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Serious Fighting-Related Injuries Produce a Significant Reduction in Intelligence

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A B S T R A C T

Purpose: Fighting-related injuries are common among adolescents within the United States, but how such injuries relate to subsequent cognitive functioning remains unclear. In particular, the long-term effect of fighting-related injuries suffered during important developmental periods, such as adolescence, on subsequent cognitive functioning has been overlooked by previous studies. The purpose of this study is to examine the association between sustaining serious fighting-related injuries and changes in verbal intelligence (IQ) over a 5- to 6-year time period.
Methods: Longitudinal multivariate statistical models were used to analyze data from the National Longitudinal Study of Adolescent Health collected between 1994 and 2002 and analyzed in 2013.
Results: Even a single fighting-related injury resulted in a significant reduction in IQ over time even after controlling for age, race, sex, and changes in socioeconomic status (SES) over the study period. Additionally, females experienced a significantly greater reduction in IQ from each fighting-related injury than males.
Conclusions: Fighting-related injuries have a significant impact on subsequent cognitive functioning and intelligence. The implications for future policies and research are discussed in more detail.

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IMPLICATIONS AND CONTRIBUTION

The results of the current study provide preliminary evidence suggesting that fighting-related injuries suffered in early adolescence result in significant reductions in intelligence in early adulthood. These reductions in intelligence may result in serious ramifications across the rest of the life course.

Empirical evidence converging from multiple lines of research reveals that adolescents are the most victimized age group in the United States [1–3]. Each year, somewhere between 30% and 50% of adolescents are victimized, a rate nearly three times higher than the adult victimization rate [1,2,4]. The overall violent crime victimization rate for adolescents, moreover, has been found to be more than twice the national average [5]. In addition to the prevalence of victimization in adolescence, physical fighting also appears to be especially salient among adolescents within the United States.

Despite the pervasiveness of adolescent victimization in the United States, the consequences associated with victimization can have serious effects on adolescents. Research has revealed, for instance, that adolescents who are victimized are at increased risk for subsequent criminal offending [6], mental health problems [7–9], and substance use [10–12]. Perhaps one of the most serious negative outcomes of adolescent victimization is the physical trauma that can result from being the victim of a serious physical crime. Studies have revealed that adolescence victimization incidents commonly result in physical injuries [2,3]. For example, the odds of suffering an injury as a result of victimization are more than three times higher for adolescents than adults [2], with somewhere between 15% and 20% of all adolescent victimizations resulting in a serious injury [3]. Findings from a recent study revealed that 19% of all adolescent assault victims had been injured and nearly 10% were assaulted with a weapon

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[13]. In addition, approximately 4% of high school students reported being injured as a result of a physical fight each year [14].

Physical injuries resulting from victimization and fighting—particularly serious injuries to the head—may also result in neurological problems. Research findings that span several decades indicate that head trauma may result in diminished cognitive functioning [15]. Although individuals who suffer a single uncomplicated injury tend to regain full cognitive functioning within 3 months [16], preliminary evidence from additional studies reveals that more severe and repeated injuries may result in more persistent cognitive problems [15] related to attention, executive functions, working memory, language fluidity, and information-processing speed [15,17]. Collectively, the available evidence provides some preliminary evidence suggesting that repeated physical injuries, particularly recurring trauma to the head, may result in diminished neurological and cognitive functioning.

The current study

The current study examined potential connection between being seriously injured in a physical fight in adolescence and subsequent changes in IQ. More specifically, whether repeated serious fighting-related injuries result in significant decreases in verbal intelligence (IQ) was examined over a 5- to 6-year time span. Importantly, the current study focuses on the effect of serious injuries suffered during adolescence, a critical period of neurological development [18], on changes in IQ. To do so, a longitudinal, empirical analysis was performed using a nationally representative sample of American youths.

Methods

Data

Data from the National Longitudinal Study of Adolescent Health (Add Health) were used in the current study. The Add Health is a prospective nationally representative sample of American youths. Wave 1 of data collection was carried out in 1994 and included students from 132 middle and high schools across the United States. In total, over 20,000 youth between the ages of 12 and 21 years participated in the first wave of the study. The second wave of data collection occurred between 1995 and 1996 and included nearly 15,000 respondents who also participated at Wave 1. Wave 3 was carried out approximately 5 years later (between 2001 and 2002), when respondents were 18–26 years old. A fourth wave of data collection was carried out between 2007 and 2008 but information on IQ and fighting-related injuries was not collected, making it inapplicable to the current study. At each wave of data collection, respondents were asked about a wide variety of topics including personality traits, social relationships, and the frequency of specific behaviors. Importantly, written informed consent was obtained from all participants, and the analysis plan carried out in the current study was approved by the Institutional Review Board at Florida State University. Additional information regarding data collection procedures has been detailed in prior studies [19,20].

