Article

Journal of Sports Economics
2019, Vol. 20(5) 690-717

DOI: 10.1177/1527002518798681
journals.sagepub.com/home/jse
SAGE

Estimated Costs of Contact in College and High School Male Sports

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Abstract
Injury rates in 12 U.S. men's college sports and 5 U.S. boys' high school sports are examined in this article. The sports are categorized as "contact" or "noncontact," and differences in injury rates between the two are examined. Injury rates in the contact sports are considerably higher than those in the noncontact sports, and they are on average more severe. Estimates are presented of the injury savings that would result if the contact sports were changed to have injury rates similar to those in the noncontact sports. The estimated college savings are 48,100 fewer injuries per year and 5,900 fewer healthy years lost-to-injury per year. The estimated high school savings are 568,600 fewer injuries per year and 92,000 fewer healthy years lost-to-injury per year. For concussions, the savings are 6,900 per year for college and 161,400 per year for high school. The estimated dollar value (in 2015 dollars) of the total injury savings is between US$433 million and US$1.5 billion per year for college and between US$5.1 billion and US$18.4 billion per year for high school.

Keywords
sports injuries, collegiate sports, high school sports

Introduction

Injury rates in 12 U.S. men's college sports and 5 U.S. boys' high school sports are examined in this paper for the 2009/2010-2013/2014 period. The college data are

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from the National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP)—the Datalys data.[1] The high school data are from the High School Reporting Information Online (RIO) project.[2] The data are compiled from a sample of reporting colleges and high schools and blown up to national totals.

The sports are categorized as "contact" or "noncontact," and differences in injury rates between the two are examined. Injury rates in the contact sports are considerably higher than those in the noncontact sports, and they are on average more severe. Estimates are presented of the injury savings that would result if the contact sports were changed to have injury rates similar to those in the noncontact sports. The estimated college savings are 48,100 fewer injuries per year and 5,900 fewer healthy years lost-to-injury per year. The estimated high school savings are 568,600 fewer injuries per year and 92,000 fewer healthy years lost-to-injury per year. For concussions, the savings are 6,900 per year for college and 161,400 per year for high school. The college concussion rate for football is about 15 times greater than that for the noncontact sports. The difference is 10 times greater for high school. The estimated dollar value (in 2015 dollars) of the total injury savings is between US$433 million and US$1.5 billion per year for college and between US$5.1 billion and US$18.4 billion per year for high school. A little over half of the college savings are from football, and a little over 70% of the high school savings are from football.

This article is not a policy paper in that no policy recommendations are made. There are many important and controversial issues in college sports. Some sports at some colleges generate considerable revenue. Should student athletes be paid? Should coaches be paid more than professors? On the negative side regarding sports, there are concerns that academic standards are being lowered in the interest of sports and that there is too much of a sports culture relative to an academic culture at some colleges. On the plus side, sports provide considerable enjoyment to fans and added gifts from alumni to colleges. Also, team sports have social benefits—learning how to work with others, socializing, and learning leadership skills. And exercise is healthy. This article does not consider these issues. It simply estimates possible injury costs that would be saved if contact were eliminated from college and high school sports. It provides estimates of injury costs for college and high school administrators and government policy makers that would be saved by eliminating contact in sports. These estimated savings can be weighed against the benefits of retaining contact. The cost estimates have the advantage that the base case is not zero injuries. All activities have some risk of injury, even walking. The base case is the injury experience in noncontact sports.

Could contact be eliminated in contact sports without destroying the sports? The team aspect of sports mentioned above would be retained, but there are undoubtedly different views on whether the sports would survive. For ice hockey, soccer, and lacrosse, the rules would have to be changed to allow no contact, and the refereeing would have to be tighter. In addition, headers would have to be banned in soccer. Rules for wrestling would have to be changed to avoid rough actions. For football, the game would have to be changed to be noncontact football. An example of noncontact football is flag football, although other noncontact options are possible. Basketball is odd in that it is not supposed to be a contact sport, but, as will be seen below, its injury rates are in the contact sports range. There is, of course, contact in basketball, and players frequently fall. Possible rule changes would be banning dunk shots (so that less of the game is in effect played above the rim) and tighter refereeing. Some experimentation would undoubtedly be needed to change the rules for each sport to achieve lower injury rates. The hypothetical in this article is that these sports could be changed as just discussed without destroying them. The hypothetical is not the elimination of the sports. Again, people will differ on whether this is a realistic hypothetical.

An important caveat regarding the estimated savings in this article is that they are only for the short term. As noted in the next section, it may be that long-term health problems and long-term costs from contact in sports are much larger than the short-term costs estimated here. The current data do not allow any long-term estimates.

It should finally be stressed that the results in this article are only approximations. The data are based on surveys, and there is obviously measurement error. Much of the analysis in this article focuses on the aggregation of all 5 years, all three divisions (for colleges), and all injuries. To the extent that measurement errors are not perfectly correlated with each other, aggregation should lessen the effects of measurement error.

Literature

Many of the previous studies that have used the Datalys data have focused on specific sports or injuries. One approach is to fix a sport and determine the breakdown of injuries incurred while playing this sport. Roos et al. (2016) analyze all injuries reported in men's and women's soccer. They compare injury rates per athletic exposure between genders, and they characterize the quality of these injuries. Kerr et al. (2016) examine cross-country injuries, comparing, among other things, injury rates across genders. Lynall et al. (2015) examine tennis injuries.

Another approach is to fix a particular injury and analyze its distribution across sports. Hibberd, Kerr, Roos, Djoko and Dompier (2016) and Dalton, Kerr and Dompier (2015) examine acromioclavicular joint sprain. Some studies fix a particular sport and injury. Dalton et al. (2016) examine hip/groin injuries in ice hockey. Gardner (2015) examines head, face, and eye injuries in women's field hockey. Lynall, Kerr, Parr, Hackney, and Mihalik (2016) find that concussive injuries in Division I football games occur more frequently at higher altitudes.

McAllister et al. (2012), not using Datalys data, examine the difference in the quantity of head impacts and subsequent cognitive effects between collegiate contact sports (football and ice hockey) and noncontact sports (rowing, track, and skiing). They used accelerometer data for a single season, finding that there was no significant difference in performance across the different sports in most cognitive tests. They did find, however, that in the contact sports, the players averaged over 400 hits above the 14.4 *g* threshold in the season, which could have longer term consequences. Using a longer time horizon, Montenigro et al. (2016) found that the estimated number of hits sustained by football players in college and high school, which were estimated through surveys and published accelerometer data, strongly predicts emotional and mental issues in later life. Their cumulative head impact index had more explanatory power than just concussive history in a probit model. This suggests that cumulative hits may be important in long-term health.

Regarding the high school RIO data, Marar, Mcllvain, Fields, and Comstock (2012) used the data to examine concussions in 20 sports for the 2008-2010 academic years. They found that concussions occur in a wide variety of high school sports, not just the full-contact sports such as football and ice hockey. Rosenthal, Foraker, Collins, and Comstock (2014) used the RIO data to examine trends in concussion rates in nine sports for the 7 academic years 2005/2006-2011/2012. They found an increase in the concussion rate in each of the nine sports, with the increase being statistically significant in five of the sports over the 7-year period. Schallmo, Weiner, and Hsu (2017) used the data to examine concussion rates in all high school sports, both boys' and girls', for the 2 academic years 2005/2006 and 2014/2015. They found a significant increase in the overall concussion rate that girls have a higher risk of concussion than boys and that in 2014/2015 the highest concussion rate was in girls' soccer.

