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# The Short- and Long-term Effects of Sport-related Concussions to Ice Hockey Players

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# EFFECTS OF CONCUSSIONS TO ICE HOCKEY PLAYERS

The Short- and Long-term Effects of Sport-related Concussions to Ice Hockey Players

A Synthesis of the Research Literature

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A Synthesis Project

Presented to the

Department of Kinesiology, Sport Studies, and Physical Education

State University of New York

at Brockport

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In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Education

(Athletic Administration)

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by

Nick Lazor

December 17, 2020

EFFECTS OF CONCUSSIONS TO ICE HOCKEY PLAYERS

SUNY BROCKPORT

BROCKPORT, NEW YORK

Department of Kinesiology, Sport Studies, and Physical Education

Title of Synthesis Project: The Short- and Long-term Effects of Sport-related Concussions to Ice  
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Date

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*Cathy Houston-Wilson*

12/21/20

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Chairperson Approval

Date

# EFFECTS OF CONCUSSIONS TO ICE HOCKEY PLAYERS

## EFFECTS OF CONCUSSIONS TO ICE HOCKEY PLAYERS

### **Abstract**

For many decades, sport-related concussions have impacted athletes with little concern and awareness given to their short- and long-term effects. Recent events, however, have brought much-needed attention to the need for increased investigation of the impacts and effects of sport-related concussions on a broad level. To this end, this synthesis reviewed literature regarding a cumulation of the known short- and long-term effects which sport-related concussions (SRC) have on ice hockey players. The data for this synthesis was collected using the EBSCOHOST search engine found on SUNY-Brockport's Drake Memorial Library online search website. The 11 studies in the critical mass were obtained using keywords in the SPORTDiscus, PubMed Central, MEDLINE, PsycINFO, Academic Search Complete and Google Scholar databases. Three research questions were answered: (a) What are the effects of sport related concussions (SRC) on ice hockey players physiological and cognitive functioning, (b) What are the psychological effects of SRC's on ice hockey players, and (c) How does sustaining an SRC affect when ice hockey players return to play and their susceptibility to another injury? Results reveal that there are many detrimental short- and long-term effects of SRC's including a decrease in cognitive mapping, reaction time, motor-visual functioning, a poorer quality of life (QoL), and mental health issues such as depression, anxiety, and post-traumatic stress disorder as. Also, athletes are more susceptible to future injuries after suffering SRC's. Findings can assist ice hockey players, their coaches, and parents better understand how SRC's affect athletes, as well as how to prevent both further injuries and to prevent players from having to give up playing ice hockey due to SRC's.

**Keywords:** Sports-related concussion, ice hockey, effects, physiological, psychological

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## Chapter 1

### Introduction

Ice hockey is a very fast-paced game, where collisions with another player, the boards, the ice surface, a stick and/or the puck are highly frequent and common. With a total of twelve athletes on the ice at a time (ten players, two goalies, and typically two to four referees), decision making and quick reaction time is essential in order to play this sport. This sport is known for its body-to-body contact, also known as checking, which puts the player at a risk for high energy impact (Gard et. al., 2020) and which could potentially lead to injuries.

Checking in ice hockey occurs when two players collide into one another, whether on purpose or accident. Checking can be done in the open ice or can be when one player checks another player into the boards, which could cause one or both players to hit the ice surface. Whether it is a player receiving or making a check, colliding with the boards or ice surface, or getting hit by a stick or puck, at any given moment an ice hockey player could sustain an injury to their body and/or to their head. Although ice hockey players are taught at a young age how to properly check as well as how to receive a check (and there are rules to enforce their proper use), it does not eliminate the possibility that a head injury, especially, could occur. Even if the head itself is not physically impacted during a check or collision, the possibility for a head injury still remains. They may happen, for example, when an ice hockey player's momentum suddenly or abruptly stops, leading to the brain shifting inside of the skull. No matter their cause, many times, these head injuries will result in what is known as a sport-related concussion (SRC).

An SRC is defined as a mild traumatic brain injury (mTBI) or concussion that was induced by biomechanical forces during playing a sport (Gard et. al., 2020). A sport-related concussion, or any type of concussion, can be caused by a bump, blow, or jolt to the head, or a

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hit to the body, which results in the brain rapidly shifting back and forth inside of the skull (Centers for Disease Control and Prevention, 2019). The signs and symptoms of a concussion are categorized into groups: somatic (headaches, nausea), behavioral and emotional (irritability, sadness), cognitive (concentration problems, slowed reaction time), or sleep related issues (Centers for Disease Control and Prevention, 2019). The lingering long-term effects of concussions consist of possible cognitive impairment, depression or neurological and physiological problems (Sarmiento et. al., 2019).

There has been an increasing amount of concern and awareness over the past few years around SRC's and their effects on athletes (Carron et. al. 2013). As mentioned previously, the fast pace and high incidence of collisions in ice hockey make SRC's a common occurrence in the sport. Recent reports suggest the number of reported concussions in Swedish ice hockey players at the present time is estimated to be around 150 concussions/ 1000 game hours; this is a huge increase when compared to the 1980 season when there was approximately 20 concussions/1000 game hours (Gard et. al., 2020). In comparison, the team sport of soccer, which is also considered to be an impact sport, has an estimate of 18.91 concussions/1000 game hours (Levy et. al., 2012). Also, something very important to take into consideration, these numbers only include game hours; they do not include any practice hours. Most importantly, these statistics do not include the number of possible concussions which go unreported or unidentified. These are staggering statistics with the increasing amount of literature and research being focused on the short- and long-term effects of SRC's.

Many athletes who suffer SRC's see post-concussion symptoms dissipate and are able to recover within seven to 10 days (Gard et. al., 2020). There is, however, an increasing number of athletes who have effects lasting months, years, or even never fully recover after sustaining

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SRC's. Short- or long-term symptoms can affect the length before athletes return to play (RTP), athletic performance (motor function, reaction time, or cognitive thinking), or could lead to more injuries (musculoskeletal or another SRC) (Benson et. al., 2011; Brooks et. al., 2016; Nyberg et. al., 2015; Pederson et. al. 2014; Siman et. al. 2015; Tapper et. al., 2017; Wright et. al., 2016), while the lingering long-term symptoms could affect the athlete's quality of life and self-identity, or even lead to invisible injuries such as post-concussion syndrome (PCS), traumatic brain injuries (TBI) and even chronic traumatic encephalopathy (CTE) (Engström et. al., 2020; Gard et. al., 2020; McFarlane et. al., 2020; Todd et. al., 2018). Because no athletes wants to miss out on playing time or give up playing the sport they love short-term or even retire from it due to sustaining SRC's.

