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Original Article

Differentiation between checks to the head or neck as a primary cause of mild traumatic brain injury in ice hockey in Slovakia

SILVIO PARNIČAN[1], PAVOL PERÁČEK[2], IGOR TÓTH[3]
[1,2,3]Department of Sports Games, Faculty of Physical Education and Sport, Comenius University in Bratislava, SLOVAKIA

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Abstract
The objective of the research was to deepen and expand the knowledge about checks to the head or neck in Slovak ice hockey,and its differentiation. Our source of information was the pedagogical practice itself; various regular season games across four ice hockey leagues in the 2019/2020 season in Slovakia.However, considering the safety and protective measures due to the COVID-19 pandemic, the season was terminated prematurely.We conducted an indirect observation of the ice hockey games recorded on data storage available in the records of the Slovak ice hockey federation. We recorded 81 incidences of checks to the head or neck in 1,297 games.To prove the statistical significance, we used the z-score test for 2 proportions ($p \leq 0.01$). We showed that thezone where the majority of head or neck checks occuris the area along the boards (zone 1) with a relative value of 59.26% ($p<0.01$).The playingposition of forward (67.90%) has proven to be significantly the most risky for being checked to the head or neck ($p<0.01$). Ultimately, we confirmed an assumption, that checking to the head or neck will most commonly happen just prior to or right after receiving a pass, or while passing or shooting the puck. A statistically significant majority of incidences of head or neck checksoccurred up to two seconds after the checked player received the puck ($p<0.01$). In 20.99% ofhead or neck checks, the checked player wasn't in control of the puck. In comparison to other researches (Hutchison, Comper, Meeuwisse and Echemendia 2015a, 2015b; Kuhn and Solomon 2015 etc.) aimed at National Hockey League(NHL) or Collegiate ice hockey leagues in North America, despite the differences in the ice hockey rink dimensions, the level of the game performance of the teams and players and the number of one-on-one battles, we are stating a similar proportion of observed variables. According to the obtained data, we recommend the progressive development of visual perception through an increase of the frequency of the utilization of game-based drills and small-sided games with modified rules and the highest possible number of one-on-one battles in training practice. It is necessary to require an absolute overview (game sense)of a game from players, an associative solution along with a productive solution of the game situation. We also recommend an interdisciplinary cooperation of competent scientific disciplinesin an effort to detect new knowledge and information on this topic.
Key words:ice hockey, physical game,head impacts, concussion, potential cause of injury

Introduction

Mild traumatic brain injury (mTBI) currently presents aglobal issue negatively affecting the health and the level of individual game performance of players. If there issome knowledge and information about theextent of its occurrence available, it is our duty to make amaximal effort to deepen and expand it.Ruhe, Gänsslen and Klein (2014) state that 2-7% of all injuries in European ice hockey leagues lead to concussion. As amatter of fact, research activity in the field of this topic in Europe is insufficient, in particular if compared to North America, the place where the evolution of ice hockey began and where the research engaged in this problem is most extensive (Theadom, Mahon, Hume, Starkey, Barker-Collo, Jones, Majdan and Feigin 2020; Pfister, Pfister, Hagel, Ghali and Ronksley 2016; Ruhe, Gänsslen and Klein 2014).The lack of this information is alarming, mainly in countries of Central Europe, where ice hockeyis one of the most popular sports, especially in Slovakia or the Czech Republic. According to the Slovak ice hockey league/Slovakia Hockey (2020), in Slovakia with 5.5 million of populationthere are 11,502 registered players of ice hockey. 8,554 players are included in U20 category and younger and 631 players are females. There are 102 ice hockey clubs in total, 61 covered and 17 outdoor ice hockey rinks. Despite the differences in the ice hockey rink dimensions, it is practicable to apply outcomes and knowledge from studies based in USA and Canada for European ice hockey rink dimensions.

