

Appendix 2

Table A1. Characteristics of Studies Included in the Meta-analysis

First Author	Year Published	Study Design	Years Included	Country	Gender-Comparable Sports	Database	Population
Agel	2010	Retrospective	2000-2007	USA	Ice Hockey	NCAA-ISS	Collegiate
Baugh	2017	Retrospective	2013-2015	USA	Volleyball	NCAA-ISP	Collegiate
Beis	2007	Prospective	Not provided	Greece	Taekwondo	None	Youth, Adults (18+ years)
Black	2017	Retrospective	2008-2011	Canada	Soccer, Volleyball, Basketball, Ice Hockey, Tennis, Swimming, Badminton, Cross-Country, Track and Field	None	Collegiate
Blumenfeld	2016	Prospective	2015-2016	USA	Water Polo	None	High School, Collegiate, Adults (21+ years)
Borowski	2008	Retrospective	2005-2007	USA	Basketball	High School RIO	High School
Campbell	2018	Prospective	2013-2014	USA	Baseball/Softball, Basketball, Cross-Country, Diving, Football, Golf, Horseback Riding, Lacrosse, Snow Sports, Soccer, Cheerleading, Swimming, Tennis, Track and Field, Volleyball, Wrestling	None	Middle and High School
Castile	2012	Retrospective	2005-2010	USA	Soccer, Basketball, Baseball/Softball	High School RIO	High School
Collins	2008	Retrospective	2005-2006	USA	Rugby	High School RIO	High School
Comstock	2015	Retrospective	2005-2014	USA	Soccer	High School RIO	High School
Covassin	2016	Retrospective	2004-2009	USA	Baseball/Softball, Basketball, Ice Hockey, Lacrosse, Soccer	NCAA-ISP	Collegiate

Covassin	2003	Retrospective	1997-2000	USA	Soccer, Basketball, Gymnastics, Baseball/Softball, Lacrosse	NCAA-ISS	Collegiate
Currie	2016	Retrospective	2009-2014	USA	Cheerleading	High School RIO	High School
Davis-Hayes	2017	Retrospective	2000-2014	USA	Soccer, Basketball, Baseball/Softball, Diving, Pole Vaulting	None	Collegiate
Fraser	2017	Retrospective	2009-2015	USA	Baseball/Softball, Basketball, Lacrosse, Soccer	NCAA-ISP	Collegiate
Fuller	2005	Prospective	1998-2004	UK	Soccer	None	Adults (18+ years)
Gessel	2007	Retrospective	2005-2006	USA	Soccer, Basketball, Baseball/Softball	High School RIO, NCAA-ISS	High School, Collegiate
Hootman	2007	Retrospective	1988-2004	USA	Baseball/Softball, Basketball, Gymnastics, Lacrosse, Soccer	NCAA-ISS	Collegiate
Kerr	2017	Prospective	2015-2016	USA	Baseball/Softball, Basketball, Soccer, Track	None	Middle School
Khodae	2016	Retrospective	2005-2014	USA	Soccer	High School RIO	High School
Koh	2004	Prospective	2001	South Korea	Taekwondo	None	Youth (11-19 years)
Lincoln	2011	Prospective	1997-2008	USA	Lacrosse, Basketball, Baseball/Softball, Soccer	None	High School
Lincoln	2007	Prospective and Retrospective	2000-2003	USA	Lacrosse	NCAA-ISS	High School, Collegiate
Lopez	2017	Prospective	2010-2013	USA	Rugby	None	Youth, Adults (18+ years)
Marar	2012	Retrospective	2008-2010	USA	Lacrosse, Soccer, Basketball, Volleyball, Baseball/Softball, Swim/Dive, Track/Field	High School RIO	High School

O'Connor	2017	Prospective	2011-2014	USA	Baseball/Softball, Basketball, Crew, Cross-Country, Golf, Lacrosse, Soccer, Track and Field, Swimming and Diving	NATION	High School
Pennington	2017	Prospective	2016	UK	Quidditch	None	Adults (18+)
Roos	2016	Retrospective	2009-2015	USA	Basketball	NATION, NCAA-ISP	High School, Collegiate
Roos	2017	Retrospective	2009-2015	USA	Soccer	NCAA-ISP	Collegiate
Rosene	2017	Retrospective	2009-2015	USA	Ice Hockey	NCAA-ISP	Collegiate
Schallmo	2017	Retrospective	2005-2014	USA	Soccer, Basketball, Baseball/Softball	High School RIO	High School
Schick	2003	Prospective	1998-1999	Canada	Ice Hockey	Canadian Intercollegiate Sport Injury Registry	Collegiate
Schulz	2004	Prospective	1996-1999	USA	Baseball/Softball, Basketball, Soccer, Track	None	High School
Simmons	2017	Retrospective	2009-2014	USA	Ice Hockey	NCAA-ISP	Collegiate
Wolf	2009	Retrospective	2002-2007	USA	Swimming	Sports Injury Monitoring System	Collegiate
Xiang	2014	Retrospective	2008-2012	USA	Lacrosse	High School RIO	High School
Yard	2008	Retrospective	2005-2007	USA	Soccer	High School RIO	High School
Zuckerman	2015	Retrospective	2009-2014	USA	Ice Hockey, Basketball, Soccer, Lacrosse, Baseball/Softball, Swim and Dive, Tennis, Track, Cross-Country	NCAA-ISP	Collegiate