In an earlier study, using data from 25 schools in a large public high school system, Lincoln et al. (2011) examined concussion rates in 12 sports for the academic years 1997/1998-2007/2008. They found that concussion rates increased over time in all 12 sports. Girls' soccer had the second highest concussion rate at 0.35 concussions per 1,000 exposures, behind the football concussion rate of 0.60.

This study provides for men's and boys' sports a broader comparison across injuries and sports than has been done so far, and it incorporates economic cost into the analysis. The base case is taken to be injury rates in noncontact sports. And college results are compared to high school results.

It is important to note that both the Datalys data and the RIO data cover only short-term injury costs. There is a growing literature examining potential long-term health consequences of competing in contact sports, such as Montenigro et al. (2016), but this is a question beyond the scope of the data used here. It may be that the long-term costs are much larger than the short-term costs computed here.

College Data

The NCAA-ISP data are created from a sample of schools. Each participating school reports injury information to the NCAA. As discussed below, multiplication factors are used to blow the sample values up to national totals.

Table 1. The Four Injury Types.

Concuss	Concussion, nervous system
Bone	Exostosis, fracture, fracture (stress), myositis ossificans, osteochondritis
Tear	Cartilage injury, dislocation, sprain, strain, strain/tear, subluxation
Muscle	Contusion (hematoma), spasm

Note. Not used: Abrasion, arthritis/chondromalacia, avascular necrosis, avulsion, avulsion/fracture, bursitis, capsulitis, cardiovascular, compartment syndrome, cysts, dental, dermatology, effusion, endocrine system, entrapment/impingement, environmental, gastrointestinal, genitourinary, hematology, illness, infection, infectious disease, inflammation, internal organ, laceration, miscellaneous, neoplasm, psychological, respiratory, rheumatology, synovitis, tendinitis, tendinosis, tenosynovitis, thrombosis.

The NCAA-ISP data contain two files. The first file documents athletic exposures. An exposure is defined as "a practice or competition in which a student-athlete was exposed to the possibility of athletic injury, regardless of the time associated with the participation." In the file, each "exposure" is one observation, with a unique identifier key and the number of athletes who participated in the session. An exposure is thus a record of a practice or competition. If one observation in the file records, say, 20 athletes participating in the session, that observation actually codes for 20 total athlete exposures. For each observation, there are codes for the sport, the college division, and the academic year. There are 12 sports, three college divisions, and five academic years. The data are for men only.

The second file documents injuries. One observation records a single injury. Included in each observation are codes for the specific injury classification, a 50 group injury classification, the year, the sport, the division, the number of days lost, whether or not the injury required surgery, and various other data.

For a given injury classification, the injury rate is the number of injuries divided by the number of exposures. Rates are calculated by simply counting the total number of athlete exposures for a certain sport, division, and year; counting the number of injuries of a particular classification in the same sport, division, and year; and dividing the two. For any given sport, division, and year, the number of exposures will always be the same. Rates only differ because the number of injuries differs not because the number of exposures differs.

In this article, four injury types, based on 15 injury group classifications, are examined. The aggregation of the injuries into the four types is presented in Table 1. Fifteen of the 50 injury group classifications have been used. The four types are, roughly, concussions, bone injuries, tear injuries, and muscle injuries. Other injury groups were deemed too rare or too mild to warrant consideration. The injury rate for all injuries, all sports, all divisions, and all years is 6.42 per 1,000 exposures. This compares to 4.92 per 1,000 for only the four injury types in this analysis.

Also included with the NCAA-ISP data are multiplication factors to convert the sample values to national totals. Each observation in both files includes a weight, which varies by sport, division, and year. For example, the weight for Division I men's baseball for the 2009/2010 academic year is 111.11. This means that each exposure or injury in the sample is assumed to be 111.11 exposures or injuries at the national level. The multiplication factors are computed by a simple formula: For each sport, division, and year, the weight is just the number of sponsoring schools divided by the number of schools participating in the ISP program, where a sponsoring school is a school with a team for the particular sport, division, and year. For additional information on the weighting procedure, Kerr et al. (2014) provide a complete guide on the methodology of the collection and weighting processes of the ISP program (see also Kerr et al., 2015). The majority of the available literature uses these weights, and our analysis has done the same.

Although the Datalys data are widely used, they have limitations. They come from a convenience sample of NCAA institutions, with athletic trainers voluntarily documenting injuries. The data are not necessarily a representative sample of the national population. The data may also be subject to underreporting. It may be that athletes experience conditions that do not quite qualify as injury but still adversely impact health. See Baugh et al. (2014) for a discussion on college football underreporting. Athletic trainers may also differ in what qualifies as an injury, and so there is some subjectivity involved in reporting injuries.

Privacy issues also limit the amount of information that can be obtained from the data. The only personal information on an athlete is gender. For example, it is not known whether an injured athlete was a starter or a bench player. The college is also not known except for which division it is in.

Although the data are not perfect, they are generally accepted as being reasonably accurate. Kucera et al. (2011) analyzed the effectiveness of the ISP by performing a capture–recapture analysis of ISP data for men's and women's soccer teams at 15 universities for the time period 2005-2008. The authors reviewed hard copy athletic trainer injury assessments and clinician notes to come up with an independent database on injuries. They then compared this database with the ISP database for the same teams over the same time period. Based on proportions of injuries captured in one, both, or (an estimate of) neither database, the authors determined that the NCAA-ISP program captured 88.3% of all time-loss-relevant injuries over that period.

Injury Rates

Consider first the aggregation of the three divisions and the 5 academic years. For this aggregation, let E_k denote the number of exposures in sport k, let I_{ik} denote the number of injuries of type i in sport k, let D_{ik} denote the number of days lost from injuries of type i in sport k, and let S_{ik} denote the number of injuries of type i in sport k that required surgery. The injury rate for injury of type i and sport k is I_{ik}/E_k.[3]

Injury rates for the four types of injuries are presented in Table 2 for the 12 sports. These rates are for the aggregation across the 5 years and the three divisions. Five of

Table 2. Injury Rates: Injuries per 1,000 Exposures All 5 Years, All Three Divisions.

		1,000 (*I*/*E*)			
Sport	All Four Injuries	Concuss	Bone	Tear	Muscle
Wrestling	8.34	1.35	.42	5.67	0.90
Football	7.79	0.92	.34	5.13	1.41
Ice Hockey	7.77	0.87	.46	3.71	2.72
Soccer	6.50	0.37	.29	4.34	1.50
Basketball	6.33	0.44	.34	4.00	1.55
Lacrosse	5.49	0.40	.28	3.46	1.35
N: Noncontact	2.62	0.06	.16	1.89	0.51
Tennis	3.50	0.09	.16	2.95	0.30
Baseball	3.17	0.11	.22	1.96	0.88
Indoor track	2.43	0.03	.09	2.02	0.29
Cross-country	2.26	0.06	.31	1.57	0.33
Outdoor track	1.75	0.02	.05	1.35	0.33
Swimming	0.70	0.04	.04	0.51	0.12

Note. Noncontact sports are taken to be tennis, baseball, indoor track, cross-country, and outdoor track. I = number of injuries; E = number of exposures.

the sports have been classified as "noncontact:" tennis, baseball, indoor track, cross-country, and outdoor track. Swimming has been excluded from the noncontact category because it is almost injury free. It is not representative of the other noncontact sports. Injury rates for the noncontact category, denoted *N*, are also presented in Table 2.

