Higher Rates of Head Contacts, Body Checking, and Suspected Injuries in Ringette than Female Ice Hockey: Time to Ring in Opportunities for Prevention

Authors: Emily E. Heming, BSc[1], Alexandra J. Sobry, BSc[1], Alexis L. Cairo, BSc[1], Rylen A. Williamson, BSc[1], Ash T. Kolstad, MSc[1,6], Stephen W. West, PhD,[1-2] Claude Goulet, PhD,[3] Kelly Russell, PhD,[4-5] Carolyn A. Emery, PT, PhD[1-2,6-10].

Affiliations:
[1]Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, Calgary, Alberta, Canada;
[2]O'Brien Institute for Public Health, University of Calgary, Calgary, Alberta, Canada;
[3]Department of Physical Education, Faculty of Education, Université Laval, Quebec City, Quebec, Canada;
[4]Department of Pediatrics and Child Health, University of Manitoba, Canada;
[5]Children's Hospital Research Institute of Manitoba, Winnipeg, Manitoba, Canada;
[6]Alberta Children's Hospital Research Institute, University of Calgary, Canada;
[7]Hotchkiss Brain Institute, University of Calgary, Canada;
[8]McCaig Institute for Bone and Joint Health, University of Calgary, Canada;
[9]Community Health Sciences, Cumming School of Medicine, University of Calgary, Canada;
[10]Department of Pediatrics, Cumming School of Medicine, University of Calgary, Canada

Corresponding Author:
Name: Emily Heming
Address: 2500 University Dr NW
Calgary, Alberta
T2N 1N4
Fax number: 1-403-210-9334
Phone Number: 647-527-0168
Email Address: emily.heming@ucalgary.ca

Acknowledgements:
The Sport Injury Prevention Research Centre is one of the International Research Centres for Prevention of Injury and Protection of Athlete Health, supported by the International Olympic Committee. We acknowledge funding from Canadian Institutes of Health Research, Alberta Innovates Health Solutions, Hotchkiss Brain Institute, and Alberta Children's Hospital Foundation. C.A.E. is supported by a Canada Research Chair (Tier 1) in Concussion.

Word count: Abstract 249/250 words Manuscript 2781/3000 words

Abstract

Objective: Ringette and female ice hockey are high participation sports in Canada. Despite policies disallowing body checking, both sports have high injury and concussion rates. This study aimed to compare physical contact (PC), head contact (HC), and suspected injury and concussion incidence rates (IR) in female varsity ringette and ice hockey.

Design: Cross-sectional.

Setting: Canadian ice arenas.

Participants: Eighteen Canadian female university ringette and ice hockey tournament/playoff games in the 2018-2019/2019-2020 seasons.

Assessment of Risk Factors: Game video-recordings were analyzed using Dartfish video-analysis software to compare both sports.

Main Outcome Measures: Univariate Poisson regression analyses (adjusted for cluster by team, offset by game-minutes) were used to estimate PC, HC, and suspected injury IRs and incidence rate ratios (IRRs) to compare rates across sports. Proportions of body checks (level 4-5 trunk PC) and direct HC (HC_1) penalized were reported.

Results: Analyses of 36 team-games (n=18 ringette, n=18 hockey) revealed a 19% lower rate of PCs in ringette than ice hockey [IRR=0.81 (95%CI:0.73-0.90)], but a 98% higher rate of body checking [IRR=1.98 (95%CI:1.27-3.09)] compared to ice hockey. Ringette had a 40% higher rate of all HC_1s [IRR=1.40 (95%CI:1.00-1.96)] and a 3-fold higher rate of suspected injury [IRR=3.11 (95%CI:1.13-8.60)] than ice hockey. The proportion of penalized body checks and HC_1s were low across sports.

Conclusions: Body checking and HC_1 rates were significantly higher in ringette compared to ice hockey, despite rules disallowing both, and very few were penalized. These findings will inform future injury prevention research in ringette and female ice hockey.

Key words: ringette, ice hockey, athletic injury, concussion, female, video analysis

INTRODUCTION

Ringette and female ice hockey are high participation female ice team sports with over 32,000 ringette and 101,000 female ice hockey players participating in Canada in the 2019-2020 season.[1,2] In Canada, participation in ringette and female ice hockey have increased since the early 2000s.[1,2] Unfortunately, both female ice sports are associated with a high risk of injury, including concussion.[3,4] Body checking (i.e., intentional forceful contact to stop an attack or separate the opponent from the puck/ring[5]) is prohibited in both ringette and female ice hockey, however previous research demonstrates that contact with another player (either intentional or unintentional) is the primary mechanism of injury.[6,7]