Abbreviations: NATION: National Athletic Treatment, Injury, and Outcomes Network; NCAA-ISP: National Collegiate Athletic Association-Injury Surveillance Program; RIO: Reporting Information Online

Table A2. Quality Assessment Results

Study	Selection*						Comparability [†]	Outcome [‡]				Quality Assessment
	A	B	C	D	E	F		A	B	C	D	
Agel 2010	1	0	1	0			1	1	1	0		Fair
Baugh 2018	1	0	1	0			1	1	1	0		Fair
Beis 2007 [#]	1		1		1	0	1	1			1	Fair
Black 2017	1	0	1	0			1	1	1	1		Fair
Blumenfeld 2016	1	0	0	1			2	0	0	0		Poor
Borowski 2008	1	0	1	0			2	1	1	1		Fair
Campbell 2018	1	0	1	1			1	1	0	0		Poor
Castile 2012	1	0	1	0			1	1	1	1		Fair
Collins 2008	1	0	1	0			1	1	1	1		Fair
Comstock 2015	1	0	1	0			2	1	1	1		Fair
Covassin 2003	1	0	1	0			1	1	0	1		Fair
Covassin 2016	1	0	1	0			1	1	1	0		Fair
Currie 2016	1	0	1	0			1	1	1	1		Fair
Davis-Hayes 2017	1	0	1	0			1	1	1	1		Fair
Fraser 2017	1	0	1	0			1	1	1	1		Fair
Fuller 2005	1	0	1	1			1	1	0	0		Fair
Gessel 2007	1	0	1	0			2	1	1	1		Fair
Hootman 2007	1	0	1	0			1	1	1	1		Fair
Kerr 2017	1	0	1	1			1	1	1	0		Good
Khodaei 2016	1	0	1	0			2	1	1	0		Fair
Koh 2004 [#]	0		1		1	0	1	1			1	Fair
Lincoln 2007	1	0	1	0			1	1	1	1		Fair
Lincoln 2011	1	0	1	0			1	1	1	1		Fair
Lopez 2017	1	0	1	0			0	1	0	0		Poor
Marar 2012	1	0	1	0			2	1	1	1		Fair
O'Connor 2017	1	0	1	0			1	1	1	1		Fair
Pennington 2017	1	0	1	1			1	0	1	1		Good
Roos 2016	1	0	1	0			2	1	1	0		Fair
Roos 2017	1	0	1	0			1	1	1	0		Fair
Rosene 2017	1	0	1	0			2	1	1	1		Fair
Schallmo 2017	1	0	1	0			2	1	1	1		Fair
Schulz 2004	1	0	1	1			1	1	1	0		Good

Schick 2003	1	0	1	1	1	0	1	0	Poor
Simmons 2017	1	0	1	0	1	1	1	0	Fair
Wolf 2009	1	0	1	0	1	1	1	0	Fair
Xiang 2014	1	0	1	0	1	1	1	1	Fair
Yard 2008	1	0	1	0	2	1	1	1	Fair
Zuckerman 2015	1	0	1	0	1	1	1	0	Fair

