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Prevalence of diagnosed depression in adolescents with history of concussion

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Abstract

Purpose—Previous studies in adults have suggested concussion and other brain injury presents a risk factor for depression. The goal of our study was to analyze the association between previous concussion and current depression diagnosis in a large nationally-representative adolescent dataset.

Methods—Retrospective cohort study using the National Survey of Children's Health 2007–2008, a nationally-representative survey conducted via random digit dialing. Data were obtained by parental report. We included youth 12–17 years old without a current concussion (N=36,060), and evaluated the association between previous concussion (binary) and current depression diagnosis (binary) using multiple logistic regression to control for age, sex, parental mental health and socioeconomic status.

Results—After controlling for age, sex, parental mental health, and socioeconomic status, history of concussion was associated with a 3.3 fold greater risk for depression diagnosis (95%CI: 2.0–5.5). Other factors significantly associated with depression diagnosis included poor or fair parental mental health (OR: 3.7, 95%CI: 2.8–4.9), and older age (15–17 years vs. 12–14 years, OR: 1.4, 95%CI: 1.1–1.8). Sex of the subject was not significantly related to depression diagnosis. Being above 200% of the poverty level was associated with approximately a 50% decreased risk of depression diagnosis (95%CI: 35–70%).

Conclusions—History of concussion was associated with a higher prevalence of diagnosed depression in a large nationally-representative adolescent dataset. Clinicians should screen for depression in their adolescent patients with concussion. Future studies should confirm this association using prospective methodology, and examine potential treatment approaches.

Keywords

Adolescents; Concussion; Depression; Traumatic brain injury

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Introduction

Approximately 1.4 million traumatic brain injuries (TBI) occur annually, 75–90% of which are mild TBI or concussion [1–3]. It was previously thought that youth recovered quickly from concussion, but new evidence suggests symptoms may persist for months or years, particularly after multiple concussions [4]. One of the most concerning such symptoms is post-concussive depression. Depression during adolescence is associated with significant morbidity and mortality, including school failure [5], obesity [6], substance abuse [7], and suicide [8].

Data on post-concussive depression comes primarily from the adult literature. Increased diagnoses of depression were found in ex-NFL players with previous concussions, with an odds ratio of 1.5 after controlling for age, education and substance abuse (18.5% vs. 13.4%, 95% CI 1.2–2.0) [9]. An additional study of ex-NFL players found those with two or more concussions had 1.5 times the risk for lifetime depression, while those with three or more had 3 times greater risk [10]. A study in a health maintenance organization in Seattle reported 2 times the risk for depression two years after a mild TBI [11].

Data from youth with mild TBI are more limited. One study of a clinical population found an 11% incidence of novel depression in youth 6 months following mild TBI, but these were only in subjects with abnormal brain imaging [12]. Studies of depression following mild TBI are complicated by the fact that risk factors for mild TBI (such as low socioeconomic status or family history of mental health issues) are also associated with depression. To more clearly understand the risk for depression following mild TBI requires a comparative population and adequate measurement of potential confounding factors. One study of youth in a health maintenance organization in Seattle found twice the risk for depression following mild TBI after controlling for potential confounding, but only for youth without previous psychiatric issues [13]. Another study in the same organization found a 1.7 fold greater risk of depression for youth following any TBI [14]. The one prospective study of depression and TBI in youth [15] found similar amounts of depressive symptoms when comparing youth with Mild I TBI (no intracranial hemorrhage) to arm-injured controls 2 years after injury, but 5% of the Mild I TBI patients were diagnosed with major depressive disorder compared to 0% of arm-injured controls.

In 2009, the Washington State Legislature passed the Lystedt Law [16], requiring all athletes to be evaluated by a clinician if suspected of having a concussion, and this and similar laws have caused an influx of concussed patients into primary care offices [17]. The goal of our study was to examine prevalence of diagnosed depression in youth with a history of concussion using a nationally representative sample that would allow us to control for potential confounding. If concussion is associated with a significant increased risk of depression, clinicians should monitor more carefully for the development of depression when managing concussed youth.

