

MANAGEMENT TOOLS FOR RECOGNIZING AND PREVENTING CONCUSSIONS DURING SPORT ACTIVITY IN HUNGARIAN ICE HOCKEY

Abstract of PhD Thesis

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1 Introduction

During the review of the literature, the importance of the topic has become apparent, i.e. concussion suffered during sport / physical activity in general, and the appropriate management of an athlete suffering from concussions in a Hungarian ice hockey game.

Why is this topic important for Hungarian sports, and thus for ice hockey as well? The international practice is well ahead of the related practice in Hungary, while there is a lot to be found in the North American publications, less in Western Europe and more less in Hungary. Sports, especially ice hockey, are developing extremely fast in Hungary, so it is important that the scientific background does not stay behind the sport and that the players receive appropriate support, which will be valuable for them in long term, specially later after their sports careers have ended.

Sport is one of the cornerstones of healthy lifestyle, but it is worth nothing if we do not pay attention to the health of ourselves or other athletes. Injury prevention is in everyone's interests, but professional rehabilitation of injuries that are common in sports is perhaps even more important. It is way easier to handle the already known, less complex injuries, but for the time being, there are still areas in medicine / physic where professionals are not able to give a clear answer in all cases and at the same time recommend a cure. Despite the fact that medicine has sufficient knowledge about the injuries to the skull and brain, about the long-term complications, it is difficult to formulate a uniform treatment because the course of each case is different. In our first article on the subject, we introduced a new concept, we call concussion as sportconcussion if the player / athlete suffers while playing sports (Nagy and Géczi 2014). With regard to the relevance of the topic in Hungary, it is important to note that this newly introduced concept is more familiare for those working in sports, while it does not exist in medical science, since the treatment of "sportconcussions" is not medically different from other concussions. After consultations with experts in various fields, until the consensus is reached, I will not use the term "sportconcussion" itself for the rest of my dissertation.

Concussions experienced during sports are globally recognized (Thurman et al. 1999). Not only the number of athletes involved in contact sports, but also the number of contact sports has increased worldwide, as has the number of sports-related

concussions. As a result, long-term effects and hazards need to be recognized (Benson 2011). In various sports, a common injury affecting the brain itself is concussion (Jordan 2013), with 1.3 to 1.8 million sports-related concussions treated annually in the United States alone (Turner 2019). It is forbidden to return to the game at any age if symptoms of a concussion are detected. The brains of young athletes are very sensitive to this type of injury, as neural networks are more immature, making them more easily injured, and more likely to develop disturbances in the longer term (Meehan, Taylor, & Proctor 2011). According to Kroshus et al. (2015), players, coaches, and parents are often unaware of or underestimate the symptoms of a concussion due to some external or internal pressure (the athlete or coaches, or even peers, want to play anyway). Proper treatment of concussions in this accelerated world is very timely, since the essence of rehabilitation here is calmness and rest, which is difficult to achieve due to the impatience of athletes and coaches. Recent studies question previous hypotheses that concussion has only transient effects, for closer links have been found between concussion and nervous system processes (Alzheimer's disease or similar conditions) and an increased risk of depression and suicide (Iverson 2014; Budavári 2015; Chatterjee et al. 2015).

Everyone can play sports in a more relaxed mood if they know they can do so in a safe environment, although sometimes athletes tend to underestimate the risk. However, traumas can happen accidentally, and if trouble happens, professional help comes in handy. In my dissertation, I examine the presence of concussions in Hungarian ice hockey, the knowledge of their symptoms and signs among those involved in sports. The prevalence of the topic is unquestionable, I am to support this statement during the breakdown by sport. The dissertation has a management approach, so I am just touching on the medical background in terms of a thorough presentation of the topic.

2 Objectives

Concussions can occur at any sporting event, in this respect, ice hockey is a higher-risk sport. The health of athletes is paramount, and those who start sports have a right to know about the dangers of their chosen sport. It is in our common interest to share knowledge and raise awareness, since ice hockey can become more popular if it can be practiced safely at all levels, including professional or amateur, child or adult. The competition begins at a younger age with the impact of performance and performance pressure on athletes' health. The number of sport injuries, including concussions, is on the rise. Many of these could be prevented with proper information, professionalism and caution. The number of long-term health problems for athletes can be reduced (Szabó 2018; Szabó et al. 2018).

