Journal of Clinical and Translational Research 2022; 8(4): 292-298

Journal of Clinical and Translational Research

Journal homepage: http://www.jctres.com/en/home

ORIGINAL ARTICLE

Socioeconomic status and injury history in adolescent athletes: Lower family affluence is associated with a history of concussion

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ARTICLE INFO

Article history:
Received: June 02, 2021
Revised: June 21, 2022
Accepted: June 21, 2022
Published online: July 18, 2022

Keywords:
concussion
musculoskeletal injury
athlete
health disparity
mild traumatic brain injury

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Abstract

Background: While healthcare and health outcome disparities have been studied across a variety of different injuries, their relation to concussion incidence and management are relatively understudied.
Aim: The aim of this study was to evaluate the association between history of concussion or musculoskeletal injury, and family affluence and/or school-level measures of socioeconomic status.
Methods: We conducted a cross-sectional study of adolescent athletes in a local school district. Adolescent athletes (n = 192; mean age = 15.3, SD = 1.6 years; 49% female), who presented for a pre-participation physical evaluation reported concussion and injury history, and family affluence scale (FAS) scores. We also examined the percent of students on free/reduced lunch at each school compared to state averages. Independent variables, individual FAS score and school-based marker of socioeconomic status, were compared between those with and without a history of concussion and time-loss musculoskeletal injury.
Results: Of the participants, 40 (21%) reported a history of concussion. Athletes with a concussion history had significantly lower FAS scores than athletes without a history of concussion (mean difference = 0.7, 95%CI = 0.1, 1.4; P = 0.027). There was no significant difference in FAS scores between those with and without a history of time-loss musculoskeletal injury (mean difference = 0.0, 95% CI = –0.5, 0.5; P = 0.97). Athletes with a history of concussion had a higher proportion of a prior time-loss musculoskeletal injury (68% vs. 32%; P < 0.001). After adjusting for age, school free-reduced lunch rate, and history of musculoskeletal injury, a lower FAS score was associated with concussion history (adjusted odds ratio = 0.79; 95% CI = 0.64, 0.96; P = 0.019). Concussion and musculoskeletal injury were not associated with school-level markers of socioeconomic status.
Conclusion: Lower individual measures, but not school-level measures, of socioeconomic status were associated with a history of concussion in our sample of adolescent athletes.
Relevance for Patients: Enhance providers' understanding of how socioeconomic factors may impact concussion history and empower providers to adequately screen for and provide concussion education to mitigate disparities.

1. Introduction

Concussions represent up to 9% of high school athletic injuries [1]. Approximately 1.1–1.9 million sports-related concussions occur annually in the United States in children <18 years old [2]. Concussions can cause a variable array of signs and symptoms acutely post-injury [3] and often result in missed school or sport participation. Past work has focused on epidemiology, recovery, and outcomes following sport-related concussion [4,5], but less

DOI: http://dx.doi.org/10.18053/jctres.08.202204.004

attention has been paid to socioeconomic factors in the setting of concussion.

While healthcare and health outcome disparities are well-recognized [6-8], including socioeconomic disparities in treatment of pediatric femoral fractures [9], disparities in relation to concussion incidence and management are relatively understudied. One study in adults found that history of concussion was associated with lower education level and lower socioeconomic status later in life [10]. Among adolescents presenting to the emergency department with a head injury, fewer black patients were diagnosed with concussion than white patients [11]. Disparities in concussion care may also exist when comparing differing socioeconomic statuses. While no significant differences in symptom duration or missed practices were observed following a concussion, those with private insurance missed more academic time than those with public insurance [12]. Another recent study showed that lower socioeconomic status was associated with differences in concussion reporting behavior, which was proposed to be secondary to reduced opportunity for cognitive development, higher risk taking behaviors, and decreased concussion knowledge [13]. Disparities in baseline neurocognitive testing have been noted based on race and socioeconomic status [14-16]. Given limited data, it is difficult to conclude how socioeconomic status among adolescent athletes is associated with concussion history.