Besides American football, basketball and baseball, ice hockey is one of the most popular sports in North America and according to American Academy of Pediatrics/Committee on Sports Medicine and Fitness (2000) and Bawa, Brussoni, De Gagne, Han and Smith (2004), more than 820,000 athletes are exposed to physical activity through ice hockey, but also annually exposed to ahigh risk of severe injury.Thereport from the

Corresponding Author: SILVIO PARNIČAN, E-mail: 26silvio@gmail.com

Emergency Department Injury Surveillance System have shown ice hockey as acontact team sport with the highest number of injuries and 43% of this total were head or neck injuries. It is proven that 75% of injuries occur without breaking the rules (Brust, Leonard, Pheley and Roberts 1992; Emery, Hagel, Decloe and Carly 2010/b). Ice hockey is a sport game characterized by high speed skating and dangerous battles and blows directed to the head area are not infrequent (Aguiar, Potvin, Yang, Hua, Bruschetta,Virani and Robinovitch 2019). Theprimary cause of head injuries is sport (Maas, Menon, Adelson, Andelic, Bell and Belli et al. 2017). and the most common type of head injury, ismTBI or literally concussion. Härgestam (2016) defines amTBI as atrauma in thecentral nervous system, occurring instantly after the blow due to an external force.Zeman and Krškaet al.(2014) state, the external force is known as the initial blow. The external force can be linear, rotational or a combination of two stated forces, known as 'angular forces'. According to Kalichová and Lukášek (2019), high angular acceleration is more threatening than linear acceleration.

Sports such as rugby, American football and ice hockey cause the highest number of mTBI witha pooled rate of 1.2 injuries per 1000 athlete exposures (AE) (Pfister, Pfister, Hagel, Ghali and Ronksley 2016). Buckley, Bryk, Van Pelt, Broglio, East, Zuckerman and Kuhn (2019) examined the impact of concussion on the individual game performance of an ice hockey player in the NHL. These authors found out that NHL players who suffered concussion, did not show adecreased level of individual game performance after their return. Kuhn, Zuckerman, Totten and Solomon(2016) agree with this claim. However, no study, except for the study of Eliason, McKay, Meeuwisse, Hagel, Nadeau and Emery (2020) has as yet examined concussion and performance of the player at youth level. These authors suggest that the Hockey Canada Skills Test (HCST) is a reliable method of measuring on-ice sports-specific skills in youth hockey players.

Donaldson, Li and Cusimano (2014) claim, that as a consequence of injury, more than 50% of all players miss at least one game of the regular season. Hutchison, Comper, Meeuwisse and Echemendia (2015a),and Benson, Meeuwisse, Rizos, Kang and Burke (2011) state that the number of concussions in the NHL is between 5.8 to 6.1 concussions/100 games. It is important to note that forwards suffer disproportionately more concussions (65.50%) in comparison to defensemen (32%) or goaltenders (3%) at an average absence of 6 days of training per injury. Based on the studies relating to the incidence of concussion and its parameters in the NHL, Hutchison, Comper, Meeuwisse and Echemendia (2015a, 2015b) state, that majority of concussions are recorded in the first period of games (47%), in the defensive zone (45%), along the boards (53%), after physical contact of players (checking) (85%), after shoulder impact (42%) and a significant majority of the head impact occurs by a blow to the lateral side of the head.

Compared toNorth America, there is alack of the research in this field of topic in our country and countries of Central Europe. This is the reason why all new obtained knowledge and information in this sphere is of high value. We also have the opportunity to compare acquired data in consideration of the differences in the ice hockey rink dimensions, level of game performance of teams and individuals inNorth America and Central Europe. All of the distinctions are reflected in the different character and pace of the game. Checking to the head or neck is, according to the rules of ice hockey in Slovakia, assessed either as aminor and misconduct penalty or major and automatic game-misconduct penalty or amatch penalty (Slovenský zväz ľadového hokeja; International Ice Hockey Federation 2018), depending on the discretion of the referee, but every single action when the player who directs ahit of any sort, with any part of his body or equipment, to the head or neck of an opposing player or drives or forces the head of an opposing player into the protective glass or boards is assessed as apenalty for checking to the head or neck (Slovenský zväz ľadového hokeja; International Ice Hockey Federation 2018).

Material and Methods

The objective of the research will be to deepen and expand the knowledge about checking to the head or neck in ice hockey in Slovakia and its differentiation.

Research hypotheses:

1. We assume, that we will record a significantly more incidences of checks to the head or neck in zone 1 in comparison with zone 2 and zone3.
2. We assume, that we will record significantly more incidences of checks to the head or neckon forwards in comparison to defensemen.
3. We assume, that we will record significantly more incidences of checks to thehead or neck in the first time section of the puck possession of the checked player in comparison with the other time sections.