The aim of our work is to examine the knowledge related to concussions in the environment of Hungarian ice hockey. The direct stakeholders in the Hungarian sports society are players, coaches, referees and parents. If a concussion occurs during a ice hockey practice or game, it is primarily the four groups mentioned that are affected, since players, coaches, and referees on the field can see the signals, while parents can experience additional symptoms at home. Early detection is key, so I examined the general knowledge of these groups about concussion and the signs and symptoms of concussion.

Watching the events of the NHL and international ice hockey, it can be seen that what is happening in North America will also appear in Hungary within a few years (i.e. tactical elements, equipment, rule changes). The concussions he suffered during a sport activity and their consequences led to lawsuits in the NHL, and thus to somewhat stricter regulations. Unfortunately, in Hungarian ice hockey, concussions occur at the level of mention in regulations and educational materials. Adult players continue to qualify from overseas to the domestic championship, while more and more youth players get opportunities over there. Young people are consistently surprised at the great emphasis they place on the prevention, detection and treatment of concussions, while they have not been encountered at the level of mention at home. My goal is that this dissertation will contribute to change in Hungarian ice hockey culture. Based on the results obtained, I can formulate recommendations that can be put into practice for sports representatives, for it is in our common interest to protect ice hockey players.

In order to achieve the objectives, I have conducted structured written interviews as a qualitative research part with the outstanding players of the Hungarian national ice hockey team, who also play in international top championships, so they have a basis for comparison with the conditions in Hungary. In the field of quantitative research, I used the Hungarian adaptation of a Canadian questionnaire.

2.1 Proposition and Hypotheses

I based my proposal for the qualitative research part on my own sports experiences. I believe that in order to develop Hungarian ice hockey, we need to move forward these points as well. Responses from players will help determine the level of lag and what to do next.

In the championships of the countries with more advanced ice hockey culture, information and actions related to concussions during sports are regulated, while in Hungarian ice hockey, the education of players is insufficient, and there are no management guidelines developed for concussions during sports.

For the quantitative research part of the dissertation, I also took into account the research results already known when setting up the hypotheses, as well as seemingly some clear assumptions that I consider important to confirm or refute.

If someone experiences something “on his/her own skin”, it is usually easier to recognize similar cases in the future, is this also the case with concussions?

Hypothesis 1: Within the groups, individuals who have already reported a concussion are more likely to recognize the real symptoms and signs of a concussion than those who have not previously experienced any concussion.

If someone plays in a more professional environment, does someone have more information?

Hypothesis 2: Players playing at a higher level are more aware of the real symptoms and signs of a concussion than players playing at a lower level.

The experience and knowledge gained during the years spent in coaching are essential in the teaching of ice hockey, so the knowledge of coaches-players about ice hockey, is usually much more extensive than the former? Is this true in terms of the symptoms and signs of concussion? Can this difference between coaches be assumed in favor of more experienced coaches?

Hypothesis 3: More experienced coaches are more aware of the real symptoms and signs of a concussion than players or their more routine colleagues.

The relationship between parents and referees involves interesting, almost one-sided communication in all sports. The symptoms and signs of a concussion are certainly a neutral topic, but is the referees' knowledge better in terms of recognition because of their education?

Hypothesis 4: First-class judges recognize the real symptoms and signs of concussion better than parents.

The original questionnaire also investigated the relationship between mothers' and fathers' outcomes and compared the knowledge of groups based on the parents' sports history about concussions. For the sake of comparability, I consider it important to examine the Hungarian results in this direction.

Hypothesis 5: The knowledge of mothers and parents with a more serious sporting history is greater than that of the parents with a less serious sporting history.

3 Methods

In terms of methods, I considered it decisive at the beginning of the research to properly explore the topic from all sides, to present the most complete picture possible about the Hungarian recognition and management practices of sports-related concussions, taking into account both subjective and objective aspects.

Qualitative research is important because it provides a better understanding of the experiences and opinions of the players than the main stakeholders (victims of injuries). I am interested in how they see the style in Hungary and what experience they have gained in foreign tournaments. The practices of the various top ice hockey tournaments in connection with concussions are not available, so they are presented on the basis of research broken down into tournaments. The outstanding players of the Hungarian ice hockey team have played in foreign top tournaments, so I approached them with a structured written interview in April 2020, to present the practices they experienced in different leagues, as well as the domestic practice they learned during the national team programs. The summary of the interviews provides a good basis for presenting an up-to-date picture through the responses of those directly involved.