In a study investigating the epidemiology of sport-related injuries reporting to Canadian emergency departments, female ringette and ice hockey players had the highest proportion of sport-related injuries diagnosed as concussions (17.1% and 13.3% respectively).[3] Further, a cross-sectional survey among high school students (ages 14-19) reported that ringette had the highest concussions rate (19.05 concussions/100 students/year) compared to all other youth sports, including male ice hockey (17.20 concussions/100 students/year).[4] In a one-season cohort study among collegiate ice hockey players, injury rates among female (7.77 injuries/1000 athletic exposures [AE]) and male (9.19 injuries/1000 AEs) players were similar (relative risk = 1.18, p = 0.258, 95% CI: 0.89-1.57) and concussions were the most common injury in females (thigh injury was the most common injury in males).[8] Moreover, concussions resulted in the greatest burden of injury (e.g., longer recovery, more severe symptoms), resulting in the greatest time loss compared to other injury types in both sexes. Specific to female varsity ice hockey, a different study reported a concussion rate of 1.18 concussions/1000 AEs.[9] In another female youth ice hockey study, the

overall injury rate reported was 1.9 injuries/1000 player-hours (including concussions) or 16.3 injuries/100 players/season.[6] To our knowledge, there is no current injury epidemiology literature in ringette that includes player exposure.

A noteworthy difference between male and female ice hockey is that body checking is not allowed in female ice hockey, whereas elite levels of male ice hockey allow body checking in 13-17-year-old leagues. This difference has resulted in the common belief that female ice hockey is a safer sport, with a lower perceived risk of injury.[10] This may explain the lack of research investigating injuries in female compared to male ice hockey. In the few studies that do include female ice hockey, the majority combine male and female into the same sample, where females make up a significantly smaller amount of that sample.[10] Previous research has shown that the injury profile of female ice hockey players differs from male ice hockey players.[11]

Despite the high risk of injury, specifically concussion, among ringette and female ice hockey players, there is a paucity of injury epidemiology research in this population. Further investigation into injury burden, risk factors, and mechanisms in ringette and female ice hockey is needed to inform injury prevention programs and strategies. It is crucial to assess the concussion and injury risk specific to ringette and female ice hockey players. This study aimed to compare physical contact (PC) and head contact (HC) incidence rates (IR), and suspected injury and concussion rates in female varsity ringette and ice hockey using video analysis. Previous research has demonstrated that video analysis is an effective tool to assess injury situations in various high injury risk team sports.[12–14]

METHODS

Design and Participants

This is a cross-sectional video-analysis study based on 18 University level ringette and female ice hockey games (games = 40 minutes for ringette and 60 minutes for ice hockey). Participants included Canadian University level ringette players participating in the University Challenge Cup tournament (n=18 team-games; N=9 games) and varsity female ice hockey players participating in the Canada West playoff games (n=18 team-games; N=9 games) in the 2018-2019 and 2019-2020 seasons. Ethical approval for this study was obtained from the University of Calgary Conjoint Health Research Ethics Board (CHREB) (Ethics ID: REB21-0968).

Video Footage Collection

Video footage was previously collected during the 2018-2019 and 2019-2020 seasons and shared with the study team via shared video viewing platforms: Periscope (ringette) and VidSwap (female ice hockey). Permissions for the video footage to be analyzed anonymously (i.e., no linkage to individual personal data) were granted by the Canadian University and College Ringette Association (CUCRA) Registrar and the University of Calgary's interim director of Dino's athletics for ringette and female ice hockey, respectively. Following permissions to access the videos, the videos were downloaded from the viewing platforms onto a secure server (SharePoint). Games were matched between sports based on game type (i.e., quarter final, semi final, final). Games with poor video quality or camera angle were excluded (approximately 30% of games excluded).

Outcome Measures

Games were analyzed for player-to-player physical contacts (PC) using previously validated criterion[15] on Dartfish Version 10.0 video-analysis software.[16] Dartfish allows for videos to be

analyzed frame-by-frame using a custom-made tagging panel. Video analyzers included those with a background (e.g., player or coach) in their respective sports (n=2 ringette; n=3 ice hockey). Video analyzers were trained and achieved an inter-rater reliability (≥ 90%) with a gold standard assessor (R.W.) on the physical contact metrics including: contact mechanisms (i.e., trunk, limb, or stick), trunk contact intensity (levels 1-5), and additional contact characteristics (e.g., location on ice, intentional/unintentional, contact made with puck/ring carrier). This gold standard assessor has extensive experience with 65+ games analyzed (i.e., 500+ hours of analysis) in team ice sports.