The research was aimed at observation, recording and differentiation of incidences of checks to the head or neck representing an extremely high-risk of a case of mild traumatic brain injury. The research was carried out ex post facto.

Head or neck checks were the object of observation within one regular season (2019/2020) in four leagues. Two senior leagues (Tipsport League, Slovak Hockey League) and two youth leagues (U20, U18). The average ages of the players in the separate leagues were: Tipsport League, 26.95 years, Slovak Hockey League, 24.36 years, U20, 18.78 years, U18, 16.65 years.The total number of games played in the observed leagues was 1,297. The total number of games, in which head or neck checks were recorded was 79 which is 6.09% of the

total. The initial age category where checking (of any kind) is allowed according to Slovak ice hockey rules is U13. Due to this fact we expect minimal differences in the pace of play and the frequency of physical contact between senior categories and youth categories (U20, U18).It is necessary to state, that research was restricted by the safety and protective measures due to the COVID-19 pandemic. The season was terminated prematurely at the beginning of March 2020. We selected 4 different leagues in order to record the widest research group possible.

The main method of obtaining research data was the indirect observation of time sections of games with an incidence of head or neck checks. Obtained data was collected from accessible game sheets onthe official website of the Slovak Ice Hockey Federation and game records available on data storage available in the Slovak Ice Hockey Federation's records. The record sheets were designed for each specific head or neck check. Incidences of checks to the head or neck were recorded and differentiated based on the following criteria:

The first criterion was the location of observed incidences of checks to the head or neck according to the separate zones of the ice hockey rink based on the graphic model seen below (Figure 1) with following variables: Zone 1, Zone 2 and Zone 3.

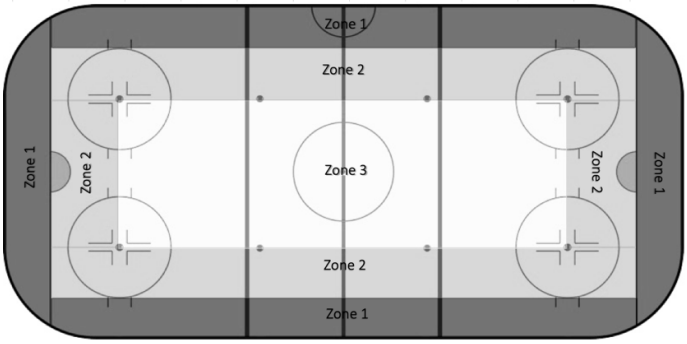

Fig. 1 The graphic model of the ice hockey rink showing zones with the assumed difference in the number of incidences of checks to thehead or neck.

The next criterion was the playing position according to its elementary distribution: forward, defenseman and goaltender.

The third criterion was the time section of the checked player's puck possession from the moment of receivinga pass to the time of the head or neck check. This criterion was divided into three variables: the time section when the player receives the pass (0-2 sec); the time section when the player has the puck under control (2.01 sec and more); the time section prior to receiving or directly after passing or shooting the puck (player is not in control of the puck).

The z-score test of two proportions was used to compare the acquired data and to evaluate the statistical significance. The selected level of significance was 1% ($p \leq 0.01$).

Results

The occurrence of checks to thehead or neckin terms of location

The total number of incidences of checks to the head or neck, obtained during one season in four observed leagues was 81. Displayed inFigure 2, the most head or neck checks occur in zone 1. The difference between the number of head or neck checks in the separate zones was shown as statistically significant ($p<0.01$) except in the comparison of zone 2 and zone 3.

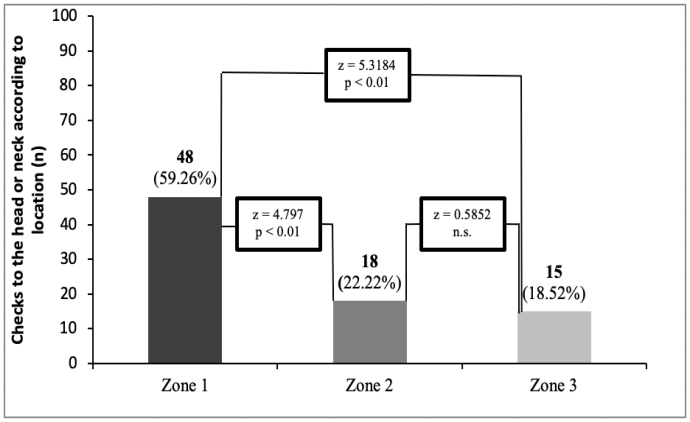

Fig. 2 The number of checks to thehead or neck according to location in the separate zones of the ice hockey rink