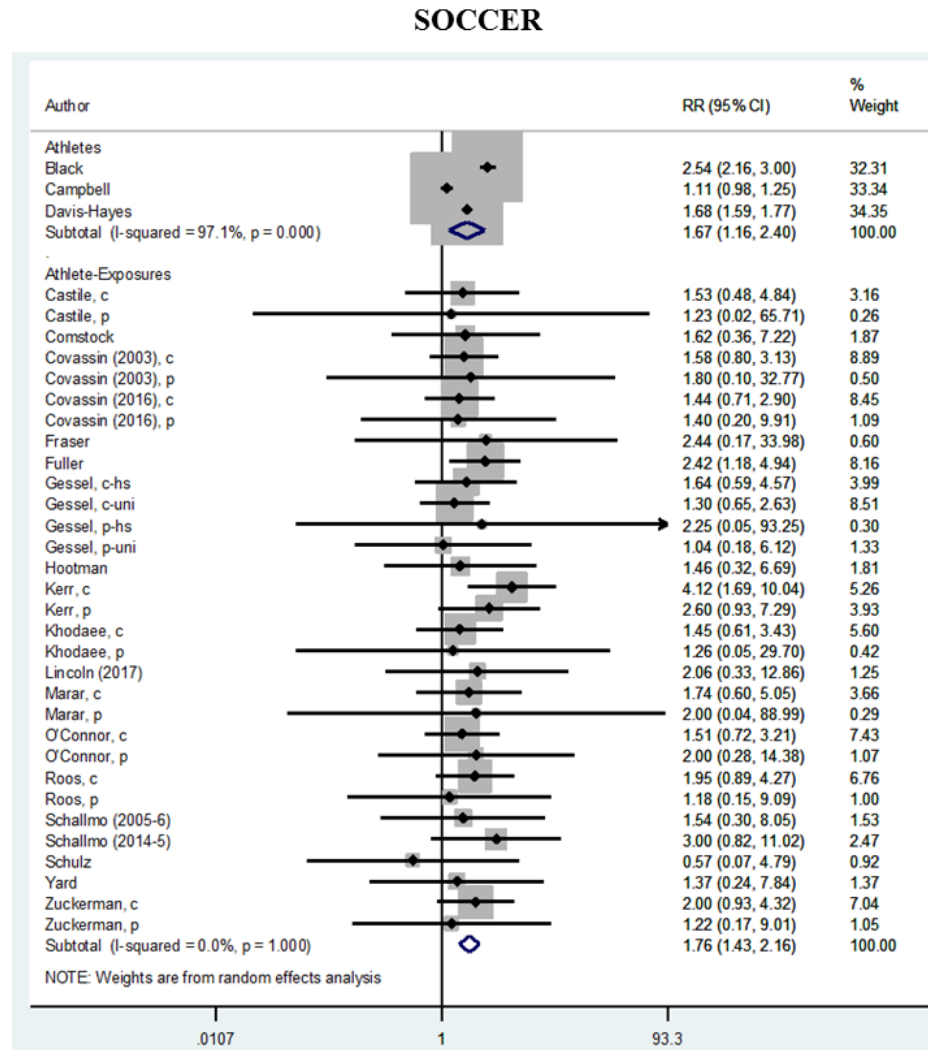
*Selection criteria - (A) representativeness of the exposed cohort (athletes), 1: truly representative of the average youth, high school, collegiate, or adult athlete in the community, 0: not representative of the average athlete in the community or no description of the derivation of the cohort; (B) selection of the non-exposed cohort, 1: drawn from the same community as the athlete cohort, 0: drawn from a different source than the athlete cohort or no description of the derivation of the non-exposed cohort; (C) ascertainment of exposure, 1: secure record of concussion incident or structured interview, 0: written self-report or no description; (D) demonstration that outcome of interest (concussion incidence) was not present at start of study, 1: yes, 0: no; (E) sample size (cross-sectional studies only), 1: justified and satisfactory, 0: not justified; and (F) non-respondents (cross-sectional studies only), 1: comparability between respondents and non-respondents is established, and the response rate is satisfactory, 0: the response rate is unsatisfactory, the comparability between respondents and non-respondents is unsatisfactory, or there is no description of the response rate or the characteristics of the responders and non-responders.

†Comparability between males and females on the basis of the design or analysis: 1, study includes concussion incidence for males and females in a specific sport; 2, study includes concussion incidence for males and females in a specific sport as well as other factors, such as age or skill level; 0, study does not include concussion incidence for males and females.

‡Outcome criteria - (A) assessment of outcome: 1: independent blind assessment or blind linkage; 0: self-report or no description; (B) was follow-up long enough for outcomes to occur: 1: yes, 0: no; (C) adequacy of follow-up of cohorts: 1: complete follow-up of all subjects or subjects lost to follow-up were unlikely to introduce bias, 0: follow-up rate not adequate or no statement; and (D) statistical test: 1: the statistical test used to analyze data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and p values, 0: the statistical test is not appropriate, not described, or incomplete.

