Report Regarding Immediate Proximity Associated with Body Contact in Ice Hockey

Prepared for USA Hockey

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Introduction

As part of the *Leveraging Technology to Address Player Safety and Enhance Player Development in US Ice Hockey* project, wearable sensors have been used to collect data for on-ice activities from players between the ages of 12 to 18 years old. To this end, over 15,000 sessions have been collected for on-ice activities across all of these age groups. The scope of the project has included multiple objectives, but specific to this report, a primary objective has been to quantify impacts incurred by players in practices and games to inform decisions regarding body contact and player safety. Of the more than 15,000 on-ice sessions collected, 10,793 were included in impact analysis based on rigorous data quality standards. From this impact data, some information may be inferred with regard to the amount of time youth hockey players are in "immediate proximity" that would be associated with physical contact.

Impact Characterization

As a first step to determining not only the quantity of impacts experienced by youth hockey players, but also the nature/characteristics of these impacts, a video corroboration study was performed (Pilotti-Riley, A., Stojanov, D., Sohaib Arif, M. and McGregor, S.J. *PLoS One,* 2019). Although impacts were being measured for this project, players could experience impacts due to numerous circumstances, not all of which would include other individuals (i.e. checking). Therefore, this study was performed with the use of video observation to confirm and characterize impacts identified by sensors.

In each of the studies referenced in this report, subjects consented to procedures approved by the Eastern Michigan University Human Subjects Committee. Also, in each of these associated studies, Bioharness-3 (Zephyr, MD) were used as wearable sensors and triaxial accelerometry signal was recorded at 100 Hz to identify impacts. Specifically for this video corroboration study, National Team Development Program (NTDP) U18 players wore Bioharness-3 (Zephyr, MD) wearable sensors (WS) to record occurrences of player incurred impacts (PII) during games. Impact waveforms were generated using Impact Processor (Zephyr, MD) from raw triaxial accelerometer signal sampled at 100 Hz. Players were observed using video and synchronized with game video collected by NTDP staff. Impacts identified by WS of 6–7.9 g (Z3), 8–9.9 g (Z4) and 10+ g (Z5) from the Impact Processor were used to corroborate PII. Preliminary studies indicated that impacts that fell below these thresholds were not associated with PII. Magnitude and duration of each identified impact were compared by category using MANOVA with Tukey post hoc (α= 0.05; SPSS 22.0, IBM, NY).

Event	Definition	Sub-category	Frequency (N)	% of total
Player incurred impacts	Board contact/no check	1	17	4.1%
	Board contact/check	2	74	17.7%
	Open ice check	3	202	48.2%
	Player fall	4	65	15.5%
Non-player incurred impacts	Other form of player to player event	5	19	4.5%
	Hard Stop	6	16	3.8%
	Slapshot	7	19	4.5%
	Other identifiable player event	8	6	1.4%
False positive			1	0.2%
		Total	419	100%

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Figure 1. Frequency of events observed by wearable sensors by sub-category. Pilotti-Riley, A. et al. (2019) .

On average, U18 players experienced 17.5 impacts per game. Of these impacts, 28% did not involve other players (e.g. falling on the ice, board contact, slap shot, hard stop; Figure 1). The remaining 72% of impacts did involve other individuals (teammates or opponents). The duration of these player to player interactions lasted 0.098 seconds on average (Figure 2).

