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Assessing Helmet Fit for Varsity Ice Hockey Athletes: A Field Intervention Study

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ABSTRACT

Background: Protective equipment is at the forefront of the discussion on reducing sports-related concussions, with the role of helmets being equivocal. Data suggest that modern helmets are not entirely protective against concussions, and ill-fitting helmets may contribute to concussions with longer-lasting symptoms. Helmet fit can be assessed via a checklist, but its application outside of youth sport is lacking. **Objectives:** The purpose of this study was to assess helmet fit and the effect of feedback for a men's (n=22) and a women's (n=20) university varsity ice hockey team across a season. **Methods:** This field intervention study used a 12-item helmet fit checklist which was divided into five categories, defining "proper fit" as meeting all criteria of the stability and size categories. Players' concussion histories and helmet fit knowledge were assessed using a survey. **Results:** The number of properly fitting helmets for males increased from 23% to 77% over the season, while remaining consistent at 50% for females. For males, 73% had an increase in overall checklist scores and 27% saw no change; 45% of females had an increase, 5% saw no change, and 50% decreased. Reported female (85%) concussion rate was double that of males (41%), but perceived knowledge of helmet fit (male=36%, female=30%) and actual knowledge (male=77%, female=85%) were similar. **Conclusions:** Feedback only had a positive effect on helmet fit for males across the season, potentially due to helmet style differences for females. Improvements to checklist criteria and scoring would increase the effectiveness of assessing fit for multiple helmet styles.

Key words: Hockey, Checklist, Feedback, Universities, Head protective devices

INTRODUCTION

Due to the adverse outcomes associated with concussions, considerable research has investigated their causes in contact sports. The majority of this research has focused on head impacts in football, given that it is the sport with the highest incidence rate of concussions in the United States (Clay et al., 2013). However, in Canada, the rates of concussion in ice hockey are the highest of all contact sports (Johnson, 2011). This is cause for concern, as Hockey Canada reported that over 549,000 individuals were registered in a hockey program at various levels in 2022-2023, placing a large number of athletes at risk for sports-related concussions (SRC) (Gough, 2024). In recent years, several changes have been made to address the SRC crisis, many in the form of rule changes, education programs, and concussion safety laws (Langer et al., 2020). From a research standpoint, protective equipment has been at the forefront of the discussion on reducing SRC, with the role of helmets being equivocal. Aside from how helmets are designed, one way in which a helmet's protective capacity against a SRC can be altered is how it fits the players who wear them. This important consideration provides rationale for the current study, whose overarching focus was to examine changes in hockey helmet fit across a season as a function of player education about helmet fit and the implementation of a standardized helmet fitting procedure.

Current data suggest modern helmets are not entirely protective against concussive injury (Gammons, 2013). One study noted that improperly fitting football helmets were a risk factor for concussions, with more concussions, and longer lasting symptoms, associated with helmets that do not fit well (Greenhill et al., 2016). Ideally, every athlete would properly wear their helmet, in a similar way to when tested in the lab, to ensure optimal protection against head impacts. Unfortunately, this is not the case, as one study found that only 30% of youth ice hockey players had a properly fitting helmet (Williams et al., 2014).

Research on bicycle helmet fit and helmet fit education programs has been ongoing since the 1970s (Bachynski & Bateman-House, 2020), however, it was not until 2014 that a validated checklist, structured using basic helmet fit guidelines (e.g., chinstrap tightness, facemask movement, and snugness), was reported in the literature that could be used to assess the fit of helmets worn in contact sports (i.e., ice hockey) (Williams et al., 2014). Williams et al. (2014) used this checklist to assess helmet fit and administered a survey

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to test helmet fit knowledge of youth ice hockey and lacrosse players. While more than 70% of players answered helmet knowledge questions correctly, only 30% (ice hockey) and 48% (lacrosse) of players met all proper helmet fit requirements (Williams et al., 2014). Unfortunately, this study was limited by a small sample size, a single data collection, and a rigid definition of 'proper fit', defining it as 'meeting all checklist requirements' (Williams et al., 2014). Seven years later, some of these limitations were mitigated by Yeargin et al. (2021), who assessed the helmet fit of approximately 150 youth football players across one season using the same validated checklist. They reported that the proportion of improperly fit helmets increased throughout the season, climbing from 71.4% preseason to 79.6% postseason. Lininger et al. (2023) further addressed the validity of the checklist by assessing helmet fit in youth football. The focus of this work was on adopting a multidimensional fit score comprised of five components (stability, snugness, size, integrity, and accessory) to determine which components accounted for variability in helmet fit checklist scoring. The results were consistent with those of William et al. (2014), in that only 24% of players' helmets fit properly. It was also found that the stability component of the checklist accounted for the most variance in helmet fit scoring. While all of the major limitations of previous research have been addressed to date, the studies have been focused predominately on male, youth, football athletes, despite the original checklist being created specifically for ice hockey and lacrosse helmets (Williams et al., 2014; Yeargin et al., 2021; Lininger et al., 2023).