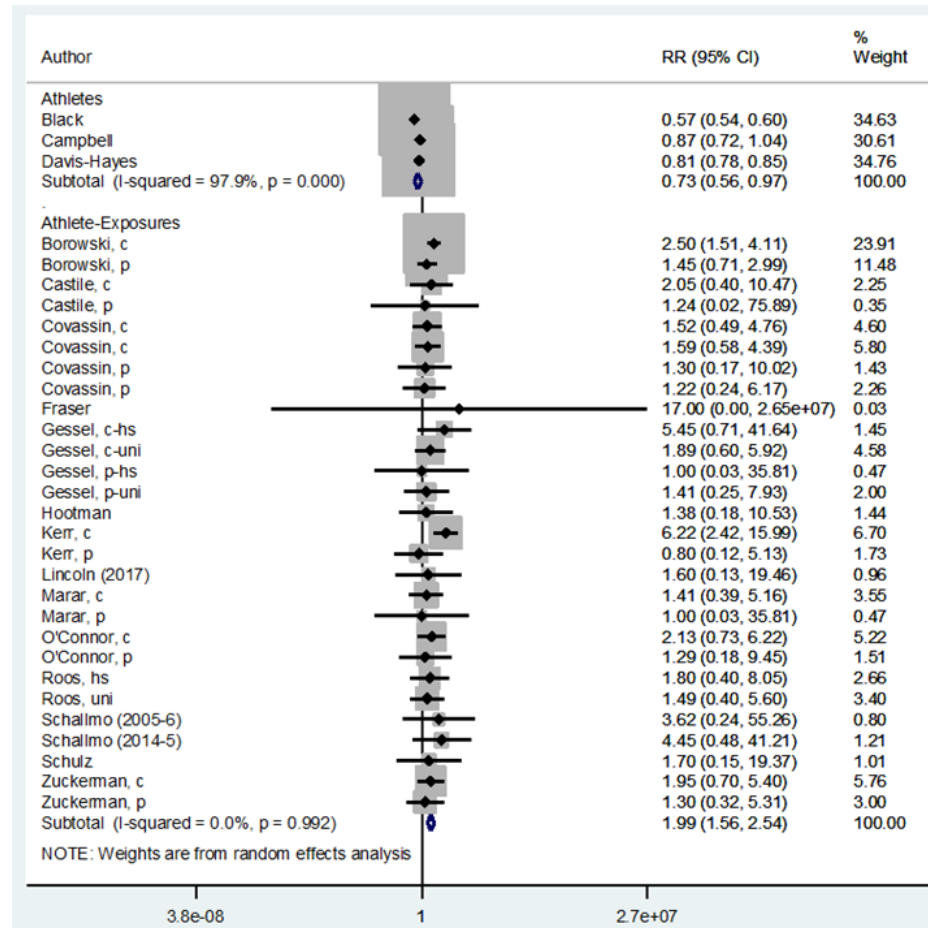
#Cross-sectional study

Figure A1. Forest plot of concussion incidence rate ratios for soccer



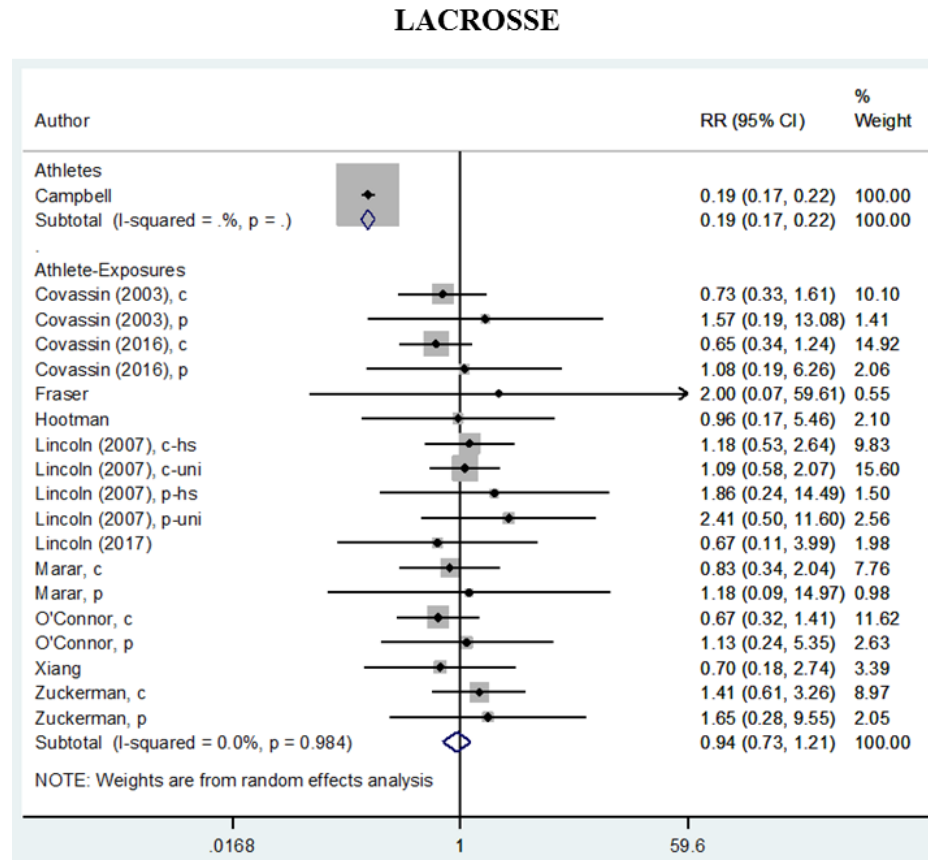
Forest plot of concussion incidence rate ratios for soccer. C: some competition; p: practice only; hs: high school or below; uni: university or above