The occurrence of checks to thehead or neck according to playing position

The proportionality of separate incidences ofhead or neck checks according to playing positions is displayed in figure No. 3 below. Forwards were checked 55 times, 67.90% of the total number of 81. The difference in the incidence of head or neck checks according to playing positions was shown as statistically significant ($p<0.01$).

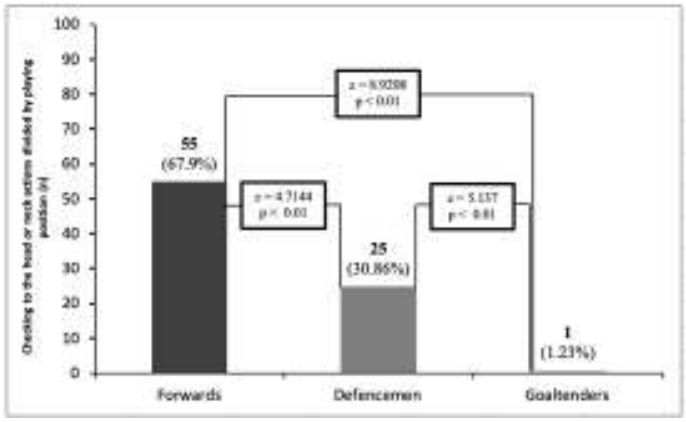

Fig. 3 The number of checks to thehead or neck according to playing positions

The occurrence of checks to thehead or neck in terms of the length of time the checked player has possession of the puck from the moment of receiving a pass to the moment of impact

Significantly the highest incidence ($p<0.01$) of head or neck checks as shown in Figure 4 were recorded in the first time section: 0-2 sec (62.96%).When comparing the first variable (0-2 sec) to the second (2.01 sec and more) and third variable (no puck possession), the differences were statistically significant ($p<0.01$). The difference between the second variable and the third variable was not shown to be statistically significant (n.s).

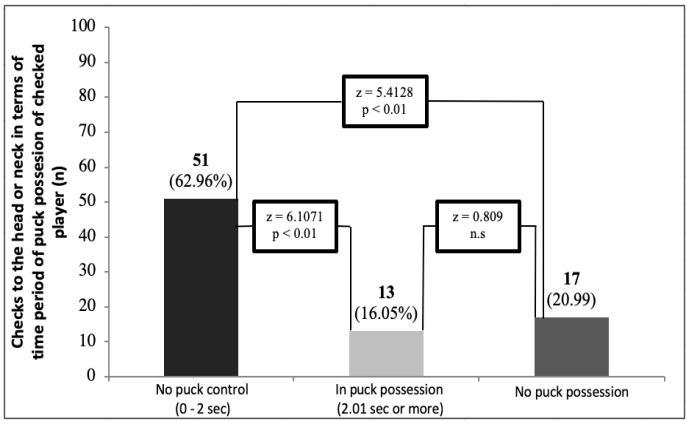

Fig. 4 The number of checks to thehead or neck in terms of the length of time the checked player has possession of the puck from the moment of receiving a pass to the moment of impact.

Discussion

Head or neck checks in ice hockey were shown to represent the highest risk of suffering mTBI and that they are determined by numerous factors with numerous variables including the zones of the ice hockey rink, playing positions, time sections relating to the player's control of the puck, such as when a player is receiving a pass, the player is controlling the puck or whenthe player is shooting or passing. In the game of ice hockey we differentiate standard game situations (face-off, penalty shot etc.), unique game situations (2 on 0 etc.) and not least typical game situations (1 on 1, 2 on 1 etc.).Players of different playing positions usually play and deal with typical game situations in specific zones for their playing position for most of their ice time (time spent on the ice during the game). That is the reason why different playing positions have varying levels of exposure tohead or neck checks and injuries generally.Equally, in different zones, there are also varying levels of exposure of players tohead or neck checks.