Measures

Serious injury was measured with two identical questions asked during Wave 2 and Wave 3 interviews. Specifically, respondents were asked how many times they had been in a physical fight in which they were injured and had to be treated by a doctor or nurse in the past 12 months. Responses to both questions were summed with the resulting measure indicating the total number of times that each respondent suffered serious fighting-related injuries in the year preceding the Wave 2 interview and the year preceding the Wave 3 interview. Values on the serious injury measure ranged from 0 to 10. Respondents who reported more than 10 total serious injuries (N = 22) were considered extreme outliers and were excluded from the final analytic sample. The final models were estimated a second time with all respondents and the results did not differ substantively from those reported in the current study.

Intelligence was measured using the Picture Vocabulary Test (PVT), an abbreviated version of the Peabody Picture Vocabulary Test-Revised (PPVT-R). Respondents completed the PVT during Wave 1 interviews and again during Wave 3 interviews. Previous studies examining the Add Health data have used the PVT as a measure of IQ [21,22].

Four control variables were also included in the current study. First, socioeconomic status (SES) was measured at Waves 1 and 3. During Wave 1 interviews, each respondent's primary caregiver reported their total household income and their own education level as well as that of their spouse/partner (if applicable). During Wave 3 interviews, respondents reported on their own total household income and highest level of educational achievement. For both waves, total household income and highest level of educational achievement were *z*-transformed and then summed. In order to measure change in SES, residualized change scores were estimated by regressing the Wave 3 SES measure on the Wave 1 SES measure. Second, age was included as a continuous variable measured in years. Third, race was measured dichotomously where 0 = white and 1 = African-American. Fourth, gender was dummy coded where 0 = female and 1 = male.

Results

Means and standard deviations were estimated for all measures included in the current study and are reported in Table 1. In addition, *t*-tests were utilized to examine the mean differences between males and females across all measures included in the current study. Results indicated that 7.2% of the overall sample ($\bar{x} = .13$, $SD = .58$), 10.2% of the male only subsample ($\bar{x} = .19$, $SD = .72$), and 4.5% of the female only subsample ($\bar{x} = .07$, $SD = .41$) experienced at least one serious injury as a result of fighting. A *t*-test (variances were assumed to be unequal) indicated that males experienced a significantly higher number of injuries than females ($t = -10.16$, $p < .001$). The mean IQ score for the full sample was 99.60 at Wave 1 and 100.46 at Wave 3. Overall, males had significantly higher IQ scores at Wave 1 ($t = -6.55$, $p < .001$) and Wave 3 ($t = -4.26$, $p < .001$) than females. The *t*-tests also revealed significant differences between males and females for changes in SES over time ($t = -4.26$, $p < .001$), age ($t = -6.86$, $p < .001$), and race ($t = 3.69$, $p < .001$).

Table 2 presents the results of three regression equations estimating the effect of serious injury on changes in IQ over time. To assess change in IQ, the "regressor variable method" was employed in which Wave 3 IQ was regressed on Wave 1 IQ, the fighting-related injury measure, and all controls in an effort to partial out the covariance or stability between both measures with the remaining variance capturing change in IQ between the two waves and measurement error [23,24]. Importantly, temporal ordering between fighting-related injury and change in

Table 1
Means, standard deviations, and *t*-score values for study measures: National Longitudinal Study of Adolescent Health, United States, 1994–2002

	Full sample		Male sample		Female sample		*t* value
	Mean	SD	Mean	SD	Mean	SD	
Serious injury[a]	.13	.58	.19	.72	.07	.41	−10.16**
	(11,405)		(5,345)		(6,060)		
Wave 1 IQ	99.60	14.97	100.60	15.08	98.72	14.82	−6.55**
	(10,900)		(5,081)		(5,819)		
Wave 3 IQ	100.46	16.26	101.17	16.06	99.84	16.40	−4.26**
	(11,034)		(5,148)		(5,886)		
SES	−.02	.75	−.05	.73	.01	.76	4.14**
	(10,111)		(4,736)		(5,375)		
Age	15.77	1.62	15.88	1.63	15.67	1.61	−6.86**
	(11,397)		(5,340)		(6,057)		
Race	.25	.44	.24	.42	.27	.44	3.69**
	(9,755)		(4,523)		(5,232)		
Gender	.47	.50					
	(11,405)						

The reported socioeconomic status (SES) measure reported is a residualized change score representing changes in SES from Wave 1 to Wave 3.
Note: Sample sizes are presented in parentheses.
[a] Unequal variances were assumed.
** $p < .001$.

