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Measuring Shock Impact with Different Ice Hockey Helmets

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Abstract

Shock impact injuries in ice hockey are common, and they cause major brain injuries. Protective helmets can reduce such risks. The purpose of this study was to explore the effects of two types of helmets (with and without a cage) on shock impact to the head. The secondary purpose was to compare the effectiveness of the four different helmets from popular brands (Nike, Bauer, and Reebok), and see which one of the four helmets receives the least amount of shock impact. To test the shock impact on different helmets, they were put on a mannequin's head. The shock impact was measured by the Vibrometer App by ExaMobile on an iphone. The phone was placed inside the helmet, by the left ear of the mannequin, on the opposite side of the impact. It was hypothesized and found that the shock impact to head was less when the helmet had a cage as opposed to not. Additionally, out of the two helmets with a cage, the shock impact to head was less when Bauer IMS 5.0 brand helmet was used as compared to the Reebok 3K brand helmet. It was concluded that helmets with cages are critical, and youth ice hockey players should use caged helmets that are manufactured by Reebok and Bauer.

Keywords: Shock impact, Injury, Ice hockey, Helmet

1. Introduction

Shock impact injuries are very common in ice hockey. Shock is a sudden vibration caused by force such as impact, kick, or explosion. The shock impact is how strong the vibrations are after an impact to the body. Vibrations are measured by the amount of acceleration which is the change in velocity or speed per time interval. They can happen in many various ways, such as, body checking, back checking, fighting, getting hit by a puck, and more. Not many people understand that head injuries are very dangerous and can even, rarely, cause death. In this study, prevention methods were examined, specifically types of helmets that reduce shock impact to help ice hockey players decide on their helmet choices.

A concussion is a type of brain injury that can be caused by a direct blow to the head. It is also known as a Mild Traumatic Brain Injury. This type of brain injury has the power to interfere with how the brain works, such as, loss of memory, judgement, reflexes, speech, balance, coordination, and sleep patterns (McCrory, Meeuwisse, Aubry, 2013). The brain is made of a soft tissue and is cushioned by spinal fluid. It is encased in the hard protective skull. When a person gets a head injury, the brain can slosh around inside the skull and even bang against it. This can cause bruising of the brain and torn blood vessels (Rechel et al., 2008). In most cases, consciousness is not common. Concussions are a potential negative outcome, which can cause a great number of movements of the brain or jarring. The most common signs of a concussion are headaches, dizziness, confusion, disorientation, and blurred vision (McCrory et al., 2009). Sports medicine researcher Guskiewicz and his colleagues (2000) found that the rate of loss of consciousness and headaches, in 1019 cases, were 8.9% and 86%.

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Concussions are very common. About 3 million US citizens have concussions per year. Currently, 5.3 million Americans need long term, or lifelong, help with daily life activities, due to this brain injury (Center for Disease Control and Prevention. 2009). The Center for Disease Control and Prevention estimates about 207-830 emergency room visits per year during the years of 2001-2005. During those same years, there were 1.6-3.8 million emergency room visits in the United States. In the years 2007-2013, Emergency room visits for traumatic brain injuries increased by 47%. But hospitalization decreased by 2.5% and death rates decreased by 5%. In 2012, 329,290 children were treated. A researcher named Benson studied and found that team physicians reported, in the US, concussions and TBI (Taylor, Bell, Breiding, Xu, 2017). Also, there were 559 concussions during regular season games with an estimated rate of 1.8 concussions per 1,000 player hours. This is how often a concussion happens.

Many people who have concussions can experience post-concussional symptoms, such as headaches, dizziness, fatigue, impaired focus, and an increased sensitivity to light and sound. Symptoms usually stop within a few weeks, but, in a small proportion of individuals, they can last longer and can be responsible for prolonged changes in cognitive function (Toy et al., 2014). While rare, a second concussion before the brain has had a chance to recover can cause life-threatening brain swelling, and repeated concussions could cause progressive cognitive decline. lso, after a concussion, it is recommended that you avoid your triggers (a trigger is an activity that increases symptoms), get some sleep, rest your brain, and rest your body.