It becomes imperative that athletes, parents and coaches are educated about and aware of the short- and long-term effects of SRC's, because more often than none, concussions are believed to have cumulative impacts that affect athletes throughout their lives. Impacts that could be detrimental to cognitive, behavioral and social functioning. In addition, sustaining one or more SRC early on in life, could accumulate to having negative, long-lasting effects on their lives, including later on in life (Pederson et. al. 2014).

### **Statement of Purpose**

The overall purpose of this study is to investigate the short- and long-term effects of sport-related concussions on ice hockey players. This study will be guided by four specific research questions:

1. What are the effects of sport related concussions (SRC) on ice hockey players physiological and cognitive functioning?
2. What are the psychological effects of SRC's on ice hockey players?

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3. How does sustaining an SRC affect when ice hockey players return to play and their susceptibility to another injury?

### **Operational Definitions**

1. **Concussion:** a brain injury caused by an impact to the head and/or when the brain rapidly shifts inside of the skull (Centers for Disease Control and Prevention, 2019).
2. **Sport-related Concussion:** a mild traumatic brain injury (mTBI) or concussion that was induced by biomechanical forces during playing a sport (Gard et. al., 2020).

### **Assumptions**

1. It was assumed that all participants involved in these reviewed studies answered surveys and questionnaires truthfully, and their stories to be honest.
2. It was assumed that all instruments, rating scales and software used within these studies were valid and reliable.

### **Delimitations**

1. Only studies focusing on ice hockey players were included.
2. Only research which involved the short- and long-term effects of sport related concussions were included.
3. All articles reviewed were written in the last decade (2010-2020).
4. All articles reviewed were peer reviewed and published in an academic journal.

### **Limitations**

1. Some studies were limited due to athletes being reluctant to report concussions.
2. Some studies were limited to level of ice hockey.
3. Some studies were limited to one gender.
4. Some studies took place in one region or country.

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### **Author Bias**

1. The author is an ice hockey player and has been for the past 27 years.
2. The author has had many concussions throughout his life, non-sport related and sport related (ice hockey) concussions.
3. The author does have his own personal experiences with the short- and long-term effects of sport related concussions.

## **Chapter 2**

### **Methods**

The purpose of this chapter is to review how the information was compiled and what methods were used to review the literature based on the short- and long-term effects of sport-related concussions (SRC) on ice hockey players.

#### **Data Collection**

The research studies for this synthesis were collected by searching the EBSCOHOST search engine, where SPORTDiscus, PubMed Central, MEDLINE, PsycINFO, and Academic Search Complete were all utilized to find useful and relevant articles. Google Scholar was also used in order to assist in a broader search.

Through the use of the listed databases above, 11 articles met the criteria to be utilized in this synthesis's critical mass literature review. The articles that met the criteria for this synthesis needed to have been published between 2010 and present day (2020). This allowed this synthesis to include the most up-to-date information as well as use current research conducted on this topic. Another area of criteria that was necessary in order to be selected includes the use of peer-reviewed, scholarly full-text articles to allow for the greatest degree of trustworthiness (qualitative articles) or validity and reliability (quantitative articles). The most important criteria that the articles needed to meet in order to be included in the critical mass was that the article had to investigate one or more of the research questions: (a) what are the effects of sport related concussions (SRC) on ice hockey players physiological and cognitive functioning (b) what are the psychological effects of SRC's on ice hockey players (c) and how does sustaining an SRC affect when ice hockey players return to play and their susceptibility to another injury? The

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articles used as the critical mass can be found properly cited in the reference portion of this paper (see References).

The search through the use of these electronic databases, along with implementing the criteria and guidelines, began with “*concussions*” and “*ice hockey*” as the two initial keywords. This initial search resulted in 1,148 articles. After the initial search, a more sport-specific term related to concussions was used, with the keywords thus being adjusted to “*sport-related concussions*” and “*ice hockey,*” which then resulted in 768 articles. In an effort to narrow the number of articles and find those of most relevance to the research questions and purpose, the keyword “*effects*” was also used in combination with the two previous keywords. This resulted in 644 articles stemming from this third search.

Of the 644 articles from this third keyword search, only 76 of them specifically included ice hockey players in the research while the other 568 articles specified other sports’ athletes but not ice hockey players. The 76 articles were then investigated thoroughly to identify which, if any, research questions they could answer. Eleven of these articles contained all the necessary requirements and criteria to be including in the critical mass of this synthesis. Any article that was eliminated from this synthesis was due to either the study not containing relevance to the research question(s) or not specifically studying ice hockey players.

The following peer reviewed journals contained the articles for this synthesis: *Journal of Sport & Exercise Psychology*, *Journal of Clinical Sport Psychology*, *Scientific Reports*, *The American Journal of Sports Medicine*, *International Review of Sport and Exercise Psychology*, *American Journal of Alzheimer’s Disease & Other Dementias*, *Journal of Athlete Development and Experience*, *Journal of Neurotrauma*, *Journal of Sports Sciences*, *PloS One*, *Canadian Medical Association Journal*, and *Frontiers in Neurology*.

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### **Data Coding**

The information extracted from the approved articles which make up the critical mass of this synthesis were put into a table in a Microsoft Word document. The information in these grids, in hopes to make it more accessible and easier to visualize all of the important content, contained the following categories: APA citation of the article, purpose, methods and procedures, analysis, findings, and discussion and recommendations for future studies. This article grid can be found in Appendix A at the end of this synthesis.

### **Data Analysis**

Research methods used for the 11 articles in the critical mass consisted of three qualitative research studies and eight quantitative research studies. Data was collected for the qualitative studies through the use of narrative interviews and life stories, which reflected theoretical approaches through using grounded theory and phenomenological perspectives. The qualitative data was analyzed through the creation of themes and sub themes which reflected the stories and interview data from the subjects. Quantitative studies utilized surveys, questionnaires, functional tests, ImPACT tests, auditory tone discrimination tests, Corsi block test, the Beck Depression Inventory II (BDI-II), the Beck Anxiety Inventory (BAI), biomarker blood samples, and MRI scans as means to collect data. The quantitative studies' data was analyzed using a variety of methods including Mann-Whitney U test, conditional logistic regression, T-test, SCAT (2-5), ANCOVA, ANOVA, QlikView, SPSS, Fishers exact test, X2 test, and Voxelwise statistical system using a tract-based spatial statistics (TBSS).