Figure A2. Forest plot of concussion incidence rate ratios for basketball



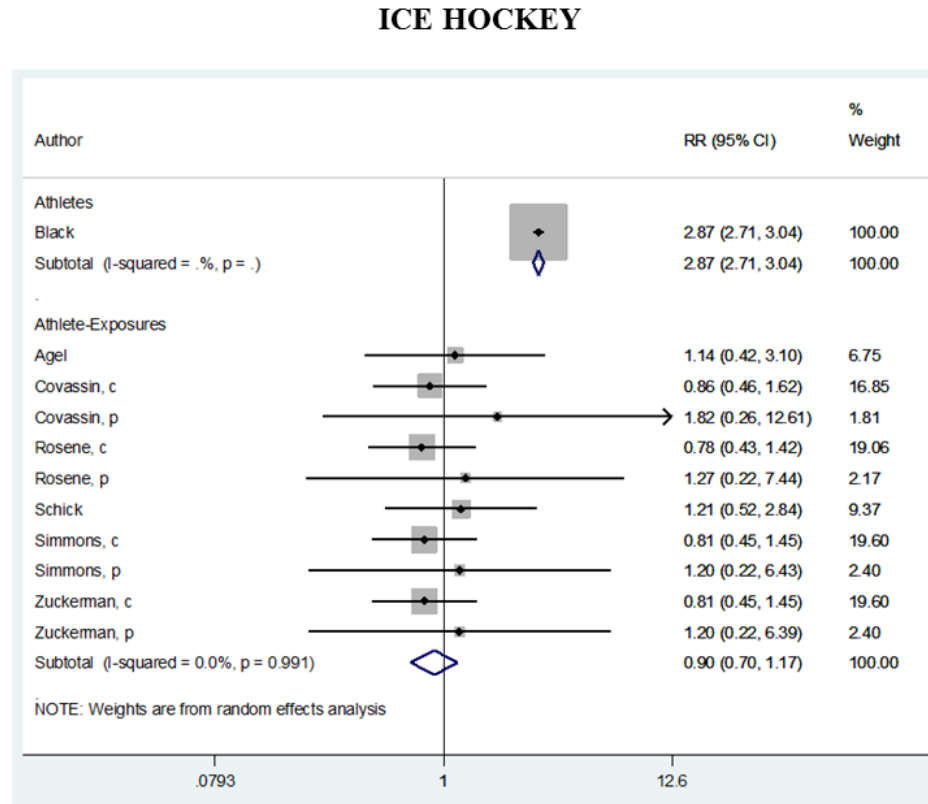
Forest plot of concussion incidence rate ratios for basketball. C: some competition; p: practice only; hs: high school or below; uni: university or above