1.1 Why is studying concussion in sports important?

Sports are a huge part of the American lifestyle and has been throughout our history. Repetitive concussion in sports is associated with brain injuries such as second impact syndrome (Tator et al., 2019), metabolic brain vulnerability and chronic traumatic encephalopathy (Musemici et al., 2019). Therefore, studying concussions is very important in reducing such injuries. Different groups, including athletes, parents and advocacy groups raised their concerns regarding the safety of athletes. However, research that studies concussion and its long-term effects is still limited (O'Halloran et al., 2022). Additionally, more research is needed to explore prevention strategies. Eliason et al.'s (2023) meta-analyses indicated that preventive strategies include using mouthguards, disallowing bodychecking in child and adolescent ice hockey, limiting contact in practices, implementation of neuromuscular training warm-up programs. However, this meta-analysis did not mention types and brands of gears that reduce concussion and TBI. All these studies about brain and head injuries bring awareness to the people playing a certain sport and let them play safe. These tests are not only for professionals, but also for amateurs (Center for Disease Control and Prevention, 2010).

Brain injuries happen in ice hockey in many ways. One way is body checking. Body checking is a useful skill in winning hockey games but is a major risk for injury. Body checking is not illegal in the NHL, but using hands and the stick to hit others is illegal and will cause a penalty. Also delivering a check to a player without the puck is illegal. Researcher Agel et al. (2007) found that the highest amount of game injuries, about 50%, resulted from body checking. It is also 86% of injuries for 9–15-year-olds. Some leagues, not professional ones, do not allow contact. Players in contact leagues are 4 times more likely to be injured, and 12 times more to get fractured than non-contact leagues. Among the 9–15-year-olds, 45% of injuries are caused by legal checks and 8% is caused from illegal checks. Now, hockey pucks are worse. A fan during an NHL game was hit by a hockey puck because it went flying above the boards and hit her. This shows how dangerous a hockey puck can be once hit in the face (Cusimano et al., 2011; Macpherson et al., 2006).

1.2 Injury prevention in ice hockey

Brain injury prevention has always been a topic in ice hockey. In fact, hockey players have an advantage in protecting their head and neck. One advantage is the slickness of the ice. If the body of the player can slide when striking the ground, it deflects the energy that might have otherwise caused the spine to be jarred or jammed if the body could not move upon impact. Also, unlike football, there is no head-to-head contact in ice hockey (Andrews & Yaeger, 2013). Protective gear such as helmets and mouthguards have been recommended over the years. A

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mouthguard is a device that helps protect the teeth and gums. Helmets are best for preventing skull fractures and direct injury to the head. Any player who makes a hard impact with the ice or a player should be examined. They have not shown how to completely prevent concussions, but how to reduce it (Pedersen et al., 2014).

There are many different types of ice hockey helmets. There are ones with cages, half visors, full visors, and simply ones with no cages at all. The most popular brands are Bauer, Reebok, Easton, and CCM. The gear that most professionals wear is Bauer. Each helmet brand is unique in their one way. The Easton E700 weighs 12.2 oz, has a polycarbonate shell, and has a width of 8.31 in. The Reebok 11K weighs 520 grams, has an aerodynamic plastic shell, and has tool free size adjustability. These are just a few of many different types of helmets out there, but this shows that each helmet is different in their own way and is useful in their own way. There have also been studies and tests on ice hockey helmets. In 2011, Virginia Tech University researchers, Cusimano et al., set up an impact test on 38 different types of ice hockey helmets. After they tested each one, they rated each helmet on a scale from 0-5, 5 being the best. They found out that the Bauer Re-Akt 100, which sells for $269.99, received the highest rating of 5.

1.3 The problem statement and hypotheses

Shock impact injuries, especially head injuries, are very dangerous and common in ice hockey. Protecting hockey players' head and neck is very critical to injury prevention. Although hockey players are required to use protective gear such as helmets, the effectiveness of different types of helmets is still being researched (Eliason et al., 2023). There are many different types of ice hockey helmets. The purpose of this study is to explore the effects of two types of helmets (with and without a cage) on shock impact to the head. The secondary purpose is to compare the effectiveness of the four different helmets from popular brands (Nike, Bauer, and Reebok), and see which one of the four helmets receives the least amount of shock impact.

The first hypothesis is that the shock impact to the head is less when the helmet with a cage is used as opposed to when the helmet without a cage is used. The reason is that the cage increases the weight of the helmet, therefore the impact lessens. The second hypothesis is that, out of the two helmets with a cage, the shock impact to head is less when Bauer IMS 5.0 brand helmet is used as compared to the Reebok 3K brand helmet is used. The reasoning is that Bauer IMS 5.0 has a thicker interior padding made of dual density foam. It has a bigger and longer ear protector and a bigger chin protector. Therefore, it should absorb more impact, and the resulting shock impact should be less. Also, Cusimano et al.'s study (2011) supports this prediction.