IQ was preserved because IQ measures were recorded during Wave 3 interviews and the number of serious injuries were reported for the year preceding Wave 2 and Wave 3 interviews. Due to the significant differences between males and females across all measures used in the current study, models were estimated using the full sample, and then restricted to the male only and female only subsamples. In order to prevent potential confounding, age, race, sex, and changes in SES were also included in all estimated regression equations.

The first column from the left of Table 2 presents results from the full sample. The results indicated that each fighting-related injury resulted in a loss of approximately 1.89 IQ points even after controlling for changes in SES, age, race, and gender. The second column from the left presents results from the same equation, but the sample was restricted to the male only subsample. The results indicated that each fighting-related injury resulted in a significant reduction of approximately 1.62 IQ points even after controlling for changes in SES, age, and race. The final column presents results from the same regression equation but restricted the sample to the female only subsample. The results indicated that each serious fighting-related injury resulted in a significant reduction of approximately 3.02 IQ points even after controlling for changes in SES, age, and race.

Table 2
Ordinary least squares regression models examining the association between serious injury from fighting and change in IQ: National Longitudinal Study of Adolescent Health, United States, 1994–2002

	Full sample		Male sample		Female sample	
	b	Beta	*b*	Beta	*b*	Beta
Serious injury	−1.89	−.07**	−1.62	−.08**	−3.02	−.07**
	(.24)		(.27)		(.51)	
Wave 1 IQ	.57	.54**	.54	.52**	.59	.56**
	(.01)		(.01)		(.01)	
SES	1.72	.08**	1.34	.06**	2.02	.10**
	(.18)		(.27)		(.25)	
Age	.24	.02**	.44	.05**	.04	.00
	(.08)		(.12)		(.11)	
Race	−5.37	−.15**	−6.39	−.18**	−4.50	−.13**
	(.32)		(.48)		(.43)	
Gender	.17	.01				
	(.27)					
N	8,193		3,794		4,399	
Adjusted R^2	.40		.39		.41	

The reported socioeconomic status (SES) measure reported is a residualized change score representing changes in SES from Wave 1 to Wave 3.
Note: Standard errors are presented in parentheses.
** $p < .001$.

Two additional analytic procedures were performed in an effort to determine whether the reported coefficients for the male only and female only subsamples were significantly different from one another (analyses not presented in tables). First, a multiplicative interaction term between gender and the fighting-related injury measure was introduced into the regression equation examining the full sample. The interaction term was significant ($b = 1.52$, $p < .001$), indicating a significant difference in the effect of fighting-related injuries on changes in IQ between males and females, with females suffering a greater loss in IQ relative to males. Second, a difference-in-coefficients *z*-test [25] indicated that the reported coefficients for the male only and female only subsamples were significantly different from one another ($z = 2.48$, $p < .01$, one-tailed test).

Figure 1 displays the mean Wave 3 IQ scores for individuals who have suffered zero injuries, between one and three injuries, and four or more injuries for the full sample, the male only sample, and the female only sample. For each of the three samples, the mean Wave 3 IQ score was lower for respondents with a greater number of fighting-related injuries. Figure 2 presents predicted IQ scores generated from the previously estimated regression equations plotted as a function of the number of experienced serious fighting-related injuries for the full sample, the male only subsample, and the female only subsample. Importantly, the predicted IQ scores were *z*-transformed prior to being plotted to aid in interpretation. For each of the three samples, each subsequent serious injury resulted in a significant decrease in IQ. Within the full sample, individuals who experienced zero serious injuries had a predicted IQ score of 101.66 ($z = .08$), while individuals who experienced 10 serious injuries had a predicted IQ score of 82.71 ($z = -1.05$). Within the male only subsample, individuals with no serious injuries had a predicted IQ of 102.31 ($z = .12$) and individuals with 10 serious injuries had a predicted IQ of 86.10 ($z = -.85$). A similar pattern of findings was present within the female only subsample where individuals with no serious injuries had a predicted IQ of 101.12 ($z = .05$) and individuals with 10 serious injuries had a predicted IQ of 70.89 ($z = -1.76$).