Figure A3. Forest plot of concussion incidence rate ratios for lacrosse



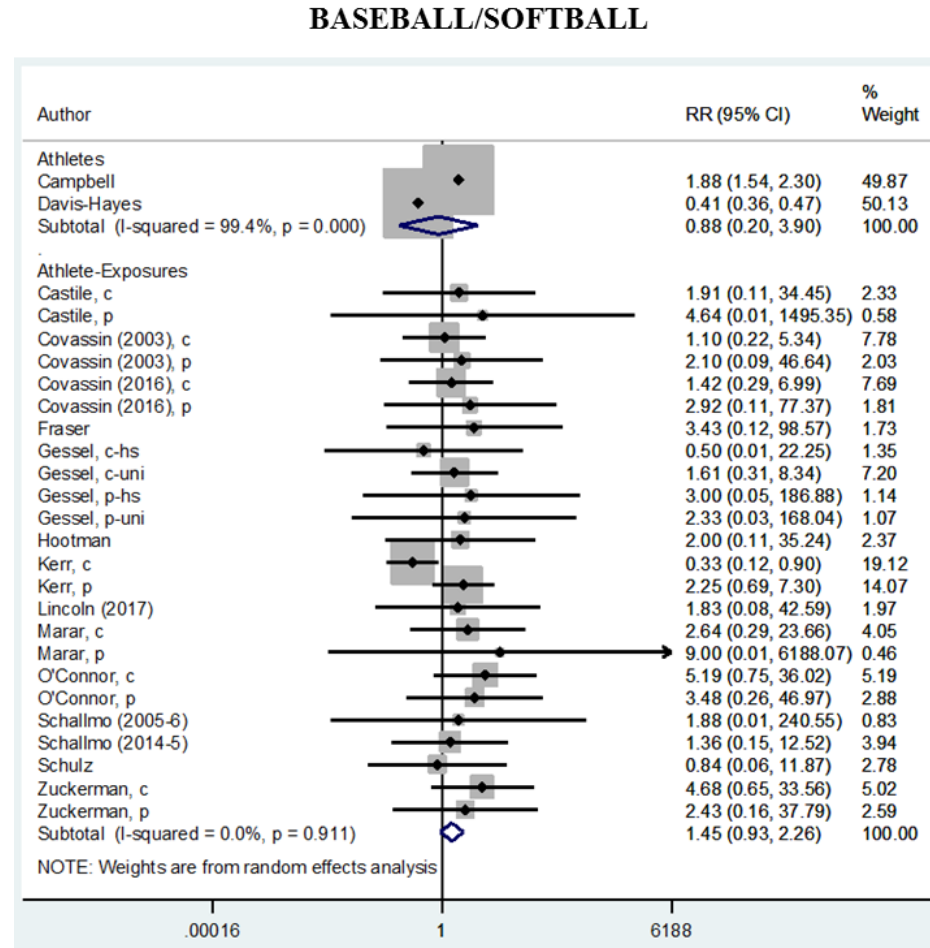
Forest plot of concussion incidence rate ratios for lacrosse. C: some competition; p: practice only; hs: high school or below; uni: university or above

Figure A4. Forest plot of concussion incidence rate ratios for ice hockey



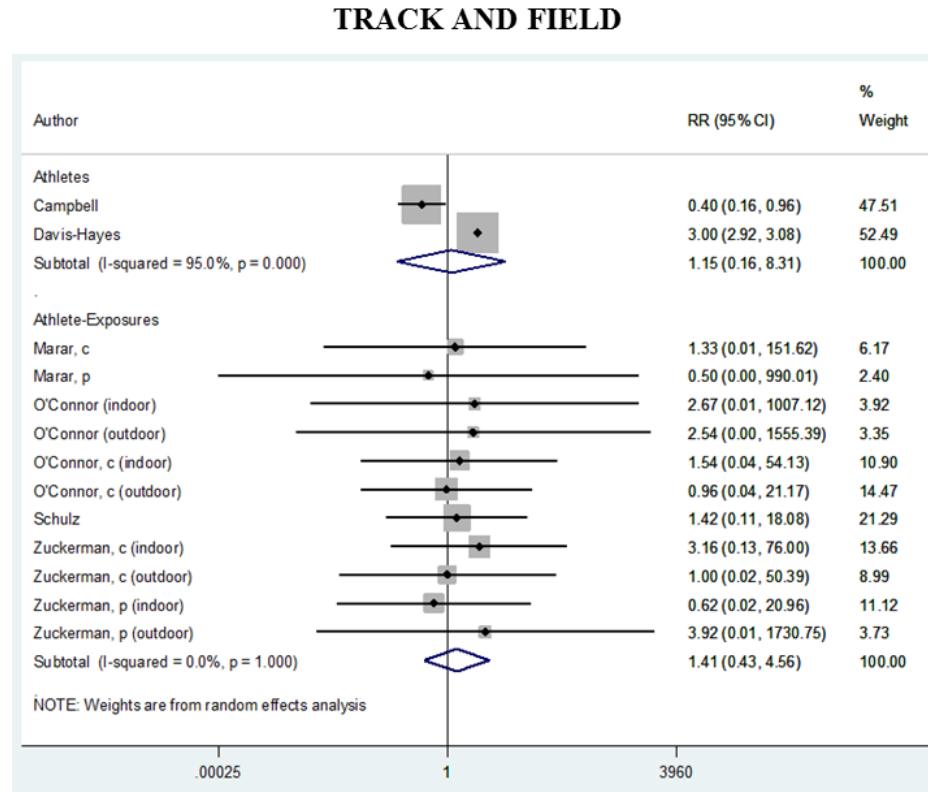
Forest plot of concussion incidence rate ratios for ice hockey. C: some competition; p: practice only; hs: high school or below; uni: university or above