In my quantitative research, I mapped the knowledge of the direct participants of the Hungarian ice hockey sport about the concussions suffered during the game. The questionnaire for this was based on a questionnaire developed in 2007 based on guidelines from the Canadian Medical Society. At the 7th Annual Penguins International Winter Classic in Toronto, questionnaires were distributed on paper to parents of 13-14 year old ice hockey players on a voluntary basis. When determining the age of athletes, it was taken into account that body play is already allowed in this age group and many more parents attend games as opposed to games in older age groups (Coghlin et al. 2009). The adaptation and validation of the questionnaire was performed on the basis of clinical experience (Geisinger 1994). In consultation with the authors of the original questionnaire, this one was translated into Hungarian and then translated back into English. The authors of the original questionnaire provided their support in my work. In the dissertation, I recorded the answers to the validated questionnaire (Nagy et al. 2016) in Hungarian conditions, paying attention to ensuring similar conditions. In the questionnaire, the demographic questions were different, specializing on the particular group. Questions about the knowledge on concussion were

uniformized for all respondents and, followed by the separation from the demographic part.

The questionnaires were completed partly on paper and partly online, depending on the availability of different cohort groups. When processing the data, it was obvious that only the completed questionnaires could be taken into account.

The questionnaire included six questions related to knowledge of concussion. Of these, the answers to the first four questions were of the Yes / No type, while in the fifth, 25 symptoms had to be decided whether they could be related to concussion. Of these, 17 true and 8 false symptoms were listed. The last question was whether the filler had ever suffered a concussion.

I divided the direct stakeholders who are entitled to decide whether an injured player should continue the game into four well-defined groups: players, coaches, referees and parents.

The questionnaires were completed at different times, which may be problematic. During this period, progress was made in the track's record, but unfortunately not in terms of concussion knowledge of the groups studied. This statement is supported by the general sports situation in Hungary as well as the deficiencies of the Hungarian Ice Hockey Federation (HIHF) sports health regulations in this respect and the answers of the top players participating in the qualitative research.

I recorded the answers of the players on the national team cohesiveness organized for the U18 and U20 age groups at the end of April 2013, with a paper-based questionnaire. Completion was voluntary and anonymous 108 questionnaires were distributed and 95 of these were returned, of which only 90 were complete according to my terms.

Data on coaches were recorded with a paper-based questionnaire at the in-service training organized by MJSZ in December 2016, which was announced for them regardless of age. A total of 57 volunteer and anonymous questionnaires were completed. Only fully completed questionnaires were considered, of which there were 48.

I sent the volunteer and anonymous questionnaire online to the referees employed in the first class ice hockey tournament, for which we did not provide any instructions for completion, only information on the purpose of research and confidentiality. The

questionnaire was received by 39 referees, 37 of whom completed it. Finally, 31 fully completed questionnaires were returned.

The inclusion of parental data was linked to online registration, but the data were treated separately and anonymously. The data collection took place in May 2014, on the “Show Me Now” talent search day organized by MJSZ every year, where parents under the age of 14 were free to register their children regardless of association. As part of the registration, the questionnaire was optionally completed and they were only informed about the purpose of the research and the confidentiality of the data management. A total of 125 questionnaires were completed, but only 113 fully completed questionnaires were considered.

For the general statistical analysis of the data, I performed descriptive statistical calculations, hypothesis testing, two-sample t-test for the analysis of gender differences, analysis of variance (ANOVA), variance homogeneity, and correlation calculations during the analysis of correlations. The significance level was $p < 0.05$. I used SPSS for the analyzes and Microsoft Excel for the diagrams.

4 Results

4.1 *The results of qualitative research*

Based on a summary of 13 structured interviews with players, it can be concluded that in the case of North American and European top ice hockey nations, the topic of concussions is topical and is also addressed at the league level. Feedback came from first and second division adult or junior tournaments in the following countries: United States (USHL, NAHL, NCAA) Finland (League, Mestis), Germany (DEL), Switzerland (U20 Elite A), Sweden (SHL and Allsvenskan), and Hungarian top teams from the Austrian (EBEL), Hungarian (Erste Liga) and Slovak (Tipsport) championships.

