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Lifetime prevalence of self-reported concussion among adolescents involved in competitive sports: A national U.S. study.

Philip Veliz, PhD[a], **James T. Eckner, M.D**[b], **Jennifer Zdroik, PhD**[c], and **John E. Schulenberg, PhD**[d]

[a]School of Nursing, University of Michigan

[b]Department of Physical Medicine and Rehabilitation, University of Michigan

[c]Bolte School of Business, Mount St. Mary's University

[d]Survey Research Center, Institute for Social Research, and Department of Psychology, University of Michigan

Abstract

Purpose: Examine lifetime prevalence of diagnosed concussion in US-national samples of 8th, 10th, and 12th graders involved in 16 different competitive sports; examine associations between concussion and individual sports, controlling for demographic characteristics and multiple sports involvement.

Methods: Analysis of nationally representative Monitoring the Future data from 2 cohorts (2016–2017; n = 25,408).

Results: Adolescents who participated in baseball, basketball, football, gymnastics, ice hockey, lacrosse, soccer, track, weightlifting, and „other sports‟ had greater odds of reporting multiple diagnosed concussions compared to peers not participating in these sports. Adolescents who participated in tennis had lower odds of reporting any diagnosed concussion or multiple concussions. Females who participated in gymnastics, soccer, and swimming showed a stronger

Address correspondence to: Phil Veliz, Ph.D. School of Nursing, University of Michigan. 400 North Ingalls, Ann Arbor, MI, 48109. PHONE: (734) 763-3663; FAX: (734) 998-6508; ptveliz@umich.edu. .

Contributors Statement

Philip T. Veliz: Dr. Veliz conceptualized the study and discussed the study design with all co-authors. Dr. Veliz interpreted the data, drafted the initial manuscript and all subsequent drafts of the manuscript, and approved the final manuscript as submitted.

James T. Eckner: Dr. Eckner reviewed and revised the manuscript, added comments to the first draft, and approved the final manuscript as submitted.

Jennifer E. Zdroik: Dr. Zdroik reviewed and revised the manuscript, and approved the final manuscript as submitted.

John E. Schulenberg: Dr. Schulenberg helped oversee collection of the data; he helped analyze and interpret the data, reviewed and revised the manuscript, and approved the final manuscript as submitted.

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association in reporting a diagnosed concussion when compared to males who participated in these same types of sports.

Conclusions: The study provides needed epidemiological information on prevalence of reported diagnosed concussion among teens participating in popular school and community sports. Certain high contact (e.g., football) and high volume (e.g., basketball) sports need increased efforts to manage adolescent athletes who already have a history of concussion or repeated concussions.

Keywords

Concussion; Sports; Adolescents

Studies show that 20% of adolescent athletes[1] and 28% of collegiate athletes[2] report at least one concussion during their lifetime (compared to roughly 10% of adolescent nonathletes).[1] The existing literature also indicates that participation in contact sports increases the risk of a sport-related or non-sport related concussion.[1–4] To date little is known regarding concussion rates across different competitive sports based on large-scale epidemiological surveys of adolescents. Moreover, studies on adolescent concussion typically focus on athletes participating in single school-based sports and do not take into consideration that these athletes participate in different sports throughout the year. Accordingly, the purpose of this study was to expand upon our prior work[1] to assess the prevalence of diagnosed concussions across participation in 16 different competitive sports among teens and to consider how these associations between concussion and individual sports are moderated by several sociodemographic characteristics.

METHODS

Study Design

The Monitoring the Future (MTF) study annually surveys a cross-sectional, nationally representative sample of 8th, 10th, and 12th graders in approximately 400 public and private schools in the coterminous United States, using self-administered paper-pencil questionnaires in classrooms. The MTF study uses a multi-stage sampling procedure. In stage 1, geographic areas or primary sampling units are selected; in stage 2, schools within primary sampling units are selected (with probability proportionate to school size); and in stage 3, students within schools are selected. The student response rates have ranged between 80 and 90% since 1991. Because so many questions are included in the MTF study, much of the questionnaire content is divided into different forms which are randomly distributed. The measures most relevant for this study were on Form 1 for 8th and 10th graders, and form 5 for 12th graders (See elsewhere for project details[5]).

Sample

The present study uses nationally representative samples of 25,048 youth participating in cross-sectional Monitoring the Future surveys for 2016 and 2017.[5] Response rates for these years were 89%, 87%, and 83% for 8th, 10th, and 12th grade participants, respectively. A measure of lifetime prevalence of concussions was included on a random one-third of 8th

and 10th grade and one-sixth of 12th grade questionnaire forms (the question measuring concussion was introduced in 2016). Refer to Table 1 for sample characteristics.

Measures

Lifetime diagnosis of concussion,[1] a single–item measure with response options "No", "Yes, once", and "Yes, more than once," was analyzed as three variables: „any concussion", „one concussion", and „multiple concussions".