Figure A5. Forest plot of concussion incidence rate ratios for baseball/softball



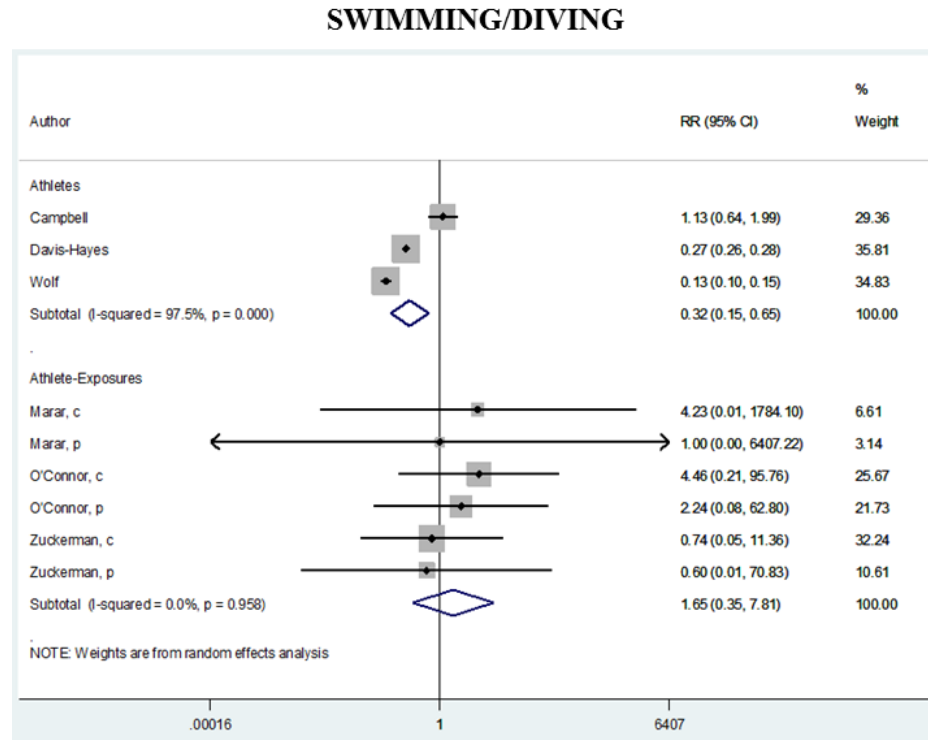
Forest plot of concussion incidence rate ratios for baseball/softball. C: some competition; p: practice only; hs: high school or below; uni: university or above

Figure A6. Forest plot of concussion incidence rate ratios for track and field



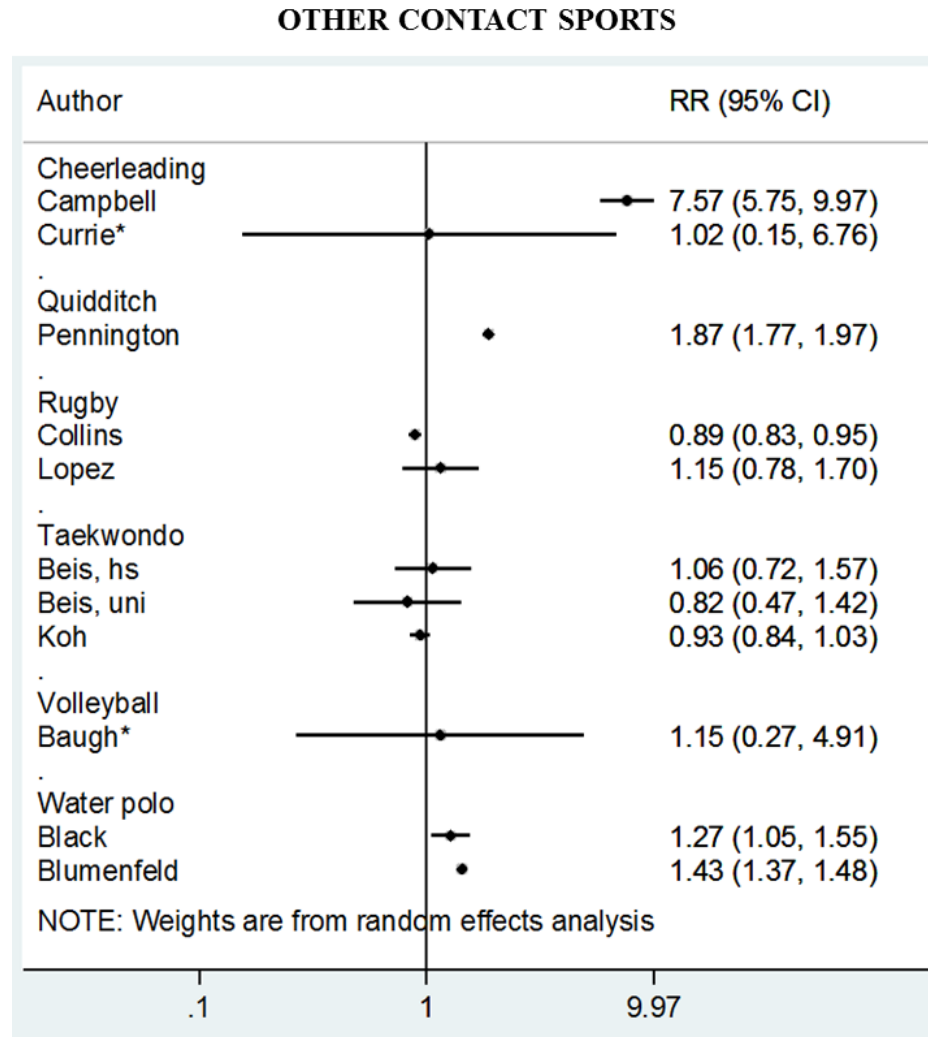
Forest plot of concussion incidence rate ratios for track and field. C: some competition; p: practice only; hs: high school or below; uni: university or above