For this synthesis, the critical mass studied 281 collegiate ice hockey players, 10,185 professional ice hockey players, 37 adolescent aged ice hockey players, and 96 mixed level of ice hockey playing experience, which totaled 10,599 ice hockey players studied. Of these 10,599

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ice hockey players who participated in these studies, 1,177 of them had been injured by an SRC. Of the 11 articles used for this literature review, seven studies were researched on North American ice hockey players and four of the 11 articles were researched on Swedish ice hockey players. Five studies specified research focusing on both female and males, while the six focused specifically on male ice hockey players. All 11 of the studies used current concussion guidelines (official guidelines that were current when the research was being conducted) when assessing and diagnosing an SRC. These official guidelines consisted of ImPACT, SCAT 1, SCAT 2, SCAT 5, 3<sup>rd</sup> Consensus Statement on Concussion in Sport, and Congress of Neurological Surgeons. Diagnosis of an SRC for these studies were given by either a physician or a doctor. Each analyzing methods used for these 11 articles demonstrated results on the premises of answering this synthesis guiding research questions and to help further the understanding of the effects of SRC's to ice hockey players.

## Chapter 3

### Review of Literature

The purpose of this chapter is to present a review of the literature on the short- and long-term effects of sport-related concussions on ice hockey players. Two specific themes, that of quantifiable statistics and qualitative perspectives, were established from the 11 articles associated with the effects of sport-related concussions (SRC).

#### Quantifiable Statistics

As is widely known, ice hockey is a fast-paced sport that requires both high physical and mental performance from its athletes, whether they play at the amateur, collegiate or professional level. An athlete who sustains any type of injury to the head, but especially an SRC, could jeopardize their physical performance or mental functioning, or in some cases, both. An increasing rate in SRC's has initiated new research on the short- and long-term effects of SRC's, and this concern for the effects of SRC's can now be shown with quantifiable data. In this synthesis, data from eight of the studies will be used to provide this quantified data.

First, Pederson et al. (2014) conducted a study in effort to help find solutions to diminish the incidences, severity, and consequences of SRC's. This study used a six-year longitudinal design to collect archival data in order to examine neuropsychological functioning of collegiate ice hockey players who have sustained one or two SRC's through the use of the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) assessment.

The ImPACT assessment is a neuropsychological test battery that is analyzed by using a computer software program. It measures aspects of cognitive functioning such as learning, immediate/ delayed/ working memory, focused attention, concentration, reaction time, response inhibition, visual processing speed and visual motor speed, while giving a quantifiable score

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(Pederson et. al., 2014). Typically, this test takes 20 minutes to complete, but no time restrictions are given for the player to complete it in. Pederson et al. (2014) states that this test is reliable and has “recently been investigated and is good” (p. 202).

The subjects of this study were a total of 74 male collegiate ice hockey players with a mean age of 23 years. The six years’ worth of archival data was granted access from the athletic trainer (Pederson et. al., 2014). The study began with obtaining a baseline for each player at the beginning of each ice hockey season; each player was administered an ImPACT assessment to establish their own personal baseline. Once the seasons began, any player who had contact to their head or reported concussive symptoms that didn’t clear up within 15 minutes from impact was re-administrated the ImPACT assessment. That athlete was then not able to return to play until symptoms cleared up for more than 24 hours (Pederson et. al., 2014). This protocol was initiated, if needed, multiple times to the same players, if they continued to sustain more than one SRC. Results from this study indicated that there was a significant decrease in level of performance, delayed memory and memory recall. Furthermore, if a player sustained an additional SRC at a later date, results showed an even larger decrease in multiple aspects of cognitive functioning.

To further examine the exploration on physiological functioning, Tapper et al. (2016) conducted a study to examine the executive functioning in two different groups of intercollegiate varsity ice hockey players: those who have a history of SRC and those who do not. In order to establish their two groups, two health history questionnaires which assessed the reliability of self-reported concussion history were given to all subjects. The same ImPACT assessment as utilized in the previous study, and the University of Waterloo health history questionnaire, were also used to determine a history of SRC or no history of SRC’s. The University of Waterloo

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health history questionnaire was comprised of 22 questions on symptoms which was completed using a six-point Likert scale. From these two measures, 29 players total (115 females, 14 males) were chosen: 18 players who reported to have a history of SRC's from playing ice hockey and 11 players who reported never having sustained an SRC. Furthermore, of the 18 players who had a history of SRC's from ice hockey, nine players reported only sustaining one SRC, seven players reported sustain two SRC's, and two players reported they sustained three SRC's.

Once the two groups were established, a single auditory tone discrimination task was conducted to test the recognition of either a high tone or low tone throughout seven levels, consisting of four tones per level. Each player had two attempts at the task (Tapper et. al., 2016). The Corsi block test was then administered using E-prime software. The Corsi block test uses memory recall in order to gather data, which tested the subjects' memory as to where certain shapes were located on the computer screen (Tapper at. el., 2016). For this, seven levels were tested; it used a maximum of eight shapes and players had two trials/attempts within each level. The last task for this study was a combination of both of the pervious tasks. This dual-task involved the simultaneous completion of the auditory tone discrimination task and the Corsi block test. This dual task involved having the subjects discriminating the frequency of auditory tones while the Corsi block sequence was presented; subjects had to use both hands in order to accomplish the tasks. Neither of these tasks stressed speed or accuracy, which eliminated any concern for a focus on handedness (Tapper et. al., 2016).

The number of accurate responses was collected from both the tone discrimination and the Corsi block test. Tone discrimination was also compared from the first singular task test phase to the second test during the dual-task phase. This was the main outcome used to compare performance between single and dual-task conditions (Tapper et. al., 2016). The dual task cost

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equation ( $DTC=D-S/S$ ) was also used to evaluate the performance of each task, where (D) represents dual-task performance accuracy and (S) represents single task accuracy. Lastly, a two-way mixed ANOVA test was incorporated for comparison against the dependent variable, who had no history of SRC's. Findings for this study indicate that players who had a history of SRC's had a significantly worse performance on the tone discrimination task during the dual task test. Additionally, the results could suggest that these players have a more difficult time with sharing attention between two tasks (Tapper et. al., 2016).

A third study by McFarlane et al. (2020) also examined the effects of SRC's on cognitive functioning in ice hockey players. Specifically, this study investigated the impact of SRC's on the athlete's "ability to form cognitive maps, mental representations of the environment that are critical for spatial orientation and navigation" (McFarlane et. al., 2020, p. 1112). This study used 37 adolescent ice hockey players, and similar to Tapper et al. (2016) study, 19 of these adolescent players (four females and 15 males) had no history of concussions, while in contrast, 18 (five females and 13 males) were currently in the acute stage of recovering from an SRC from playing ice hockey. Players from each group were matched up in accordance of age, sex, and handedness.