There are a number of ways, in which socioeconomic status may affect concussion diagnosis and management. Students from a lower socioeconomic status may be diagnosed with fewer concussions due to underreporting, limited access to medical resources, or perhaps due to biases in medical care [17]. In the United States, students at approximately 34% of high schools do not have access to athletic trainers [18], and these schools disproportionately represent students from lower socioeconomic statuses [19]. Furthermore, access to athletic trainers has been associated with reduced disparities in concussion reporting behavior, use of appropriate return to play protocols, and lower rates of injury and concussion [20-23]. Thus, students from a lower socioeconomic status may attend schools without adequate athletic training staff [24,25] and have a lower chance of receiving proper medical care and a diagnosis of a concussion.

Alternatively, it is possible that athletes from a lower socioeconomic status may have higher concussion prevalence secondary to limited coaching/athletic training staff to guide safe practice or higher rates of concussion sustained outside of sports due to non-sports related concussion sustained outside of practice or games [26]. Although schools likely provide students with relevant sports equipment, helmets alone do not decrease concussion risk, and appropriate helmet fit is essential in reducing injuries [27]. Limited athletic training and coaching staff could lead to higher rates and severity of concussions due to inadequate attention to helmet fitting [28]. A systematic review showed that parent and coach education can result in increased concussion knowledge and behavioral changes to reduce concussion risk [29]. Inadequate training, differences in medical literacy, and coaching staff access may result in inability to adopt safe play practices, subsequently leading to an increased incidence of concussions. In addition, these concussions may not be diagnosed if these students have insufficient access to athletic trainers.

It is important to note that individual and school-level measures of socioeconomic status and resources may both contribute to possible disparities in athletic injury prevalence and diagnosis. For example, individual families with a lower socioeconomic status may have more limited access to outside medical services or lower health literacy [30]. On the other hand, students who attend schools in lower-resourced areas may not have access to the same in-school sport-related safety infrastructure. Thus, an integrated approach considering both family level and school-level measures of economic resources may provide a robust view on how socioeconomic status is associated with concussion.

There are reasons to consider the association of socioeconomic status and injury history beyond just concussion. For example, higher socioeconomic status has been linked with increased rates of sports specialization, which was associated with high rates of overuse injury [31]. In addition, there is a well-documented link between history of concussion and musculoskeletal injury [32,33]. Thus, understanding the overlap among socioeconomic status, musculoskeletal injury history, and concussion history based on school-level and individual markers of socioeconomic status may shed light on the intersection among the variables and guide further clinical intervention on injury and concussion prevention.

The purpose of our study was to examine the association among individual level and school-level measures of socioeconomic status and history of prior concussion or musculoskeletal injury among adolescent athletes. The primary hypothesis we tested is those with a concussion history that would have lower individual- and school-level socioeconomic status measures than those without a concussion history.

2. Methods

2.1. Participants and study design

We conducted a cross-sectional study of adolescent athletes, 13–18 years of age, presenting for a sports pre-participation physical evaluation. We excluded potential participants if they reported a current injury that prohibited sport participation, if they reported a pre-existing neurological disorder, or if they had limited English proficiency.

2.2. Ethical considerations

All participants, as well as their legal guardians (if the participant was under the age of 18), provided written informed consent at enrollment. The local Institutional Review Board and the school district approved the study protocol before commencement.

2.3. Assessment protocols

Participants completed a standardized questionnaire during their pre-participation evaluations developed by the study team. The collected data included demographics, medical history, level of sports participation, history of concussion, history of musculoskeletal injury, and the Family Affluence Scale (FAS)

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questionnaire. For concussion history, we asked, "Have you ever had a head injury or concussion?" and responses were categorized as "yes" or "no." If they responded "yes," participants were asked to record the total number of concussions, they had sustained in their lifetime. To assess history of time-loss musculoskeletal injuries, we asked, "Have you ever had an injury to a bone, muscle, ligament, or tendon that caused you to miss a practice or a game?" Similarly, their responses were, then, categorized as yes/no for further analyses.

To provide an individual-level measure of socioeconomic status, we used the FAS (Table 1). The FAS is a six-item scale that has been validated among adolescents as a surrogate for family affluence using an "assets approach" rather than zip code or household income [34]. Participants rate household "assets" including number of cars, household bedrooms and bathrooms, number of computers, and recent travel. The final scores range from 0 to 13, with higher scores suggesting higher family affluence [34,35]. To provide a school-level measure of socioeconomic status, we obtained the free and reduced lunch rate for the most recent school year available (2016-2017) of each high school attended by study participants [36]. Given a state-wide average of free and reduced lunch rate across all high schools of 36%, we calculated whether each participant attended a school ≥36% free and reduced lunch rate or <36% free and reduced lunch rate and grouped participants according to this binary classification based on their school's characteristics.

