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Prescription opioid misuse and sports-related concussion among high school students in the United States

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Abstract

Study objective: Concussion is highly prevalent in adolescents and associated with a higher risk of substance use. With the rising use of opioids among adolescents, one form of substance use of concern is misuse of prescription opioids. This study aimed to examine the association between history of sports-related concussion in the past year and current prescription opioid misuse among high school students in the United States (US).

Setting: Secondary data analysis from the 2019 Youth Risk Behavior Survey.

Participants: Nationally representative sample of high school students (n = 7,314).

Design: Cross-sectional study

Main measures: Participants were asked whether they experienced any concussions related to sports or being physically active during the past 12 months; and whether they had any prescription opioid misuse within the past 30 days.

Results: Amongst this cohort, 14.0% reported sustaining a concussion in the past 12 months and 6% reported current prescription opioid misuse. Prevalence of prescription opioid misuse was higher among those with history of concussion (9.9%) compared to those without concussion (5.5%, $p = 0.0015$). Controlling for covariates (sex, race/ethnicity, other substance use, depressive symptoms), the odds of prescription opioid misuse was 1.5 times higher for adolescents with concussion compared to those without (adjusted odds ratios [OR] = 1.5; 95% confidence interval 1.0, 2.3; $p = 0.029$).

Conclusion: Concussion was associated with prescription opioid misuse among US youth, even after accounting for depressive symptoms and other substance use. Longitudinal studies

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Conflict of interest:

See Wan Tham: No conflict of interest to report

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are needed to test causal relationships and understand biobehavioral mechanisms that underlie associations between concussion and opioid misuse in adolescents.

Keywords

Concussion; prescription opioid misuse; adolescents

Introduction

Concussion is a significant public health issue affecting adolescents in the United States (US). Recent national surveys have shown that approximately 20% of adolescents experienced at least one lifetime concussion (1, 2). In particular, the highest rates were documented in adolescents 15 to 19 years old. Although the impact of concussion may be self-limited, longer term physical and mental health consequences are increasingly reported (3). More recently, research has demonstrated that adolescents who sustained concussions are at greater risk of substance use (4, 5). Specifically, adolescents with a history of concussion have double the odds of tobacco, alcohol and cannabis use (5).

One particular form of substance use of increasing interest in the adolescent population is prescription opioid misuse. Up to 6% of adolescents in the US report prescription opioid misuse in a 12-month period (5), defined as using prescribed opioids such as oxycodone, hydrocodone, or codeine in a manner other than directed by a health care provider (CDC Opioid Basics). Prescription opioid misuse is associated with a host of negative consequences including the development of an opioid use disorder, opioid overdose, and initiation of heroin use (6–8), and adolescents have an increased risk for prescription opioid misuse relative to older adults (9). Over the last two decades, we have seen a three-fold increase in opioid related mortality in adolescents, highlighting the severity of the opioid epidemic for youth in the US (10).

Research on the association between pediatric concussion and prescription opioid misuse is sparse. One epidemiological study conducted in Canada found that adolescents with a history of traumatic brain injuries (TBI) including concussions had 2.9 times greater odds for prescription opioid misuse compared to those without TBI (11). Studies have not been conducted on this topic in the US.

Several hypotheses have been proposed to understand the association between concussion and the use of substances, including opioids. First, headaches are commonly experienced after a concussion. Persistent pain may contribute to decisions to self-medicate with prescription opioids, a commonly reported reason for prescription opioid misuse in adolescents (12). Second, rates of depression, anxiety and post-traumatic stress symptoms are increased after a head injury (13–16). Comorbid psychiatric diagnoses are associated with substance use as well as prescription opioid misuse (17–19). Finally, post-concussive neurocognitive changes in impulse control and reward-motivation behaviors may predispose adolescents to higher risk behaviors including using tobacco, alcohol, and cannabis as well as misusing prescription opioids (18, 20, 21). However, our understanding is currently hampered by limited data on the association between adolescent concussion and prescription opioid misuse.

The primary aim of this study was to examine the relationship between concussion and prescription opioid misuse among high school students in a large nationally representative US dataset. We hypothesized that history of recent concussion would be associated with current prescription opioid misuse (in the past 30 days) after accounting for symptoms of depression and concurrent substance use. We also hypothesized that increased number of concussions in the past 12 months would be associated with an incremental increase in prescription opioid misuse.