The diagnosis of an SRC was determined by a trained medical staff member by using the Sport Concussion Assessment Tool, 5<sup>th</sup> Edition (SCAT5) to players who were suspected to have sustained an SRC (McFarlane et. al., 2020). This assessment measures a number of domains to be affected by a concussion which includes 22 commonly known symptoms. The spatial configuration task (SCT) was specifically designed to measure the ability to form a mental representation of spatial surroundings. The SCT is performed by using a computer and consists of 60 trials. The player is shown multiple viewpoints of an animation of outer space, all digitally

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created on a computer screen. All of these viewpoints contained the same seven stationary objects. When the screen stopped at a random objects' viewpoint, which is the view as if the subject was the object looking out at the outer space, the player had to identify which objects viewpoint they are looking from (McFarlane et. al., 2020).

Reaction time and accuracy data from each player's SCT was collected for the use of measurement and analysis. McFarlane et al. (2020) claims that the SCT is a valid and reliable method to measure the ability to form cognitive maps and spatial orientation skills in real life. A one-way analysis of covariance (ANCOVA) was performed in order to analyze and compare the number of correct responses and response time between the two groups (McFarlane et. al., 2020). The results from this study indicate that players with an SRC perform significantly worse than those without in terms of accuracy, which can suggest that there is a negative effect of SRC on the ability to form cognitive maps (McFarlane et. al., 2020).

Cognitive dysfunction is just one aspect of the physiological effects that an SRC has on an ice hockey player. While the three previous studies focused on the visibly seen effects of SRC's, Siman et al. (2015) conducted a study which evaluated serum calpain-derived alpha-spectrin N-terminal fragment (SNTF) as a diagnostic and prognostic biomarker for SRC's. These blood plasma levels of calpain-cleaved SNTF that are found in blood serve as useful markers for acute to severe TBI (Siman et. al., 2015).

In their study, Siman et al. (2015) used 288 professional ice hockey players from the Swedish Hockey League (SHL). The 288 players were selected from the 12 SHL teams (24 players per team), during the 2012-2013 season. A physician from each of the 24 teams documented signs and symptoms as well as performed the physical exams to diagnose an SRC according to the latest guidelines in Sweden on SRC. Blood samples from two random SHL

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teams were sampled at the beginning of the season for a baseline serum biomarker level. In addition, players from one of the two randomly selected teams provided blood samples at one and 12 hours after a training game without sustaining an SRC (Siman et al., 2015). When a player sustained an SRC during regular season play, blood samples were drawn at one, 12, 36 and 144 hours after occurrence of diagnosis as well as on the player's RTP day.

Siman et al. (2015) used a deidentifying sera to quantify SNTF, which used an "electrochemiluminescence-based sandwich". In doing so, this blinded the experimenter to the data on PCS severity and the serum levels of other biomarkers. Furthermore, a t-test was used to compare blood biomarker levels after a player who sustained an SRC during a game or training versus the players' preseason or pretraining levels. The Mann-Whitney U-test determined longitudinal biomarker levels between players with RTP within less than six days and six days or greater, while linear regression compared the longitudinal post-concussion serum levels of STNF with the electrochemiluminescence-based sandwich (Siman et al., 2015).

Findings from this study revealed that of the 73 players who sustained an SRC, serum SNTF levels increased at one hour after sustaining the SRC, and the levels remained significantly elevated from 12 hours to six days before declining to the players' baseline. Furthermore, 20 of these players were withheld from play for more than six days; their serum STNF levels between 12 and 36 hours after suffering an SRC differed significantly from the less-severe concussed players who recovered in less than six days (Siman et al., 2015).

This research by Siman et al. (2015), is not the only study that focused on the "invisible" physiological effects of SRC's in ice hockey players. Wright et al.'s (2016) study focused on observing the changes in myelin water fractioning (MWF) relative to baseline, at acute, sub-acute, and chronic post-mTBI time points in a group of individuals who are high-risk of sustain

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an SRC. In their study, 25 male and 20 female collegiate age amateur ice hockey players with a mean age of 21.2 +/- 3.1 years were selected from two ice hockey teams to participate in this study. All 45 players had an MRI scan of their brains as well as a neuropsychological test- the Sport Concussion Assessment Tool, version 2 (SCAT2)- at the beginning of their ice hockey seasons. All SRC's were diagnosed by an independent physician, which was basing diagnosis on the 3<sup>rd</sup> Consensus Statement on Concussion in Sport (Wright et. al., 2016). Following a diagnosis of an SRC, another MRI scan and SCAT2 test occurred within no more than 72 hours, followed by again at two weeks and again after two months.

The MWF MRI images after sustaining an SRC were then compared to the players individual baseline in alignment with each time period the images were taken at. The SCAT2 test was also compared following the same guidelines as the MRI images. This data was analyzed using the Voxelwise statistical system which used a tract-based spatial statistic (TBSS), and a white matter skeleton of each participants brain was created using the Functional MRI of the Brain Software Library in order to register MWF maps into diffusion tensor imaging (DTI) space (Wright et. al., 2016). Results demonstrated a reduction in MWF at two weeks after sustaining a SRC in several brain areas in relation to preseason scans and recovered to preseason values by two months post-SRC (Wright et al., 2016).

Physiological effects are not the only “invisible” way ice hockey are being impacted by SRC's. Psychological injuries have also been researched in order to determine the effects of SRC's on quality of life rather than mental and cognitive functioning. Gard et al. (2020) assessed the post-concussive symptom burden, quality of life and post-traumatic stress in former Swedish professional ice hockey players with prior concussions.

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This study involved 76 professional Swedish hockey players; 70 males and 6 females, who had retired due to the high burden of symptoms from SRC's which made it impossible for them to continue to play, or because they were concerned of sustaining additional SRC's (Gard et al., 2020). The 76 total participants for this study were recruited by Gard et al. (2020) from the 400 professional ice hockey clubs in Sweden, which consisted of roughly 50,000 players.

Gard et al. (2020) used their own questionnaires that addressed athletic career and concussions sustained during playing ice hockey. These questionnaires included inquiries about level of play, number of years, reason for terminating hockey career, number of concussions, age of first concussion, last concussion date, age of retirement, hospitalization from SRC, and current work situation. From these questionnaires, Gard et al. (2020) was able to create two groups for reasons of termination of the players hockey career: group Concussion Symptoms (gCS) and group Concussion Concerns (gCC).

