Incidence of Concussion in Youth Ice Hockey Players

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abstract

BACKGROUND: Ice hockey is a fast-paced collision sport that entails both intentional (ie, body checking) and incidental contact that may involve the head. The objective of this study was to determine the incidence of concussions in relation to games/practices and age among competition-level youth ice hockey players (ages 12–18 years).

METHODS: Participants included 397 youth ice hockey players from Western Pennsylvania; Boston, Massachusetts; and Birmingham, Alabama, during the 2012–2013 and 2013–2014 youth ice hockey seasons. Incidence rates (IRs) and incidence rate ratios (IRRs) of concussion were calculated for games/practices and age groups.

RESULTS: A total of 23 369 (12 784 practice/10 585 game) athletic exposures (AEs) involving 37 medically diagnosed concussions occurred. More than 40% of concussions involved illegal contact. The combined IR for games and practices was 1.58 concussions per 1000 AEs. The IRR was 2.86 times (95% confidence interval 0.68–4.42) higher during games (2.49 per 1000 AEs) than practices (1.04 per 1000 AEs).

CONCLUSIONS: The overall IR for concussion in youth ice hockey was comparable to those reported in other youth collision sports. The game-to-practice IRR was lower than previously reported in ice hockey and other youth sports, although more concussions per exposure occurred in games compared with practices. Younger players had a higher rate of concussions than older players.

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Dr Kontos contributed to the conceptualization and design of the study, and supervised analysis and interpretation of the data; Dr Elbin supervised collection of the data, and assisted with analysis and interpretation of the data; Dr Sufrinko assisted in data interpretation; Mr Dakan and Ms Bookwalter assisted in data collection and analysis; Ms Price assisted in data interpretation; Drs Meehan and Collins contributed to the design of the study, and assisted with the interpretation of data; and all authors assisted with the writing and editing of the manuscript, and approved the final manuscript.

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WHAT'S KNOWN ON THIS SUBJECT: Participation in youth ice hockey has doubled in the past 20 years and there is growing concern about concussions in this sport. However, concussion incidence rates among ice hockey participants have only been reported for scholastic student-athletes.

WHAT THIS STUDY ADDS: This study reports incidence rates for concussions during practice and games across age groups for youth ice hockey.

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Sport-related concussion (SRC) is considered a serious public health concern in the United States and worldwide. Youth athletes between the ages of 5 and 18 account for 65% of all sports and recreation-related head injuries treated in US emergency departments,[1] with a 62% increase in concussion-related visits between 2001 and 2009.[2] Concussions comprise ~13% of all sport-related injuries compared with only 5% 2 decades ago.[3]

Increased awareness and incidence of SRC[4] have accompanied the steady rise in youth sports participation across the past 20 years.[5] Participation rates in youth ice hockey have doubled over the past 2 decades,[6] with ~350 000 participants in the United States.[7] Ice hockey is a fast-paced collision sport that entails both intentional (ie, body checking) and incidental contact that may involve the head. A recent epidemiologic study examining concussion rates across 20 high school sports revealed boys' ice hockey had the second-highest incidence rate (0.54 per 1000 athletic exposures [AE]), and concussions represented a greater proportion of total injuries among boys' ice hockey (22.2%) compared with all other sports (13%).[8] This study also found that concussions were 13 times more likely to occur during competition than practice. In a study of male youth ice hockey players aged 11 to 12 years, however, researchers reported that the concussion incident rate (IR) in games only was 1.47 per 1000 AEs.[9] This higher concussion IR was likely due to the inclusion of only game-related data in the study of 11- to 12-year-olds.

To our knowledge, researchers have yet to compare concussion IRs of games to practices in youth ice hockey players of varying skill level. We recently reported a nearly 26-fold increase in concussion IRs in games compared with practices among 468 youth football players aged 8 to 12 years.[5] In the same study, we reported that concussion IRs in older (11–12 years) players were 2.72 times higher than for younger (8–10 years) players.[10] It is likely that similar findings would be supported among youth ice hockey players. The primary purpose of this study was to prospectively examine concussion IRs in a multisite cohort of male and female youth ice hockey players aged 12 to 18 years across a competitive season, and to compare IRs in games and practices, and between younger (12–14) and older (15–18) players.