Methods

Participants and procedure

We used cross-sectional data from the 2019 Youth Risk Behavior Survey (YRBS). The YRBS is conducted every two years by the Centers for Disease Control and Prevention and is the largest public health surveillance system of high school student health behaviors in the US. The YRBS uses a 3-stage cluster sampling design to produce nationally representative estimates of health behaviors through public and private school students in grades 9 to 12. Surveys are school based: parents provide permission, and surveys are then self-administered to participating youth at their schools during one class period. The overall response rate for 2019 was 60.3%. Additional information about YRBS is available at <https://www.cdc.gov/healthyyouth/data/yrbs/index.htm>. As data were deidentified and publicly available, our Institutional Review Board deemed this study as non-human subjects research which is exempt from review.

Measures

Concussion frequency—The number of concussions sustained in the past 12 months was assessed by asking youth: "During the past 12 months, how many times did you have a concussion from playing a sport or being physically active?" The response options were "0 times", "1 time", "2 times", "3 times", and "4 or more times". The YRBS dichotomized responses with those reporting 1 or more concussions defined as having a concussion during the past year versus 0 if no concussions were reported. Two variables, presence or absence of concussions and the number of concussions, were used in separate analyses.

Current prescription opioid misuse—Current prescription opioid misuse during the past 30 days was assessed by asking adolescents: "During the past 30 days, how many times have you taken prescription pain medicine without a doctor's prescription or differently than how a doctor told you to use it?". The response options were: "0 times", "1 or 2 times", "3 to 9 times", "10 to 19 times", "20 to 39 times", and "40 or more times". The YRBS categorized responses as a binary variable defined as those participants without current prescription opioid misuse and those who reported more than 1 time as having current prescription opioid misuse.

Covariates—We specified covariates for inclusion in our models that have been shown to be associated with prescription opioid misuse and concussion, including sociodemographic factors (age, sex, race & ethnicity) (1, 9, 22), depressive symptoms (23, 24), and other substance use behaviors (tobacco, marijuana, alcohol).

Sociodemographics.: Participants reported their age, sex, and race/ethnicity (White, non-Hispanic; Black, non-Hispanic; Hispanic; Asian, non-Hispanic; American Indian/Alaska Native; Native Hawaiian/Other Pacific Islander; and multiple race).

Alcohol, tobacco, and marijuana use.: Current alcohol, tobacco, and marijuana use were reported by participants over the past 30 days. These data were coded as binary variables (0 = no, 1 = yes) based on whether one or more instances of use was reported over the past 30 days vs no use.

Depressive symptoms.: YRBS captures depressive symptoms by asking participants “During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?”. Consistent with previous YRBS publications, we categorized participants as having depressive symptoms if they answered “yes” in response to this question (25).

Statistical analysis.: Analyses were conducted using Stata version 14.2 (StataCorp College Station, TX); α was set at .05, and hypothesis testing was two-tailed. Missing data were not imputed. We adjusted for the complex sample design of YRBS by using sampling weights, regional stratification, and primary sampling unit information to provide nationally representative estimates of high school students in the US.

First, we conducted descriptive analysis to summarize the distribution of variables in the sample. Pearson chi-square analysis was used to compare rates of prescription opioid misuse between participants with concussion relative to those without concussion. Next, we used Pearson chi-square analysis to compare prevalence rates of current prescription opioid misuse according to the number of concussions in the last 12 months to determine whether increased number of concussions were incrementally associated with increased probability of prescription opioid misuse. We then performed multivariate logistic regression analysis to test the association between concussion and current prescription opioid misuse. The multivariate models controlled for socio-demographics (age, sex, race and ethnicity), depressive symptoms, and other substance use behaviors (tobacco, alcohol, and marijuana use).

Results

Sample characteristics

Our sample included 7,314 participants, mean age 16 years ($SD = 1.1$), with 49.3% males. Over half of the adolescents identified as White and non-Hispanic (54.7%), followed by 22.2% who identified as multi-racial, 8.8% as Black and non-Hispanic, 8.8% as Hispanic, and 5.0% as Asian. In the sample, 976 (14.0%) reported having at least one concussion during the past 12 months. Of the 976 children with concussions, 339 (33.2%) reported more than 1 concussion during the past 12 months. This is a prevalence of 4.6% with multiple concussions in this sample.