Therefore, the purpose of this research project was to utilize the validated helmet fit checklist (Williams et al., 2014; Yeargin et al., 2021; Lininger et al., 2023) to assess the fit of men's and women's university varsity ice hockey athletes' helmets early (Fall) and late (Winter) in the 2023-2024 competitive season. Feedback was provided to all athletes regarding the fit of their helmets following the initial assessment. By focusing on both male and female athletes, potential sex differences in fit and helmet styles could be determined to inform whether continued education on proper helmet fit needs to differ between teams. Lastly, by focusing on players at a competitive level, the validity of the fit checklist for players who have had near complete autonomy related to helmet fit for years, could be assessed. The findings from this study will help advance knowledge of helmet fit for young adult hockey athletes and provide insight into whether continued education regarding helmet fit is required.

The following research questions were addressed in this study: i) Does providing feedback to players improve helmet fit?; ii) Are there differences in helmet fit between male and female players?; iii) Is player knowledge of helmet fit consistent with measured helmet fit?; iv) Can the checklist effectively identify improper helmet fit in high-level athletes?

METHODS AND MATERIALS

Participants and Study Design

In this field intervention study, the effect of feedback on the fit of helmets was assessed over a season for varsity ice hockey players at a Canadian university. Players were recruited from the men's (n=22) and women's (n=20) 2023-2024 teams. All players except goalies were included. Goalies were not included because their helmets were very different in design and fit. The teams had equipment managers who were responsible for the care and initial fitting of helmets, but no formal helmet fitting procedures or education about helmet fit were in place prior to this study. The mean playing history was 16.3 ± 2.6 years (men: 17.9 ± 1.7 years, women: 14.8 ± 2.5 years). Written consent was provided by each player before participation at the start of the season. Verbal consent was also provided prior to the second data collection at the end of the season. The Research Ethics Board at the University of Windsor approved the study prior to data collection.

Instrumentation: Observational Checklist

A modified version of the helmet fit checklist developed on youth hockey and lacrosse athletes (Williams et al., 2014) was used in this study. This checklist contains 12 binary criteria separated into five categories (stability, size, snugness, integrity, accessory) (Table 1) (Lininger et al., 2023). Fit was scored in two ways from checklist outcomes. 'Proper helmet fit' was defined as meeting all criteria under the stability and size categories; participants were given a binary score of 'fit' or 'not fit'. Participants were also scored out of 12 on their "overall helmet fit", based on the number of criteria they met on the checklist.

Instrumentation: Helmet fit Knowledge Survey

Participants answered a helmet fit knowledge survey comprised of questions related to helmet fit knowledge, history of concussions, basic playing background, and opinion of current helmets. Participants' knowledge was scored in two ways. First, they ranked their 'perceived knowledge' on a 5-point scale from 'not knowledgeable' to 'extremely knowledgeable'. For the purposes of this study, 'knowledgeable' participants selected either 'moderately' or 'extremely' knowledgeable. Players' 'actual knowledge' was assessed in relation to how they answered the question, "What makes a helmet fit properly?" To be defined as 'knowledgeable', the participant must have described three or more of the six criteria from the stability and size categories of the checklist (Table 1) in sufficient detail.