Validated player-to-player PC metrics included trunk contacts classified by severity into 5 levels (Table 1) where levels 1-3 were classified as body contact and levels 4-5 were considered body checking.[15] Other contacts included contacts made with the limbs or stick (e.g., pushing, hitting, holding, hooking). Each PC was tagged with the contact zone on the ice (Figure 1), directionality of the player giving the contact (offensive or defensive), intention of the contact (deliberate or non-deliberate), if the contact was on the puck/ring carrier, and if a penalty was assessed by the referee. Of the PCs recorded, all head contacts (HC) were examined further as a subset, whereby HC were classified as either primary/direct contact by opposing players (HC_1) or secondary/indirect contact to the head after a collision via the boards, glass, or ice surface (HC_2). Suspected non-concussion injuries were assessed based on criteria from previous video analysis from professional soccer.[17] Criteria included: referee stopped play for injury, player remained on the ice for longer than 15 seconds after contact, and the player appeared to be in pain. Suspected concussions were assessed using 17 previously used video signs of concussion from professional sport based on expert consensus (e.g., lying motionless, dazed, slow to get up, clutching at head).[18] Suspected injuries,

including concussion, were included in the analysis if they met one or more criteria from the aforementioned video analysis studies.

Table 1. Trunk and other physical contact definitions based on Malenfant et al. (2012).[15]

	Definition
Trunk physical contact (PC)	
Level 1	Very light contact between two stationary players
Level 2	Light contact between two players moving in the same relative direction
Level 3	Moderate contact between two players moving in the same relative direction
Level 4	Heavy contact, with one player forcefully exerting one's body into the opposing player, usually moving in the opposite direction. Minimum requirement of a body check
Level 5	Excessive, deliberate contact from one player with the intention beyond impeding the progress of the opponent, moving in the opposite direction
Other physical contact (PC)	
Limb	Contact using one or both upper extremities, such as pushing, punching, or holding
Stick	Contact to the body using the stick, such as slashing or hooking

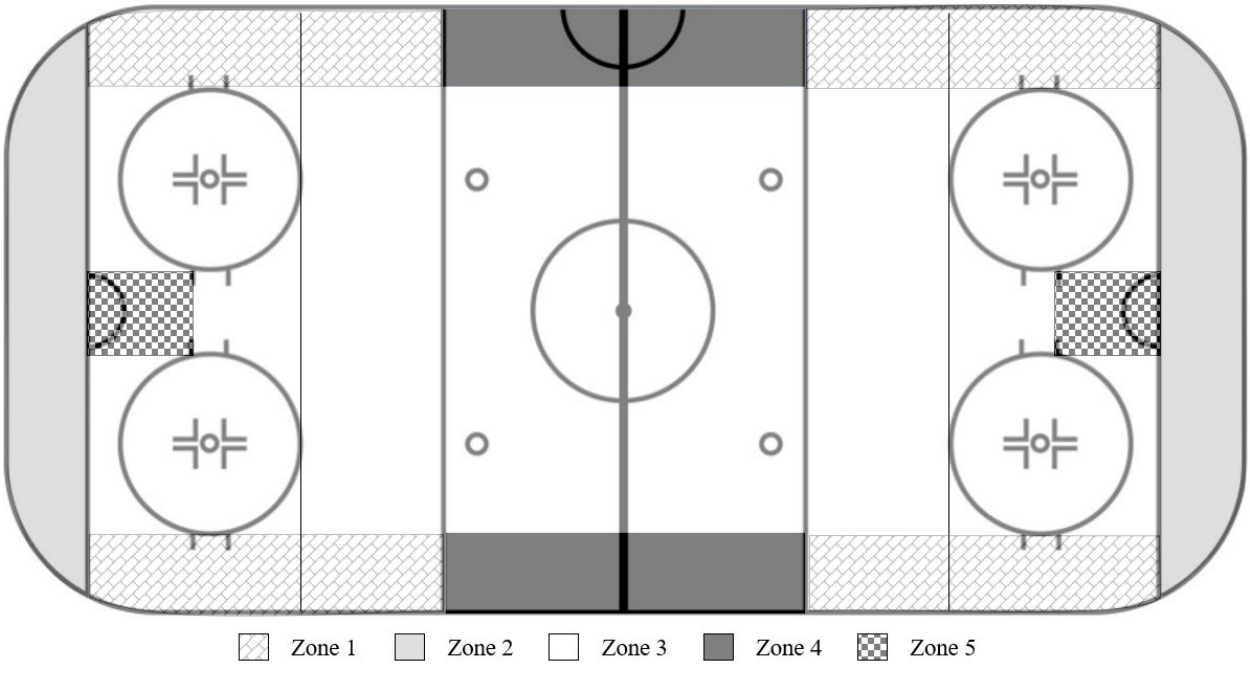

Figure 1. Zones of the ice hockey/ringette arena adapted from Malenfant et al. (2012).[15]

Data Analysis

All data was analyzed using STATA version 15.1 statistical software.[19] Incidence rates (IR) were expressed as the number of contacts per 100 team-minutes. Incidence rate ratios (IRR) were used to compare rates between sports using univariate Poisson regression analyses adjusted for cluster by team and offset by game length (in minutes). IRs and frequencies were used to describe PC behaviours including PC mechanisms and characteristics.