Discussion

Recently, when asked about the physical impact football takes on its players, President Obama replied, “I’m a big football fan, but I have to tell you if I had a son, I’d have to think long and hard before I let him play football” [26]. President Obama’s concerns regarding the potentially negative repercussions of repeated head trauma suffered in contact sports, such as football, have been echoed in recent media reports regarding the suicide of former NFL linebacker, Junior Seau. In another recent incident, Jovan Belcher, a linebacker for the Kansas City Chiefs, murdered his girlfriend and then committed suicide hours later. In both cases, diminished neurological functioning, resulting from repeated head trauma, has been considered as a possible contributing factor. Concerns regarding the potential association between head trauma and diminished neurological and cognitive functioning have resulted in

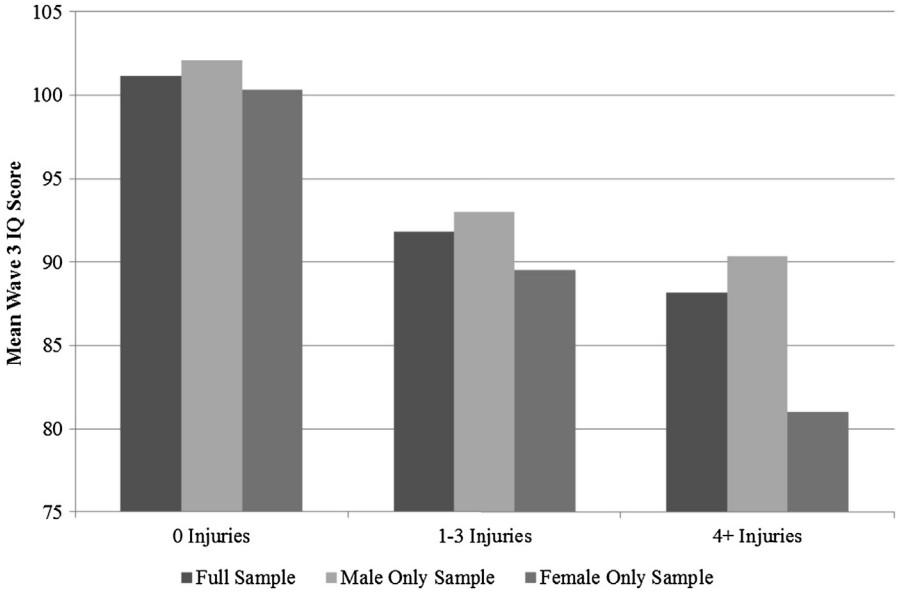

Figure 1. Mean Wave 3 IQ score by mean number of serious fighting-related injuries at Wave 1 and Wave 2: National Longitudinal Study of Adolescent Health, United States, 1994–2002.

a related line of empirical research [27]. Preliminary results flowing from these studies have indicated that athletes who suffer severe and repeated head injuries are at-risk to suffer from diminished cognitive functioning later in life [28–30]. In addition, the results of a recent study revealed that a significant number of deceased professional athletes who participated in contact sports, such as football and wrestling, have suffered neurological damage that ultimately resulted in cognitive impairment [31].

Although the current study was unable to directly examine the effect of head injuries suffered as a result of participation in a contact sport, the association between another common source of injury—physical fighting—and changes in IQ over time was examined. The results indicate that suffering a serious injury during a fight resulted in a significant reduction in verbal IQ over time. More specifically, each significant injury suffered as a result of fighting resulted in a 1.89 point reduction in IQ for the full sample, a 1.62 point reduction in IQ for the male only subsample, and a 3.02 point reduction in IQ for the female only subsample. These findings were not only statistically significant, but also have substantive importance for a wide variety of later life outcomes. Previous studies have indicated that missing a single year of school is associated with a loss of 2–4 IQ points [32]. In this way, males suffer a loss in IQ roughly equivalent to missing an entire year of school after approximately two fighting-related injuries, and females suffer a similar loss of IQ after only a single fighting-related injury. Decreases in IQ can also have serious implications for a wide variety of outcomes that span several aspects of the life course, including educational achievement [33], occupational