Procedures

Data collection occurred for both teams on two occasions (Fall, Winter) separated by approximately nine weeks during the 2023-2024 varsity season. Each data collection occurred over a period of three days. During the Fall session, each player was given a letter of information about the study and read and signed a consent form in a private space at the ice rink, before or after practice. Participants then completed the helmet fit knowledge survey, which was followed up by the helmet fit assessment using the checklist (Williams et al., 2014). Using a standardized script, participants were

Table 1. Frequency of participants (n=42) meeting helmet fit criteria across a season

Criteria	Category	Males (% [n])		Females (% [n])	
		Fall	Winter	Fall	Winter
Helmet fits head snugly on all sides	Stability	100 (22)	100 (22)	100 (20)	100 (20)
Facemask doesn't slip when pulled L/R	Stability	45 (10)	100 (22)*	70 (14)	90 (18)
Facemask doesn't slip when pulled U/D	Stability	23 (5)	77 (17)*	50 (10)	55 (11)
Helmet does not cover eyes when pressing down	Size	91 (20)	100 (22)	90 (18)	95 (19)
Helmet covers the base of the skull	Size	100 (22)	100 (22)	100 (20)	100 (20)
Crown of helmet is 1-2 fingers above eyebrows	Size	100 (22)	100 (22)	100 (20)	100 (20)
Helmet doesn't impinge neck movement	Snugness	86 (19)	82 (18)	70 (14)	100 (20)
All padding is in place	Snugness	100 (22)	100 (22)	100 (20)	100 (20)
Chin straps have equal tension	Integrity	18 (4)	36 (8)	10 (2)	0 (0)
The helmet appears to be in good condition	Integrity	77 (17)	91 (20)	90 (18)	90 (18)
All snaps and screws are in place	Accessory	95 (21)	95 (21)	100 (20)	100 (20)
All certification stickers/logos are visible	Accessory	72 (16)	64 (14)	90 (18)	90 (18)
Total overall properly fitted		23 (5)	77 (17)	50 (10)	50 (10)

Abbreviations: L- left; R- right; U- up; D- down
*$p<0.05$

instructed to put on their helmets as if they were getting ready for practice or game. Upon conclusion of the assessment, participants were provided feedback on which criteria they failed to meet and were encouraged to speak to the equipment manager regarding any structural issues (e.g., snap or screw missing) that were noted with their helmet. The procedures for the Winter data collection were the same as in the Fall, including the provision of feedback.

Statistical Analysis

Descriptive statistics in the form of percentages were calculated for the following binary variables: history of concussions (yes/no), perceived helmet knowledge (knowledgeable, not knowledgeable), and actual helmet knowledge (knowledgeable, not knowledgeable). Percentages were also calculated to assess the change in the number of participants who had properly fitting helmets across the season. Additionally, means were calculated to assess the change in overall checklist scores for both teams. Paired *t*-Tests were conducted to determine if there were differences in overall helmet checklist scores over the season. McNemar tests were used to determine the effect of feedback on late-season helmet fit. Lastly, Fisher's Exact Chi-Square tests assessed the association between helmet fit and player factors (history of concussions, perceived helmet knowledge, actual helmet knowledge). Statistical significance for all analyses was indicated by p values < 0.05. Statistics were performed using SPSS Version 29.

RESULTS

Forty-two players (male: 22, female: 20) completed both data collection sessions. On the men's team, 73% (n=16) and 27% (n=6) of players' overall checklist scores increased or did not change across the season, respectively. At the time of the Fall assessment, 23% (n=5) of players had properly fitting helmets, which increased to 77% (n=17) during the Winter assessment. Half (n=10) of the players on the women's team saw an increase in their overall checklist scores across the season, 45% (n=9) saw no change, and 5% (n=1) saw a decrease. The percentage of female players who had properly fitting helmets remained consistent at 50% (n=10) for both Fall and Winter assessments (Table 1). Feedback had a positive effect on the proportion of male players who met two criteria under the stability category at the time of the Winter assessment ($p < 0.05$), but there was no effect on female players. More than double the number of female players (85%) reported having suffered concussions previously, compared to males (41%). Males and females had similar perceived knowledge of helmet fit (male=36%, female=30%), and actual knowledge of helmet fit (male=77%, female=85%). The associations between initial helmet fit and history of concussions, perceived knowledge of helmet fit, or actual knowledge of helmet fit for both male and female players, were not statistically significant ($p > 0.05$) (Table 2).