Wrestling has the highest injury rates for concuss and tear. The rate is particularly high for concuss—1.35 concussions per 1,000 exposures. Football and ice hockey are similar, as are soccer and basketball. The concussion rate for football is 0.92. Lacrosse has the lowest overall rate of the six contact sports at 0.40. The rates are noticeably lower for the five noncontact sports, especially for concuss. The main type of injury for these sports is tear. As just noted, swimming has very low rates.

Interesting checks on the football concussion rate of 0.92 are football concussion rates computed from an Ivy League/Big Ten epidemiology study. Concussion data have been collected since the fall of 2013 from Ivy League and Big Ten universities. Preliminary results for the Ivy League have been reported by Carolyn S. Campbell-McGovern in a March 2017 talk at the MIT/Sloan Analytics Conference.[4] The rates for the 4 academic years 2013/2014-2016/2017 are, respectively, 1.18, 1.62, 1.08, and 0.99. These rates are slightly higher than the 0.92 rate in Table 2 but only slightly. They are essentially consistent with the Datalys data. This is an important check on both sets of data, since the NCAA and Ivy League/Big Ten data collections are completely independent of each other. The same trainer is not recording both data.

Table 3. Total Injuries and Severity All 5 Years, All Three Divisions.

Sport	1,000 (*I*/*E*)	*E* Million	*I* Thousand	*D* Thousand	*D*/*I*	100 (*S*/*I*)
All four injury types						
Wrestling	8.34	2.87	23.9	454.3	19.0	4.69
Football	7.79	25.77	200.7	3,106.1	15.5	7.40
Ice hockey	7.77	1.93	15.0	173.3	11.6	3.17
Soccer	6.50	8.42	54.8	568.9	10.4	2.62
Basketball	6.33	9.76	61.8	520.6	8.4	3.91
Lacrosse	5.49	4.26	23.4	294.7	12.6	5.56
N: Noncontact	2.37	40.35	105.9	1,033.1	9.8	2.83
Tennis	3.50	3.12	10.9	161.6	14.8	0.68
Baseball	3.17	14.26	45.2	475.5	10.5	4.06
Indoor track	2.43	10.44	25.4	182.5	7.2	1.87
Cross-country	2.26	4.72	10.7	87.0	8.1	0.00
Outdoor track	1.75	7.81	13.7	126.5	9.2	2.55
Swimming	0.70	6.23	4.4	15.7	3.6	8.68

Note. Noncontact sports are taken to be tennis, baseball, indoor track, cross-country, and outdoor track. I = number of injuries; E = number of exposures; D = number of days lost due to injuries; S = number of injuries that required surgery.

For *N*, the overall injury rate in Table 2 is 2.62 per 1,000 exposures. The rates for wrestling, football, and ice hockey are about 3 times this. The rates for soccer and basketball are about 2.5 times this, and the rate for lacrosse is about 2 times this. For *N*, the concussion rate is 0.06. The rate for wrestling is about 22 times this, the rates for football and ice hockey are about 15 times this, and the rates for soccer, basketball, and lacrosse are about 7 times this. There is obviously a clear difference between the contact and noncontact sports, with the differences for concussions being particularly large.

Table 3 presents the injury rates plus the total number of exposures, the total number of injuries, the number of days lost from the injuries, the number of days lost per injury, and the percentage of injuries that required surgery. Table A1 in the Appendix is the same table disaggregated by the four injury types. The data are for all 5 years and all three divisions.

Football has the largest number of exposures at 25.77 million, followed by baseball and indoor track. Ice hockey, wrestling, and tennis are relatively small. The injury rates have already been discussed. The number of days lost per injury is highest for wrestling at 19.0, followed by tennis and football. The number of days lost per injury for *N* is 9.8, which is smaller than for the contact sports except basketball. Excluding swimming, the percentage of injuries that require surgery is highest for football at 7.40%, followed by lacrosse, wrestling, and baseball. The percentage for swimming is high, but the overall number of injuries for swimming is small and the large percentage could be due to measurement error.

Table 4. Injury Rates by Division All 5 Years.

	1,000 (*I*/*E*)			
Sport	I	II	III	All
All four injury types				
Wrestling	10.74	3.47	8.88	8.34
Football	9.57	5.96	6.60	7.79
Ice hockey	7.13	6.79	8.36	7.77
Soccer	7.43	3.29	7.52	6.50
Basketball	7.94	5.29	5.51	6.33
Lacrosse	3.54	4.45	6.73	5.49
N: Noncontact	3.28	1.81	2.40	2.62
Tennis	4.58	3.19	2.49	3.50
Baseball	3.98	2.53	2.98	3.17
Indoor track	3.14	1.89	1.94	2.43
Cross-country	2.19	1.16	2.96	2.26
Outdoor track	2.65	0.50	0.93	1.75
Swimming	0.54	0.49	1.04	0.70

Note. Noncontact sports are taken to be tennis, baseball, indoor track, cross-country, and outdoor track. *I* = number of injuries; *E* = number of exposures.

For concuss in Appendix Table A1 by far, the most concussions are in football at 23,700. The next highest is 4,300 in basketball. For *N*, the number of concussions is 2,500.

Table 4 presents the injury rates for the three divisions, aggregated by the 5 years. Except for lacrosse, the rates are higher for Division I than for Division II. In most cases, they are considerably higher. For example, for football, the rate for Division I is 9.57 versus 5.96 for Division II. The rates for Division III are generally higher than those for Division II. Comparing Division III to Division I, the rates are higher for Division III for ice hockey, soccer, lacrosse, cross-country, and swimming. It is interesting that Division III is closer to Division I than is Division II.

Table 5 presents the injury rates for each of the 5 academic years, aggregated by the three divisions. Five years is not a long enough time period to test for any trend effects, but the data can at least be examined to see whether any trends look like they are developing. For the aggregation of all four injury types, there are no systematic patterns in the table. The rate for wrestling is highest in the first year, and the rate for football is highest in the fifth year. For *N*, the rate is highest in the first year and then essentially flat for the remaining 4 years. Basketball and lacrosse are fairly flat for all 5 years. Ice hockey and soccer are erratic.

For concuss in Table 5, there is a downward trend for wrestling and an upward trend for football and lacrosse. For football, the rate rises from 0.78 for the first year to 1.12 for the fifth year. The positive concussion trend for football is contrary to the

Table 5. Injury Rates Over Time All Three Divisions.

	1,000 (*I/E*)					
	Years					
Sport	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	All 5 Years
All four injury types						
Wrestling	14.64	8.49	6.34	6.19	7.79	8.34
Football	7.95	6.50	7.54	7.74	9.11	7.79
Ice hockey	5.93	9.10	7.86	8.11	7.89	7.77
Soccer	5.32	7.55	6.31	6.45	6.83	6.50
Basketball	6.07	6.78	6.13	6.11	6.56	6.33
Lacrosse	5.33	5.02	5.43	6.32	5.33	5.49
N: Noncontact	4.08	2.34	2.49	2.26	2.46	2.62
Tennis	4.08	3.20	2.75	2.94	4.20	3.50
Baseball	3.54	2.61	3.17	3.51	3.14	3.17
Indoor track	4.00	2.24	3.03	1.53	1.94	2.43
Cross-country	7.92	2.07	0.86	2.16	1.70	2.26
Outdoor track	3.72	1.64	1.60	1.64	1.51	1.75
Swimming	0.24	0.48	1.16	0.55	0.94	0.70
Concuss						
Wrestling	2.01	1.58	1.55	1.30	0.53	1.35
Football	0.78	0.75	0.86	1.05	1.12	0.92
Ice hockey	0.76	1.19	0.80	0.76	0.85	0.87
Soccer	0.37	0.66	0.23	0.13	0.52	0.37
Basketball	0.32	0.45	0.38	0.42	0.60	0.44
Lacrosse	0.10	0.24	0.49	0.42	0.65	0.40
N: Noncontact	0.02	0.10	0.07	0.06	0.07	0.06
Tennis	0.00	0.16	0.00	0.00	0.23	0.09
Baseball	0.04	0.16	0.09	0.14	0.11	0.11
Indoor track	0.00	0.08	0.04	0.00	0.02	0.03
Cross-country	0.00	0.00	0.11	0.15	0.00	0.06
Outdoor track	0.00	0.00	0.05	0.02	0.00	0.02
Swimming	0.00	0.00	0.11	0.09	0.02	0.04

Note. Noncontact sports are taken to be tennis, baseball, indoor track, cross-country, and outdoor track. I = number of injuries; E = number of exposures.