2. Materials and Methods

Materials used for this experiment were as follows: Neewer Pro Photography Studio Kit: 7.8ft/2.4M, 2 sand bags, HAIREALM Head Bald Mannequin Head, vibrometer App, CAP Barbell 10 -Pounds Kettlebell, 49-strand Cable Vinyl Coated 7x7 Stainless Steel Kit 30 ft 275lb, 1.2mm W/10 1.4mm Crimps, Carabiners, iPhone 12s. Three types of helmets that were compared were Reebok 3k, Bauer IMS 11.0, Bauer IMS 5.0, and Nike Bauer NBH1500S. Two of these had a cage (Reebok and Bauer 5.0). A more detailed description of these helmets is in Table 1.

Table 1. The Description of Four Different Helmets Tested in The Experiment

Helmet Brand/Name	Cage or No Cage	Shell/Interior Padding
Reebok 3k	Has Cage	Aerodynamic Shell
Bauer IMS 11.0	No Cage	High-density polyethylene
Bauer IMS 5.0	Has Cage	Dual-Density Foam
Nike Bauer NBH1500S	No Cage	VN Foam

2.1 Procedure

This experiment was done in the backyard of a house with a balcony on the second floor (See Figure 1). The helmets were placed on the mannequin's head in the backyard, 20 feet away from the edge of the balcony. A cable from the balcony was attached to the fence behind the mannequin to create tension. A kettlebell was placed on the

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cable and a rope was attached to pull the kettlebell back to the balcony. Right in front of the fence was the mannequin attached to the tripod, which was secured by three sandbags which was 50 pounds.

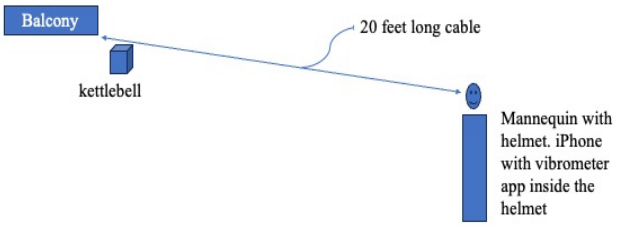

Figure 1: Illustration of the experimental set-up

Next, the experimenter made the beginning part of the rope go through the 10-pound kettlebell. When ready, the research assistant released the kettlebell from the balcony, and it started to slide across the rope. It finally hit the helmet on the mannequin within seconds.

The shock impact was measured by the Vibrometer App by ExaMobile SA (www.examobile.com) on an iphone 12s. This app measures the strength of the vibrations (i.e., acceleration) of the body or object. Acceleration is the change in velocity or speed per time interval. The meter per second squared (m/s^2) is the unit of acceleration in the International System of Units (SI). As a derived unit, it is composed from the SI base units of length, the meter, and time, the second. The iphone was placed inside the helmet, by the left ear of the mannequin, on the opposite side of the impact. After the kettlebell hit the helmet on the mannequin's head, the experimenter looked at the iphone, recorded the shock impact on my notebook and took a screenshot. The experimenter repeated this procedure 4 times per helmet (16 trials) and 4 times with no helmet (20 trials in total).

3. Results

The results are shown in Table 2 below. There were 4 trials per helmet, and 4 trials with no helmet (20 trials in total). The experimenter took an average of 4 trials per helmet. The average shock impact for helmet Reebok 3k was 12.8 m/s^2, for helmet Bauer IMS 11.0 was 17.6 m/s^2, for Nike Bauer NBH1500S was 16.0 m/s^2, and for helmet Bauer IMS 5.0 was 11.6 m/s^2. The average shock impact was 21.2 m/s^2 when there was no helmet. Therefore, the average for helmets with a cage (Bauer IMS 5.0 and Reebok 3k) was 12.2 m/s^2, whereas the average for the helmets without a cage (Bauer IMS 11.0 and Nike Bauer NBH1500S) was 16.8 m/s^2.

Table 2. The shock impact factor for each trial.

Helmet Type	Trial 1 (m/s^2)	Trial 2 (m/s^2)	Trial 3 (m/s^2)	Trial 4 (m/s^2)	Average (m/s^2)
Reebok 3k	12.6	13.1	12.8	12.5	12.8
Bauer IMS 11.0	17.9	17.5	17.8	17.0	17.6
Nike Bauer NBH1500S	15.6	16.9	15.2	16.3	16.0
Bauer IMS 5.0	11.3	11.3	11.7	12.2	11.6
No Helmet	23	21.8	19.8	20.1	21.2

A statistical analysis using SPSS (Statistical Package for Social Sciences V.23) was run. Specifically, a One-way ANOVA was run to compare the 4 types of helmets. The results showed that Reebok 3k and Bauer IMS 5.0 had less shock impact than the other two helmets ($F(4,15) = 63.2$, $p<.001$, effect size eta-square = .94) (See Table 3). Since the p-value (i.e., the level of statistical significance) was below the threshold of significance (typically $p < 0.05$), therefore the null hypothesis was rejected, the alternative hypothesis was supported.