DISCUSSION

Overall, it was found that feedback positively affected male players' helmet fit, suggesting that helmet wearing habits can change throughout a season when feedback is provided. In comparison, helmet fit for the female players was fairly consistent across the season on average, despite the higher mean concussion rate they reported. This finding differs from previous work of Yeargin et al. (2021) who found that youth male players saw a decrease in properly fit helmets, from 28.6% to 20.4%, across a football season. This difference between hockey and football may stem from the contrasting characteristics of the play between the sports, including the number of games per season and average contact force experienced during play (Van Pelt et al., 2021). With respect to overall checklist scores, both male and female players

Table 2. Association between player factors and helmet fit

	Improper Initial Helmet Fit, % (n)	Proper Initial Helmet Fit, % (n)	p
Males			
History of one or more concussions			
Yes	32 (7)	9 (2)	1.000
No	45 (10)	14 (3)	
Perceived Helmet Knowledge			
Knowledgeable	27 (6)	9 (2)	1.000
Not Knowledgeable	50 (11)	14 (3)	
Actual Helmet Knowledge			
Knowledgeable	54 (12)	23 (5)	0.290
Not Knowledgeable	23 (5)	0 (0)	
Females			
History of one or more concussions			
Yes	10 (50)	35 (7)	0.211
No	0 (0)	15 (3)	
Perceived Helmet Knowledge			
Knowledgeable	10 (2)	20 (4)	0.628
Not Knowledgeable	40 (8)	30 (6)	
Actual Helmet Knowledge			
Knowledgeable	40 (8)	45 (9)	1.000
Not Knowledgeable	10 (2)	5 (1)	

saw high rates of change across the season, highlighting the importance of assessing helmet fit and helmet structure at different times throughout a season. Nearly one quarter of male players displayed initial proper helmet fit in this study. This is similar to previous research which found that 30% of male youth hockey players (Williams et al., 2014) and 26% of male football players (Lininger et al., 2023) had properly fitting helmets. While 50% of female players displayed initial proper helmet fit in the current study, female players have been relatively underrepresented in research compared to male players. Consequently, a direct comparison to other female athletes regarding helmet fit could not be made at this time.

The most common issue related to helmet fit during the initial assessment for males and females was the facemask slipping up/down and left/right. Facemask slippage was reduced by the Winter assessment, except for females in the vertical direction (where it showed no appreciable change). The most prominent issue related to slippage across both teams was chin strap tightness. Women's chin strap fit worsened across the season, while the men's team showed a slight improvement over the same time period. The major differences in helmet fit between teams are likely a result of multiple factors, including helmet type. The players on the men's team wore visor-style helmets, and the women's helmets had cages. Cage-style helmets allow for a greater number of contact points between the helmet and players' heads due to the cage brackets and chin guard; two components that were not included as criteria in the checklist. Visor-style helmets leave the lower half of the face fully exposed, thus if the chin strap slid out of place, there would be a greater likelihood of the helmet shifting significantly on the head. Comparatively, cage-style helmets cover the entire face, making it very difficult for the helmet to shift far on the head, even when the chin strap is not securely fastened (Lemair & Pearsall, 2007). Perhaps this perception of protection and secure fit makes caged helmet wearers more likely to wear loose chin straps. Despite the fact that chin straps are intended to securely fasten a helmet to the head and that it was an issue for both teams, it was a conscious decision to exclude the criterion of chin strap tightness from this study's definition of "proper fit". Research has found that a single chin strap allows helmets to shift backwards on the head when a force is applied to the frontal region of the head, which is common in collisions (LaPrade et al., 1995). LaPrade et al. (1995) suggested that to provide proper security on the head and prevent helmet shifting in this way, a double chin strap should be used. Therefore, the role that single chin straps specifically, like those seen on all helmets in the current study, have on ensuring proper helmet fit, remains in question.

The knowledge of helmet fit for all players was greater than they perceived it to be, yet there was no statistically significant association with initial helmet fit. This aligns with previous findings from Williams et al. (2014) who reported that a high rate (70%) of youth male hockey players answered helmet fit knowledge questions correctly. Similarly, despite females having a reported concussion rate that was double that of males, there was no association with initial helmet fit, which corroborates previous findings (Williams et al., 2014). This is not entirely surprising since Liller et al. (1998) found

that knowledge of the protective capabilities of helmets was not a predictor of helmet use. Despite the lack of a significant relationship between fit and knowledge, we must continue to educate players about proper protective equipment use, while also considering other factors such as comfort. When participants in the current study were asked "Why do you choose to wear the helmet the way you do?", 59% (n=13) of males and 70% (n=14) of females cited comfort as a leading factor. This is an important finding to note, as these young adult players had near autonomy over how they wore their helmets. If proper fit is being compromised to improve comfort, the protective capacity of the helmets they are wearing may be significantly diminished. While every helmet model differs in its biomechanical performance and protective capacities, it must meet standardized criteria to be certified as safe for play (Rowson et al., 2015). The testing needed to pass this certification typically occurs in controlled lab settings where helmet fit is optimized by using a headform that maximizes the contact area of the helmet with the base of the skull, jaw, cheeks, and chin (Rowson et al., 2015). If players wish to benefit from the intended maximal protective capacities of the helmet they wear, they must adopt proper fit habits.