Methods

i. Data source

The National Survey of Children's Health 2007 [18] is a telephone survey of parents administrated by the Maternal and Child Health Bureau, U.S. Department of Health and Human Services. The survey was conducted in several waves, and we used data from the 2007–2008 survey only. Phone numbers were selected by random digit dialing to identify households with one or more children under 18 years old, and one of those children was randomly selected to be discussed. If respondents reported no children under 18 years old lived in the household, the interview was stopped. The interview was conducted with the parent or caregiver, and interviews were completed in 66% of households identified with children, for a total of 91,642 surveys. Surveys were conducted in English and Spanish. The survey was designed to collect a nationally representative sample of the non-institutionalized population aged 0–17 years, with at least 1700 surveys per state. A wide range of topics were covered including 1) medical insurance coverage, 2) child and family demographics, 3) parental physical and mental health, 4) child physical and mental health, 5) school performance, and 6) neighborhood description.

ii. Variables

The primary outcome was a current diagnosis of depression. Parents were asked whether their child had ever been diagnosed with depression by a clinician, and were prompted with this information: "Depression is an illness that involves the body, mood, and thoughts. It is marked by persistent sadness or an anxious or empty mood. It affects how a person feels, and the way a person eats, sleeps, and functions." Parents were then asked whether their child suffered depression currently or only in the past, and the outcome we chose was "current" depression. Subjects with previous depression diagnosis were included in the sample as not having current depression. Our predictor of interest was history of brain injury or concussion. Parents were asked whether their child had ever been diagnosed with a brain injury or concussion, and were prompted with this information: "A concussion is an injury of the brain that causes a brief disruption in brain function. Brain tumors should not be considered brain injuries." Parents were then asked whether the brain injury was current or in the past, and we only included subjects with previous brain injury. For simplicity in this study, we use the term "concussion" to describe these injuries rather than "concussion or other brain injury" as the question specifically mentioned concussion. Data suggest that the preponderance of brain injuries suffered by youth are mild brain injuries, or concussions [19].

Potential confounders of the relationship between previous concussion and current depression were selected based on literature review, and included age [20], sex [21], parental mental health [22] and poverty level [23–24]. We generated a binary age variable (15–17 years old vs. 12–14 years old), and a binary parental mental health variable (poor or fair vs. excellent, very good or good). Sex (female vs. male) was available in the data set and poverty level (100%, >100 to 200%, >200 to 400%, >400%) was constructed by the staff at the National Survey of Children's Health using annual household income and the total number of persons living in the household, with the 2007 Department of Health and

Human Services poverty threshold guidelines as a reference. Either annual income or number of persons in the household was missing for >10% of the subjects in the dataset, and thus multiply imputed data constructed by the researchers at the National Survey for Children's Health were used for analysis [25]. These data contained five imputations for each subject.

iii. Sample

For this study we examined only 12–17 year olds, as this was our population of interest.

iv. Analysis

We modeled the unadjusted relationship between the primary predictor (previous concussion) and current depression (binary variable, yes/no) using logistic regression to generate odds ratios and 95% confidence intervals. We also generated individual logistic regression models to assess the strength of the relationship between each potential confounder (age, sex, parental mental health and poverty level) and current depression. We then created a multivariate logistic regression model to calculate adjusted odds ratios and 95% confidence intervals for the relationship between the predictor of interest (previous concussion) and the outcome (current depression diagnosis), while controlling for potential confounders. We chose the potential confounders a priori based on previous literature, and thus they were retained in the model regardless of the numerical value of their p-values. Given that our outcome was rare (<10%), we felt confident that odds ratios would provide a reasonable estimate of relative risk. Our analysis plan was submitted to the Institutional Review Board at the University of Washington and was determined to be exempt as it was a secondary analysis of de-identified data. All analyses were performed with STATA, version 12 [26], using survey commands to adjust for complex survey weighting and multiple imputation to allow the inclusion of multiply imputed poverty level data.

Results

Data from 36,060 individuals met the criteria for analysis, 49.2% of whom were female (Table 1). A small proportion of these subjects had had a previous concussion (2.7%) and a similarly small number had a current depression diagnosis (3.4%). There were slightly more males than females (50.8% vs. 49.2%) and slightly more younger adolescents than older adolescents (50.8% vs. 49.2%). Few of these subjects (10.7%) had parents with poor or fair mental health and it was uncommon (15.2%) for subjects to be at or below the poverty level.