Characteristics of the sample by concussion status (with and without concussion in the past 12 months) are presented in Table 1. The rates of concussion were higher among

males relative to females (15.4% versus 12.7%, $p = 0.03$), highest among students who self-identified as American Indian/Alaskan Native (41.0%), relative to other racial and ethnic groups. We also found that a history of concussion was more prevalent among students with current substance use (tobacco, alcohol, and marijuana) and those who reported depressive symptoms over the past 12 months. There was no association between age and concussion status.

Associations between concussion and prescription opioid misuse

The prevalence of prescription opioid misuse was significantly higher (9.8%) among students with at least one concussion compared to those without concussion (5.5%, $p < 0.0001$; Table 2). Furthermore, as hypothesized, the prevalence of prescription opioid misuse was related to the frequency of reported concussions over the past year in a dose-dependent pattern (Table 2). Among adolescents who reported one concussion, the prevalence of current prescription opioid misuse was 7.7%; while the prevalence of prescription opioid misuse was 12.8% among adolescents who reported 2 concussions. Among adolescents reporting 4 or more concussions, the prevalence of prescription opioid misuse was 16.0%.

Factors associated with current prescription opioid misuse

Results of the multivariate logistic regression analysis between concussion and current prescription opioid misuse are presented in Table 3. After controlling for age, sex, depressive symptoms, current tobacco, alcohol and marijuana use, concussion was significantly associated with prescription opioid misuse (adjusted odds ratio (aOR) = 1.5; 95% confidence interval (CI): 1.0 – 2.3; $p = 0.029$). Students who self-reported their race and ethnicity as Black, non-Hispanic, Hispanic, or multi-racial had increased odds for current prescription opioid misuse relative to being White and non-Hispanic. Current alcohol, tobacco, and marijuana use were all associated with increased odds of prescription opioid misuse. Similarly, those with depressive symptoms in the past year had increased odds of prescription opioid misuse. Age and sex were not associated with prescription opioid misuse.

Discussion

This is the first study to establish an association between sports-related concussion and prescription opioid misuse in high school students in the US. Using data from a nationally representative sample, we found that high school students with one or more concussions in the past 12 months due to sports or physical activity had a higher prevalence of prescription opioid misuse in the past 30 days. Furthermore, increased frequency of concussions was associated with increased prevalence of prescription opioid misuse. Finally, this association remained significant in multivariate analysis after controlling for sociodemographic factors, depressive symptoms, and comorbid substance use.

The prevalence of single (14.0%) and multiple concussions (4.6%) in the past 12 months in this study were comparable to other published studies. One Canadian study of 357 students (11–15 years) found that 10.7% had a diagnosed concussion within the past year (24). Comparatively, using a different metric of lifetime concussions, another nationally

representative study in the US (2016 Monitoring the Future Survey) revealed that 14% of youth reported one diagnosed lifetime concussion; and 5.5% reported more than one lifetime concussion (4). Taken together, our findings highlight concussion as a highly prevalent injury in adolescents and remains an important public health issue.

Findings revealed that prescription opioid misuse was significantly higher (9.8%) among students with one or more concussions in the past year compared to those without (5.5%). This was consistent with results from a Canadian study, that past year prescription opioid misuse was 2.69 times greater for students with a history of TBI than those without (11). Similarly, the prevalence of prescription opioid misuse in adolescents without concussions in this study was also similar to that found in other epidemiological studies in the general adolescent population (National Survey on Drug Use and Health 2015 to 2016) (20). The relationship between concussion and prescription opioid misuse has also been found in adult athletes, that a history of concussion increased the odds of prescription opioid misuse (AOR 4.25) (26). The dose response relationship in this study provides further evidence that repetitive concussions are associated with increased risk of substance use (5). Our findings extend the limited body of work, highlighting associations between concussion and prescription opioid misuse.

Several risk factors associated with prescription opioid misuse emerged in our multivariate models, including elevated depressive symptoms and current use of alcohol, nicotine, or cannabis. Following a concussion, up to 36.7% of adolescents report elevated depressive symptoms (13), highlighting the importance of screening for depression post-injury. With regard to the relationship between concussion, prescription opioid misuse and substance use, an underlying mechanism has been hypothesized. That is, adolescents have an increased propensity for risk taking behaviors (27). This is due to the delicate balance between a developing capacity for cognitive control, versus strong reward-based behaviors (28). This balance may be tested in the setting of neurocognitive and psychological vulnerability following a concussion and influenced by the reinforcing effects of substances (including opioids). Taken together, findings provide data that assessment of adolescents after a concussion should include early screening for psychological distress, substance use, and prescription opioid misuse.