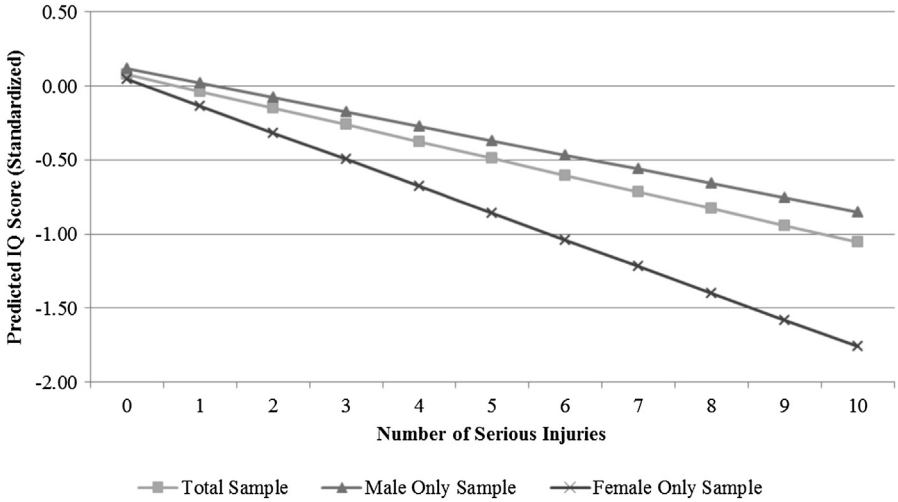

Figure 2. Predicted standardized IQ scores as a function of serious injuries from fighting: National Longitudinal Study of Adolescent Health, United States, 1994–2002. Note: Predicted standardized IQ scores with all covariates (Wave 1 IQ, change in SES, age, race, and gender) held to their means.

performance [34], health outcomes [35], mental disorders [36], behavioral problems [37], and even longevity [38]. When viewed in this way, even individuals who suffer a single injury from fighting during adolescence may experience significant ramifications that span the entire life course.

The results of the current study also indicate that females suffer a significantly greater decrease in IQ with each serious injury resulting from fighting as compared with males. This finding suggests that females are more susceptible to cognitive decline resulting from physical injury. This finding directly coincides with a broad line of research indicating significant sex differences in fighting ability and the ability to withstand physical trauma [39]. More specifically, males have been found to possess specific physiological characteristics that result in an increased ability to inflict and withstand physical damage. The results of the current study directly coincide with findings from this line of literature and indicate that females suffer greater cognitive decline from fighting-related physical injuries than males.

The findings of the current study should be interpreted with caution due to three key limitations. First, the physical injury measure used in the current study likely underestimates the effect of head injuries on subsequent cognitive performance. Because the measure used takes all fighting-related physical injuries into account, it is quite likely that some respondents suffered injuries to body regions other than the head. In this way, the actual impact of each serious head injury on cognitive performance may be significantly greater than the results of the current study indicate. Second, the current study only examined a measure of verbal IQ. Although verbal IQ measures are used quite frequently in the literature [32], future research should examine the potential impact of serious injuries on additional IQ measures. Third, due to limitations of the Add Health data, the current study only examined IQ at two time points. Examining the potential effects of serious injuries over a longer period of time would provide a more detailed description of the long-term effects of such injuries on cognitive performance and other related life outcomes.

Although adolescent fighting is generally discouraged, all too often it is viewed as "boys will be boys" when in reality fighting may be promoting cognitive decline later in life. The complete elimination of physical fighting in adolescence is likely impossible and many schools and communities already have procedures in place that are directly aimed at preventing and quickly resolving physical fights. Although the results of the current study highlight the importance of such policies, these findings may also have implications for related sources of physical injury, such as contact sports. In this way, future studies should aim to better understand the underlying intricacies of the association between serious injuries and diminished cognitive functioning with an eye toward generating policy recommendations aimed at limiting injuries suffered during adolescence.

Endnote

1. In an effort to examine the sensitivity of the results, a series of supplemental analyses were performed. First, the analyses were repeated using a difference score approach in which each respondent's Wave 3 IQ score was subtracted from their Wave 1 IQ score and included in each of the estimated models as the dependent variable. Although the analysis produced attenuated effects, the overall pattern of results did not differ substantively from the analyses presented in the current study for the full ($b = -1.08$, $p < .001$), male only ($b = -.80$, $p < .001$), or female only ($b = -2.06$, $p < .001$) samples. Second, the effect of injuries suffered prior to Wave 2 and Wave 3 on changes in IQ were examined separately. The Wave 2 measure of fighting-related injuries failed to significantly predict changes in IQ for the full sample ($b = -.51$, n.s.) and for the same-sex male sample ($b = -.39$, n.s.) but was marginally significant for the female sample ($b = -1.11$, $p = .08$). The Wave 3 measure of fighting-related injuries significantly predicted changes in IQ in the full sample ($b = -3.34$, $p < .001$), the male sample ($b = -2.73$, $p < .001$), and the female sample ($b = -5.71$, $p < .001$). Third, the SES measure was excluded from each of the models but all other covariates were retained. The overall pattern of results for the full ($b = -1.99$, $p < .001$), male only ($b = -1.67$, $p < .001$), and the female only ($b = -2.95$, $p < .001$) samples was virtually identical to those presented in the current study.

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