RESULTS

Game Selection

A total of 9 games or 18 team-games were analyzed in ringette and female ice hockey. Four round robin/quarter-final games were selected from each season (2018-2019 and 2019-2020) as well as one final game from the 2019 season in both ringette and female ice hockey. Five ringette games were excluded due to poor quality/angle of video where analysis could not be accurately completed. No female ice hockey games were excluded due to poor quality/angle of video, but ice hockey games were instead chosen to match ringette on game type (round robin and finals) and season (2018-2019 and 2019-2020 seasons).

Physical Contact Incidence Rates and Mechanisms

In total, 2133 PCs in 686.3 ringette team-minutes and 4085 PCs in 1068.3 female ice hockey team-minutes were analyzed. Overall, ringette had a 19% lower rate of total PCs (levels 1-5 trunk contacts and other contacts) than ice hockey (IRR=0.81, 95% CI: 0.73-0.90) (Figure 2). Ringette also had a lower rate of total trunk (levels 1-5) PCs (IRR=0.65, 95% CI: 0.57-0.73) and body contact PCs (levels 1-3 intensities; IRR=0.61, 95% CI: 0.54-0.70) compared to ice hockey

(Figure 2). However, ringette had a higher rate of body checking PCs (levels 4-5 intensities; IRR=1.98, 95% CI: 1.27-3.09) and other non-trunk PCs (IRR=1.46, 95% CI: 1.19-1.80) compared to ice hockey (Figure 2). Ringette and female ice hockey had high rates of intentional contacts compared to unintentional (95% for ringette and 97% for hockey) as well as contact made with the puck/ring carrier compared to a non-puck/ring carrier (92% for ringette and 73% for hockey). Incidence rates of all PCs including trunk and other contacts were analyzed (Table 2) as well as the frequency of all PCs by each ice surface zone (Figure 3). When considering higher intensity body checks (level 4-5 intensities), the proportion of body checks penalized were low in ringette (22%) and ice hockey (15%), despite policy disallowing body checking in both sports.

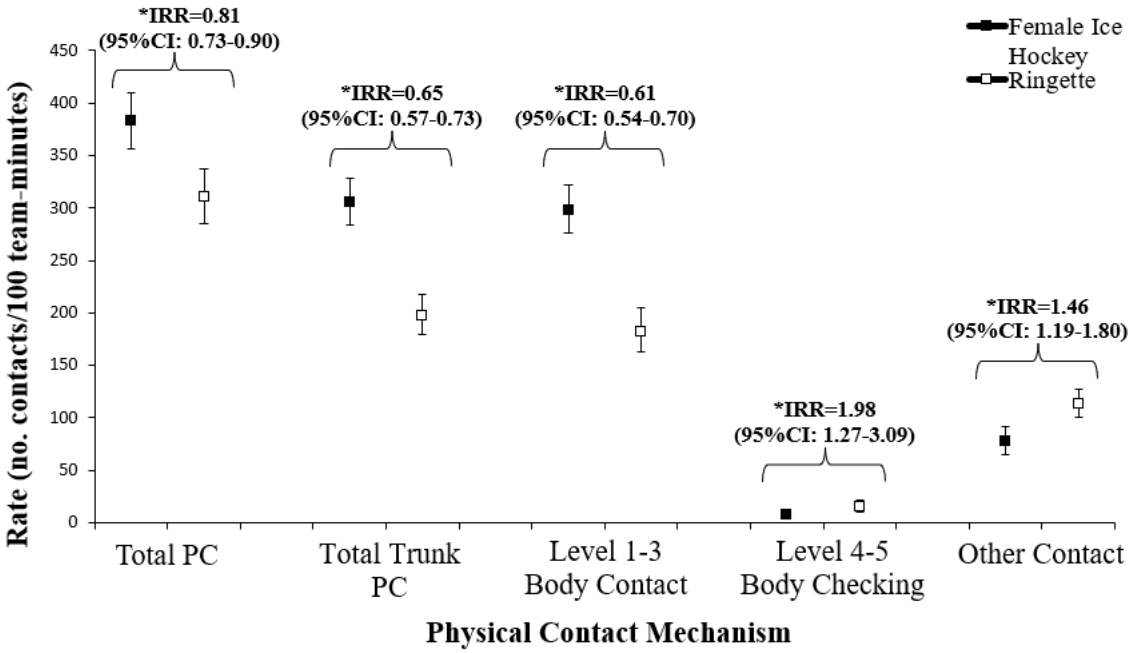

Figure 2. Comparison of incidence rates for total physical contacts (PC), total trunk, body contact (level 1-3 intensities), body checking (level 4-5 intensities) and other (stick or limb inflicted) in-game physical contacts in ringette and female ice hockey using incidence rate ratios (IRR) adjusted for cluster by team and offset by game length.
Notes. *Statistically significant, 95% CI (confidence interval).

Table 2. Incidence rates of all player-to-player physical contacts (PC) including trunk contact intensities and other contact types.