In each of the foreign leagues, the teams pay close attention to the knowledge of concussions suffered during sports. Two questions in the interview were related to the foreign league as well as the team - if the respondent received any information about concussion. The vast majority of the answers were “Yes”, “Yes, I also had to take tests”, “Yes, verbal”. Based on the responses, the leagues in most places require the players of the teams to attend the briefing. According to the league breakdown, the Swiss U20 League organizes club performances at the beginning of the season, while the other foreign leagues, with the exception of the NAHL, organize the players' union or the league (Allsvenskan, DEL, League, SHL, USHL, WHL). .

Has the respondent participating in the program of the current Hungarian national team received any information about the concussion? The majority of the answers here are "No".

"I remember not," "I haven't received any tests or information since I was on my national team program." The answers given about the relationship between the Hungarian league and the national team suggest that neither the Hungarian ice hockey team nor the leagues in which the Hungarian teams also participated did the association, the league or the clubs hold any information about the concussions to the players before the games.

Table 1: Summary of the qualitative research on information and survey on concussion; broken down by country

Country – Highest league	Education before the season about concussion	Concussion test before the season
Hungary (EL, EBEL, Tipsport)	NO	NO
Finland (Liiga)	YES	YES
Sweden (SHL)	YES	YES
Germany (DEL)	YES	YES
Switzerland (U20 Elite)	YES	YES
Canada (WHL)	YES	YES
USA (USHL)	YES	YES

(Source: Selfedited)

Comparing the foreign and Hungarian championships and the Hungarian national team, unfortunately people in Hungary are not properly prepared, knowing the importance of the topic, this is also shown in the table above (Table 1).

Furthermore, the above suggests that the proposed formulation is justified, information and actions related to concussion suffered during sports are regulated in the championships of countries with a more developed ice hockey culture. From the responses to the interviews, I came to the conclusion that educating the players about concussion is not enough. Unfortunately, at the time of writing this dissertation, I am not aware of any guidelines for the management of concussion suffered during sports in Hungarian ice hockey.

4.2 The results of the quantitative research

The questionnaire was completed by players and coaches on paper, while parents and referees completed it online, in both cases anonymously. Regarding the sum of the subsamples, the analysis and comparison of 282 data sets divided into groups is the

main goal of the research, as well as the confirmation or rejection of the hypotheses raised.

The first question was mostly answered correctly by parents (93%) and referees (97%) while players (47%) and coaches (31%) answered it incorrectly. This difference is due to the fact that players and coaches focused too much on sports when interpreting the issue, so if an athlete has a loss of consciousness during a game, it mostly occurs in ice hockey when a collision has occurred. Parents and referees, who are less involved in the sport on a daily basis, have a much more general view of things, for example, they think a child may lose consciousness even if their blood sugar drops.

In the answers to the second question, both coaches and parents answered well in all cases, while players (6%) and referees (7%) answered similarly poorly.

Children and players are generally not allowed by parents and coaches to continue playing or go to training with a concussion. Players listen to the coach, while referees have no right to make such a decision. Overall, it is good to see that the vast majority know that an athlete who has had a concussion should not return to the game that day.

The third question was also answered more correctly by players, coaches, and referees than by parents. In this case, the opposite is the case as compared to the first question. Players, coaches, and referees have repeatedly encountered a case of a concussion even on a headless blow, while parents were less affected in ice hockey. The referees' 100% correct response rate is probably due to the fact that they have seen many video case studies where although the collision itself is regular (shoulder and shoulder contact, there is no blow to the player's head area), the player is almost knocked out. These cases also confirm that it is not necessary to hit a head directly in order to suffer a concussion.

For the fourth question, 100% of the parents answered correctly, while 3-6% of the other three groups answered incorrectly. The discrepancy in this issue is presumably due to parental care and anxiety, since at the slightest sign of restlessness, parents would turn to a doctor, while players, coaches, and referees would be less worried.

The fifth question focused on the symptoms and signs of a concussion, and respondents had to mark the symptoms they thought were correct. A total of 25 symptoms were listed in a completely random order, of which 17 were correct (real, possible) symptoms or signs of concussion, while 8 were false symptoms.