Study findings should be considered in light of several limitations. First, this is a cross-sectional design, limiting our ability to determine causal relationships between concussion and prescription opioid misuse. Longitudinal data are needed to understand the directionality of this relationship. Second, prescription opioid misuse was measured using a single item. Future studies should include the use of a validated questionnaire measure to provide a clearer understanding of the extent of prescription opioid misuse, including intention of misuse. Specific measures have been developed that can be used in the pediatric population, including the CRAFFT screening tool (29).

In summary, this study highlighted the increased rate of prescription opioid misuse among youth who have sustained a sports-related concussion. The clinical implications of these findings suggest the need to develop and implement screening measures for prescription opioid misuse behaviors as well as associated risk factors (depression, other substance

use) among adolescents who present following concussion. Clinicians should also screen for concussion-related complications, such as persistent headaches or changes in cognitive, behavioral and emotional regulation, which may predispose youth to prescription opioid misuse and other behaviors (e.g., violence) (30, 31). Of note, opioids are not recommended for the routine management of chronic headache pain, particularly in the context of concussion (32). Non-pharmacological approaches (e.g. physical therapy, cognitive behavioral therapy) and other pharmacologic agents such as abortive and prophylactic medications for headaches can be used in the treatment of persistent headaches following a concussion (33). When opioids are prescribed, the adolescent and parent/caregivers should be provided with information on risks, expected duration of treatment, monitoring and safe practices on storage and disposal (34, 35). For practitioners, validated screening tools for substance use can be incorporated to detect opioid use disorders. Additionally, efforts at the national level have provided guidelines for opioid prescribing and strategies to reduce the risk of prescription opioid misuse (36).

There is a clear need to further research aimed at understanding the role of concussion in the development of prescription opioid misuse, including longitudinal research to examine the temporal patterns of prescription opioid misuse (post-injury versus long term persistence) and to test the directionality of this relationship.

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Abbreviations

aOR	adjusted odds ratio
95% CI	95% confidence interval
YRBS	Youth Risk Behavior Survey

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Table 1.

Sample characteristics comparing high school students with (n = 976) and without concussion in the past 12 months (n = 6338)

Characteristics	Concussion						p-value
	Total sample (n=7,314)		Yes (n = 976; 14%)		No (n = 6338; 86%)		
Current prescription opioid misuse							<i>0.0015</i>
No	93.9	(92.9–94.8)	90.1	(87.1–92.5)	94.5	(93.4–95.5)	
Yes	6.1	(5.2–7.1)	9.9	(7.5–12.9)	5.5	(4.5–6.6)	
Age							0.793
14 years	11.8	(10.6–13.0)	12.5	(10.1–15.2)	11.6	(10.4–13.0)	
15 years	24.7	(23.2–26.2)	23.2	(20.0–26.8)	24.9	(23.5–26.4)	
16 years	26	(24.6–27.4)	27.4	(23.7–31.4)	25.7	(24.1–27.4)	
17 years	24.1	(22.8–25.5)	23.8	(20.5–27.6)	24.2	(22.8–25.6)	
18 years or older	13.5	(12.2–15.0)	13.1	(9.9–17.1)	13.6	(12.3–14.9)	
Female							<i>0.031</i>
Male	49.3	(47.3–51.4)	54.1	(49.0–59.3)	48.5	(46.5–50.5)	
Female	50.7	(48.6–52.7)	45.9	(40.7–51.0)	51.5	(49.5–53.5)	
Race & ethnicity							<i><0.0001</i>
White- non-Hispanic	54.7	(49.1–60.1)	58.3	(52.0–64.4)	54.1	(48.4–59.6)	
Black- non-Hispanic	8.8	(6.6–11.5)	9.6	(7.2–12.6)	8.7	(6.4–11.6)	
Hispanic	8.8	(6.9–11.0)	6.5	(4.5–9.4)	9.1	(7.2–11.4)	
Asian	5.1	(2.6–9.6)	3.3	(1.9–5.9)	5.3	(2.7–10.3)	
Am Indian/Alaska Native	0.5	(0.3–0.6)	1.3	(0.8–2.3)	0.3	(0.2–0.5)	
Native Hawaiian/Other PI	0.3	(0.2–0.5)	0.3	(0.1–1.5)	0.3	(0.2–0.5)	
Multiple	22	(18.6–25.7)	20.6	(17.1–24.6)	22.2	(18.8–26.1)	
Current tobacco use							<i><0.0001</i>
No	65.9	(63.3–68.4)	50.9	(46.4–55.4)	68.3	(65.7–70.9)	
Yes	34.1	(31.6–36.7)	49.1	(44.6–53.6)	31.7	(29.1–34.3)	
Current marijuana use							<i><0.0001</i>
No	78.7	(76.4–80.9)	70.4	(65.1–75.1)	80.1	(77.8–82.3)	
Yes	21.3	(19.1–23.6)	29.6	(24.9–34.9)	19.9	(17.7–22.2)	
Current alcohol use							<i><0.0001</i>
No	70.2	(67.9–72.5)	57.1	(53.0–61.2)	72.4	(69.9–74.7)	
Yes	29.8	(27.5–32.1)	42.9	(38.8–47.0)	27.6	(25.3–30.1)	
Felt sad or hopeless							<i>0.018</i>
No	62.9	(61.0–64.8)	57.3	(52.2–62.3)	63.8	(61.7–65.8)	
Yes	37.1	(35.2–39.0)	42.7	(37.7–47.8)	36.2	(34.2–38.3)	