In bivariate analysis using logistic regression to examine the association between the primary predictor and the outcome of depression diagnosis (Table 2), history of concussion was associated with a 3.2-fold greater risk for current depression compared to those with no such history (95% CI: 2.0 – 5.2). We also generated similar logistic regression models to examine the relationship between each potential confounder and the outcome of depression diagnosis. Being an older adolescent (15–17 years) was associated with 1.5-fold greater risk for depression (95% CI: 1.2 – 1.9) compared to being a younger adolescent (12–14 years). Poor or fair mental health of either parent was associated with a 4.8-fold greater risk for depression compared to parental mental health rated as good, very good or excellent

(95%CI: 3.6 – 6.2). Being above the poverty level was associated with a 33–64% decreased risk for depression compared to being at or below the poverty level (95%CI: 23–91%). While there were more females than males who were depressed, a subject's sex was not significantly associated with depression diagnosis.

All variables were then included in a multivariate logistic regression model to evaluate the association between previous concussion and current depression diagnosis while controlling for potential confounders (Table 2). In this adjusted analysis, history of concussion was associated with a 3.3-fold greater risk for depression diagnosis (95% CI: 2.0 – 5.5) compared to no such history. Older adolescents (15–17 years old) were at 1.4-fold greater risk for depression (95%CI: 1.1 – 1.8) than younger adolescents (12–14 years old). Poor or fair paternal or maternal mental health was associated with a 3.7-fold greater risk for depression (95%CI: 2.8 – 4.9) compared with parental mental health rated as excellent, very good, or good. Being in a family that was greater than 200% of the poverty level was associated with about a 50% decreased risk of depression compared to being below the poverty level (95%CI: 34–70%), but there was no significant difference in risk for those at lower above-poverty incomes (i.e., those between 100–200% of the federal poverty level). There was also no association between sex and depression in the multivariate model.

Discussion

In this secondary analysis of data from the National Survey of Children's Health we found that history of concussion was associated with greater than a 3-fold risk of a current diagnosis of depression, even after controlling for age, sex, parental mental health and socioeconomic status. This study adds to the evidence for an association between concussion and depression [9–15], and is the first study to find such an association in a large nationally representative dataset. Although there was little information about timing of the depression diagnosis in this survey making it difficult to draw conclusions regarding causality, it is suggestive of a need to more closely monitor this population for depression.

We found a much stronger association between brain injury and depression than a previous study by Massagli and colleagues [13]. Massagli and colleagues utilized an administrative dataset rather than parental report, and thus there were significant differences in the manner in which our two studies defined both the exposure (concussion) and the outcome (depression diagnosis). Using ICD-9 codes for concussion or brain injury most likely produces an underestimate of the true brain-injured population, as previous studies have shown that most youth with mild brain injury do not present to clinical care [19]. Massagli and colleagues also reported only on depression diagnoses from ICD-9 codes, and prior research has shown that pediatricians often do not code for depression or mental health conditions [27]. Thus, parental report may identify additional depressed youth who were diagnosed with depression, but for whom no visit code for depression was used.

In a prospective evaluation of depression following TBI of varying severity, O'Connor and colleagues [15] found that their most mildly injured patients (brain injury symptoms with normal imaging) had no significant differences in depressive symptoms at 3, 12 or 24 months compared to injured controls, but did have a numerically increased rate of

depression diagnosis (5% vs. 0%). While these results are in a similar direction to our findings, no statistical testing was conducted to evaluate the significance of this difference.

There are many potential explanations for this observed association between concussion and depression. It is possible this association is due to diagnostic bias, or in other words concussion may lead to increased physician visits since so few adolescents visit physicians [28], and this could cause increased diagnosis of depression. It is also possible that both depression and concussion occur secondary to confounding factors we were unable to control for in this analysis [29]. It could also be true that this association actually represents diagnostic confusion, since many of the symptoms of concussion (sleep difficulties, irritability and fatigue) are also symptoms of depression. Some have even suggested that symptoms of concussion (such as sleep disruption) may lead to depression, and a recent study found an association between sleep difficulties and depressive symptoms even a year after brain injury [30–31].