Figure A7. Forest plot of concussion incidence rate ratios for swimming/diving



Forest plot of concussion incidence rate ratios for swimming/diving. C: some competition; p: practice only; hs: high school or below; uni: university or above

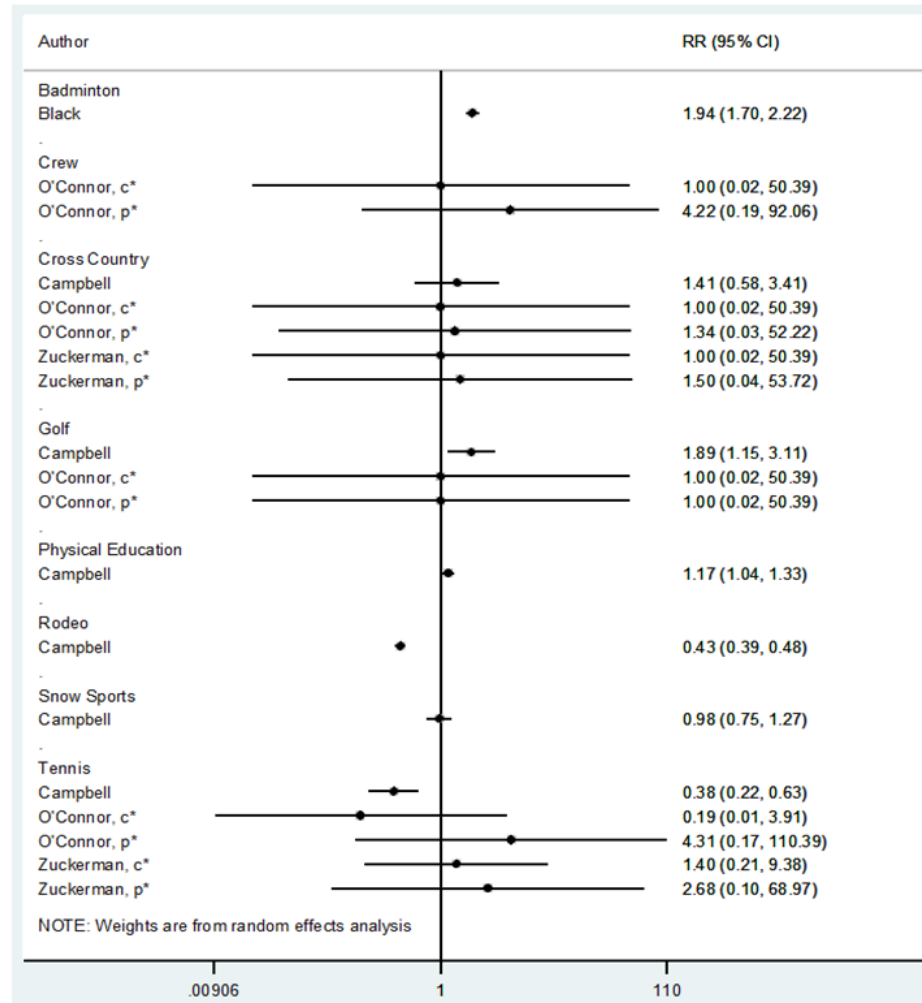
Figure A8. Forest plot of concussion incidence rate ratios for other contact sports



Forest plot of concussion incidence rate ratios for other contact sports. C: some competition; p: practice only; hs: high school or below; uni: university or above. *based on 10,000 athlete-exposures.

Figure A9. Forest plot of concussion incidence rate ratios for other non-contact sports

OTHER NON-CONTACT SPORTS



Forest plot of concussion incidence rate ratios for other non-contact sports. C: some competition; p: practice only; hs: high school or below; uni: university or above. *based on 10,000 athlete-exposures.