The assumption of hypothesis No. 1 was the significantly highest incidence of head or neck checks in zone 1 based on the graphic model of the ice hockey rink (Figure 1). This assumption was confirmed in relative value – 59.26% ($p<0.01$). The assumption was based on the character of the game and the reality that there is thehighest incidence of one-on-one battles along the boards. Findings obtained in the study of Hutchison, Comper, Meeuwisse and Echemendia (2015a) agree with this claim. According to this collective of authors, 53%

of concussions in NHL occur along the boards. Aguiar, Potvin, Yang, Hua, Bruschetta, Virani and Robinovitch (2019) confirmed the highest incidence of head impacts around the perimeter in the same manner. As stated in their study, of the total number of head impacts (449), 273 (60.80%) occurred along the boards. Tuominen, Stuart, Aubry, Kannus and Parkkri (2017), in the study from the World Championship and Winter Olympic Games states to the contrary, that the majority of injuries related to concussion (55.80%) occur without the player being in contact with boards.In this case, it is highly questionable to what extent the differences in the ice hockey rink dimensions affected the results. From the point of view of the incidence of checks to the head or neck in zone 2 (22.22%) and in zone 3 (18.52%), there was not a significant difference registered on 1% level. Aguiar, Potvin, Yang, Hua, Bruschetta, Virani and Robinovitch (2019) recorded 11.60% of a total number of head impacts in the central part (open ice) of the ice hockey rink.

Assumption ofhypothesis No. 2 was based on knowledge from available studies and from predictabilities resulting from the character of thegame. If we consider to what extent are our three criteria related, we will be able to substantiate the assumption of hypothesis No. 2, that checking to the head or neck primarily occurs when the player is not ready forphysical contact (prior to, while and after receiving a pass, after the passing or shooting etc.).Such asituation occurs mainly after the game transition during the breakout start with organized defence of the opponent. The results obtained in Hutchison's, Comper's, Meeuwisse's and Echemendia's (2015a) study correlates with this claim to some extent. He identifiesthe offensive playerskating with the puck out of the defensive zoneas a situation where the player is at risk of a head or neck check,also after some other game combinations such as shooting through the defending player etc. Offensive players are in such situations more often and this indicates the statistically significant difference between the incidence of head or neck checks on forwards (67.91%) and defensemen (30.86%) in our research. Asimilar conclusion is stated by Adams, Li, Dai, Haider, Lau, Cheung, Post, Gometz and Choudri (2018) who present the relative value (58%) of concussions suffered by forwards.In areview of the number of studies aimed at the incidence of concussion in the NHL, Kuhn and Solomon (2015) present the studies that have shown similar proportionality of head impacts. In Benson's Meeuwisse's, Rizos's and Burke's (2011) study, forwards suffered 63.90% head injuries of atotal number, defensemen 31.60% and goaltenders 4.49%.Hutchison, Comper, Meeuwisse and Echemendia (2015a) present the following numbers in his study: forwards 65.50%, defensemen 32%, goaltenders 2.54%. Wennberg and Tator (2003): forwards 62.20%, defensemen 35%, goaltenders 2.76%.

In hypothesis No. 3, we assumed the significant dominance of part of the game situation, when the player is receiving a pass (0 – 2 sec) compared toother time sections. With its relative value 62.96% and proving statistical significance ($p<0.01$), we confirmed hypothesis No. 3.We did not prove the statistically significant difference between 2nd and 3rd variable of 3rd criterion (n.s.). We showed the high relative value of 3rd variable (20.99%), when the player did not have the puck under control. Hutchison, Comper, Meeuwisse and Echemendia (2015b) state similar results. He states that in 34% of recorded concussions, the checked player did not have the puck under control, while concussions suffered in fights were not included. In 23% of concussion incidences, the player was controlling the puck and in 42% the player suffered ahit immediately after he received the puck. In 70% of hits when the player was in possession ofthe puck, the player was checked within 0.5 sec of gaining possession ofthe puck. It is necessary to consider that this study is from the NHL, where the game is defined by its faster pace, in particular as aresult of the different ice hockey rink dimensions and higher level of game performance. According to Parničan, Tóth and Peráček (2020), the game has a higher frequence of one-on-one battles. When comparing proportionalities of relative values obtained in NHL studies and our research, the differences are minimal.