The SCAT, similar to previously reviewed studies, was used in reference to collect data on symptoms. The Short Form Health Survey (SF-36) was used to determine QoL, which measured health domains from a 36- question measure

The SF-36 uses eight subscales with four relating to functional outcomes, three scales relating to well-being and one overall health scale. Functional scales include: physical functional, indicating limitations in physical activity; role physical, indicating problems with work and daily activities due to physical health; social functioning, indicating interference with normal social activities due to physical or emotional issues; and role-emotional, indicating problems with work or daily activities due to emotional problems. Scales relating to well-being include: bodily pain, indicating limiting pain; vitality, indicating fatigue; and

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mental health, indicating feelings of nervousness or depression. The overall measure of health is the scale of general health (Gard et. al., 2020, The Short Form Health Survey quality of life section).

The last measurement for this study was measured through the impact of event scale-revised (IES-R). Gard et al. (2020) used IES-R to identify self-reporting of PTSD to measure distress during a traumatic event but also a Swedish IES-R version that incorporates whiplash and other traumatic events. Furthermore, for the purpose of this study and the use of IES-R, traumatic event is classified as the realization that the players had to give up their hockey careers due to effects of SRC's (Gard et. al., 2020).

Findings indicate that gCS differed significantly worse in all domains of QoL, while gCC differed significantly worse in role physical, general health, social functioning, emotional and mental health. Results also found that there was a significant negative correlation for both gCS and gCC with symptom severity and SF-36, number of symptoms and SF-36, symptom severity and IES-R, and number of symptoms and IES-R (Grad et. al., 2020).

Furthering effects of traumatic events and SRC's, Nyberg et al. (2015) also utilized Swedish ice hockey players to examine if athletes who have sustained an SRC are at an increased risk for sustaining another traumatic injury. Investigation for this study took place on a single Swedish Hockey League (SHL) team, over 28 SHL seasons, from 1984 to 2012. There was a total of 264 SHL players who participated, consisting of an estimated 1,700 games and 6,185 practices throughout the 28 seasons. The data was collected by the same team physician for all 28 seasons, who also diagnosed a SRC's for the team, in accordance with the guidelines of the Congress of Neurological Surgeons and guidelines purposed to the SHL by Cantu and McCrory (Nyberg et. al., 2015).

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Players were divided into two groups- players who sustained an SRC, or players who experienced knee injuries such as MCL tear or knee distortion. The reason knee injuries were chosen to be compared to SRC's, was determined due to the similarity of RTP time (Nyberg et. al., 2015). From these two groups, if a player sustained another injury during a 42 day follow up period, they were placed into one of two sub-groups- either injury occurring during games only or injury occurring during a game and practice. The follow up data of 0 to seven days, 0 to 21 days and 0 to 42 days after RTP was analyzed using QlikView version 8.5. Injury and no injury results were treated as binary, and statistics were calculated using SPSS version 17, which used Fisher's exact test (Nyberg et. al., 2015). The results from this study revealed that players who had suffered from more than one SRC had a tendency to experience a subsequent injury during a game or a practice within a 42-day period when compared to those with a knee injury. Furthermore, players who missed more than 28 days of participation due to SRC had a more severe injury with 21 days after returning to play in comparison to a player with a knee injury (Nyberg et al., 2015).

Lastly, Benson et al. (2011) designed an important study that also focused on susceptibility to another injury. Prior to a player sustaining an SRC this study included RTP concerns and playing time loss due to injury. The objective of this study was to determine rates of concussions and trends related to SRC's in NHL players. Furthermore, it descriptively explored initial post-concussion signs, symptoms, physical examination findings and time loss, which was time between sustaining the injury and being medical clearance to RTP.

There were 9,619 NHL players assessed over seven years for this study. Team physicians documented all signs, symptoms and examinations of head trauma. At the time of this study, the NHL and NHL players association did not have a concussion grading scale or RTP guidelines

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established, so the physicians used their own personal clinical judgement on diagnosis of SRC's. The date was recorded when a player was diagnosed with an SRC as well as when that player was medically cleared to RTP. Additionally, Benson et al. (2011) used the RTP date as a best estimate on the severity of the SRC.

Independent variables were established such as age, position, recurrent SRC during the study, and initial post-concussion symptoms, signs and neurological findings. This allowed Benson et al. (2011) to use descriptive univariable and bivariable statistics to analyze data between the independent and dependent variables. In order to explore the initial signs and symptoms of an SRC as a predictor of time loss, Benson et al. (2011) used a linear regression model. This led to an analysis of a 10-day time loss cut-point which was used as a marker to retrospectively distinguish the severities of reported SRC's ( $\leq 10$  v.  $\geq 10$  days) (p. 906). This revealed common post-concussion symptoms (PCS) were 71% headaches and time loss in days increased 2.25 times for every subsequent SRC. In this study 69% of the players missed up to 10 practice days while 31% missed more than 10 days due to SRC PCS. Additionally, this study's results showed time loss significantly increased for every subsequent SRC sustained during this study which suggests that concussed players are more susceptible to sustain further injuries and will be out longer from competition in order to recover (Benson et. al., 2011).

### **Qualitative Perspectives**

Being physically and mentally tough is an unwritten rule for ice hockey players to possess; anything less is presumed a weakness (Miller, 2003). Sport-related concussion symptoms and effects are making this unwritten rule increasingly outdated. Whether the symptoms are acute or the effects are short- or long-term, SRC's are impacting ice hockey players not just on the ice surface, but off the ice as well. Through narrations and interviews with

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professional and amateur ice hockey players, this invisible injury is detrimental in more ways than one.

Engström et al. (2020) interviewed nine former semi-professional and professional Swedish born ice hockey players with a purpose to describe what suffering multiple SRC's means to them and how SRC's ultimately forced them to end their hockey careers. The eight men and one woman that participated in this study were all diagnosed according to the latest guidelines on SRC, and post concussive syndrome diagnosis was based on DSM-IV criteria (Engström et al., 2020).

Data was collected by Engström et al. (2020) during dialogic interviews, where the participants were asked to narrate their experiences of being forced to quit playing hockey due to multiple SRC's. A hermeneutic phenomenological approach was used during the analysis of the transcripts, during which themes and sub themes were created in order to gather results from the players transcripts. This data revealed players were limited in everyday life, struggled with forming a post-career identity, wanted to return to playing as soon as possible, and had a concern regarding lack of understanding and support (Engström et al., 2020).