	Ringette	Ice Hockey
	PC Incidence Rate per 100 Team-Minutes (95% CI)	
Total PC	**310.4 (285.4-337.5)**	**382.5 (356.8-410.0)**
Trunk Contact	**197.59 (179.09-218.01)**	**305.44 (283.92-328.58)**
Total Levels 1-3	**182.58 (162.89-204.66)**	**297.86 (275.81-321.66)**
Level 1	46.0 (36.2-58.6)	109.8 (96.6-124.4)
Level 2	101.4 (86.5-118.9)	145.5 (132.4-159.8)
Level 3	35.1 (27.8-44.4)	42.6 (37.5-48.4)
Total Levels 4-5	**15.01 (10.45-21.56)**	**7.58 (5.80-9.92)**
Level 4	14.1 (9.6-20.8)	6.8 (5.3-8.8)
Level 5	0.9 (0.5-1.7)	0.7 (0.3-1.7)
Other Contact & Other Contact Type	**112.79 (100.07-127.12)**	**77.04 (64.73-91.68)**
Limb hit	5.5 (3.7-8.3)	3.4 (2.0-5.7)
Holding	1.2 (0.5-2.8)	3.0 (2.1-4.2)
Limb push	52.3 (44.7-61.2)	36.3 (27.4-48.2)
Slashing	35.1 (30.2-40.9)	12.4 (9.5-16.3)
Hooking	15.3 (11.3-20.7)	3.8 (2.6-5.7)
Cross checking	3.2 (1.6-6.4)	15.4 (9.8-24.3)

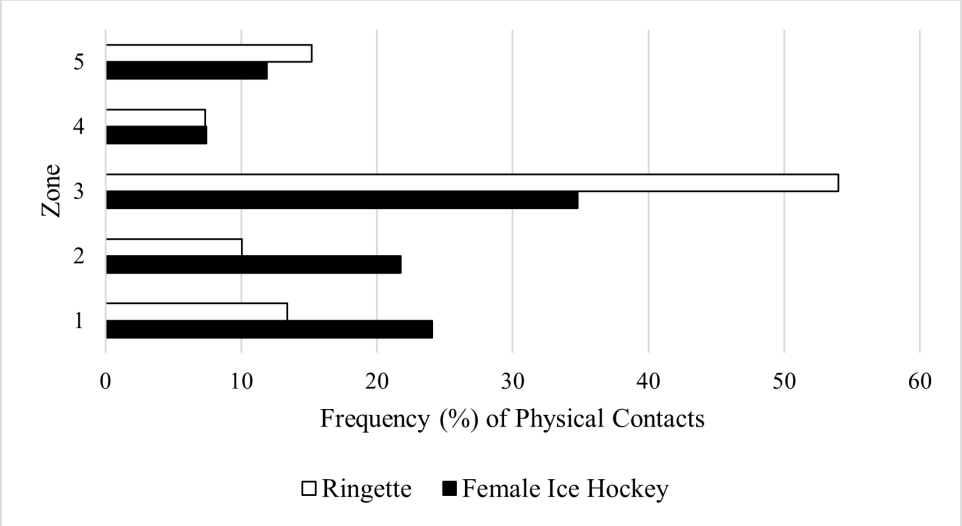

Figure 3. Frequency of all player-to-player physical contacts by each ice surface zone for both ringette and female ice hockey.

Head Contact Incidence Rates and Mechanisms

In total, 116 HCs in 686.3 ringette team-minutes and 111 HCs in 1068.3 female ice hockey team-minutes and were analyzed. Overall, ringette had a 68% higher rate of total HCs (IR=17.92 HCs/100 team-minutes, 95% CI: 14.71-21.83) compared to ice hockey (IR=10.67 HCs/100 team-minutes, 95% CI: 8.28-13.75) (IRR=1.68, 95% CI; 1.22-2.31) (Figure 4). The point-estimate showed a higher rate of HC_1 in ringette (IR=10.49 HC_1s/100 team-minutes, 95% CI: 9.14-12.04) compared to ice hockey (IR=7.49 HC_1s/100 team-minutes, 95% CI: 5.50-10.20) (IRR=1.40, 95% CI: 1.00[1]-1.96). Ringette also had a significantly higher rate of HC_2 (IR=7.43 HC_2s/100 team-minutes, 95% CI: 5.08-10.86) compared to ice hockey (IR=3.18 HC_2s/100 team-minutes, 95% CI: 2.15-4.72) (IRR=2.34, 95% CI: 1.36-4.00). In ringette, 14% of all HC_1s were penalized and 5% of all HC_1s were penalized in ice hockey, despite HC_1s not being allowed in either sport. HC frequency by trunk contact intensities as well as other contact types were analyzed (Table 3).

[1] *95% CI deemed significant based on (95% CI: 1.004-1.956) before rounding.