Table 2.

Association between frequency of concussions and the prevalence of prescription opioid misuse

Number of concussions in past 12 months	n	Prescription opioid misuse	
		Weighted %	95% CI
0	360	5.5	(4.5–6.6)
1	61	7.7	(5.6–10.5)
2	28	12.8	(7.6–20.8)
3	14	15.9	(7.5–30.9)
4 or more	12	16.0	(7.5–30.9)

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Table 3.

Multivariate logistic regression analysis to estimate the association between sample characteristics and current prescription opioid misuse.

Characteristic	% With Prescription Opioid Misuse	95% Confidence Interval	aOR	95% Confidence Interval	<i>p</i>
Concussion past 12 months					
No	5.5	(4.5 – 6.6)	ref		
Yes	9.9	(7.6 – 12.7)	1.5	(1.0 – 2.3)	<i>0.029</i>
Age					
14 years	5.7	(3.5 – 9.0)	ref		
15 years	6.1	(4.5 – 8.3)	1.2	(0.6 – 2.1)	0.619
16 years	6.2	(4.8 – 7.9)	1.0	(0.6 – 1.7)	0.990
17 years	5.4	(4.2 – 7.1)	0.8	(0.5 – 1.3)	0.363
18 years or older	7	(5.2 – 9.4)	1.0	(0.5 – 1.9)	0.890
Biological sex					
Male	4.9	(4.0 – 6.0)	ref		
Female	7.2	(6.0 – 8.6)	1.2	(1.0 – 1.5)	0.107
Race & ethnicity					
White- non-Hispanic	5	(3.9 – 6.3)	ref		
Black- non-Hispanic	5.6	(3.3 – 9.1)	1.7	(1.0 – 2.8)	<i>0.041</i>
Hispanic	8.3	(6.2 – 11.1)	1.9	(1.2 – 3.1)	<i>0.006</i>
Asian	4.2	(2.8 – 6.2)	1.3	(0.8 – 2.3)	0.273
Am Indian/Alaska Native	4.2	(1.1 – 15.1)	0.6	(0.1 – 2.7)	0.487
Native Hawaiian/Other PI	9.6	(1.7 – 39.5)	2.0	(0.3 – 12.3)	0.455
Multiple	8.5	(6.5 – 11.0)	1.8	(1.2 – 2.7)	0.005
Current tobacco use					
No	3.5	(3.0 – 4.2)	ref		
Yes	10.9	(9.1 – 13.1)	1.7	(1.2 – 2.2)	<i>0.001</i>
Current marijuana use					
No	4.4	(3.7 – 5.2)	ref		
Yes	12.2	(10.1 – 14.8)	1.4	(1.1 – 1.8)	<i>0.013</i>
Current alcohol use					
No	3.6	(2.8 – 4.5)	ref		
Yes	11.9	(10.1 – 14.0)	2.2	(1.7 – 2.9)	<i><0.0001</i>
Felt sad or hopeless					
No	3.2	(2.4 – 4.2)	ref		
Yes	10.9	(9.2 – 12.8)	2.7	(2.0 – 3.6)	<i><0.0001</i>