2.4. Statistical analysis

Continuous variables are presented as mean (standard deviation; SD), and categorical variables are presented as the number included and corresponding percentage. We assessed differences in demographic characteristics between athletes with and without a history of prior concussion using independent samples t-tests (continuous variables) and Chi-square tests (categorical variables). We examined between group differences in FAS for athletes with and without a history of concussion and with and without a history of time-loss musculoskeletal injury using independent samples t-tests. To examine the effect of school-level affluence, we compared the proportion of participants who reported a concussion history or musculoskeletal injury history and attended a school at/above the statewide average free and reduced lunch rate (36%) with those below this rate, using Chi-square analyses [36].

Table 1. The family affluence scale (FAS) questions and responses. Total FAS score is calculated as the sum of all responses and ranges from 0 to 13.

Question	Score
1. Does your family have a car or a van?	(0=no; 1=yes one; 2=yes two or more)
2. Do you have your own bedroom for yourself?	(0=no; 1=yes)
3. How many times did you travel out of state for holiday/vacation last year?	(0=not at all, 1=once, 2=twice, 3=more than twice)
4. How many computers does your family own?	(0=none, 1=one, 2=two, 3=more than two)
5. At home, do you have a dishwasher?	(0=no, 1=yes)
6. How many bathrooms (room with a bath) are in your home?	(0=none, 1=one, 2=two, 3=more than two)

To interpret clinical meaningfulness between individual- and school-level socioeconomic status measures and to adjust for potential confounders, we constructed one multivariable binary logistic regression model. Our primary outcome variable was concussion history (yes/no), our independent variables were FAS score and free/reduced lunch rate (≥36% vs. < 36%), and covariates that were significantly different between groups (defined as $P < 0.05$) were included in the model. Thus, covariates included in the model included age and musculoskeletal injury history, based on results shown in Table 2. We assessed collinearity using condition indices and corresponding variance inflation factors. A condition index >30 was determined to require individual collinearity assessments, which were performed using variance inflation factors. Collinearity between two variables was detected with a variance inflation factor (VIF) >2.5. Statistical significance for multivariable analyses was defined as a 95% confidence interval (CI) that did not cross zero, and all tests were two-sided. Statistical analyses were performed using Stata version 15 (StataCorp, College Station, TX).

3. Results

A total of 192 adolescent athletes completed the study questionnaire, out of 195 who enrolled in the study ($n = 3$ did not complete the FAS questionnaire). A total of 40 participants, 21%, ($n = 40$; 43% female), reported sustaining a prior concussion. Most of this subgroup ($n = 29$; 73%) sustained one prior lifetime concussion, $n = 5$ (13%) reported two lifetime concussions, 5 (13%) reported three lifetime concussions, and 1 (3%) reported four lifetime concussions. Compared to athletes with no prior concussion, athletes who reported a history of prior concussion were older (Table 2) and, on average, had lower FAS scores (Figure 1A; mean difference = 0.7, 95% CI = 0.1, 1.4; $P = 0.027$). There were no statistically significant differences in history of contact/collision sport participation, hours of training per week, or competition level between those with and without a history of concussion (Table 2). The group of athletes with a concussion history had a higher proportion of time-loss musculoskeletal injury compared to those without a concussion history (Table 2). However, there was no significant difference in FAS scores between those with and without a prior musculoskeletal injury (Figure 1B; mean difference = 0.0, 95% CI = –0.5, 0.5; $P = 0.97$). School-level socioeconomic status measures (free/reduced lunch rate) were not significantly associated with concussion history or musculoskeletal injury history (Table 3). Multi-variable logistic regression revealed that concussion history was significantly associated with a lower FAS score after adjusting for age and musculoskeletal injury history (Table 4).