Ivy League rates mentioned above, where they show a slight downward trend. But more data are needed before any conclusions can be drawn.

Estimated Injury Savings From Banning Contact

It is clear that injury rates are higher in contact than noncontact sports. It is interesting to consider the injury savings that would result if contact sports could be

Table 6. Injury Savings Estimates: All Four Injury Types, All 5 Years, and All Three Divisions.

		1,000 (*I*/*E*)	*E* Million	*I* Thousand	*D*/*I*	*D* Thousand
N: Noncontact	Actual	2.62	40.34	105.9	9.8	1,033.1
Wrestling	Actual	8.34	2.87	23.9	19.0	454.3
Wrestling[a]	Like *N*	2.62	2.87	7.5	9.8	73.5
Difference	Actual − like *N*			23.9		454.3
Football	Actual	7.79	25.77	200.7	15.5	3,106.1
Football[a]	Like *N*	2.62	25.77	67.5	9.8	661.7
Difference	actual − like *N*			133.2		2,444.4
Ice hockey	Actual	7.77	1.93	15.0	11.6	173.3
Ice hockey[a]	Like *N*	2.62	1.93	5.1	9.8	50.0
Difference	Actual − like *N*			9.9		123.3
Soccer	Actual	6.50	8.42	54.8	10.4	568.9
Soccer[a]	Like *N*	2.62	8.42	22.1	9.8	216.6
Difference	Actual − like *N*			32.7		352.3
Basketball	Actual	6.33	9.76	61.8	8.4	520.6
Basketball[a]	Like *N*	2.62	9.76	25.6	9.8	250.9
Difference	Actual − like *N*			36.2		269.7
Lacrosse	Actual	5.49	4.26	23.4	12.6	294.7
Lacrosse[a]	Like *N*	2.62	4.26	11.2	9.8	109.8
Difference	Actual − like *N*			12.8		184.9
Total savings				240.6		3,755.4
Total savings per year				48.1		751.1

Note. Actual values are from Table 3.
[a]Values if *I*/*E* and *D*/*I* were like *N*.

changed so that their injury rates were the same as those for *N*. An attempt is made in this section to estimate these savings. It will be assumed that wrestling, football, ice hockey, soccer, basketball, and lacrosse can be changed to have the same injury rates as for *N*.

Use of Datalys Data Only

Calculations of the savings using the Datalys data are presented in Table 6. The table estimates the number of injuries that would be saved if the contact sports were changed to have injury rates like those for *N*. The table considers all four injury types together, all three divisions, and all 5 years.

The actual injury rate for football is 7.79, and the table shows that if this rate were instead the rate for *N*, namely 2.62, the number of injuries would be 67,500 instead of 200,700. The difference of 133,200 injuries is the number of injuries saved. The table also shows that if the number of days lost per injury were 9.8, the rate for *N*, instead of the actual rate of 15.5, there would be 2,444,400 fewer days lost. The calculations for the other sports are similar. The total savings over the 5 years are 240,600 fewer injuries and 3,755,400 fewer days lost. More than half of the total is from football. On a per year basis, the totals come to 48,100 fewer injuries and 751,100 fewer days lost.

The same calculations in Table 6 can be done for concussions alone. The most interesting case is football, which dominates in concussions. In Appendix Table A1, the concussion rate for football is 0.92, and the number of days lost per injury is 13.2. For *N*, the two rates are 0.06 and 18.8, respectively. Using 0.06 in place of 0.92 and 18.8 in place of 13.2 yields the number of football concussions saved over the 5 years of 22,200 or 4,400 per year and the number of days lost saved over the 5 years of 284,600 or 56,900 per year.[5]

The data for concuss in Appendix Table A1 can be used to compute the number of concussions saved for the other five contact sports as just done for football. The number of concussions saved per year is 700 for wrestling, 300 for ice hockey, 500 for soccer, 700 for basketball, and 300 for lacrosse. The total across the six sports is 6,900.

Use of Mathers, Vos, and Stevenson's Disability Indices

Mathers et al. (1999) in a massive study in Australia have estimated disability indices for many diseases and injuries. The values range from 0 for no disability (no loss of quality of life) to 1 for essentially death. These indices pertain to a year of life. Let *Z* denote this index. If *Z* is 0, there is no loss in the quality of life for the year. If *Z* is, say, 0.3, the quality of life for the year is 70% of a healthy or injury free year of life.[6]

Table A2 in the Appendix presents the Mathers et al. disability indices. The NCAA injury categories in Table 1 are matched to the Mathers et al. injuries. For two of the injury groups that make up bone, fracture and fracture (stress), there are a number of different injuries in Mathers et al.'s (depending on where the fracture is). In this case, the more detailed Mathers et al. categories were used and matched to the more detailed NCAA fracture and fracture (stress) injuries.

There are 33 injuries in Appendix Table A2 and thus 33 disability index values. Some of the values are the same because the same Mathers et al.'s category was sometimes matched to more than one NCAA injury. Given the values of *Z*, it is possible to do the following, as presented in Table 7. Take, for example, football, where there are 200,700 injuries across the four injury types, the three divisions, and the 5 years (Tables 3 and 6). This number is in row (1) in Table 7. There is a value of *Z* for each injury, that is, each NCAA injury falls into 1 of the 33 categories in Appendix Table A2. For a particular injury, *Z* is the fraction of the year that is not healthy, that is, injured. Summing the values of *Z* for all 200,700 injuries gives the total number of healthy years lost-to-injury, which is 22,600 years. This number is in row (2) of the table. Row (3) is the ratio of row (2) to row (1), which is the average number of healthy years lost-to-injury per year. For football, this average is

Table 7. Estimates of Healthy Years Lost-to-Injury Saved.

	Wrestling	Football	Ice Hockey	Soccer	Basketball	Lacrosse	Total
Actual							
(1) Number of injuries (Table 6)	23.9	200.7	15.0	54.8	61.8	23.4	379.6
(2) Number of years lost to injury	2.9	22.6	1.8	5.4	6.3	2.4	41.5
(3) = (2)/(1): Average number of years lost-to-injury per injury	0.121	0.113	0.120	0.099	0.102	0.103	0.109
Contact sports same as *N*							
(4) Number of injuries (Table 6, like *N*)	7.5	67.5	5.1	22.1	25.6	11.2	139.0
(5) Average number of years lost-to-injury per injury for *N*	0.088	0.088	0.088	0.088	0.088	0.088	0.088
(6) = (4) × (5): Number of years lost-to-injury	0.7	5.9	0.4	1.9	2.3	1.0	12.2
(7) = (2) − (6): Number of years lost-to-injury saved	2.2	16.7	1.4	3.5	4.0	1.4	29.3
(8) = (7)÷ (5): Number of years lost-to-injury saved per year	0.4	3.3	0.3	0.7	0.8	0.3	5.9

Note. All four injury types, all 5 years, all three divisions. Numbers are in thousands. Row (2) is computed using the Mathers et al. disability indices. Row (5) is the value for *N* computed using the Mathers et al. disability indices.