It is important to point out that these data were collected in a manner that limits our ability to draw conclusions regarding the direction of the association between concussion and depression, and more work is needed to validate this association with prospective methodology. However at minimum, this finding merits additional screening in the concussed adolescent population and further discussion regarding concussion management. Current concussion consensus guidelines [32] recommend that “in the early stages of concussion, youth should not engage in physical or cognitive activities that result in an increase in symptoms.” Unfortunately, many clinicians have interpreted this statement to mean that return to activity should not begin until symptoms have completely resolved. Such relative social isolation [33] and increase in sedentary behavior [34] can lead to depressive symptoms. A recent article found little data supporting rest as a treatment for prolonged concussive symptoms [35], and specifically stated that if “normal activities are restricted for extended periods of time, they [youth] are at risk for secondary problems such as physical deconditioning, anxiety and stress, mild depression and irritability.”

The approach of waiting until symptoms resolve to begin return to physical activity is more conservative than the treatment used for patients with more severe traumatic brain injury (TBI), where patients are entered into physical rehabilitation programs because of brain-injured symptoms, not despite them. New data suggests patients with severe TBI who receive earlier intervention fare even better than those for whom rehabilitation is delayed [36]. A recent review [37] framed this well: “In medicine, rest is often prescribed by default when the presenting condition is poorly understood.” As we learn more about concussive injury, we are finding that while some rest is good, too much rest may be detrimental. A few studies suggest that physical activity interventions for concussion, where youth are slowly returned to activity even while symptomatic, may be more effective than rest [35,37].

One of the advantages of our study was the use of a large nationally representative dataset, which allowed us greater power to detect differences and better representation of the general population. This dataset also contained detailed information about socioeconomic status and parental mental health, which provided us a means to examine the association between brain injury and depression diagnosis while minimizing these potential confounders. Previous

studies such as those by Massagli and colleagues [13] and O'Connor and colleagues [15] were undertaken using clinical samples or administrative datasets, both of which contain bias. Patients are only included in those samples if they seek care, and many patients with concussion or depression do not seek care.

One of the main weaknesses of the present study is that it relied on retrospective parent report. There is always concern regarding memory bias in retrospective studies, but in addition to those concerns we have added the complexity of determining the exposure and the outcome simultaneously. We have attempted to minimize these issues by examining the association between “previous” concussion and “current” depression, but it is still possible that the association we describe is due to reverse causality. In other words, we cannot rule out the possibility that some of these youth were depressed before their concussion. However, if there is an increased prevalence of depression in the population of youth who have suffered a concussion compared to those who have never had a concussion, this still suggests a need for enhanced screening in this population. It is expected that diagnosed depression would underestimate true depression in this population, but this should only decrease our association rather than generate a spurious association.

Asking parents about a diagnosis of “concussion or other brain injury” is also likely to generate an underestimate of true injury, since parents may not know about mild brain injury, and/or mild brain injuries may go undiagnosed [19]. To place this in context, a recent survey that utilized youth self-report of brain injured symptoms after head impact, suggested a prevalence of 20.2% for brain injury [38]. It is not surprising that the numbers in our study would be so much less, since we are both relying on parental report and asking only about diagnosed concussion.

An additional limitation of this study was that data was not available regarding timing of when the concussions occurred. Very different factors would be suspected to explain this association if depression occurred soon after the concussive injury than if it was more prolonged. Perhaps in future editions of the National Survey of Children's Health the authors will consider asking about timing of the diagnoses they discuss as this could prove useful for many purposes beyond this study. Future studies will need to address this issue prospective data.

In summary, this study adds to the evidence that there is an association between depression and concussion in youth. Clinicians caring for youth with concussion should be aware of this association, and should screen youth for depressive symptoms. More work is needed using prospective studies with youth to understand the pathways that mediate this association and explore treatment possibilities.