4. Discussion

In our sample, adolescent athletes who reported a prior concussion history had lower family-level affluence than athletes

DOI: http://dx.doi.org/10.18053/jctres.08.202204.004

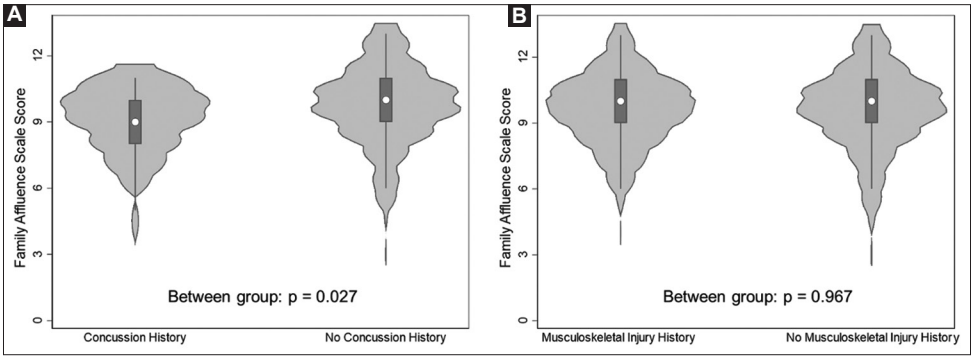

Figure 1. Violin plot describing the distribution of family affluence scores for those (A) with or without a concussion history and (B) with or without a musculoskeletal injury history. Data are presented as median (center dot) and interquartile range (box around the median). The shaded area represents the probability density of data at each Family Affluence Scale level (range = 0–13), smoothed using a kernel density estimator.

Table 2. Characteristics of athletes with and without a history of concussion. Data presented as mean (standard deviation) or number (%).

Variable	Concussion History (*n*=40)	No Concussion History (*n*=152)	*P* value
Age (Years)	15.8 (1.0)	15.2 (1.7)	0.04
Sex (Female)	17 (43%)	77 (51%)	0.36
Height (cm)	169.8 (9.3)	168.8 (12.5)	0.64
Weight (kg)	65.0 (13.4)	63.6 (16.6)	0.63
History of time-loss musculoskeletal injury	27 (68%)	48 (32%)	<0.001
Lifetime history of collision or contact sport participation	33 (83%)	117 (77%)	0.82
Hours per week participating in organized sports	11.9 (4.5)	12.0 (5.1)	0.93
Competition level (Varsity athlete)	16 (40%)	52 (34%)	0.50

cm: centimeters, kg: kilograms. Data were compared between groups using independent samples t-tests (continuous variables) or Chi square analyses (categorical variables).

Table 3. The association between school free/reduced lunch rate and injury history. Data presented as number (%) in group, and groups were compared using Chi square analysis.

Variable	Attends school with ≥ statewide free/reduced lunch rate *n*=42 (%)	Attends school with < statewide free/reduced lunch rate *n*=151 (%)	*P* value
Concussion history	7 (17)	32 (21)	0.55
Musculoskeletal injury history	12 (29)	63 (42)	0.12

Table 4. The association of family affluence with concussion history, adjusting for the independent effects of age, and musculoskeletal injury history.

Variable	Adjusted odds ratio	Standard error	95% confidence interval	*P* value
FAS Score	0.782	0.082	0.636, 0.961	0.019
School free-reduced lunch rate	0.735	0.373	0.272, 1.990	0.545
Age	1.297	0.214	0.939, 1.791	0.115
Musculoskeletal injury history	4.048	1.618	1.849, 8.860	<0.001

without a concussion history, even after adjusting for age and musculoskeletal injury history. However, school-level markers of socioeconomic status (free and reduced lunch rate) were not associated with injury history.

It is unlikely, there are intrinsic biological differences to explain why lower family affluence was associated with history of concussion. However, it is possible that athletes with lower family affluence may be at increased risk for concussion due to differences in coaching, equipment access and fit [27,28], adoption of safe play practices, or parent or coaching education [29]. It is also plausible that concussions could have been sustained outside of a school setting where lack of supervision, unsafe play practices, or unsafe play location could be contributing factors. Additional research looking into differences in concussion history based on individual measures of socioeconomic status is needed to further understand this finding. Further, research may be directed at understanding differences in parent or guardian supervision, access to healthcare, and whether adolescents are involved in high injury risk activities outside of school.