Caron et al. (2013) also used dialogic and open-ended interviews in order to understand the meanings and lived experiences of sustaining multiple SRC's in professional ice hockey players. By using a hermeneutic, idiographic, and inductive approach based on an interpretative phenomenological viewpoint, Caron et al. (2013) interviewed five former National Hockey League (NHL) players who were diagnosed with severe SRC's throughout their careers and who had to retire from professional ice hockey due to symptoms from sustaining SRC's. Each of these players had played professional hockey for more than 10 seasons and had been retired from hockey for at least four seasons. Three of these players careers were during the 1990's, one

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played an equal amount in the 1980's and 1990's, and one played an equal amount in the 1990's and 2000's. It is important to note that the interviewer was also an athlete who had suffered multiple concussions due to sports.

The collection of data from the interviews focused on the players experiences of SRC's, how SRC's have affected them physically, psychologically, and how the symptoms affected their professional careers, personal relationships, and QoL (Caron et. al., 2013). Open-ended interviews were used to collect data. To help prevent any theoretical and research biases pseudonyms for the players were established as well as codes in effort to maintain anonymity. The interviewer conducted the first three steps of analyzing the data; (a) reading and rereading transcripts, (b) note taking on thoughts impressions and (c) a detailed analysis of events, situations and experiences that were discussed during the interviews (Caron et. al., 2013).

From here, the author collaborated with the coauthors to identify and connect themes. The creation of player pseudonyms from earlier were then compared with a delayed literature review in order to identify emergent themes and to connect such themes with other players who were interviewed for this study. Furthermore, a coding sheet was designed in order for the interviewer to reflect his own personal perspectives to the findings (Caron et. al., 2013). Findings indicate that players who suffer multiple SRC's have trouble with performing everyday tasks, are susceptible to having depressions and anxiety which affects their families and social lives, in addition to the physical pain such as headaches as well as vision impairments and memory issues (Caron et. al., 2013).

Lastly, using a grounded theory approach, Todd et al. (2018) qualitative research study's purpose was to investigate the effects of SRC of psychological illness on ice hockey players and their caregivers. The participants for this study were comprised of 17 men and three women who

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either played or coached minor or professional ice hockey, were a parent of an ice hockey player who was diagnosed with an SRC, or was a physician for ice hockey players. Certain criteria had to be met in order to participate in this study, which included being 16 years of age or older, English speaking, and have at least 10 years of experience with ice hockey through their profession, volunteering, or family (Todd et. al., 2018). Data collection in this study involved the use of 20 video-taped, semi-structured interviews. There were five primary questions asked during these 30-minute interviews:

- (a) what are the psychiatric effects of ice hockey concussion, (b) what is your experience with ice hockey concussion, (c) what is your experience with the psychiatric effects of ice hockey concussion, (d) what are the issues surrounding ice hockey concussion today, and (e) is there a stigma of psychiatric illness in ice hockey? (Todd et. al., 2018, p. 5)

The data from the interviews was then open coded into themes and then into corresponding categories established by the researcher. Todd et al. (2018) had two investigators, a psychiatric resident and a medical sociologist, independently open code the five transcripts. From here, axial coding was used to group codes together into conditions of phenomenon, actions related to a phenomenon, or consequences of a phenomenon. Throughout the coding process, commonalities, differences, behaviors, attitudes and perspectives were focal points when connecting concepts and relationships amongst the experiences of SRC's on the participants for this study (Todd et. al., 2018).

The results from this study reveal that the players felt they went through a biographical deconstruction which lead to a change in the players self-identify and their QoL. Players shared that they suffer from post-traumatic stress disorder, mental illnesses, anxiety, and the thoughts of

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suicide. Additionally, these players felt that their QoL was negatively affected and these illnesses will always be a part of them now (Todd et. al., 2018). These studies provide proof that players lives are negatively affected long-term from their lived experiences. Results from these studies reveal that some effects of SRC's cannot be determined through medical data.

## Chapter 4

### Results

The purpose of this chapter is to report the results of this synthesis based on the four research questions. A total of 11 studies that met the criteria to be included in the critical mass were used to create the results for this synthesis.

#### **Research Questions:**

1. What are the effects of sport related concussions (SRC) on ice hockey players physiological and cognitive functioning?
2. What are the psychological effects of SRC's on ice hockey players?
3. How does sustaining an SRC affect when ice hockey players return to play and their susceptibility to another injury?

#### **What are the effects of SRC's on physiological and cognitive functioning?**

For this research question there were a total of four studies which concentrated on physiological functions; more specifically, how cognitive and neurological functions are affected by an athlete suffering an SRC. The four studies used in answering this research question go beyond the typical short-term effects such as headaches, dizziness, nausea, and blurred vision. The results from these studies confirmed there are more serious effects that occur such as physiological functions such as motor-, visual-, and auditory-functioning, spatial orientation, cognitive mapping, memory recall, reaction time, neurobiology, and executive functioning are greatly affected after ice hockey players sustain SRC's.

Relative to spatial accuracy, results from McFarlane et al. (2020) revealed that adolescent ice hockey players who suffered one or more SRC's perform significantly worse on a spatial cognitive task (SCT) compared to players without a history of SRC's. This led the researchers to

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determine that the ability to form cognitive maps (i.e. when an individual familiarizes themselves with an environment that includes both salient environmental landmarks and their own spatial relationship to others) in adolescent ice hockey players are negatively affected by sustaining an SRC. Cognitive maps “are critical to successful orientation since, once formed, they allow individuals to reach any target location from anywhere within the environment, and even permit generating alternative, unexplored routes if required by environmental circumstances” (McFarlane et. al., 2020, p. 1112). This is important for any ice hockey players to be able to do on the ice surface, quickly, in order to effectively execute hockey skills and to make plays. This study demonstrates that adolescent ice hockey players suffer significant short- and long-term effects from head injuries.

Tapper et al. (2016) found that ice hockey players who have a history of SRC’s performed poorer on a tone discrimination task during a dual-task test. In this study, both the Corsi block task and the tone discrimination tasks were tested to measure attention and executive functioning. Results showed that collegiate ice hockey players with a history of SRC’s had an increased difficult time with sharing attention between the two tasks when compared to players with no history of SRC’s. They additionally concluded that concussed players’ visuospatial working memory and attention are both directly affected from suffering one or more SRC’s. This is important because the evaluations of attention and executive functioning, according to Tapper et al. (2016) appear to be helpful in order to determine who has a history of SRC’s and those who have no history of an SRC.

Performance of memory, specifically that of immediate and delayed memory, also decreased when compared to baseline (Pederson et. al., 2014). This study’s results revealed that when comparing concussed ice hockey players to non-concussed players, the concussed players’

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immediate recall was reduced for memory of both target words as well as designs. It also showed that delayed recall was lower when remembering target words and designs, and during both memory recalls, distractor words were not remembered either (Pederson et. al., 2014).