Past-year participation in different competitive sports, the key set of predictors, assessed past-12-month participation among the following school and community sports: baseball, basketball, cross-country, field hockey, football, gymnastics, ice hockey, lacrosse, soccer, swimming, tennis, track and field, volleyball, weightlifting, wrestling, and „other" sports.

Control/moderating variables included the following: sex, grade-level, race/ethnicity, parental level of education, urbanicity, and geographic location (see Table 1 for response options).

Analysis

Descriptive statistics, odds ratios (OR), and adjusted odds ratios (AOR) were used to assess the association between different types of sports participation and lifetime diagnosis of concussion when controlling for sociodemographic variables. All 16 different types of sports were included in the logistic regression models simultaneously to account for participation in multiple sports.[6,7] We then added interaction terms to examine potential sex differences with respect to the association between different types of sports participation and lifetime diagnosis of concussion (in preliminary analyses, it was determined that none of the other sociodemographic characteristics were consistent moderators of this association [i.e., grade-level, race/ethnicity, parental education, region and urbanicity]). All multivariate analyses were weighted to account for probability of selection and difference in sample size across grade levels. Due to missing data on some of the items, analyses were conducted using both listwise deletion and multiple imputation.[8] Both sets of analyses yielded similar results; analyses using listwise deletion were presented for ease of reproducibility.

RESULTS

Table 1 shows that 18.4% of the sample indicated at least one diagnosed concussion during their lifetime (athletes–20.8%, non-athletes–11.2%); 13.4% indicated only one diagnosed concussion (athletes–14.9%, non-athletes–8.9%) while 5.0% indicated multiple diagnosed concussions (athletes–5.8%, non-athletes–2.2%).

Table 2 shows that participation in 11 of 16 sports was modestly associated with increased odds of any lifetime diagnosed concussion. Participation in baseball, football, weightlifting, and wrestling showed modest but significant associations with reporting only one diagnosed concussion. Participation in baseball, basketball, gymnastics, lacrosse, soccer, track and weightlifting was modestly associated with multiple diagnosed concussions. Participation in football and ice hockey showed substantial associations with multiple diagnosed

concussions. Only participation in tennis (compared with no participation in tennis) was associated with lower odds of any diagnosed concussion.

The interaction effect models (not shown) yielded significant findings with respect to different types of sports participation and gender. The association between any lifetime diagnosis of concussion and participation in gymnastics (gymn.-X-female: AOR=4.14, 95% CI=1.80,9.52; prevalence rate - male gymn.=17.4%, male no gymn.=21.5% *versus* female gymn.=26.0%, female no gymn.=14.6%), swimming (swim.-X-female: AOR=1.75, 95% CI=1.28,2.39; prevalence rate, male swim.=22.7%, male no swim.=21.4% *versus* female swim.=21.8%, female no swim.=14.5%), and soccer (soc.-X-female: AOR=1.45, 95% CI=1.17,1.81; prevalence rate, male soc.= 21.5%, male no soc.=21.5% *versus* female soc.=20.8%, female no soc.=14.1%) was stronger for females when compared to males who participated in these sports. It should be noted that the interaction effect between females and participation in gymnastics (gymn.-X-female: AOR=3.57, 95% CI=1.63,7.81; prevalence rate, male gymn.=11.2%, male no gymn.=15.2% *versus* female gymn.=18.7%, female no gymn=11.2%) was significantly associated with reporting only one diagnosed concussion, while the interaction effect between females and participation in soccer (soc.-X-female: AOR=2.42, 95% CI=1.68,3.51; prevalence rate, male soc.=5.7%, male no soc.=6.5% *versus* female soc.=6.6%, female no soc.=2.9%) was significantly associated with reporting multiple diagnosed concussions.

DISCUSSION

This study provides needed epidemiological information on the lifetime prevalence of diagnosed concussion across 16 popular sports in the U.S. In particular, when controlling for sociodemographic factors and participation in multiple sports, participation in the majority of the sports assessed was associated with greater odds of indicating at least one diagnosed concussion. Participation in football and ice hockey showed the strongest association with any lifetime diagnosed concussion and multiple diagnosed concussions; this is consistent with other studies of athletes in the U.S.[2,4] Only participation in tennis was found to be associated with lower odds of any diagnosed concussion. While participation in tennis may not be a direct cause of lowering the risk of concussion, the structure of the sport (i.e., non-contact) may lower the possibility of sustaining a concussion among participants due to the lack of any physical contact with opponents; and playing competitive tennis means less involvement in other more concussion-prone sports.