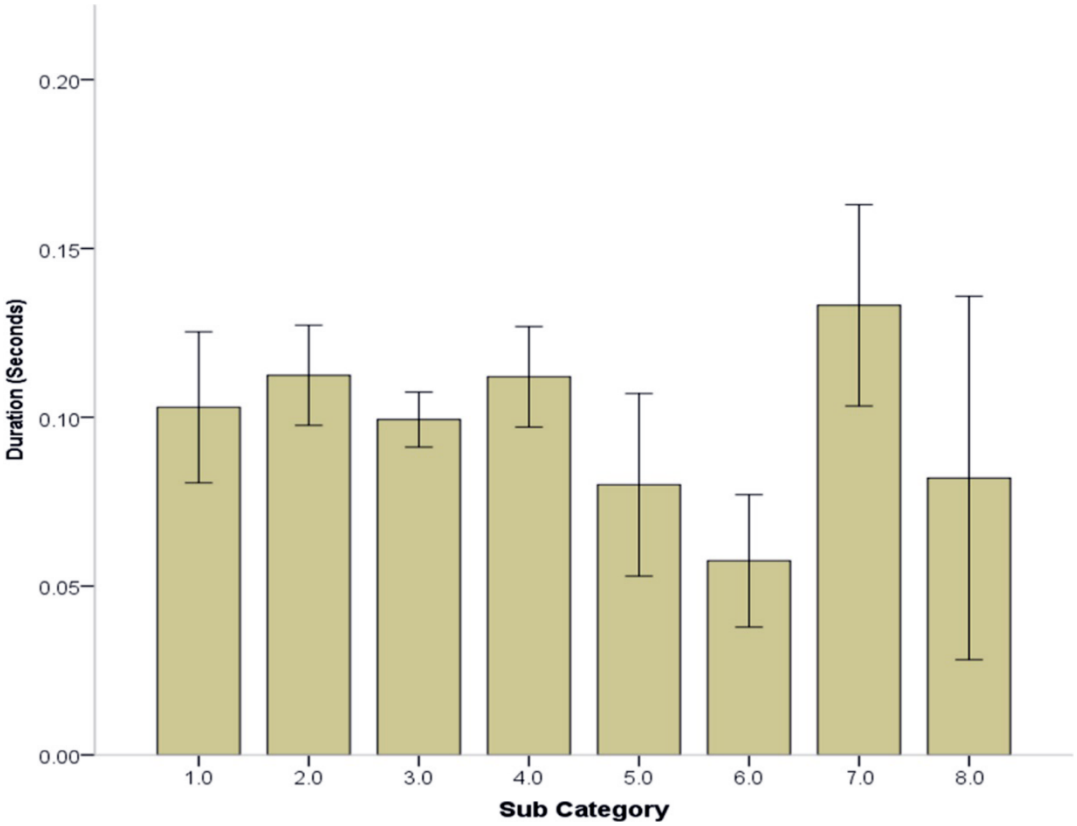

Figure 2 Mean durations of events observed by wearable sensors. Sub-category (1) Board contact/no check, (2) Board contact/check, (3) Open ice check, (4) Player fall, (5) other form of player to player event, (6) Hard Stop, (7) Slapshots and (8) other identifiable player events. Pilotti-Riley, A. et al. (2019).

Therefore, if we assume 72% of the 17.46 impacts per player with an average duration of 0.098 seconds, the duration of immediate proximity with other individuals totals 1.23 seconds per player per game. If we extend these observations to the entire data set collected as part of the larger project, this is what can be inferred with regard to impacts incurred at each level of play and the result time of immediate exposure as a result (Figure 3). As can be seen from the complete dataset, which is more robust (e.g. n= 1210 games for U18), that the inferred duration of immediate proximity is greater than determined from the video corroboration dataset, but is still less than 3 seconds for each and level.

Team/Level	Session Type	Impacts per Player per Session	Inferred Duration of Immediate Proximity (Seconds)
12 U	Game (n = 529)	13.41	0.95
	Practice (n = 376)	14.13	1.00
13 U	Game (n = 452)	15.41	1.09
	Practice (n = 322)	11.20	0.79
15 U	Game (n = 272)	10.32	0.73
	Practice (n = 176)	7.68	0.54
U17	Game (n = 1538)	34.16	2.41
	Practice (n = 3297)	20.98	1.48
U18	Game (n = 1210)	30.76	2.17
	Practice (n = 2621)	24.77	1.74

Figure 3. Impacts per player per session and inferred duration of immediate proximity. Impacts determined from triaxial accelerometry Bioharness-3 (Zephyr, MD). Duration of immediate proximity inferred from previous work (Pilotti-Riley, A. et al. (2019)). Data in preparation.

Player proximity inferred from ice rink dimensions

These data indicate the duration of time that players are in immediate proximity, but it does not provide direct evidence as to how long players are in close, but not immediate proximity. Although it is likely players are in immediate proximity for shorter periods of time than are commonly believed it cannot be determined from this data if that is the case for other distances. That being said, given the surface area of a North American ice rink, (approximately 200 ft x 85 ft = 17,000 ft^2), each player could be evenly distributed with 1,416.67 ft^2 to themselves. Of course, as a dynamic game, it is highly unlikely that players would be evenly distributed over the ice surface. A typical scenario that is more likely to be encountered in most game situations would be when one team is trying to maintain possession within the attacking zone and all players (save one goalie) are in one offensive zone. The dimensions of one team's zone (e.g. blue line to boards) are typically 75 ft x 85 ft = 6,375 ft^2. Therefore, if the zone was populated with 11 players (10 skaters and 1 goalie), the average area occupied by each player would be 579.55 ft^2 or 24 ft x 24 ft. Although players may not be evenly distributed in the zone, strategy generally dictates players maintain a structure that keeps them spread over the entire zone in relatively even proportions. This is likely the most concentrated on the playing surface players would generally be, on average, at any given time during a game. So, although hockey is a dynamic game, where players do come within immediate proximity numerous times per game, the

players are not limited to small distances and therefore may not be in close proximity for substantial amounts of time.

In conclusion, using a relatively large, robust dataset collected in ecologically valid settings (i.e. on-ice practices and games), it can be determined that youth hockey players are in immediate proximity for less than a few seconds for practices and games, regardless of age or level of play. Additional datasets will be necessary to determine duration of exposure of players at other distances, but it is plausible that the durations of exposure of ice hockey players to others in close proximity during on-ice activities is less than is commonly believed.

References

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