0.113 years. Rows (4)–(8) in Table 7 assume no wrestling and that the other contact sports are like *N*. Row (4) is the number of injuries from Table 6. Row (5) is the average number of healthy years lost-to-injury computed for *N* using the Mather et al.'s disability indices, which is 0.088. Row (6), which is row (4) times row (5), gives the total number of healthy years lost-to-injury. Row (7) is the actual number of healthy years lost-to-injury from row (2) minus the number of healthy years lost-to-injury from row (6), which is the number of healthy years lost-to-injury saved. Row (8) is row (7) divided by 5, which is the number of healthy years lost-to-injury saved per year. For football, this is 3,300 years per year. The last column in Table 7 gives the totals. The total number of healthy years lost-to-injury saved per year is 6,000. More than half of the total is from football.

It is interesting to compare the average number of days lost per injury in Table 6, namely *D/I*, to the average number of healthy years lost-to-injury in row (3) in Table 7. For football, the average number of days lost per injury in Table 6 is 15.5, and the average number of healthy years lost-to-injury in Table 7 is 0.113, which is about 41 days. The number of days computed using the Mathers et al. disability indices is thus considerably larger than the number of days lost from the Datalys data. The number of days lost in the Datalys data is the number of days before the student returns to his sport. For better or worse, the Mathers et al. disability indices are in effect assuming some continuing loss to the student after he returns.

Estimated Dollar Savings From Banning Contact

The estimated injury savings in Tables 6 and 7 are descriptive statistics. They are not based on any assumptions about the cost of an injury or the value of a year of life. In this section, an attempt is made to put dollar values on these estimates. How should they be valued? One possibility would be to ask students and their parents how much they would be willing to pay to have avoided an injury. If this were done by injury types, one could attempt to value the saved injuries. Specific college surveys of this type do not appear to exist, but there are injury cost estimates available. These estimates are in part based on medical costs, but they also take into account pain and suffering and opportunity cost of lost time. They are thus likely to be picking up some of what would be revealed by willingness-to-pay surveys.

National Safety Council (NSC) Estimates

The NSC (2017) puts an estimated cost of a disabling injury at US$9,000 for a home injury and US$8,800 for a public injury in 2015. (The cost of a work injury is estimated to be about 4 times larger.[7]) A disabling injury is "one which results in death, some degree of permanent impairment, or renders the injured person unable to effectively perform his or her regular duties for a full day beyond the day of injury." The cost includes "wage and productivity losses, medical expenses, and administrative expenses."

If US$9,000 per injury is used and there are 48,100 fewer injuries per year, as estimated in Table 6, this is a cost-saving of US$433 million per year. With 751,100 fewer days lost, also from Table 6, this comes to US$576 per day. Put another way, the estimated average cost of a day lost due to an injury is US$576 using the US$9,000 figure.

Department of Health and Human Services Estimates

Estimates are also available from the Department of Health and Human Services, Misra (2014), which are roughly supportive of the NSC estimates. These estimates are for medical expenses only and so are narrower in scope than the NSC estimates. Converted into 2015 dollars using the CPI, the estimates for 10- to 19-year-olds are

US$4,941 for fracture of leg, US$3,025 for fracture of arm, US$2,417 for sprains and strains, and US$7,315 for dislocation. These estimates are thus not too far off from the NSC estimate of US$9,000, especially considering that the NSC estimate also includes wage and productivity losses. They provide at least mild support to the use of the US$9,000 figure.

Value of a Year of Life

There is a large literature on estimating the statistical value of a life. Estimates are less often presented of the value of a year of life, which is what is needed here. Cutler (2004) cites a value of US$100,000 per year, which in 2015 dollars is about US$125,000. This estimate, however, assumes that the value of a year of life does not vary with age. Murphy and Topel (2006), using a utility maximization framework, argue that the value of a year of life varies by age and is hump shaped, peaking at around age 50. Aldy and Viscusi (2008) make a similar argument, where they also estimate a peak at around age 50.

For the calculations here, the interest is in people around age 20, namely students. Figure 2 in Murphy and Topel (2006) shows a value of a year of life at age 20 of US$200,000, which in 2015 dollars is about US$250,000. Figure 2 in Aldy and Viscusi (2008) gives similar values at age 20—US$150,000 cohort-adjusted and US$200,000 cross section (before conversion to 2015 dollars). In the following calculations, a value of US$250,000 in 2015 dollars will be used.

Table 7 estimates that 5,900 healthy years lost-to-injury would be saved per year if the contact sports were like *N*. Multiplying this number by US$250,000 is a cost-saving of US$1.5 billion per year. This is considerably larger than the US$433 million using US$9,000 as the average cost of an injury. This difference may be due in part to the fact that the Mathers et al. indices are in effect assuming more days lost than are estimated in the Datalys data. The results thus suggest that the value of the injury costs that would be saved is between US$433 million and US$1.5 billion per year.

High School Data

The collection of the high school data is similar to that for the college data. A sample of about 100 high schools is selected, and each of these schools reports injury data. The sample data are then blown up to estimate national totals. The data are on the site: http://www.ucdenver.edu/academics/colleges/PublicHealth/research/ResearchProjects/piper/projects/RIO/Pages/Study-Reports.aspx. The data have been collected since 2005, and yearly reports are available for each year beginning with the 2005/2006 academic year. There are five boys' sports: wrestling, football, soccer, basketball, and baseball.

To match the college results, data for the 5 academic years 2009/2010-2013/2014 were used. For each of the five sports, the following data were collected from the reports: (1) the nationally estimated number of injuries, (2) the injury rate per 1,000 athlete exposures, (3) the number of injuries that required surgery, (4) the number of injuries for each of the top 10 injuries for the year, and (5) data to compute the total number of days lost due to injury. Given (1) and (2), the total number of exposures is simply the number of injuries divided by the injury rate times 1,000. The top 10 injuries for the year varied slightly by year. For present purposes an "all other" injury category was computed as the difference between total injuries and the sum of the ten injuries.

The number of days lost was computed as follows. Six days-lost categories are listed in the reports, and a frequency is assigned to each category, where the six frequencies sum to 1. The categories are (1) 1–2 days, (2) 3–6 days, (3) 7–9 days, (4) 10–21 days, (5) >21 days, and (6) other. "Other" include medical disqualification for the season or for career, athlete chooses not to continue, and the season ended before the athlete returned to play. Frequencies were assigned separately to competition injuries and practice injuries, where the sum of competition and practice injuries is total injuries. For present purposes, the following number of days was assigned to each category: 1.5, 4.5, 8.0, 15.5, 30.0, and 50.0. The first four are mid points, and the last two are subjective choices. For competition, these numbers were multiplied by the relevant frequency to get total number of days lost from competition. The same was done for practice, and the two were summed to get the total number of days lost.

Regarding the 10 injury categories, each category was assigned to one of the four injury types in Table 1. A fifth injury type was also used, which is the "all other" category mentioned above. There was always a concussion category, always first or second in the ranking, but in a few cases, there were no injuries for one of the other three types in Table 1. However, the number of injuries in the "all other" category is quite large and clearly includes injuries that would be classified as bone, tear, or muscle if they were known separately (but not concuss, which was always available).

The only noncontact sport of the five is baseball, and it is used as the noncontact sport, *N*. In Table 2, baseball for college has an overall injury rate of 3.17, slightly higher than the aggregate noncontact rate of 2.62. For concussions, the value is 0.11 versus 0.06. In general, baseball is close to the noncontact aggregate in Table 2, which supports its use as the noncontact base for the high school data.

