generalizability of our findings. A potential recall bias may have been present when ascertaining preinjury factors that defined an athlete's family and personal health history. Finally, our results indicate a potential compounding effect of having both a family and personal psychiatric history in PCS development when compared with controls. While the direct comparison between the two groups was not statistically significant, further study is needed to understand the prognostic importance and risk relationship between having an FPH only and having both an FPH and a PPH.

Conclusions

In this retrospective cohort study, we found that high school athletes with FPH/PPH were over 5 times more likely to develop PCS than controls. Athletes with FPH only were over 2.5 times more likely to develop PCS compared to controls. Athletes with a family history of anxiety or bipolar disorder were more likely to develop PCS compared to other diagnoses of FPH studied (i.e., depression or schizophrenia). These results confirm prior findings of FPH as a potential predictor of PCS and identify FPH/PPH as a novel predictor of PCS. Athletes without a personal psychiatric history but rather a family psychiatric history only may also be at risk of PCS, and athletes with both a family and personal psychiatric history may have a compounded risk of PCS. Finally, these results support taking a detailed family and personal psychiatric history in the management of SRC and PCS.

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Disclosures

G. S. Solomon is a consultant for the Nashville Predators, Tennessee Titans, and the athletic departments of Tennessee Tech University and the University of Tennessee, fees paid to institution. He is also a consultant to the National Football League Department of Health and Safety.

Author Contributions

Conception and design: Zuckerman, Legarreta, Solomon. Acquisition of data: Legarreta. Analysis and interpretation of data: all authors. Drafting the article: Zuckerman, Legarreta, Brett. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Zuckerman. Statistical analysis: Zuckerman, Legarreta, Brett. Administrative/technical/material support: Zuckerman, Solomon. Study supervision: Zuckerman, Solomon.

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