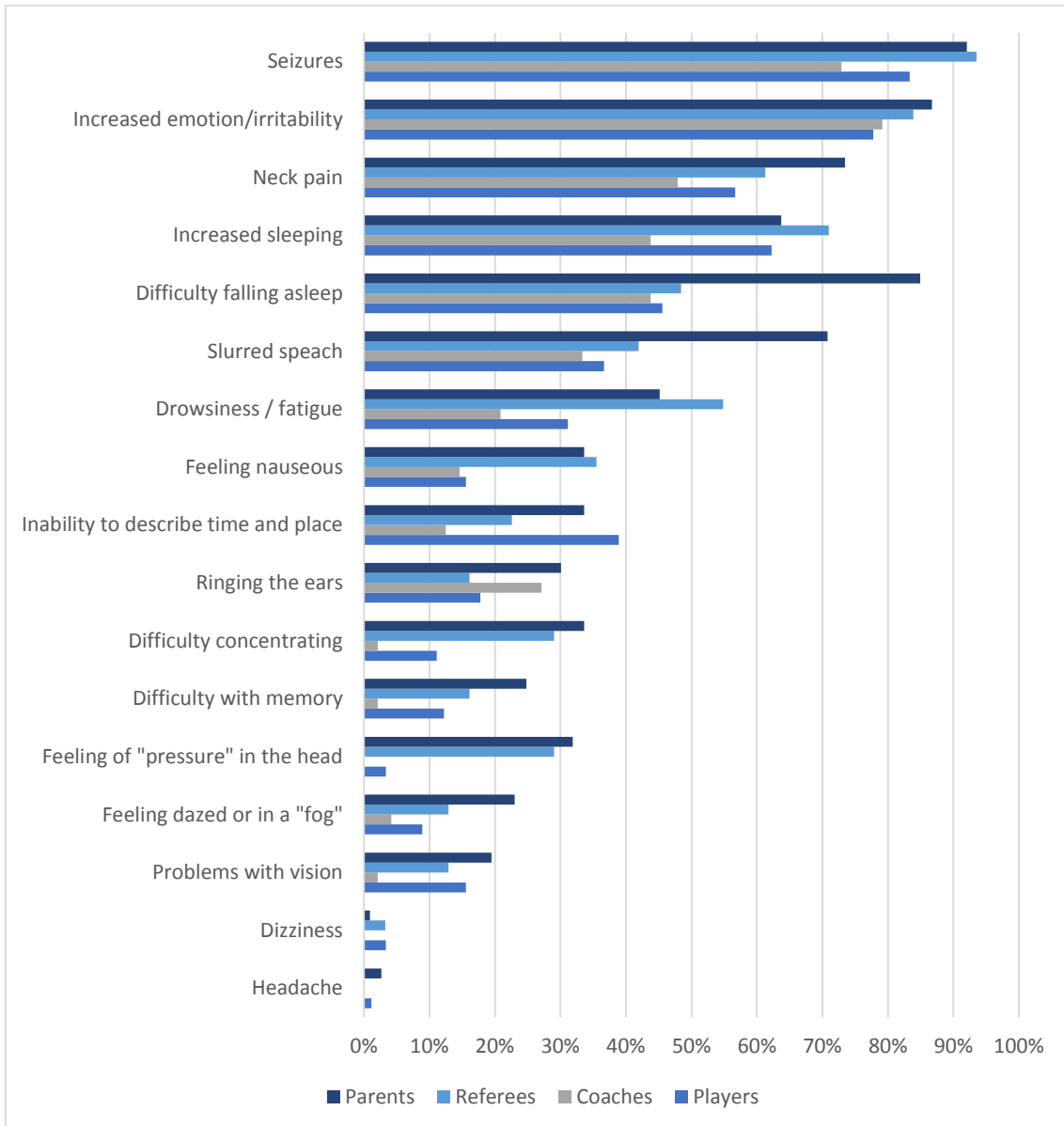


Figure 1: What percentage of the respondents did not mark the perceived symptoms as correct (real)
(Source: Self edited)

A total of 282 questionnaires were completed, with at least 50% of respondents recognizing the following 12 symptoms: signs of headache, dizziness, problems with

vision, feeling dazed or in a "fog", feeling of pressure in the head, difficulty with memory, difficulty concentrating, ringing the ears, inability to describe time and place, feeling nauseous, drowsiness / fatigue, slurred speech. The diagram on the previous page (Figure 1) shows how often the characteristic symptoms and signs were not marked as correct by the different groups when filling in the questionnaire.