Table 3. Summary of the ANOVA analysis

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	180.577	4	45.144	63.198	.000
Within Groups	10.715	15	.714		
Total	191.292	19			

When the average value of helmets with cage (12.2 m/s^2) and without cage (16.8 m/s^2) were compared using a t-test, the results showed that the shock impact was less with helmets with cage ($t(14) = 8.37$, $p<.001$). Additionally, t-test analysis showed that Reebok 3k with cage had more shock impact than Bauer IMS 5.0 with cage ($t(14) = 7.44$, $p < .05$). These results provided support for both hypotheses.

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4. Discussion

It was concluded that helmets with a cage resulted in less shock impact than helmets without a cage. Therefore, a cage is an important prevention gear in ice hockey. Out of the 4 helmets, Reebok 3k and Bauer IMS 5.0 (caged helmets) were the most effective in absorbing the shock. Furthermore, as predicted, Bauer IMS 5.0 was shown to be more effective in protecting from shock impact. It is suggested that youth ice hockey players should use caged helmets that are manufactured by Bauer.

There are some limitations in this experiment. First, tension on the cable may not always be the same. In future experiments, tension on the cable should be tested to ensure equal tension in each trial. Second, the force from the kettlebell may be less than the force in an ice hockey game. Therefore, in future experiments, forces that mimic reality can be used. A higher number of trials would improve the strength of this experiment. Additionally, different measurement devices should be used to test the shock impact in comparison to Vibrometer to test its validity. Finally, future studies should test the validity of the results by examining the variety of helmets and diverse playing conditions.

The results of this experiment have important implications. First, it is recommended that ice-hockey athletes should wear caged helmets to reduce injury. Second, Reebok 3k and Bauer IMS 5.0 brands are preferrable.

References

Agel, J., et al. (2007). Descriptive epidemiology of collegiate women's ice hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 2000-2001 through 2003-2004. *Journal of Athletic Training,* 42(2), 249-254.

Andrews, J., & Yaeger, D. (2013). *Any Given Monday: Sports injuries and how to prevent them, for athletes, parents, and coaches: Based on my life in sports medicine*. New York: Scribner.

Center for Disease Control and Prevention. Heads up: concussion in youth sports. Published December 8, 2009. Accessed May 5, 2010.

Cusimano, M. D., et al. (2011). Effect of bodychecking on rate of injuries among minor hockey players. *Open medicine: a peer-reviewed, independent, open-access journal*, *5*(1), e57–e64.

Eliason, PH., et al. (2023). Prevention strategies and modifiable risk factors for sport-related concussions and head impacts: a systematic review and meta-analysis. *British Journal of Sports Medicine*, 57, 749-761.

Macpherson, A., Rothman, L., & Howard, A. (2006). Body-checking rules and childhood injuries in ice hockey. *Pediatrics*, *117*(2), e143–e147.

McCrory, P., et al. (2013). Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. *British Journal of Sports Medicine, 47*, 250-258.

McCrory, P., et al. (2009). Consensus statement on concussion in sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. *Journal of athletic training*, *44*(4), 434–448.

Musumeci, G., et al. (2019). Concussion in Sports. *J. Funct. Morphol. Kinesiol. 4*, 37. https://doi.org/10.3390/jfmk4020037

O'Halloran, P.J., Kontos, A.P. & Collins, M.W. (2022). Concussion and Sport: Progress is Evident. *Sports Med,* 52, 2803–2805.

Pedersen, H. A., et al. (2014). Neuropsychological factors related to college ice hockey concussions. *American journal of Alzheimer's disease and other dementias*, *29*(3), 201–204.

Rechel, J. A., Yard, E. E., & Comstock, R. D. (2008). An epidemiologic comparison of high school sports injuries sustained in practice and competition. *Journal of athletic training*, *43*(2), 197–204.

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ISSN 2688-3651 [online]

Tator, C., et al. (2019) Fatal Second Impact Syndrome in Rowan Stringer, A 17-Year-Old Rugby Player. Can. *J. Neurol. Sci.*, 4, 1–4.

Toy, O., Etienne, M., & Bogdasarian. R. (2014). Consequences of traumatic brain injury in male ice hockey players. *Neurology*, 82, 319-330.