Conclusions

We proved a statistically significant difference ($p<0.01$) in the incidence of head or neck checks between zone 1 (59.26%) and zone 2 (22.22%) and also between zone 1 and zone 3 (18.52%). Finding that the difference between zone 2 and zone 3 is not statistically significant on 1% level showed, that zone 3 is not as 'clear' as we assumed.

The finding of the statistically significant difference ($p<0.01$) in the incidence of head or neck checks in terms of the playing positions, between forwards (67.90%), defensemen (30.86%) and goaltenders (1.23%) with the predominance of forwards, is showing the playing position of forward as a position with the highest risk for suffering head or neck checks in the sport of ice hockey.

The duration of the significantly most frequent ($p<0.01$) time section of the checked player's puck possession (0-2 sec) prior to the head or neck check, which represented 62.96% of atotal number 81, showed that the majority of head impacts occur just prior to receiving or passingthe puck, or shooting and dumping the puck into the zone when the player is not ready for the hit. In 20.99% of head or neck checks, the player was not in possession of the puck.

We confirmed that the highest number of incidences of checksto the head or neck is in zone 1 (along the boards), also when the player is receiving a pass. Apparently, despite the different ice hockey rink dimensions in the USA and Canada, the proportionality of observed factors, which contribute significantly toincidences of checks to thehead or neck is similar in Slovakia.

We agree with the claim of Sigmund, Lehnert and Kudláček (2015) that ice hockey is one of the fastest and most demanding sports games with an increasing level of top world leagues and specific requirements of various player roles (Sigmund, Kutáč, Kudláček, Kvintová, Kohn and Sigmundová2016). The results and findings of our research signify that it is necessary to develop abilities of visual perception in game conditions, disjunctive reaction, visual memory, and the ability toreact quickly and to be able to anticipate the actions of opponents. The mechanism of these abilities is the actionspeed of the central nervous system, whichcan overtake the actions in player's surroundings. This means that the player could react automatically and not necessarily according to external stimuli.

It is possible to achieve the implication of these changes in game conditions, solely by incorporation of the game drills aimed at the breakout start with organized defence of the opponent, game combinations and situations with physical contact (1 on 1, 2 on 1, 3 on 2 etc.), drills aimed at the forechecking, small sided games with frequent 1 on 1 battles mainly in problematic zones (along the boards-zone 1). Equally, in the off-ice training process by utilizing sports games and movement activities with an emphasis on high frequency of typical game situations. Obetko, Babic and Peráček (2019) state that sports games have a positive and significant impact on the level of simple and disjunctive reaction time. It is also necessary to focus on adequate bioenergetic systems.It is unavoidable to put an emphasis on each player to literally have his or her head up after receiving a pass and while controlling the puck and therefore to have amaximal overview of the game actions, location of the puck, positions of teammates and opponents. We point out the development of the regulatory motor system which Linhart (1989) named the sensorimotor intelligence in this context.There can be found the close relationship between the intelligence and sensorimotor functions – understanding of spatial relationships, orientation, sensorimotor reaction, docility, differentiation of movement etc. With the new and more complex knowledge about the mTBI causes, we assume that there will be the option of the creation of a new training program, which will be able to minimize the risk and maximize the preparedness of the players for dangerous and health threatening situations on the ice. This will be possible in addition to pedagogical and therapeutic modules, which could arise as aproduct of an interdisciplinary cooperation of competent scientific disciplines engaged in this problem.

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This study is apart of the research VEGA 2/0076/18: Changes in circulating miRNA in ice hockey players after a head injury: potential marker of traumatic brain injury.

References

Adams, R., Li, A. Y., Dai, J. B., Haider, S., Lau, G. K., Cheung, K. P., Post, A. F., Gometz, A., & Choudri, T. F. (2018). Modifying factors for concussion incidence and severity in the 2013-2017 National Hockey League Seasons. *Cureus,* **10**(10), pp. 1-16, art. no. e3530. ISSN 2168-8184.