There were also five symptoms, signs that were not correctly identified by either the players or the coaches, referees, or parents. Seizures are thought by 83% of players, 73% of coaches, 94% of referees, and 93% of parents to be not a real symptom of a concussion. 78% of players, 79% of coaches, 84% of referees and 87% of parents, 57% of players with neck pain and 48% of coaches with symptoms of increased emotion / irritability, 61% of referees and 73% of parents thought it was not a real symptom. 62% of players, 44% of coaches, 71% of referees and 64% of parents demand increased sleep (sleepiness), while 46% of players and 44% of coaches have difficulty falling asleep. 48% of referees, while 85% of parents, did not mark it as a real symptom.

4.3 Hypotheses based on the results

To test Hypothesis No. 1, we were able to differentiate respondents within the groups based on question 6 of the questionnaire; whether they already had a concussion on the grounds of their own declaration (Table 8). To this question, 57 players (26%), 28 coaches (14%), 17 referees (8%) and 104 parents (50%) answered that they had never had a concussion, while 33 players (44%), 20 coaches (26%), 14 referees (18%) and 9 parents (12%) indicated that they had had a concussion before. The difference between the means of the subgroups within the groups was examined using a two-sample t-test for the number of correct answers. Results of the t-test: players $t(88) = -0.676$ and $p = 0.50$; coaches $t(46) = -1.657$ and $p = 0.10$; referees $t(29) = 0.012$ $p = 0.99$; parents $t(111) = 0.997$, $p = 0.34$. The values of the t-test show that there is no difference between the four groups in terms of their ability to correctly identify the symptoms of concussion. Based on the above data, I completely reject Hypothesis 1.

Table 2. The average number of correct answers among those who had a concussion or had not yet suffered a concussion

(Source: Self edited)

Non concussed	M	SD	Group number
Players	18,19	2,33	57
Coaches	19,14	1,74	28
Referees	17,94	2,99	17
Parents	17,22	2,80	104
Concussed			
Players	18,55	2,41	33
Coaches	20,05	1,96	20
Referees	17,93	2,89	14
Parents	16,44	2,19	9

For players, one of the demographic questions was which was the highest, oldest league level he has ever played at (adult, U20, U18). In Hungarian ice hockey, there is no first or second class in the U18 and U20 age groups, the teams play in one league, the more skilled players can also play a role in the adult first class. For lower-level adult tournaments, the rules do not allow replay from junior tournaments, so the age order is the same as the professional strength order of the tournaments. In the Hungarian ice hockey league system, quality differences within age groups from U16 downwards are divided into three level categories. 18 people had some adult league experiences, the average of their correct answers was 18.72 (standard deviation: 2.05), 39 people had some U20 experiences, the average of their correct answers was 18.87 (standard deviation: 1.75), and 33 people had some U18 experiences, the mean of their correct answers is 17.45 (standard deviation: 2.88). The analysis of variance (ANOVA) has an effect on experience (at what level they play) on how well the players know the real symptoms: the mean of the three groups differed ($F = 3.784$; $p = 0.026$). H_2 is related, which I reject in the adult-U20 relationship, but retain it for adult and U18, U20, and

U18 studies, since the results showed that players with adult or U20 experiences better recognized the symptoms and signs of concussion than those with U18 experiences. So it is true here that those who play at a higher level have better knowledge, but not in terms of a comparison between adult and U20 players. The difference may not be caused by the level difference, it is conceivable that age and adulthood can also be the boundary line.

Based on the results of Hypothesis No. 3, the mean of the correct answers of the players is 18.32 (standard deviation: 2.35), and the average of the correct answers of the coaches is 19.52 (standard deviation: 1.87). Based on the values of the ANOVA study, the difference between the groups is significant ($F = 9.3$; $p = 0.003$), so the original hypothesis that coaches have more knowledge about the symptoms and signs of concussion, so I keep the first part of my assumption.