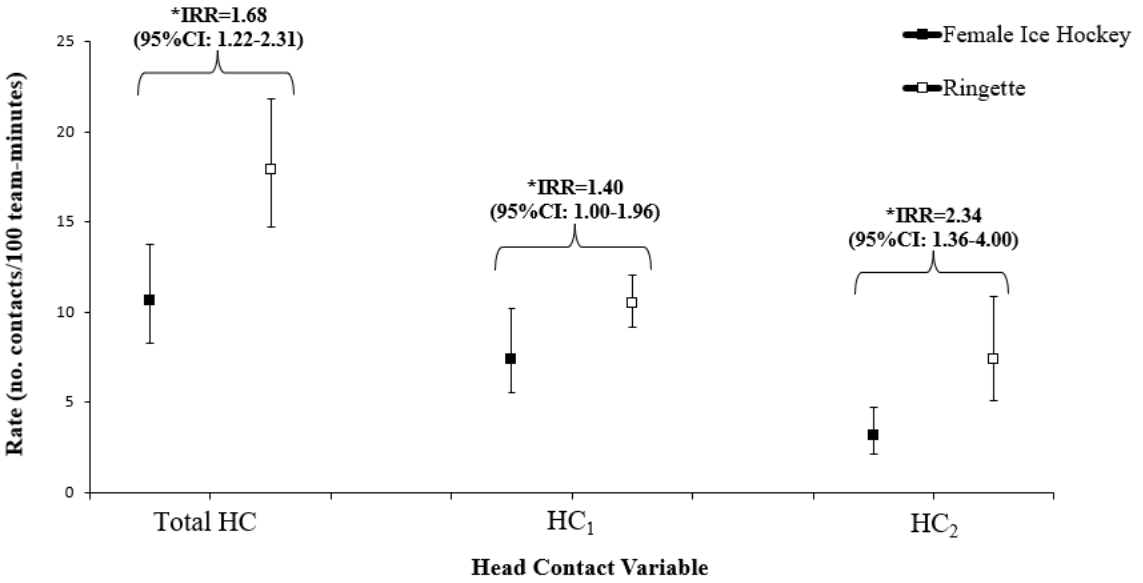

Figure 4. Comparison of incidence rates for total head contacts (HC), direct (HC_1), and indirect (HC_2) in-game head contacts in ringette and female ice hockey using incidence rate ratios (IRR) adjusted for cluster by team and offset by game length.
Notes. *Statistically significant, 95% CI (confidence interval)

Table 3. Incidence rates of all Head Contacts (HC) by intensities and other contact types.

	Ringette		**Ice Hockey**	
	HC Incidence Rate per 100 Team-Minutes (95% CI)			
	HC_1	HC_2	HC_1	HC_2
Level 1-3	6.4 (4.9-8.5)	2.2 (1.4-3.5)	4.6 (2.9-7.2)	1.6 (1.0-2.5)
Level 4-5	3.5 (2.6-4.7)	2.5 (1.1-5.6)	0.9 (0.4-2.1)	0.6 (0.2-1.3)
Object	0.1 (0.0-1.0)	1.2 (0.6-2.4)	0.6 (0.2-1.4)	0.3 (0.1-0.8)
Limb	0.4 (0.2-1.3)	0.4 (0.2-1.3)	1.4 (0.9-2.2)	0.5 (0.2-1.0)

Suspected Injuries and Concussions

Ringette had a 3-fold higher rate of suspected injury (IR=1.46 suspected injuries/100 team-minutes, 95% CI: 0.72-2.93) compared to ice hockey (IR=0.47 suspected injuries/100 team-minutes, 95% CI: 0.22-1.00) (IRR=3.11, 95% CI: 1.13-8.60). Although not statistically significant, based on the point-estimate, ringette had a clinically relevant higher rate of suspected

concussion (IR=0.87 suspected concussions/100 team-minutes, 95% CI: 0.34-2.24) compared to ice hockey (IR=0.19 suspected concussions/100 team-minutes, 95% CI: 0.05-0.72) (IRR=4.67, 95% CI: 0.92-23.61) and higher rate of non-concussion injury (IR=0.58 suspected non-concussion injuries/100 team-minutes, 95% CI: 0.24-1.40) compared to ice hockey (IR=0.28 suspected non-concussion injuries/100 team-minutes, 95% CI: 0.10-0.80) (IRR=2.08, 95% CI: 0.54-8.01).

DISCUSSION

This was the first known study to compare PC, HC, and suspected injury and concussion IRs between ringette and female ice hockey. Overall, we determined that ringette had a 19% lower rate of total PCs compared to female ice hockey in varsity tournament/playoff games. Given this is the first study to assess in-game PC rates in ringette and female ice hockey, it is difficult to compare the findings to literature in the same populations. However, the PC IRs observed in ringette (IR=310.38 contacts/100 team-minutes, 95% CI: 285.40-337.54) and female ice hockey (IR=382.48 contacts/100 team-minutes, 95% CI: 356.80-410.00) were comparable to that previously observed in elite U15 male youth ice hockey in 2020-21 where body checking was permitted (IR= 367.85 contacts/100 team-minutes 95% CI: 340.83-397.01).[20] The high PC IRs observed provides further support for future examination of injury in ringette and female ice hockey.