METHODS

A prospective cohort study was conducted during 2 competitive ice hockey seasons between September 2012 and April 2014. A total of 401 of 449 (89.3% participation rate) youth ice hockey players aged 12 to 18 years (mean 14.23, SD 2.00) participated in the study. Data were collected for a cohort of 165 players between September 2012 and April 2013. Data were collected for an additional independent cohort of 236 players between September 2013 and April 2014. Players were recruited from 3 sites: Western Pennsylvania (n = 343), Boston, Massachusetts (n = 31), and Birmingham, Alabama (n = 27). Thirty-one teams (11 high school, 10 midget, 7 bantam, and 3 peewee) participating in 9 youth ice hockey leagues (3 high school, 2 AAA, and 4 AA/A) were involved in the study. The 3 peewee-level teams (n = 37) and the 4 girls teams (n = 67) were the only nonchecking teams in the study. Inclusion criteria included the following: age 12 to 18 years, written informed consent (parent) and assent (child), players participating only in the sport of ice hockey (during the study period), and league and coach agreement to participate in the study. Exclusion criteria included the following: self-reported history of brain surgery, history of moderate or severe traumatic brain injury (ie, Glasgow Coma Scale <13 or positive neuroimaging [computed tomography, MRI] findings), neurologic or psychiatric disorder, and current concussion or a concussion in the past 6 months.

A concussion was defined as any mild closed head injury involving altered cognitive functioning (eg, confusion, memory loss, disorientation), or signs/symptoms (eg, headache, dizziness, balance problems, nausea), or brief loss of consciousness of no longer than 1 minute after a direct or indirect blow to the head.[11,12] We decided a priori that head injuries involving structural damage or abnormality (eg, skull fracture, subdural hematoma, other lesions) would be treated emergently and excluded from the research study; however, none of the injuries in this study resulted in structural damage or abnormality.

Procedures

The study was approved by the University of Pittsburgh and Boston Children's Hospital institutional review board committees. The Alabama site was not an academic site and was therefore included under the University of Pittsburgh's institutional review board protocol. Administrative approval was obtained from organization and team representatives before the recruitment of participants from the Pittsburgh, Boston, and Birmingham sites in either the fall of 2012 or fall of 2013. After informational consent meetings, all participants completed written informed parental consent and child assent.

Team representatives (ie, coach or designated parent) were trained by the research team to collect and report player exposure, defined as participation by a player in a game or practice. Team representatives were contacted 2 to 3 times per week throughout the season to determine if any suspected concussions occurred.

We provided concussion education and study-specific training to these individuals before the start of the study. During games and practices, licensed medical professionals (eg, emergency medical technician, athletic trainer, physician) were present and assessed and managed all injuries in accordance with each league's and ice rink's policies (eg, brief on-ice evaluation of signs and symptoms with follow-up in-clinic clinical examination, symptom reports, and neurocognitive testing). Medical professionals (eg, pediatrician, neuropsychologist, primary care physician) conducted follow-up evaluations of players with suspected concussions. Researchers then followed up with coaches and parents to record additional information for confirmed diagnosed concussions. We obtained additional information about each injury, including injury mechanism (ie, player-to-player contact, penalty, contact with ice) from medical professionals, coaches, and parents when available. Only players with a concussion that was diagnosed by a licensed medical professional by using the criteria described earlier were recorded as a concussion for this study.

Statistical Analyses

Player exposure data were tabulated for each participant and used to calculate overall incidence rates per 1000 exposures with 95% confidence intervals (CIs) for both practices and games. Incidence rate ratios (IRRs) with 95% CIs comparing the rates of concussion in games to practice, between the 12- to 14- and 15- to 18-year age groups were also calculated. Mantel-Haenszel χ^2 analyses with odds ratios were used to compare the odds of a concussion for 12- to 14- to 15- to 18-year-olds. A statistical significance level of $P \leq .05$ was used for all analyses in this study. SPSS version 22 (IBM SPSS Statistics, IBM Corporation, Chicago, IL) was used for all analyses.