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Implications and Contributions

This is the first study to show a higher rate of depression diagnosis in a national sample of adolescents with concussion history. These data suggest clinicians should screen concussed youth for depression, so that they may effectively treat these individuals.

Table 1

Characteristics of youth aged 12–17 in the National Survey of Children's Health, 2007–2008.^{a,b,c}

	All Children 11–17 yo		Currently Depressed		Not Currently Depressed	
<i>N</i>	36,060		1,278		34,782	
<i>History of concussion</i>						
<i>None</i>	%	(S.E.)	%	(S.E.)	%	(S.E.)
	97.3	(0.2)	92.2	(1.7)	97.4	(0.2)
<i>Past</i>	2.7	(0.2)	7.8	(1.7)	2.6	(0.2)
<i>Sex</i>						
<i>Male</i>	50.8	(0.7)	48.2	(2.9)	50.9	(0.7)
<i>Female</i>	49.2	(0.7)	51.8	(2.9)	49.1	(0.7)
<i>Age (years)</i>						
<i>12–14</i>	50.8	(0.7)	41.8	(2.9)	51.2	(0.7)
<i>15–17</i>	49.2	(0.7)	58.2	(2.9)	48.9	(0.7)
<i>Poor or fair mental health in father or mother</i>						
<i>No</i>	89.3	(0.5)	65.7	(2.8)	90.1	(0.5)
<i>Yes</i>	10.7	(0.5)	34.3	(2.8)	9.9	(0.5)
<i>Poverty level^c</i>						
<i>100%</i>	15.2	(0.6)	29.6	(2.7)	14.7	(0.6)
<i>>100 to 200%</i>	20.9	(0.7)	26.6	(3.0)	20.7	(0.7)
<i>>200 to 400%</i>	32.9	(0.7)	23.2	(2.4)	33.3	(0.7)
<i>>400%</i>	31.0	(0.6)	20.7	(2.3)	31.4	(0.6)

^aRestricted to subjects without current brain injury

^bPercentages are calculated using survey weighting and so do not represent percentages of observed counts. Missing values were not included in the calculation of percentages.

^cThere was significant missing data for poverty level (n=3,164) and thus multiply imputed data was used in logistic regression analysis

^dThere was also significant missing data for "Poor or fair mental health in father or mother" (n=1,593) but we did not feel we had adequate data from other variables in the dataset to impute these values, so subjects without this data were omitted from the multiple regression analysis

Table 2

Relationship between past brain injury and current depression in children ages 12–17 in the National Survey of Children's Health 2007–2008, with and without adjustment for potential confounders.^a

	OR (95%CI) ^{b,d}	P	adjusted OR ^{c,e} (95%CI)	P
<i>Brain Injury</i>				
None	1.0		1.0	
Past	3.23 (2.02 – 5.18)	<0.001	3.34 (2.02 – 5.51)	<0.001
<i>Sex</i>				
Male	1.0		1.0	
Female	1.12 (0.88 – 1.42)	0.36	1.18 (0.92 – 1.52)	0.20
<i>Age (years)</i>				
12–14	1.0		1.0	
15–17	1.46 (1.15 – 1.85)	0.002	1.41 (1.09 – 1.82)	0.01
<i>Poor or fair mental health in 1st degree relative</i>				
No	1.0		1.0	
Yes	4.75 (3.64 – 6.18)	<0.001	3.73 (2.82 – 4.92)	<0.001
<i>Poverty level^d</i>				
100%	1.0			
>100 to 200%	0.64 (0.45 – 0.91)	0.01	0.72 (0.49 – 1.09)	0.09
>200 to 400%	0.35 (0.25 – 0.48)	<0.001	0.49 (0.35 – 0.70)	<0.001
400+ %	0.33 (0.23 – 0.46)	<0.001	0.48 (0.34 – 0.69)	<0.001

^aRestricted to subjects without current brain injury

^bThese estimates were calculated using bivariate logistic regression (N= 32,928–36,060)

^cThese estimates were calculated using multiple logistic regression, and adjusting for all other variables listed (N=34,438)

^dMultiple imputation was used to control for missingness (5 imputations)

^eSignificance of the full model: F=24.99, p<0.00001