Based on the difference between the coaches - based on education - A (5 people), B (30 people) or C (4 people) license, and I do not have a qualification yet (9 people) I formed groups. Because the number of subgroups was quite different, I discarded the ANOVA. To further investigate the hypothesis, I used another demographic question. Based on the number of years spent in the coaching field, it is already worth forming groups. I nominated him as a beginner coach if he has been on the field for a maximum of 3 years ($n_{\text{starter}} = 17$), as an experienced coach if he has already spent between 4 and 10 years as a coach ($n_{\text{trained}} = 18$). The average of correct answers for beginner coaches is 19.17 (standard deviation: 3.27), the average for experienced coaches is 19.94 (standard deviation: 4.17), while the average for routine coaches is 19.38 (standard deviation: 2.92). Thus, the years spent in the coaching career have no effect on the extent to which coaches know the true symptoms based on analysis of variance (ANOVA): the mean of the three groups did not differ ($F = 0.779$; $p = \text{ns}$). Based on the results, I reject the second part of Hypothesis 3.

To confirm Hypothesis No. 4, it is necessary to examine the concussion-related knowledge of referees and parents. The average of the correct answers was 17.94 (standard deviation: 2.90) for the referees and 17.16 (standard deviation: 2.76) for the parents. Due to the two groups, I performed a two-sample t-test, based on the results of which I reject Hypothesis 4 based on $t(46) = 1.33$ and $p = 0.188$, the knowledge of the referees does not differ significantly from that of the parents.

For parents, one of the demographic issues was whether the child's mother (legal female representative) or father (legal male representative) was the filler. This also provided an opportunity to compare the knowledge of mothers (51 people) and fathers (62 people). The number of correct answers for mothers was 17.25 (standard deviation: 2.90), while for fathers it was 17.09 (standard deviation: 2.66). Furthermore, I used the fact that parents were able to indicate in the questionnaire, based on their own statements, what level athlete past they had. The average of the correct answers of parents who have ever exercised at a low level (30 people) is 16.56 (standard deviation: 2.48), the average of parents who have exercised at a low level (50 people) is 16.66 (standard deviation: 2.37) for athlete parents (24 people), the mean was 18.45 (standard deviation: 3.09). Nine of the parents indicated that they had never played any sports, so I did not take their data into account in the analysis. In the first case, I examined the difference between the means using a two-sample t-test for the number of correct answers. Based on the t-test, it can be concluded that there was no significant difference between mothers and fathers in terms of their ability to correctly identify the symptoms of concussion ($t(103): 0.333; p = 0.74$). I reject this part of Hypothesis No. 1, however, further results suggest that parents' sporting history has an effect on symptom recognition. I thus partially accept this part of Hypothesis 5, as the ANOVA results show that the number of correct answers was higher for parents who once played at a high level compared to the other two groups ($F = 4.644; p = 0.012$). However, the difference between the responses of low and intermediate-level sports parents is not significant ($t(59) = -1.65$ and $p = 0.86$), so I reject the relevant part of Hypothesis 5.

5 Discussion

Taking into account the situation of Hungarian sports, the results can be considered good, since the first four questions of the questionnaire were answered correctly by the narrow stakeholders of the ice hockey sport, players, coaches, referees and parents.

When recognizing the true symptoms and signs, the five most commonly unreported true symptoms were the same in the groups (seizures, neck pain, hypersensitivity irritability, difficulty falling asleep, increased sleep). These results indicate that although the general knowledge of the groups is adequate, they need further training in recognizing concussion. The close rank correlation between the recognition of symptoms and signs indicates that a better understanding of the symptoms of concussion is not closely related to ice hockey culture, which emphasizes the general importance of teaching the topic at school, in the media, etc.

Players are aware of the most important symptoms and signs. Comparing the Hungarian results with those results of players of similar age the Canadian had, I came to the following conclusions: The Canadian players identified more real symptoms and signs compared to the Hungarian players. One possible reason for this is that ice hockey is Canada's number one sport and the union, Ice Hockey Canada, runs a special program to raise awareness about safe sports. Furthermore, if a professional ice hockey player suffers a concussion in Canada and needs to be left out for a few days, weeks or months, the media will cover the case much more than similar situations in the Hungarian press. The most widely known case of ice hockey occurred when Sidney Crosby had to be absent from the NHL for nearly 11 months after suffering a concussion in a game (Boylan 2017). These reasons may explain the differences between the two samples. Interestingly, in the case of recognizing false symptoms and signs, the Hungarian players were more accurate. This result can be attributed to a confirmation bias in the Canadian responses, since more ice hockey players in Canada are likely to find their sport risky, for a common injury is concussion. It can lead to misunderstandings with the consequences of a concussion when in fact these symptoms are not even related to the concussion. This interpretation may explain the surprising result, although Canadian players performed better in recognizing real symptoms and signs. The false-marked real symptoms in Canadians were also the same as the five symptoms mentioned earlier.