TABLE 1 Summary of Demographic Information for Participants by Age Group and Competition Level ($n = 397$)

	Age		Total, $n = 397$
	12–14, $n = 159$	15–18, $n = 238$	
Age, y, mean (SD)	12.79 (1.12)	16.25 (1.03)*	14.73 (1.99)
Girls, *n* (%)	24 (15.1)	43 (18.1)	67 (16.9)
Height, cm, mean (SD)	158.59 (10.13)	174.46 (11.06)*	167.40 (12.52)
Weight, kg, mean (SD)	50.10 (11.82)	69.59 (11.99)*	61.00 (15.60)
No. previous concussions, mean (SD)	0.27 (0.57)	0.48 (0.93)*	0.39 (0.79)
Learning disorder, *n* (%)	2 (1.3)	9 (3.8)	11 (2.8)
ADD/ADHD, *n* (%)	6 (3.8)	12 (5.0)	18 (4.5)
Migraine/headache, *n* (%)	18 (11.3)	33 (13.9)	51 (12.8)
Games, *n* (%)	2785 (49.4)**	7800 (44.0)	10 585 (45.3)
Checking not allowed, *n* (%)	37 (23.3)	67 (28.2)	104 (26.2)
Western Pennsylvania site, *n* (%)	142 (89.3)	218 (84.2)	104 (26.2)
Boston, Massachusetts, site, *n* (%)	10 (6.3)	21 (8.8)	31 (7.8)
Birmingham, Alabama, site, *n* (%)	7 (4.4)	20 (8.4)	104 (26.2)

* $P < .05$; ** $P < .01$.

RESULTS

Demographics

Thirty-one youth ice hockey teams (27 male, 4 female) were asked to participate in this study. A total of 401 (89.3%) of 449 possible participants aged 12 to 18 years participated in the study. Forty-eight players declined to participate in the study because of disinterest, perceived time constraints associated with participating in the study, refusal of parent to sign consent form, or inability to attend informational and testing sessions. Complete self-reported demographic data were available for 397 (99%) of the 401 participants (see Table 1). Parents assisted youth in providing demographic information and history, as needed. A total of 159 (40.1%) of 397 participants were in the 12- to 14-year and 238 (59.9%) of 397 were in the 15- to 18-year age groups. Most ($n = 330$, 83.1%) participants were boys. Participants in the 15- to 18-year-old age group were significantly ($P < .05$) older, taller, and heavier; and reported more previous concussions than those in the 12- to 14-year-old age group and nonelite competition levels, respectively. There were 292 participants (73.5%) who did not have a self-reported history of diagnosed concussion, 74 participants (18.6%) had a history of 1 concussion, 25 participants (6.3%) had a history of 2 concussions, 3 participants (0.8%) had a history of 3 concussions, and 3 participants (0.8%) had a history of 4 concussions. A total of 104 (26.2%) participants were in nonchecking leagues. There were no differences in the proportion of players in nonchecking leagues between the 2 age groups. The proportion of games in the 12- to 14-year age group (49.4%) was 1.13 times ($\chi^2 = 75.4$, 95% CI 1.10–1.17, $P < .01$) higher than in the 15- to 18-year-old age group (44.0%).

Concussions in Games and Practices

Overall there were 23 369 total (12 784 practice/10 585 game) exposures recorded during the study. A total of 37 (9.3%) of the 397 participants incurred a medically diagnosed concussion during the study period. There were 11 (29.7%) concussions that occurred in practices and 26 (70.3%) in games. No players sustained multiple concussions during the study. Among players who had a concussion, 23 (62.2%) had no history of previous concussion, 9 (24.3%) had a history

of 1 concussion, and 5 (13.5%) had a history of ≥2 concussions. All identified mechanisms of injury involved player-to-player contact and more than half (n = 19) involved secondary contact with the boards. A total of 43% (n = 16) of the concussion injury mechanisms involved illegal contact resulting in a penalty. The combined concussion incidence rate for games and practices was 1.58 concussions per 1000 exposures (95% CI 1.13–2.16). The IR was higher during games (2.46/1000 AEs; 95% CI 1.64–3.55) than during practices (1.17/1000 AEs; 95% CI 0.68–1.89). The IRR for concussions in games to practices was 2.86 (95% CI 1.43–6.01, P = .01).

Concussions in 12- to 14- and 15- to 18-Year-Old Age Groups

Regarding age, there were 5638 total (2853 practice, 2785 game) exposures for the 12- to 14-year-olds (n = 159), during which 16 medically diagnosed concussions occurred. There were 17 731 total (9931 practice, 7800 game) exposures for the 15- to 18-year-old age group (n = 238), during which 21 medically diagnosed concussions occurred. The combined concussion IR for practices and games in the 12- to 14-year old age group was 2.84 per 1000 (95% CI 1.68–4.51) exposures, and the combined concussion IR for practices and games in the 15- to 18-year-old age group was 1.18 per 1000 exposures (95% CI 0.75–1.78). The combined practice and game IRR of concussions for 12- to 14-year olds compared with 15- to 18-year-olds was 2.40 (95% CI 1.23–4.61, P = .01).