The analysis also found that the association between lifetime diagnosis of concussion and participation in gymnastics, swimming, and soccer was stronger among female than male participants. While other studies have found that soccer has the highest prevalence/risk of concussion among female athletes[2–4] and female gymnasts have been found to suffer more serious injuries when compared to male gymnasts,[9] the stronger association between participating in swimming and reporting a diagnosed concussion among females is more challenging to interpret due to prior work that has found a similar injury rate between female and male collegiate swimmers.[10] Given that girls have been found to be more likely to report concussive symptoms when compared to boys,[11] girls in high injury sports like gymnastics

and soccer (and even in non-contact sports like swimming) may be more prone than boys in similar sports to report and see a medical expert regarding these types of injuries.

Finally, this study helps pinpoint certain clusters of sports that may be targeted for increased efforts to manage and monitor adolescent athletes who already have a history of concussion or repeated concussions. Given that roughly 40% of adolescent athletes participate in two or more different competitive sports,[12] intervention and prevention efforts could benefit from following concussed athletes across seasons to track new incidents of concussion and to assess influences on cognitive functioning.

Several limitations must be noted. First, the measure of diagnosed concussion was based on self-report and may be prone to measurement error (e.g., self-report bias). While the self-report measure used to assess concussion in the MTF produced lifetime prevalence rates that were similar to another regional study of adolescents in Canada (i.e., 20%)[13–14] other large-scale nationally representative samples like the 2016 National Health Interview Survey (NHIS child sample)[15] find that 11.9% of parents report that their adolescent child (i.e., age 14 – 17) has had at least one "significant head injury or concussion" during their lifetime. The differences in these estimates (i.e., MTF versus NHIS) as it relates to concussion are clearly sensitive to how the questions are asked, who is responding to the survey, and how the survey is delivered. However, it should be highlighted that these self-reported measures of concussion on large-scale epidemiological surveys allow researchers to assess national estimates across a wide range of subpopulations in order to determine who may be at greatest risk of these types of head injuries. Second, the study is cross-sectional and cannot determine if participation in a certain sport was the specific cause of the self-reported concussion. Moreover, due the how the questions were asked, there was a temporal inconsistency between how competitive sport participation (past-year) and self-reported concussion (lifetime) were measured. Given this limitation in how sport participation was measured, we may be underestimating the number of adolescents who participated across the sixteen different sports that were assessed. Despite these limitations, the study provides nationally representative findings for adolescents in the U.S. bringing needed epidemiological data to track concussion history among both athletes and non-athletes during adolescence.

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Abbreviations:

MTF	Monitoring the Future

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Implication and Contribution

Roughly one out of every five adolescents involved in competitive sports has indicated at least one diagnosed concussion during their lifetime. Adolescents who participate in high contact sports like football and ice hockey have a substantially higher lifetime prevalence of indicating any concussion or multiple concussions.

Table 1.

Sample characteristics for 8th, 10th, and 12th grade respondents for 2016 and 2017 (n= 25,408)

	n[1]	%[1]
Sex[2]		
Male	(11979)	49.6%
Female	(12043)	50.4%
Race/Ethnicity[2]		
White	(11421)	44.6%
Black	(3028)	12.3%
Hispanic	(5323)	21.1%
Other[3]	(5636)	22.1%
Grade Level[2]		
8th Grade	(11232)	44.1%
10th Grade	(9817)	40.3%
12th Grade	(4359)	15.6%
Parental Level of Education[2]		
Both parents have less than a college degree	(9633)	43.3%
At least one parent has a college degree or higher	(12747)	56.7%
Urbanicity[2]		
Urban [Large MSA]	(8681)	32.0%
Suburban [MSA]	(11645)	48.8%
Rural [Non-MSA]	(5082)	19.2%
Region[2]		
Northeast	(4752)	17.3%
Midwest	(5622)	21.7%
South	(8872)	37.4%
West	(6162)	23.6%
Competitive Sport Participation (past 12 months)[2]		
Baseball	(3498)	15.0%
Basketball	(6151)	26.7%
Cross Country	(1273)	5.7%
Field Hockey	(359)	1.5%
Football	(4117)	17.6%
Gymnastics	(656)	2.8%
Ice Hockey	(391)	1.5%
Lacrosse	(813)	3.2%
Swimming	(1762)	7.2%

	n[1]	%[1]
Soccer	(4371)	18.3%
Tennis	(1227)	5.1%
Track	(3562)	15.6%
Volleyball	(2883)	12.6%
Weightlifting	(2334)	10.0%
Wrestling	(1013)	4.1%
Other Sport[4]	(5829)	24.2%
Reported a Diagnosed Concussion (Lifetime)		
Never Diagnosed with a Concussion	(19812)	81.6%
Only one Diagnosed Concussion	(3264)	13.4%
More Than One Diagnosed Concussion	(1207)	5.0%

Notes: % = Percent. MSA = Metropolitan Statistical Area.

[1]Percentages were estimated using custom weights provided by the MTF that only account for the probability of selection into the sample. Unweighted sample sizes were provided.