Like for the college data, much of the following analysis focuses on aggregates—all 5 years and all injuries. Again, this is to lessen the effects of measurement error.

Injury Rates

The injury rates are reported in Table 8. This table has the same format as Table 2. The injury rates are smaller in Table 8 than in Table 2. For example, the high school rate for football is 3.73 injuries per 1,000 exposures, and the college rate is 7.79. For baseball, high school is 0.90 and college is 3.17. In a few cases, however, the injury rates are essentially the same. The concussion rate for football is 0.90 for high school

Table 8. Injury Rates: Injuries per 1,000 Exposures All 5 Years.

	1,000 (*I*/*E*)					
Sport	All Five Injuries	Concuss	Bone	Tear	Muscle	Other
Wrestling	2.30	.44	.06	0.98	.01	0.81
Football	3.73	.90	.18	1.48	.07	1.10
Soccer	1.59	.36	.02	0.75	.09	0.37
Basketball	1.36	.17	.06	0.75	.04	0.33
N: Baseball	0.90	.10	.05	0.42	.02	0.30

Note. The noncontact sport is baseball. *I* = number of injuries; *E* = number of exposures.

Table 9. Total Injuries and Severity All Five Years.

Sport	1,000 (*I*/*E*)	*E* Million	*I* Thousand	*D* Thousand	*D*/*I*	100 (*S*/*I*)
All five injury types						
Wrestling	2.30	185.17	425.5	4,778.5	11.2	5.10
Football	3.73	754.06	2,812.2	28,116.0	10.0	8.14
Soccer	1.59	467.91	743.3	5,779.9	7.8	5.74
Basketball	1.36	281.74	381.9	3,054.4	8.0	6.49
N: Baseball	0.90	275.71	246.8	2,137.3	8.7	7.55
Concuss						
Wrestling	0.44	185.17	81.2			
Football	0.90	754.06	679.3			
Soccer	0.36	467.91	166.3			
Basketball	0.17	281.74	49.2			
N: Baseball	0.10	275.71	28.9			

Note. The noncontact sport is baseball. *I* = number of injuries; *E* = number of exposures; *D* = number of days lost due to injuries; *S* = number of injuries that required surgery.

versus 0.92 for college. For soccer, the two concussion rates are 0.36 versus 0.37, and for baseball, the two concussion rates are 0.10 versus 0.11. Concussions are clearly a larger fraction of total injuries in high school than in college.

It is interesting that the high school football concussion rate is similar to the college rate (from both the Datalys data and the Ivy League data) at about 1 concussion per 1,000 exposures. This rate is much higher than 0.06 concussions in the Datalys data for the noncontact sports and 0.10 concussions in the RIO data for the noncontact sport, baseball.

Table 9 presents the injury rates plus other information. This table has the same format as Table 3. The number of exposures is much larger for high school than for college. For football, there are 754.06 million high school exposures versus 25.77 million for college. For baseball, the two numbers are 275.71 million versus

Table 10. Injury Rates Over Time.

	1,000 (*I/E*)					
	Years					
Sport	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	All 5 Years
All five injury types						
Wrestling	2.01	2.50	2.33	2.48	2.12	2.30
Football	3.50	3.78	3.87	3.74	3.73	3.73
Soccer	1.56	1.64	1.52	1.62	1.60	1.59
Basketball	1.35	1.40	1.47	1.45	1.08	1.36
N: Baseball	0.81	0.83	0.88	1.01	0.94	0.90
Concuss						
Wrestling	0.30	0.62	0.34	0.51	0.40	0.44
Football	0.82	0.89	0.96	0.89	0.94	0.90
Soccer	0.30	0.37	0.39	0.39	0.30	0.36
Basketball	0.19	0.19	0.20	0.19	0.09	0.17
N: Baseball	0.11	0.12	0.07	0.10	0.13	0.10

Note. The noncontact sport is baseball. *I* = number of injuries; *E* = number of exposures.

14.26 million. Total injuries and total days lost are thus also much larger for high school. For football, there are 2,812,200 injuries in high school over the 5 years compared to 200,700 in college. Concussions in football total 679,300 in high school compared to 23,700 in college (Appendix Table A1). The number of days lost per injury is similar between high school and college, slightly lower for high school. The surgery rates are also similar.

Table 10 presents injury rates over time. It is in the same format as Table 5. The total injury rates are fairly stable over time. No obvious patterns emerge. There are also no patterns for concussions in Table 10. The concussion rate for football ranges from 0.82 to 0.96. For baseball, the range is from 0.07 to 0.13. Some of the studies discussed in the second section found significant trends in concussion rates using the RIO data, but no trends are obvious for concussions in Table 10. In the present case, however, the sample is not large enough to test for any trends.

Estimated Injury Savings From Banning Contact

As with the college data, injury rates for high school are higher in contact than noncontact sports, where for high school, baseball is used as the noncontact sport. Table 11 provides estimates of the injuries that would be saved if wrestling, football, soccer, and basketball were changed to have injury rates the same as those for baseball. The table is in the same format as Table 6.

Table 11. Injury Savings Estimates All Five Injury Types, All Five Years.

		1,000 (I/E)	E Million	I Thousand	D/I	D Thousand
N: Baseball	Actual	0.90	275.71	246.8	8.7	2,137.3
Wrestling	Actual	2.30	185.17	425.5	11.2	4,778.5
Wrestling[a]	Like N	0.90	185.17	166.7	8.7	1,450.3
Difference	Actual − like N			258.8		3,328.2
Football	Actual	3.73	754.06	2,812.2	10.0	28,116.0
Football[a]	Like N	0.90	754.06	678.7	8.7	5,904.7
Difference	Actual − like N			2,133.5		3,904.7
Soccer	Actual	1.59	467.91	743.3	7.8	5,779.9
Soccer[a]	Like N	0.90	467.91	421.1	8.7	3,663.6
Difference	Actual − like N			322.2		2,116.3
Basketball	Actual	1.36	281.74	381.9	8.0	3,054.4
Basketball[a]	Like N	0.90	281.74	253.6	8.7	2,206.3
Difference	Actual − like N			128.3		848.1
Total savings				2,842.8		28,503.4
Total savings per year				568.6		5,700.8

Note. Actual values are from Table 9.
[a]Values if I/E and D/I were like baseball, N.

Considering football, the actual injury rate is 3.73 per 1,000 exposures. If it were instead 0.90, the rate for baseball, there would be 678,700 injuries in the 5-year period instead of the actual 2,812,200 injuries. There would thus be 2,133,500 fewer injuries. There would also be 3,904,700 fewer days lost using 8.7 as days lost per injury, the baseball rate, rather than the actual 10.0 days lost per injury.

The table shows that for all four sports, the total savings on a per year basis are 568,600 injuries and 5,700,800 days lost. These compare to the college numbers in Table 6 of 48,100 injuries and 751,100 days lost. The injury savings are thus about 12 times greater for high school due to the larger number of exposures.

As with college, it is interesting to look at the concussion rate for football. Table 9 shows that the concussion rate is 0.90 for football and 0.10 for baseball. If the rate for football were 0.10, there would be 75,406 concussions rather than the actual number of 679,300. The number of concussions saved is thus 603,894, which on a per year basis is 120,800. This compares to the college number of 4,400 fewer concussions per year.

For the other three contact sports, the number of concussions saved per year is 12,500 for wrestling, 23,900 for soccer, and 4,200 for basketball. The total across the four is 161,400.