We demonstrated that ringette had almost a 2-fold higher rate of body checking PCs (level 4-5 trunk intensities) compared to female ice hockey. The explanation for the paucity of literature in ringette and female ice hockey is often attributed to policy prohibiting body checking and assuming that this minimizes injury risk. Despite this prohibition, our results show that PCs

(including body checking PCs) are still common in these sports and likely contributes to increased injury risk. This finding is consistent with Keays et al. (2014) who reported that 33.7% of ringette-related injuries reported to emergency departments resulted from intentional contact with another player. Similarly, in female ice hockey, Decloe et al. (2012) reported that body checking was responsible for 20.7% of all female ice hockey injuries consistent across all age groups (ages 9-17).

Ringette was found to have a 68% higher rate of total HCs compared to female ice hockey. The HC_1 and HC_2 rates observed in ringette are higher than previously reported in male U15 ice hockey.[21] Given these alarmingly high HC rates, our findings further support the need for additional research in this population to target the prevention of HCs in ringette and female ice hockey.

Regarding the intentionality of the contacts, ringette observed deliberate contacts 97% of the time and female ice hockey 95% of the time. This aligns with the literature that suggests many contacts in ringette and male ice hockey are deliberate in nature.[4,21] Given that many contacts are deliberate, this finding suggests that perhaps prevention strategies targeting better enforcement of rules are necessary in both ringette and female ice hockey.

Finally, we determined that ringette had a 3-fold higher rate of suspected injury compared to female ice hockey. While not statistically significant but clinically relevant, ringette was also found to have higher rates of suspected concussion and non-concussion injury. These results are consistent with the literature that report a high rate of injury and concussion in youth ringette

compared to other female team sports.[4,6] It may be postulated that the higher suspected injury rate observed in ringette is the result of the higher rates of body checking behaviours (PC level 4-5 intensities) that were observed. Research has shown that body checking is associated with higher rates of injury and concussion.[22,23] Despite policies prohibiting body checking and head contacts in ringette and female ice hockey, our results show that these behaviours are still prevalent, with only a small proportion of them being penalized. The high incidence of suspected concussion and non-concussion injuries further supports the need for additional injury epidemiology research and tailored prevention strategies in these populations.

LIMITATIONS

As with any video-analysis study, this study was limited by the quality of video. Overall, approximately 30% of the recorded games were excluded due to poor video quality. However, it is unlikely that there were systematic differences in PCs, HCs, and suspected injuries between the videos that were included compared with those that were excluded. Due to the nature of the pre-recorded videos, differences in video quality may have arisen. However, this limitation may have resulted in an underestimation of low intensity trunk impacts and other contacts, but high intensity PCs were evident and likely unaffected by video quality. Further, it is likely that PCs and HCs were underestimated in both sports due to contacts occurring outside the frame of the camera. PCs and HCs would also be underestimated as each contact is described from the perspective of the player receiving the contact, so no information about the player giving the contact is recorded. However, this would likely not be systematically different between the two sports. Another limitation is the difference in exposure time between sports due to differences in game length (ringette games=40 minutes, female ice hockey games=60 minutes). However, differences in game length were addressed in the analysis by calculating rates accounting for

playing exposure minutes. Lastly, the concussion criteria for video analysis used was designed for professional sports where they have multiple different angles and high-quality cameras. For this study, only one camera angle was used posing some challenges to the identification of suspected concussions using the same criteria. Additionally, some of the 17 video signs of concussion used (e.g., dazed) may be more difficult to assess in players wearing an ice hockey or ringette face mask. Further, the video analysis was anonymous and not linked to any injury surveillance. Future directions may consider video analysis including validation of suspected injuries and penalties using injury surveillance and game records.

CONCLUSION

In this study we demonstrated that ringette had a 19% lower rate of total PCs compared to female ice hockey, however, ringette had a higher rate of HCs (total HC, HC_1, and HC_2) and a three-fold higher rate of suspected injury compared to ice hockey. Despite rules disallowing body checking and HC_1s, the incidence of body checking and HC_1 rates were high and are rarely penalized in both sports. These findings can be used to better understand injury mechanisms in female ringette and ice hockey and to help inform future injury and concussion prevention strategies targeting high intensity PCs and HCs.