DISCUSSION

The current study prospectively examined concussions and their association to age in male and female youth ice hockey players aged 12 to 18 years. The concussion IR of 1.58/1000 exposures in our sample of youth ice hockey players aged 12 to 18 years was comparable to rates reported for other youth sports.[8,10,13–15] In fact, in a recent study of youth football players, researchers reported a total concussion IR of 1.76/1000 exposures,[10] which is similar to the rate reported in the current study. In the current study, players had nearly 3 times more concussions per exposure in games compared with practices. This game-to-practice IRR suggests that games are more risky for concussion than practices; however, the IRR in the current study is lower than those previously reported in ice hockey (eg, IRR= 13.20) and other sports.[8,14] This finding may be due in part to the equitable medical coverage during practices and games, which may have increased the identification of concussions in practice in the current study compared with previous studies. However, this finding also may have been the result of more "gamelike" contact and play during practice in the current sample of youth ice hockey players.

All reported concussions in the current study resulted from player-to-player contact (ie, checking or collision). This finding is consistent with a recent study conducted on professional hockey players,[16] in which 88% of concussions from 2006 to 2010 resulted from contact with an opponent. A significant percentage (43%) of concussion-causing impacts in the current study were also the result of illegal contact, which supports the need for more stringent enforcement of penalties for illegal contact in youth ice hockey to mitigate this behavior, especially when involving a player's head. Similarly, to avoid illegal and aggressive or risky play, the most recent policy from the American Academy of Pediatrics Council on Sports Medicine and Fitness suggests delaying introduction of checking until age 15.[17] Youth leagues that permit body checking have higher concussion rate than those do not,[18] and a rule change to prohibit body checking was shown to decrease the incidence of concussion after 2 years.[19,20]

In the current study, the concussion IR for 12- to 14-year-olds were 2.4 times higher than for 15- to 18-year-olds. This finding is in contrast to research in other youth sports, such as football, which reported higher concussion IRs in 11- to 12-year-olds compared with 8- to 10-year-olds.[10] In their study examining concussions in youth football, Kontos and colleagues[10] concluded that the increase IR in older athletes could be attributed to those athletes being bigger, faster, and stronger and engaging in more tackling than their younger counterparts. The overlap in age groups with higher concussion IRs in these 2 studies suggests that concussion risk may increase from childhood to early adolescence (age 12–14 years) and then drop off again in later adolescence. One reason for this increased risk in early adolescence may be the disparity in size, strength, and speed across boys at this time.[21] In addition, the introduction of checking at age 13 may result in injuries due to poor checking technique and lack of awareness on the ice, leading to more collisions. However, it is important to note that research comparing high school and college athletes has supported a more linear increase in concussion with age.[13,22] As such, future research should compare younger and older adolescents to determine if younger adolescents are at increased risk for concussion, and if so, determine which factors may play a role in this finding. Additional factors, such as game play characteristics and rules changes, should also be examined.

The current study had several limitations. The sample size was small for an epidemiologic study. The sample included only players from the greater Pittsburgh, Boston, and Birmingham areas, and thus, the

findings may not be generalizable to all locales. We collected data in only 2 independent competitive seasons and did not calculate playing time for each player, so all game and practice exposures were treated the same. We were unable to determine if the playing style of each league or team contributed to the incidence of concussion, as this is difficult to quantify. Concussion history was documented based on self-report, and as such may not be completely accurate. Interestingly, this cohort of athletes had a relatively high rate of previous concussions, potentially limiting the generalizability of our findings. Additionally, different medical professionals were in charge of diagnosing and documenting concussions at each site, potentially leading to bias and inconsistencies in the numbers of concussions reported.

CONCLUSIONS

The concussion IR of 1.58 per 1000 AEs in our sample of youth ice hockey players aged 12 to 18 years was comparable to rates reported for other youth collision sports. The game-to-practice IRR was lower than those previously reported in ice hockey and other youth sports, although 2.9 times more concussions per exposure occurred in games compared with practices.Younger players (eg, 12--14 year olds) had a higher rate of concussions than older players (eg, 15--18 year olds). Future research should compare younger and older adolescents, male and female cohorts, and investigate further the possible risk factors for discrepancies in concussion rates, such as checking policies and illegal contact.

ABBREVIATIONS

AE: athletic exposures
CI: confidence interval
IR: incidence rates
IRR: incidence rate ratios

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