Based on the results of a survey conducted among Hungarian ice hockey coaches, we can conclude they can correctly identify the symptoms and signs of a concussion. The results are also somewhat better than an international study based on a similar questionnaire (McLeod et al. 2007). There is no significant difference in the recognition of true and false symptoms based on responses from coaches who have experienced or those who have not experienced a concussion. However, coaches who suffered a concussion recognized several correct symptoms. Based on the results of the comparison based on the years spent in the coaching field, it can be stated that the experienced and routine coaches recognized the real symptoms in a higher percentage. Probably because the coaches themselves have been exposed to concussions during their athletic careers, either as injured or just because of information they have received in the athletic environment. After comparing the results from the statistical analysis of the parental and coaching data, it can be said that there is no difference between the distribution of the respondents and their responses. It is interesting to note, however, that coaches less often marked the correct symptom as false.

The results of a survey of referees show that their knowledge differs from that experienced of players and coaches. Probably these two groups are better informed, thanks to the time spent in the sport on a daily basis, as well as the media coverage of the aforementioned concussions. Players and coaches spend several hours a day on hockey, while referees work as civilians. In addition, there was no significant difference between the number of symptoms and signs correctly recognized by the referees and the parents.

Based on the results of a survey conducted among the parents of ice hockey players under the age of 14, parents can correctly identify the symptoms and signs of a concussion. Two of the first four questions about concussion were answered correctly by all respondents. Based on the answers given by mothers and fathers, there is no significant difference between them in the recognition of real and false symptoms, so the social stereotype that mothers are more aware of their children's illness and injury seems to be overestimated. At the same time, it alters the picture that mothers in general have recognized more correct symptoms. Based on the results of a comparison based on the athlete's past, it can be stated that parents involved in high-level sports recognized a higher percentage of real symptoms.

Probably because parents also have their own experience as either injured or eyewitnessed. After comparing the results of the original Canadian questionnaire and the statistical analysis of the Hungarian data, I found that there is no difference between the respondents and their answers.

It is interesting to note that there is discrepancy in the athletes' past, which is probably due to the different sports system, as many high-level athletes in Hungary have amateur status, while in the Canadian system the high level is mostly understood for professional championships, where there are already professional athletes. So fewer people in Canada mark high levels because it is more difficult to get there.

5.1 The concussion management model (CMM)

The progress mentioned above is easily achievable if sport federations start to use a management-approach model of concussion management, under strict medical supervision. The use of the ImPACT test, which is widespread in North American leagues, is key to the model. This program helps athletes and teams in a transparent way. The model detailed below and working closely with healthcare professionals offer a solution for treating the concussion suffered by athletes and their parents before, during and after the suspected concussion has arisen or been diagnosed. A safe return to full activity is of paramount importance to all concerned, certainly reducing the likelihood of long-term injuries.

Steps in the Concussion Management Model (CMM):

1. Teach pre-season ImPACT basic test and concussion knowledge.
2. If a concussion is suspected the following steps are necessary to be taken:
 - immediate termination of the game or activity;
 - medical examination, X-ray, CT or MR if necessary;
 - vestibular examination.

3. Perform a post-concussion test and develop a recovery plan - follow RTS

- light aerobic exercises,
- sport-specific exercises,
- medical examination.

4. The Athlete is ready for contactless sports under the following conditions:

- asymptomatic at rest, during easy movement and in theoretical tasks;
- the post-concussion test is in the normal range compared to the baseline test;
- the result of the vestibular (equilibrium) test is normal;
- medical examination.

5. Return to full activity (game)

- only with a medical permit,
- the value of the newer test is better or at least at the level of the basic test.

For the above model, it is absolutely necessary to obtain the ImPACT software for sports association, sports club, and to employ the person who can manage it. The basic test and the post-injury test are already available for an amount of around HUF 15,000 per athlete, which must be an acceptable amount for a sports organization in terms of the annual budget of a club or the price of sports equipment.

6 List of publications by the author

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