In contrast to individual measures of socioeconomic status (family affluence), school-level measures of socioeconomic status (percent free or reduced lunch) were not associated with concussion history in our population. It was initially hypothesized that concussion diagnosis could be influenced by access to school-

DOI: http://dx.doi.org/10.18053/jctres.08.202204.004

based athletic trainers or other healthcare providers [18,19]. Athletes attending urban high schools were found to less concussion knowledge than athletes attending suburban schools, and those attending urban schools without an athletic trainer had significantly less concussion knowledge than urban schools with an athletic trainer [37]. In our study population, the medical and athletic training structure was similar across participating schools, despite variations in free and reduced lunch rates among the schools included in our sample. Students had full-time access to athletic trainers during practices and games and access to physicians during athletic training room visits, which likely resulted in little variability in access to appropriate medical care. Although students had standardized medical coverage at games and athletic training staff in school, individual-based differences including access to medical care and health insurance may contribute to disparities in concussion diagnosis and management outside of the school setting, as supported by the association of concussion history and individual family affluence. Limited relevant literature suggests socioeconomic disparities in the management of severe traumatic brain injuries [38-40] and indicates that insurance status is associated with duration of time away from school in adolescents with concussion [12]. It would be beneficial to further research the management of concussion based on socioeconomic status.

Unlike concussion, history of musculoskeletal injury was not associated with family affluence. In line with extant literature, concussion history was associated with history of musculoskeletal injuries [32,33]. However, the link between history of musculoskeletal injury and socioeconomic status has favored a higher risk of overuse musculoskeletal injury in athletes from a higher socioeconomic status who also demonstrate higher sport specialization [31]. Our study did not assess the difference between overuse and acute injury, which may have resulted in the lack of association between time-loss injury and family affluence, as time-loss injury may be due to acute injuries rather than overuse injuries. Understanding the types of musculoskeletal injuries sustained, as well as the timing and setting of these injuries, in relation to individual measures of socioeconomic status, would offer further insight into whether an association exists.

Future research studying disparities in sport-related injury should consider whether sources of variation are anticipated at the school- or individual-level. In this study, we measured both, using the percent of students on free or reduced lunch to capture school-level resources and the FAS to understand individual-level affluence. The FAS is a helpful tool when surveying adolescents who may not know or wish to disclose their family's annual income [35] and may be useful for future work in the area.

4.1. Limitations

The cross-sectional nature of the study limits our ability to understand underlying mechanisms or draw causal inferences. We are also limited by our exclusive use of self-reported concussion and musculoskeletal injury history, which did not query setting, timing, or severity of injury nor whether it was medically diagnosed and managed by a healthcare provider. While the schools had similar athletic training and medical coverage during practices and games, disparities in access to care may exist outside of the sporting event including limitations in follow-up for injuries or concussions. As all concussions require evaluation and clearance for return-to-play by a licensed medical professional, this variability in access could have significant impact on the student-athlete's health and time-loss from sport. Further, queries into the management including missed practice/game/school and setting, in which student athletes received initial and follow-up care after a concussion would shed light on whether disparities in access to care outside of the school setting contributed to differences in concussion management. Finally, we did not collect demographic information to enable us to analyze the well-documented intersections between race and socioeconomic status [41] or the effect of race or racism on health outcomes including concussion [42].

5. Conclusion

Lower individual, but not school-level, measures of socioeconomic status were associated with a history of concussion in our sample of adolescent athletes. In addition, history of musculoskeletal injury was not significantly associated with any measures of socioeconomic status. Future research is needed to identify mechanisms underlying these findings, but potential reasons involve differences in both individual- and school-based medical care that could be influenced by socioeconomic status. Future research should also carefully consider issues in the diagnosis of concussion, measures of socioeconomic status, and the intersectionality of a variety of social determinants of health on sports injury outcomes.

Conflicts of Interest

The authors have no conflicts of interest relevant to this article to disclose.

Acknowledgments

Unrelated to this study, Dr. Howell has received research support from the Eunice Kennedy Shriver National Institute of Child Health & Human Development (R03HD094560, R01HD108133), the National Institute of Neurological Disorders And Stroke (R01NS100952, R43NS108823), the National Institute of Arthritis and Musculoskeletal and Skin Diseases (1R13AR080451), MINDSOURCE Brain Injury Network, the Tai Foundation, and the Colorado Clinical and Translational Sciences Institute (UL1 TR002535-05) and he serves on the Scientific/Medical Advisory Board of Synaptek, LLC. Dr. Baugh presently has a grant from the Greenwall Foundation. She has previously received funding from the Datalys Center for Sports Injury Research and Prevention, the National Collegiate Athletic Association, the Football Players Health Study at Harvard, and the National Institutes of Mental Health.

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DOI: http://dx.doi.org/10.18053/jctres.08.202204.004