[2]The percent of data missing from each of the items listed above are the following: sex (5.5%), race/ethnicity (0.0%), grade level (0.0%), parental level of education (11.9%), urbanicity (0.0%), region (0.0%), participation in competitive sport (5.6%), and reported a diagnosed concussion (4.5%).

[3]Other race includes Asian, American Indian, those who selected multiple races/ethnicities, and those with missing racial information.

[4]Non-specified other types of sport (“Other sport”). If a participant indicated involvement in cheerleading, crew, equestrian, golf, water polo, or „other sports‟, they were defined as „other sport‟ participants.

Table 2.

Examining the association between different types of sport participation and lifetime diagnosis of concussions.

	Any concussion (n = 20,726)			One concussion (n = 20,726)			Multiple concussions (n = 20,726)		
	%	AOR	95% CI	%	AOR	95% C	%	AOR	95% CI
Sport Participation[1]									
Baseball	26.7%	1.32***	(1.17, 1.49)	18.4%	1.23**	(1.08, 1.40)	8.3%	1.36**	(1.09, 1.69)
Basketball	23.3%	1.21***	(1.09, 1.34)	16.2%	1.09	(0.96, 1.23)	7.1%	1.44***	(1.19, 1.73)
Cross Country	18.7%	0.83	(0.67, 1.04)	13.4%	0.88	(0.70, 1.11)	5.3%	0.77	(0.54, 1.10)
Field Hockey	22.6%	0.78	(0.51, 1.21)	15.9%	0.81	(0.53, 1.22)	6.6%	0.79	(0.39, 1.58)
Football	29.6%	1.60***	(1.39, 1.84)	20.0%	1.39***	(1.19, 1.63)	9.6%	1.79***	(1.45, 2.21)
Gymnastics	24.7%	1.43**	(1.11, 1.85)	17.2%	1.30	(0.99, 1.70)	7.5%	1.56*	(1.02, 2.37)
Ice Hockey	38.9%	1.89***	(1.38, 2.60)	23.0%	1.37	(0.93, 2.02)	15.9%	2.21***	(1.48, 3.28)
Lacrosse	29.5%	1.29*	(1.03, 1.61)	19.4%	1.15	(0.92, 1.43)	10.0%	1.43*	(1.00, 2.03)
Swimming	22.3%	0.98	(0.84, 1.14)	16.8%	1.10	(0.93, 1.28)	5.5%	0.75	(0.56, 0.99)
Soccer	21.4%	1.18**	(1.06, 1.32)	15.3%	1.11	(0.99, 1.26)	6.1%	1.28*	(1.05, 1.55)
Tennis	19.9%	0.80*	(0.66,0.98)	15.0%	0.91	(0.73, 1.13)	4.9%	0.64*	(0.43, 0.95)
Track	22.8%	1.14*	(1.00, 1.29)	15.9%	1.06	(0.92, 1.23	6.9%	1.28*	(1.03,1.61)
Volleyball	19.9%	1.04	(0.90, 1.19)	15.2%	1.11	(0.96, 1.30)	4.7%	0.85	(0.65,1.11)
Weightlifting	31.7%	1.38***	(1.21, 1.57)	21.5%	1.32***	(1.13, 1.55)	10.2%	1.25	(0.95,1.65)
Wrestling	33.7%	1.37**	(1.11, 1.69)	23.2%	1.33*	(1.06, 1.68)	10.5%	1.21	(0.85,1.70)
Other Sport	21.3%	1.17**	(1.06, 1.30)	14.6%	1.07	(0.96, 1.19)	6.7%	1.36***	(1.15,1.61)

% = Percent (i.e., prevalence rate); AOR = Adjusted Odds Ratio; CI = Confidence Interval

* p<.05

** p<.01

*** p<.001

All analyses control for sex, grade-level, race/ethnicity, parental education, urbanicity (e.g., does respondent live in a metropolitan statistical area [MSA]), and region of the country (e.g., does respondent live in the Northeast). Please refer to Table 1 for more details on these variables.

[1] All sports were entered into the binary logistic regression simultaneously to account for participation across different sports. Average variance inflation factor for main effect models was 1.52. Interaction effects were then added to these models to assess if various sociodemographic variables (i.e., grade-level, sex, race, parental education, region and urbanicity) moderated the association between different types of sports participation and lifetime diagnosis of concussion. The interaction effect models tested each interaction separately between different types of sports participation and the sociodemographic variables listed above (i.e., one outcome would test 144 possible interaction effects – only results significant at .001 alpha level were considered reliable due to the number of comparisons). Two sociodemographic variables (i.e., race and urbanicity) were collapsed into dichotomous measures to maintain an adequate sample size between various subgroups (i.e., Non-White versus White, rural/suburban versus urban).