Aguiar, O. M. G., Potvin, B. M., Yang, Y., Hua, K. N., Bruschetta, M. L., Virani, S., & Robinovitch, S. N. (2019). American society of biomechanics journal of biomechanics award 2019: circumstances of head impacts in men's university ice hockey. *Journal of Biomechanics,* **108**(July), pp. 1-7, art. no. 109882. ISSN 0021-9290; eISSN 1873-2380.

American Academy of Pediatrics/Committee on Sports Medicine and Fitness (2000). Safety in youth ice hockey: the effects of body checking. *Pediatrics,* **105**(3), pp. 657-658. ISSN 0031-4005; eISSN 1098-4275.

Bawa, H., Brussoni, M., De Gagne, D., Han, G., & Smith, D. (2004). *2001-2003 Sports-related injury data report.* Vancouver: BC Injury research and prevention unit.

Benson,B. W., Meeuwisse, W. H., Rizos, J., Kang, J., & Burke, C. J. (2011). A prospective study of concussions among National Hockey League players during regular season games: the NHL-NHLPA Concussion Program. *CMAJ : Canadian Medical Association Journal = Journal de L'Association Medicale Canadienne,* **183**(8), pp. 905-911. ISSN 0820-3946; eISSN 1488-2329.

Brust, J. D., Leonard, B. J., Pheley, A., & Roberts, W. O. (1992). Children's ice hockey injuries. *American Journal of Diseases of Children,* **146**(6), pp. 741-747. ISSN 0002-922X; eISSN 2374-3018.

Buckley, T. A., Bryk, K. N., Van Pelt, K. L., Broglio, S. P., East, S. A., Zuckerman, S. L., & Kuhn, A. W. (2019). Concussion and National Hockey League player performance: an advanced hockey metrics analysis. *Journal of Athletic Training,***54**(5), pp. 527-533. ISSN 1062-6050; eISSN 1938-162X.

Donaldson, L., Li, B., & Cusimano, M. D. (2014). Economic burden of time lost due to in NHL hockey players. *Injury Prevention,* **20**(5), pp. 347-349. eISSN 1475-5785.

Eliason, P. H., McKay, C. D., Meeuwisse, W. H., Hagel, B. G., Nadeau, & Emery, C. A. (2020). History of previous concussion and sport-specific skills in youth ice hockey players. *Journal of Physical Education and Sport,* **20**(Supplement issue 3), pp. 2174-2181, art. no. 292. ISSN 2247-8051; eISSN 2247-806X.

Emery, C. A., Hagel, B., Decloe, M., & Carly, M. (2010). Risk factors for injury and severe injury in youth ice hockey: a systematic review of the literature. *Injury Prevention,* **16**(2), pp. 113-118. eISSN 1475-5785.

Härgestam, C. (2016). *Old and new therapeutic approach to the topic of traumatic brain injury.* Master thesis. Martin: Comenius University, Jessenius Faculty of Medicine, Department of Anaesthesiology and intensive medicine.

Hutchison, M. G., Comper, P., Meeuwisse, W. H., & Echemendia, R. J. (2015a). A systematic video analysis of National HockeyLeague (NHL) concussions, part I: who, when, where and what? *British Journal of Sports medicine,* **49**(8), pp. 547-551. ISSN 0306-3674; eISSN 1473-0480.

Hutchison, M. G., Comper, P., Meeuwisse, W. H., & Echemendia, R. J. (2015b). A systematic video analysis of National Hockey League (NHL) concussions, part II: how concussions occur in the NHL. *British Journal of Sports Medicine,* **49**(8), pp. 552-555. ISSN 0306-3674; eISSN 1473-0480.

International Ice Hockey Federation (2018). *IIHF official rule book 2018 – 2022* [online]. Zurich: International Ice Hockey, pp. 12-165. https://lnk.sk/fknz

Kalichová,M., & Lukášek, M. (2019). Soccer heading evaluation during learning process using an accelerometer. *Journal of Physical Education and Sport, 19(Supplement issue 2),* 335-343. ISSN 2247-806X.

Kuhn, A. W., & Solomon, G. S. (2015). Concussion in the National Hockey League: a systematic review of the literature. *Concussion,* **1**(1), pp. 1-7. eISSN 2056-3299.

Kuhn, A. W., Zuckerman, S. L., Totten, D., & Solomon, G. S. (2016). Performance and style of play after returning from concussion in the National Hockey League. *American Journal of Sports Medicine,* **44**(8), pp. 2152-2157. ISSN 0363-5465; eISSN 1552-3365.