REFERENCES

1. Hockey Canada. *Hockey Canada Annual Report 2019-2020*. Accessed January 10, 2022. https://cdn.hockeycanada.ca/hockey-canada/Corporate/About/Downloads/2019-20-hockey-canada-annual-report-e.pdf
2. Ringette Canada. *Player-Registration 19-20*. Accessed January 10, 2022. https://www.ringette.ca/wp-content/uploads/2020/12/Player-Registration-19-20.pdf
3. Fridman L, Fraser-Thomas JL, McFaull SR, et al. Epidemiology of sports-related injuries in children and youth presenting to Canadian emergency departments from 2007–2010. *BMC Sports Sci Med Rehabil*. 2013;5(1):30. doi:10.1186/2052-1847-5-30
4. McCalum J, Emery C, Eliason P, et al. Lifetime prevalence and one-year incidence of sport-related concussion in adolescents. *Br J Sports Med*. 2020;54(Suppl 1):A133-A134. doi:10.1136/bjsports-2020-IOCAbstracts.326
5. Hockey Canada. *Teaching Checking*. Accessed January 20, 2022. https://cdn.hockeycanada.ca/hockey-canada/Hockey-Programs/Coaching/Checking/Downloads/teaching_checking_progression_body_checking.pdf
6. Decloe MD, Meeuwisse WH, Hagel BE, et al. Injury rates, types, mechanisms and risk factors in female youth ice hockey. *Br J Sports Med*. 2014;48(1):51-56. doi:10.1136/bjsports-2012-091653
7. Keays G, Gagnon I, Friedman D. Ringette-Related Injuries in Young Female Players. *Clin J Sport Med*. 2014;24(4):326-330. doi:10.1097/JSM.0000000000000049
8. Schick DM, Meeuwisse WH. Injury Rates and Profiles in Female Ice Hockey Players. *Am J Sports Med*. 2003;31(1):47-52. doi:10.1177/03635465030310011901

9. Dick RW. Is there a gender difference in concussion incidence and outcomes? *British Journal of Sports Medicine*. 2009;43(Suppl_1):i46-i50. doi:10.1136/bjsm.2009.058172
10. Keightley M, Reed N, Green S, et al. Age and Competition Level on Injuries in Female Ice Hockey. *Int J Sports Med*. 2013;34(08):756-759. doi:10.1055/s-0032-1327574
11. Farace E, Alves WM. Do women fare worse: a metaanalysis of gender differences in traumatic brain injury outcome. *Journal of Neurosurgery*. 2000;93(4):539-545. doi:10.3171/jns.2000.93.4.0539
12. Arnason A, Tenga A, Engebretsen L, et al. A Prospective Video-Based Analysis of Injury Situations in Elite Male Football: Football Incident Analysis. *Am J Sports Med*. 2004;32(6):1459-1465. doi:10.1177/0363546504262973
13. Gardner AJ, Kohler R, McDonald W, et al. The Use of Sideline Video Review to Facilitate Management Decisions Following Head Trauma in Super Rugby. *Sports Med - Open*. 2018;4(1):20. doi:10.1186/s40798-018-0133-4
14. Lincoln AE, Caswell SV, Almquist JL, et al. Video Incident Analysis of Concussions in Boys' High School Lacrosse. *Am J Sports Med*. 2013;41(4):756-761. doi:10.1177/0363546513476265
15. Malenfant S, Goulet C, Nadeau L, et al. The incidence of behaviours associated with body checking among youth ice hockey players. *Journal of Science and Medicine in Sport*. 2012;15(5):463-467. doi:10.1016/j.jsams.2012.03.003
16. Dartfish V 10.0. *Dartfish Video Analysis Software*.; 2017.
17. Andersen TE. Football incident analysis: a new video based method to describe injury mechanisms in professional football. *British Journal of Sports Medicine*. 2003;37(>3):226-232. doi:10.1136/bjsm.37.3.226

18. Davis GA, Makdissi M, Bloomfield P, et al. International consensus definitions of video signs of concussion in professional sports. *Br J Sports Med*. 2019;53(20):1264-1267. doi:10.1136/bjsports-2019-100628
19. StataCorp. *Stata Statistical Software: Release 17*. College Station, TX: StataCorp LLC; 2021.
20. Williamson RA, Kolstad AT, Nadeau L, et al. Does increasing the severity of penalties assessed in association with the 'zero tolerance for head contact' policy translate to a reduction in head impact rates in youth ice hockey? *Br J Sports Med*. 2021;55(Suppl 1):A86-A86. doi:10.1136/bjsports-2021-IOC.203
21. Williamson RA, Kolstad AT, Krolikowski M, et al. Incidence of Head Contacts, Penalties, and Player Contact Behaviors in Youth Ice Hockey: Evaluating the "Zero Tolerance for Head Contact" Policy Change. *Orthop J Sports Med*. 2021;9(3):2325967121992375. doi:10.1177/2325967121992375
22. Emery CA, Kang J, Shrier I, et al. Risk of Injury Associated With Body Checking Among Youth Ice Hockey Players. *JAMA*. 2010;303(22):2265-2272. doi:10.1001/jama.2010.755
23. Emery C, Palacios-Derflingher L, Black AM, et al. Does disallowing body checking in non-elite 13- to 14-year-old ice hockey leagues reduce rates of injury and concussion? A cohort study in two Canadian provinces. *Br J Sports Med*. 2020;54(7):414-420. doi:10.1136/bjsports-2019-101092