Furthermore, results discovered that when an ice hockey player sustains a second SRC, their performance is reduced even more in multiple cognitive domains, specifically those of memory and recall, when compared to their baseline performance. This includes severe decreases in visual motor speed, an increase of errors on tasks of visual processing discrimination, and even more errors on immediate recall of designs (Pederson et. al., 2014). Ice hockey players must be able to process situations on the ice and make quick decisions, along with remembering certain plays and positions in which they need to be. Anything that hinders the player from being able to do this, most likely results in making errors or losing playing time.

A fourth study of physiological effects on neurobiology was discovered by Siman et al. (2015) during a study on serum calpain-derived alpha-spectrin N-terminal fragment (SNTF). SNTF “is a plausible blood biomarker for the diffuse axonal injury of functionally deleterious mild traumatic brain injury (mTBI)” (Siman et. al., 2016, p. 1295). In other words, serum SNTF levels can indicate the severity of a brain injury. Twenty-eight players, all who suffered an SRC, were subjects for this study; they were divided into two groups, a less-severe group and a more severe group. The less-severe group consisted of eight players whose serum SNTF levels were low, and post-concussion symptoms dissipated within three to six days before returning to baseline. The more severe group included the remaining 20 players from the 28 players who suffered an SRC severe enough to be withheld from play for six days or longer. These players’ serum SNTF levels continued to rise from one hour to six days post-concussion; at 12 to 36 hours post-concussion, their serum SNTF levels differed significantly higher from those players

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in the less-severe group (Siman et. al., 2015). A rise in serum SNTF in players who sustained an SRC can be linked to the severity of the brain injury and it provides evidence that SNTF is a mechanism-based blood biomarker which can help indicate brain function impairment.

In summary, there were many factors that were significantly impaired due to SRC's. These impairments include motor-visual and auditory functioning, spatial orientation, cognitive mapping, memory, reaction time, executive functioning, athletic performance, and attention. Furthermore, serum SNTF levels suggest to be an indicator of brain functioning impairment.

### **What are the psychological effects of SRC's on ice hockey players?**

Multiple common themes were compiled from the results which focused on the psychological effects of SRC's on ice hockey players. For the purpose of this synthesis, the psychological effects focused on were anything affecting the mental, emotional, and social state/health of ice hockey players. The results from four studies provided information on these life-hindering psychological effects.

The use of focus group interviews conducted by Caron et al. (2013) with ice hockey players who had to give up playing hockey due to SRC's presents both short- and long-term psychological effects of suffering from one or more SRC's. These interviews revealed that players felt isolated during their rehabilitation after sustaining an SRC; they described feelings of withdrawal and being alone because they felt no one understood what they were going through. Some players explained they even felt alienated from their team. Some players thought this was encouraged by the general manager and coaches. Their reasoning behind this thought might be due to the thought this helped the player recover quicker (Caron et. al., 2013), or could be due to the lack of knowledge and training on how to properly handle concussed athletes.

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In relation to the long-term psychological effects, Caron et al.'s (2013) interviews showed that quality of life (QoL) in these players was severely impacted as a result of sustaining one or more SRC's. Multiple players indicated that everyday tasks, such as remembering where they put their keys to helping take care of themselves or their children, became more difficult to perform. Some of the players' narratives described how their home lives were affected because of lingering post-concussion symptoms (PCS) and mental struggles. Players had trouble helping their wives raise their children; one player even said that after sustaining an SRC he became a different person, which he believes led to him and his wife filing for a divorce. Thoughts of suicide due to depression, physical pain, and feelings of isolation and anxiety were expressed by each of these players during the interviews. This shows their mental struggles affects their everyday life (Caron et. al., 2013). This data is further supported by the findings in Gard et al. (2020), which shows that players who retired due to substantial SRC symptom burdens had a lower QoL (as indicated by general health, vitality, social functioning, and emotional mental health) and a high probability of having post-traumatic stress disorder (PTSD).

Data in Todd et al. (2018), shows similar results of anxiety, suicide, depression, and mental illnesses among ice hockey players who sustained one or more SRC's. Players from this study describe their struggles with issues surrounding substance abuse due to coping with the psychological effects from suffering SRC's. Results from this study also described how players underwent a "biographical deconstruction" which can lead to a change in a person's self-identity and affect their QoL. Engström et al. (2020) provides further support of how participants felt they lost their identity of being an ice hockey player after having to retire from the sport due to SRC's. In addition, data from this study show that these players have challenges in their everyday lives, they wanted to return to playing hockey as soon as possible, struggled forming a

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post career identity, and it was hard to find ways to live a good life (Engström et. al., 2020).

Thus, taken together, psychological effects are not only affecting the athletes but also the people in their lives.

### **How does sustaining an SRC affect when a player returns to play and their susceptibility to another injury?**

The return to play (RTP) time for any player after suffering an SRC can vary due to severity of SRC, the number of concussions sustained throughout their lives and/or the overall health of the athlete (Benson et. al., 2011). Typically, post-concussion symptoms (PCS) of SRC's determine the length of a player's recovery. Symptoms ranging from headaches, low energy, amnesia, dizziness, blurry vision, and/or nausea (Benson et. al., 2011; Caron et. al., 2013; Todd et. al., 2018) are all reasons RTP time is extended for certain players. The study by Benson et al. (2011) revealed that 69% of the players in their study missed up to 10 practice days while 31% missed more than 10 days due to PCS. Additionally, this study's results showed that time loss from participating and practicing became significantly longer with every subsequent SRC sustained during this study (Benson et. al., 2011). This suggests that concussed players are more susceptible to sustain further injuries and will be out longer from practice and competition in order to recover.

Nyberg et al. (2015) also focused on RTP, but more directly, when the players did RTP, how susceptible were they to another traumatic injury. When compared to players with knee injuries who were also recovering for more than 28 days, the concussed players from this study suffered more serious injuries within 21 days after RTP from their initial injury. This can suggest that ice hockey players are more vulnerable and susceptible to sustaining another injury during

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their recovery time period than a player with a comparable musculoskeletal injury that has a similar RTP time period.