Linhart, J.(1989). Cognitive sciences and cognitive psychology I. Evaluation. *Studia Psychologica,* **31**(1), pp. 5-12. ISSN 0039-3320.

Maas, A. I. R., Menon, D. K., Adelson, P. D., Andelic, N., Bell, M. J. & Belli, A. et al. (2017). Traumatic brain injury: integrated approaches to improve prevention, clinical care, and research. *Lancet Neurology,* **16**(12), pp. 987-1048. ISSN 1474-4422; eISSN 1474-4465.

Obetko, M., Peráček, P., & Babic, M. (2019). Changes in disjunctive reaction time of soccer goalkeepers in selective training load zones. *Journal of Physical Education and Sports,* **19**(Supplement issue 2), pp. 420-426, art. no. 62. ISSN 2247-8051; eISSN 2247-806X.

Parničan, S., Tóth, I., & Peráček, P. (2020). Connection between the success of a team at one-on-one battles in the defensive phase of the game and the final results of ice hockey matches in the National Hockey League and the 2018 Winter Olympic Games. *Journal of Physical Education and Sport,***20**(3), pp. 1529-1537, art. no. 210. ISSN 2247-8051; eISSN 2247-806X.

Pfister,T., Pfister, K., Hagel, B., Ghali, W. A., & Ronksley, P. E. (2016). The incidence of concussion in youth sports: a systematic review and meta-analysis. *British Journal of Sports Medicine,* **50**(5), pp. 292-297. ISSN 0306-3674; eISSN 1473-0480.

Ruhe, A., Gänsslen, A., & Klein, W. (2014). The incidence of concussion in professional and collegiate ice hockey: are we making progress? A systematic review of the literature. *British Journal of Sports Medicine,* **48**(2), pp. 102-106. ISSN 0306-3674; eISSN 1473-0480.

Sigmund, M., Kutáč, P., Kudláček, M., Kvintová, J., Kohn, S., & Sigmundová, D. (2016). Assessment of physical parameters and age of current Canadian-American National Hockey League (NHL) ice hockey players in relation to game position and player success. *Journal of Physical Education and Sport,* **16**(Supplement issue 2), pp. 1046-1051, art. no. 166. ISSN 2247-8051; eISSN 2247-806X.

Sigmund, M., Lehnert, M., & Kudláček, M. (2015). Comparison of influence of eight-week preparatory period on changes in selected morphological parameters in seventeen-year-old football and ice hockey players. *Journal of Physical Education and Sport,* **15**(4), pp. 838-843, art. no. 129. ISSN 2247-8051; eISSN 2247-806X.

Slovak ice hockey league/Slovakia Hockey (2020). *Slovak hockey in numbers* [online]. https://lnk.sk/fwb1

Slovenský zväz ľadového hokeja (2018). *Pravidlá ľadového hokeja 2018 – 2022 (IIHF official rule book 2018 – 2022)* [online]. Bratislava: Slovenský zväz ľadového hokeja, pp. 10-162. https://lnk.sk/nqvC

Theadom, A., Mahon, S., Hume, P., Starkey, N., Barker-Collo, S., Jones, K., Majdan, M., & Feigin, V. L. (2020). Incidence of sports-related traumatic brain injury of all severities: a systematic review. *Neuroepidemiology,* **54**(2), pp. 192-199. ISSN 0251-5350; eISSN 1423-0208.

Tuominen, M., Stuart, M. J., Aubry, M., Kannus, P., & Parkkri, J. (2015). Injuries in men's international ice hockey: a 7-year study of the International Ice Hockey Federation Adult World Championship Tournaments and Olympic Winter Games. *British Journal of Sports Medicine*, **49**(1), pp. 30-36. ISSN 0306-3674; eISSN 1473-0480.

Wennberg, R. A., & Tator, C. H. (2003). National Hockey League reported concussions, 1986-87 to 2001-02. *Canadian Journal of Neurological Sciences,* **30**(3), pp. 206-209. ISSN 0317-1671.

Zeman, M., & Krška, M. et al. (2014). *Speciální chirurgie = Special surgery.* 3. doplněné a přepracované vydání. Praha: Galén.ISBN 978-80-7492-128-5.