It is also possible to use the Mathers et al. disability indices to estimate the number of healthy years lost-to-injury and the number saved. As discussed in the

Table 12. Estimates of Healthy Years Lost-to-Injury Saved.

	Wrestling	Football	Soccer	Basketball	Total
Actual					
(1) Number of injuries (Table 11)	425.5	2,812.2	743.3	381.9	4,362.9
(2) Number of years lost-to-injury	59.6	429.4	107.8	45.8	642.6
(3) = (2)/(1): Average number of years lost-to-injury per injury	0.140	0.153	0.145	0.120	0.147
Contact sports same as baseball, *N*					
(4) Number of injuries (Table 11, like *N*)	166.7	678.7	421.1	253.6	1,520.1
(5) Average number of years lost-to-injury per injury for *N*	0.120	0.120	0.120	0.120	0.120
(6) = (4) × (5): Number of years lost-to-injury	20.0	81.4	50.5	30.4	182.4
(7) = (2) − (6): Number of years lost-to-injury saved	39.6	348.0	57.3	15.4	460.2
(8) = (7) ÷ (5): Number of years lost-to-injury saved per year	11.9	69.6	11.5	3.1	92.0

Note. All five injury types, all 5 years. Numbers are in thousands. Row (2) is computed using the Mathers et al. disability indices. Row (5) is the value for baseball, *N*, computed using the Mathers et al. disability indices.

seventh section, data were collected on 10 injury categories per year and sport, where the categories sometimes changed slightly across years. An "all other" category was also created. Each category was matched to one of the Mathers et al. injuries in Appendix Table A2, and the corresponding Mathers rate was used. For example, for concussions the rate of 0.359 was used. For the all other category, the rate of 0.118 was used, which is the Mathers rate for "sports injuries." This then allowed the number of healthy years lost-to-injury to be calculated per injury category, per sport, and per year. For a given sport and year, the total number of healthy years lost-to-injury is the sum across the injury categories.

Given the estimates of the number of healthy years lost-to-injury, the number saved can be computed. This is done in Table 12, which is in the same format as Table 7. For example, for football, the number of healthy years lost-to-injury is 429,400 (row [2]), which is an average of 0.153 per injury (row [3]). If football were like baseball, the number of healthy years lost-to-injury would be 81,400 (row [6]). On a yearly basis, the number of healthy years lost-to-injury saved is 69,600 (row [8]). Across the five sports, the total number of healthy years lost-to-injury saved is 92,000 (row [8]). This compares to 5,900 in Table 7 for college. For high school, over 70% of the savings is from football.

Similar to college, it is interesting to compare the average number of days lost per injury in Table 11, namely, *D/I*, to the average number of healthy years lost-to-injury in row (3) in Table 12. For football, the average number of days lost per injury in

Table 11 is 10.0, and the average number of healthy years lost-to-injury in Table 12 is 0.153, which is about 56 days. As with college, the number of days computed using the Mathers et al. disability indices is considerably larger than the number of days lost from the Datalys data. Remember that the 10.0 number in Table 11 is computed using 30 days for the category >21 days and 50 days for the category "other." These are guesses, and if larger numbers were used, the 10.0 number would increase since there would be more days lost.

Estimated Dollar Savings From Banning Contact

As with the results in Tables 6 and 7, the estimated injury savings in Tables 11 and 12 are just descriptive statistics. Dollar values, however, can be put on these using the same methodology as in the sixth section. In Table 11, there are 568,600 fewer injuries per year, and at US$9,000 per injury this is a saving of US$5.1 billion per year. With 5,700,800 fewer days lost, also from Table 11, this comes to US$895 per day. This value per day would be smaller if larger values were used for the last two injury categories discussed above. For college, the value was US$576 per day.

Regarding the value of a year of life, if figure 2 in Murphy and Topel (2006) is extrapolated back to age 17, the value of a year of life is about US$160,000, which in 2015 dollars is about US$200,000. In Table 12, there are 92,000 injury years that would be saved per year if the contact sports were like baseball. Multiplying 92,000 by US$200,000 gives a cost-saving US$18.4 billion. As with the college data, computing costs this way gives a larger value than using the cost of US$9,000 per injury.

The range of the estimated cost-savings is thus US$5.1 billion to US$18.4 billion, which compares to the range of US$433 million to US$1.5 billion for college. Again, the high school savings are much larger because of the much larger number of exposures.

Summary

Table 13 summarizes some of the main findings of this article. Five sports are presented: wrestling, football, soccer, basketball, and noncontact, where noncontact for college consists of tennis, baseball, indoor track, cross-country, and outdoor track and where noncontact for high school is baseball. Except when the results for concussions are presented separately, the aggregation is across all the injury types and across all three divisions for college. The aggregation is also across all 5 years, although the aggregate values have been divided by 5 to put them on a yearly basis.

Table 13. Summary Results.

	Wrestling	Football	Soccer	Basketball	*N*	Total
Injury rate (Col)	8.34	7.79	6.50	6.33	2.37	
Injury rate (HS)	2.30	3.73	1.59	1.36	0.90	
Total injuries (Col)	4.8	40.1	11.0	12.4	21.2	
Total injuries (HS)	85.1	562.4	148.7	76.4	49.4	
Concussion rate (Col)	1.35	0.92	0.37	0.44	0.06	
Concussion rate (HS)	0.44	0.90	0.36	0.17	0.10	
Total concussions (Col)	0.8	4.7	0.6	0.9	0.5	
Total concussions (HS)	16.2	135.9	33.3	9.8	5.8	
Injuries saved (Col)	3.3	26.6	6.5	7.2		48.1
Injuries saved (HS)	51.8	426.7	64.4	25.7		568.6
Concussions saved (Col)	0.7	4.4	0.5	0.7		6.9
Concussions saved (HS)	12.5	120.8	23.9	4.2		161.4
Total estimated dollar cost-savings per year						
College: US$433 million to US$1.5 billion						
High school: US$5.1 billion to US$18.4 billion						

Note. All injuries, divisions, and years' injury values are in thousands per year. "Total" for injuries saved and concussions saved for college includes Ice hockey and lacrosse. Col = college; HS = high school.

The total number of injuries saved for a contact sport depends on the difference between its injury rate and the rate for *N*. For college football, the actual rate is 7.79, and the rate for *N* is 2.37. For high school football, the actual rate is 3.73, and the rate for *N* (baseball) is 0.90. The differences are much larger for concussions: 0.92 for college football versus 0.06 for *N* and 0.90 for high school football versus 0.10 for *N*. Football is clearly the main sport. More than half of the college savings are from football, and more than 70% of the high school savings are from football.

More work clearly needs to be done to see how well the current results hold up. Many institutions are reluctant to release data on injuries, and so data are not easy to come by. For example, 18 Big Ten and Ivy League universities contribute concussion data to the Epidemiology of Concussions in Ivy League/ Big Ten Sports study mentioned earlier. This collection is part of the Big Ten-Ivy League Traumatic Brain Injury Research Collaboration. The data from this project are not currently available to outside researchers except some summary values. Also, a survey of 19 Big Ten and Ivy League universities described in Yang et al. (2018) finds that only 17–42% of concussion data collected by the universities are available for research purposes. The hope is that this article and the increased interest in sports injuries will encourage release of more data. Data for women would be particularly useful. Datalys data for women exist, but these data were not available to the authors for the current research project. It would also be interesting to examine data for individual college.

Appendix

Table A1. Injuries and Severity per Injury Type All 5 Years, All Three Divisions.