Lastly, the checklist criteria do not effectively identify proper helmet fit across multiple helmet types (i.e., cage-style and visor-style). Due to minimal criteria addressing several aspects of cage-style helmets, such as "cage hang" or "chin cup fit", the checklist was ineffective at assessing the entirety of helmet fit for the female athletes.

Limitations

Although this study was the first to address helmet fit across a season for male and female young adult ice hockey players, it is not without its limitations. The initial assessment in the Fall did not occur until two months after the season had started. This may have contributed to the differences in overall helmet fit scores as helmet wearing habits could have changed significantly early in the season. The accuracy of players' self-reported variables, such as concussion history, was not confirmed by injury records. Inaccurate reporting would have an effect on the association between concussion history and helmet fit. Additionally, severe head impacts during the season were not documented. While there are normal recommendations on replacing noticeably damaged helmets, there is no clear ruling on whether helmets should be replaced and/or adjusted following severe head impacts. Therefore, by not tracking their occurrence, the role that severe impacts play on helmet condition and players' wearing habits, was not considered (Swarén & Fahlstedt, 2023). Lastly, changes in hair growth and hairstyle across both assessments were not accounted for. To properly fit a helmet and maximize contact between the helmet's padding and the skull of the player, it is recommended that hair be wet to mimic sweating during gameplay (Gieck & McCue, 1980). This was not controlled during the assessments. As a result, there is the potential that changes in the amount of hair and hairstyle may have played a role in helmet fit scores.

Strengths and Practical Implications

Unique to the literature, this study utilized the helmet fit checklist of Williams et al. (2014) to assess varsity-level male and female hockey helmet fit and examine the effect that feedback had across a season. The results of this study showcase the need for providing ongoing education of helmet safety and for advancing the knowledge of helmet fit for university varsity ice hockey players. This study also offers evidence of the importance of providing regular feedback on helmet fit to players and support for adopting regular helmet fit assessments and education for the teams at the contributing institution. It is important for coaches, equipment managers, and players to recognize how helmet fit changes throughout a season, and why it is necessary to maintain adjustments to helmet fit to provide a high level of safety and to ultimately reduce concussive injuries.

CONCLUSIONS

This study aimed to assess hockey helmet fit and helmet fit knowledge over a male and female varsity ice hockey season. The findings suggest that even hockey players with sufficient knowledge about helmet fit can benefit from a helmet fit intervention. Due to the changes in fit across the season, it is recommended that regular helmet fit assessments with players take place, to address any fit or structural issues with their helmets that players may fail to recognize. The helmet fit checklist described in the current study could be administered quickly by coaches, equipment managers, athletic therapists or even by other players on a team following little training. While players can use the checklist as a tool to assess their own helmet fit, it is recommended that official scoring should not be done by the athletes themselves as their perception of comfort will likely affect how they interpret the checklist criteria. Regarding the checklist itself, a concise scoring system should be established to limit score variability due to different interpretations of proper helmet fit. Dividing the checklist into five categories was the first step towards this end (Lininger et al., 2023), however, input from equipment managers could be used to determine the degree to which each criterion directly affects helmet fit. A noticeable difference in male and female helmet fit scoring also suggests that the checklist criteria should be revised to be inclusive of all helmet types (i.e., cage-style and visor-style). Lastly, future research needs to establish a threshold, representing the minimum checklist score an individual must obtain to have their helmet classified as 'safe for play'. The results of this study highlight not only the work that is still to be done, but the importance of prioritizing regular helmet fit assessments to maximize player safety.

AUTHOR CONTRIBUTIONS

J.R. provided the initial conceptualization for the study; J.R. and D.A. developed and refined the methodology and established the data collection and analyses procedures; J.R. conducted the data collection and analyses; Supervision was provided by D.A. The manuscript was written and revised

by both authors. The final version of the manuscript was approved by both authors prior to publication.

ETHICAL APPROVAL

The Research Ethics Board at the University of Windsor approved the study prior to data collection. The research was carried out in accordance with the guidelines of the Declaration of Helsinki for human research.

DATA AVAILABILITY

Requests for data presented in this manuscript may be sent to the corresponding author for consideration.

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