Sport	1,000(*I*/*E*)	*E* Million	*I* Thousand	*D* Thousand	*D*/*I*	1,000(*S*/*I*)
Concuss						
Wrestling	1.35	2.87	3.9	91.9	23.6	0.00
Football	0.92	25.77	23.7	312.8	13.2	0.78
Ice hockey	0.87	1.93	1.7	44.6	26.2	0.00
Soccer	0.37	8.42	3.1	41.7	13.5	0.00
Basketball	0.44	9.76	4.3	34.8	8.1	0.00
Lacrosse	0.40	4.26	1.7	19.3	11.4	0.00
N: Noncontact	0.06	40.34	2.5	47.0	18.8	0.00
Tennis	0.09	3.12	0.3	27.7	92.3	0.00
Baseball	0.11	14.26	1.5	17.2	11.5	0.00
Indoor track	0.03	10.44	0.3	1.5	5.0	0.00
Cross-country	0.06	4.72	0.3	0.0	0.0	0.00
Outdoor track	0.02	7.81	0.1	0.6	6.0	0.00
Swimming	0.04	6.23	0.2	2.1	10.5	0.00
Bone						
Wrestling	0.42	2.87	1.2	42.6	35.5	9.58
Football	0.34	25.77	8.8	466.0	53.0	29.61
Ice hockey	0.46	1.93	0.9	31.8	35.3	15.53
Soccer	0.29	8.42	2.4	97.9	40.8	18.37
Basketball	0.34	9.76	3.4	141.9	41.7	28.15
Lacrosse	0.28	4.26	1.2	75.2	62.7	31.96
N: Noncontact	0.16	40.34	6.5	185.8	28.6	12.09
Tennis	0.16	3.12	0.5	28.8	57.6	0.00
Baseball	0.22	14.26	3.2	88.8	27.8	12.44
Indoor track	0.09	10.44	1.0	14.5	14.5	14.67
Cross-country	0.31	4.72	1.5	40.1	26.7	0.00
Outdoor track	0.05	7.81	0.4	13.6	34.0	64.24
Swimming	0.04	6.23	0.2	1.9	9.5	0.00
Tear						
Wrestling	5.67	2.87	39.0	311.6	8.0	5.87
Football	5.13	25.77	132.1	2,223.9	16.8	8.99
Ice hockey	3.71	1.93	7.2	88.0	12.2	4.39
Soccer	4.34	8.42	36.6	397.6	10.9	2.48
Basketball	4.00	9.76	16.3	321.9	16.8	3.55
Lacrosse	3.46	4.26	14.7	191.0	13.0	5.42
N: Noncontact	1.89	40.34	76.2	726.0	9.5	2.56
Tennis	2.95	3.12	9.2	98.6	10.7	0.81
Baseball	1.96	14.26	27.9	351.9	12.6	5.16
Indoor track	2.02	10.44	21.1	162.3	7.7	1.59

(continued)

Table A1. (continued)

Sport	1,000(*I*/*E*)	*E* Million	*I* Thousand	*D* Thousand	*D*/*I*	1,000(*S*/*I*)
Cross-country	1.57	4.72	7.4	30.3	4.1	0.00
Outdoor track	1.35	7.81	10.6	82.9	7.8	0.97
Swimming	0.51	6.23	3.2	4.8	1.5	11.96
Muscle						
Wrestling	0.90	2.87	2.6	8.2	3.2	2.00
Football	1.41	25.77	36.2	103.4	2.9	0.55
Ice hockey	2.72	1.93	5.3	8.8	1.7	0.42
Soccer	1.50	8.42	12.6	31.7	2.5	0.66
Basketball	1.55	9.76	15.1	22.0	1.5	0.54
Lacrosse	1.35	4.26	5.7	9.2	1.6	1.99
N: Noncontact	0.51	40.34	20.7	74.5	3.6	0.00
Tennis	0.30	3.12	0.9	6.6	7.3	0.00
Baseball	0.88	14.26	12.6	17.7	1.4	0.00
Indoor track	0.29	10.44	3.1	4.2	1.4	0.00
Cross-country	0.33	4.72	1.5	16.6	11.1	0.00
Outdoor track	0.33	7.81	2.6	29.4	11.3	0.00
Swimming	0.12	6.23	0.7	6.8	9.7	0.00

Table A2. Disability Rates from Mathers, Vos, and Stevenson (1999).

NCAA Category	Mathers Study	Mathers Rate
Concuss		
Concussion	Intracranial injury (short term)	.359
Nervous system	Intracranial injury (short term)	.359
Bone		
Exostosis	Sports injuries	.118
Myositis ossificans	Sports injuries	.118
Osteochondritis	Sports injuries	.118
Fracture and fracture (stress)		
Ankle	Ankle	.196
Upper arm	Clavicle, scapula, or humerus	.153
Cervical spine/neck	Vertebral column	.266
Chest/ribs	Rib or sternum	.199
Elbow	Radius/ulna	.180
Foot/toes	Foot bones	.077
Forearm	Radius/ulna	.180
Hand/fingers	Hand bones	.100
Head/face	Face bones	.223
Hip/groin	Pelvis	.247
Knee	Patella, tibia, or fibula	.271

(continued)

Table A2. (continued)

NCAA Category	Mathers Study	Mathers Rate
Lower leg/achilles	Patella, tibia, or fibula	.271
Lumbar spine	Vertebral column	.266
Mouth	Episode resulting in tooth loss	.014
Nose	Face bones	.223
Sacrum/pelvis	Pelvis	.247
Shoulder/clavicle	Clavicle, scapula, or humerus	.153
Thigh	Femur: Short term	.372
Thoracic spine	Vertebral column	.266
Wrist	Hand bones	.100
Tear		
Cartilage injury	Sports injuries	.118
Dislocation	Dislocation	.074
Sprain	Sprains	.064
Strain	Sprains	.064
Strain/tear	Sprains	.064
Subluxation	Dislocation	.074
Muscle		
Contusion (hematoma)	Sports injuries	.118
Spasm	Sports injuries	.118

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Notes

1. These data are created, compiled, or produced by the Datalys Center for Sports Injury Research and Prevention, Inc. on behalf of the National Collegiate Athletic Association.
2. Various reports produced by Comstock, Currie, and Pierpoint (2011–2015).
3. The number of days lost was computed as follows. Included for each observation in the second Injury Surveillance Program file is a variable that gives the exact number of days lost for each specific injury; this variable is denoted as $D1$. Unfortunately, $D1$ has many missing observations. Also included is a variable giving rough categories of days lost due to an injury. The categories are: (1) did not have to sit out, (2) sat out but returned within the same practice or competition, (3) missed 1–6 days of participation, (4) missed 7–13 days, (5) missed 14–29 days, (6) missed 30+ days, or (7) missed the entire season; this variable is denoted as $D2$. It has only a few missing observations. To come up with a value

for the number of days lost for Categories (3)–(7), when data were available on both *D*1 and *D*2, the average of the *D*1 values was computed for each of the categories. This gave five numbers: 3.303, 9.477, 19.620, 53.330, and 147.880. Values of 0.5 and 1.0 were assigned to Categories (1) and (2), respectively. These seven numbers were then used to fill in the missing values for *D*1, given the information on the classification from *D*2.

4. This talk is available on YouTube: https://youtu.be/2RJ6mW$_U$OM
5. Note that the number of days lost per concussion is higher for *N* than for football. The higher number has been used here to be consistent with the procedure in Table 6.
6. Abelson (2004) has used these estimates to examine whether injury compensation in Australia is excessive (see also Abelson 2003).
7. The larger estimate for a work injury does not seem relevant in the present case because students do not have full time jobs.

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