Additionally, the results from myelin water fractioning (MWF) magnetic resonance imaging (MRI) images showed that ice hockey players who suffered a single SRC had a significant reduction in MWF in several area of the brain which did not fully return to baseline until two months after sustaining the SRC (Wright et. al., 2016). These results could suggest that in relation to transient reductions in the myelination status of axons following an SRC (when the brain is trying to fix and recover), there can be a temporal window of vulnerability to a player after suffering just one SRC. This can be due to the brain being more sensitive to any additional trauma during the recovery period (Wright et. al., 2016). Additionally, to further lend support to this study, Siman et al.'s (2015) results provide evidence of elevated blood biomarkers in serum SNTF after suffering an SRC. This could lead to the player being vulnerable to another injury due to progressive neurodegenerative condition (the time it takes the body and brain to recover and heal itself) in the chronic postinjury time period (Siman et. al., 2015). These results provide data that show that ice hockey players, if not fully recovered from an SRC, they could further be injured which can result in loss of playing time.

## **Chapter 5**

In this synthesis a total of 11 articles were examined in order to investigate the short- and long-term effects of sport-related concussions (SRC) on ice hockey players.

### **Conclusion**

The research studies in the critical mass revealed that there are many short- and long-term effects which result from sustaining an SRC. These include observable physiological effects, a vulnerability to sustaining another injury, and an impact as to when and if a player returns to play. The most impactful evidence found within the research, however, showed that SRC's can cause "invisible," even more serious psychological damage to any ice hockey player who sustains an SRC, such as post-traumatic stress disorder (PTSD), anxiety, depression, and more. This is crucially important because those players who sustain more than one SRC are at an even higher risk of suffering from the effects throughout the rest of their lives and there is evidence to show that they suffer from these "invisible" injuries forever (Caron et. al., 2013; Engström et. al., 2020; Gard et. al., 2020).

The short-term effects explored by Pederson et al. (2014), Tapper et al. (2017), and McFarlane et al. (2020) suggest that beyond the headaches, dizziness, nausea, and blurred vision, there are even more serious effects which occur from SRC's. These include slowed reaction time, decreased motor-visual and spatial skills, and difficulty with dual tasks and memory. Each one of these physiological functions are hindering ice hockey players from achieving their peak performance, their overall quality of life (QoL) and being able to perform daily tasks (e.g. taking care of children). It is crucial for any ice hockey player to be able to form cognitive maps quickly (i.e. analyze a defender or where to shoot the puck), to have impeccable reaction time and motor-visual skills, and to have the ability to use their memory as well as multitask (i.e. marking a

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player while keeping an eye on the play). These are all typical skills and functions that an ice hockey player should possess in order to successfully play the game at a high level, but suffering SRC's negatively affects a player's ability to do so.

Additionally, these short-term effects then are shown to affect ice hockey players' recovery time, vulnerability to sustaining another injury, and when the player can return to play (Benson et. al., 2011; Siman et. al., 2015; Wright et. al., 2016; Nyberg et. al., 2015). This can mean that depending on the severity of the SRC as well as the number of SRC's a player has had, the player's recovery time can be significantly longer when compared to other injuries. In turn, this can cause the player to miss important games. This also means that players who have sustained more than one SRC are even more vulnerable to sustaining another SRC during their recovery time (Wright et. al., 2016; Nyberg et. al., 2015).

All of these factors affecting the recovery and return to play (RTP) time, as well as a player possibly receiving another SRC are important for keeping players safe, healthy and continuing to play the game. They can help players and coaches better understand why a player might fear losing their spot on the starting line or their playing time, or their passion to continue playing ice hockey, or even their fear of being injured again (Caron et. al., 2013; Engström et. al., 2020; Gard et. al., 2020). These studies are important because they show that ice hockey players are in fact physically and cognitively affected from SRC's which can lead to severe injuries if not properly diagnosed or identified, especially if they are allowed to continue to play after sustain an SRC.

What is crucial to understand about these short-term effects is that they can escalate into long-term effects for ice hockey players. Such long-term effects presented by Caron et al. (2013), Engström et al. (2020), Gard et al. (2020), and Todd et al. (2018) suggest that long-term effects

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include a poorer QoL, players suffer from PTSD, CTE, depression, and anxiety due to having to retire or quit playing ice hockey because of these affects or they fear sustaining another SRC. These studies are important because a majority of the long-term effects are not a visible injury (i.e. PTSD, depression, anxiety and CTE), but they have the most damaging effects not only to the player suffering from them, but also the ones around them. It is important to better understand the psychological effects of SRC's, so that way it becomes easier to detect and help out these players that are struggling.

Lastly, it is important to note that the research could provide evidence that lower SNTF levels and slowed MWF process that could be a way to detect if a player sustained an SRC or not (Siman et. al., 2015 and Wright et. al., 2016). This could be a turning point in ways to scientifically identify and diagnose SRC's. This could possibly eliminate any player returning to play even if they somehow pass concussion protocol with an SRC, which could save them from suffering further damages and being affected long-term.

### **Future Research**

Throughout the 11 studies that were presented in this synthesis, there were some limitations which were presented and which may benefit from future research considerations. The limitations from the studies that were reviewed for this synthesis were small sample sizes, no way to track unreported concussions, the use of multiple tests to diagnose SRC's, length of research, focalization on only one task, and lack of pre-injury data. Furthermore, there is a limited number of studies which focus solely on the effects of SRC's on ice hockey players.

From these limitations, there needs to be continuous investigation of these short- and long-term effects of SRC's. One suggestion for future research is to study a professional ice hockey team throughout multiple seasons (a case study approach) using the same concussion

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diagnosis protocol throughout every diagnosis of an SRC. Furthermore, the tests should consist of testing blood biomarkers, MRI and CT scans, as well as examining executive functioning tasks, motor-visual testing, memory task, and other cognitive testing measures. If these test and tasks are all done as a whole, it will allow a further understanding of the detrimental damages SRC's have on ice hockey players, but also hopefully find ways to help reduce the effects of SRC's throughout their lives.

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*Canadian Medical Association Journal (CMAJ), 183(8), 905-911.*

Purpose	Methods & Procedures	Analysis	Findings	Discussion/Recommendations
<p>To determine rates of concussions and trends related to concussion in the NHL, to descriptively explore initial post-concussion signs, symptoms, physical examination findings and time loss, and to assess the utility of initial post-concussion clinical manifestations as predictors of time loss among male professional ice hockey players.</p>	<p>-9619 NHL hockey players over 7 years.</p> <p>-Physicians documented all signs, symptoms and examinations.</p> <p>-Dates were recorded, SRC occurred, RTP medically.</p> <p>-RTP or clearance date, served as best estimate on severity of SRC.</p> <p>-NHL-NHLPA at time of study, did not adopt a concussion grading scale or RTP guidelines, physicians would use their own clinical judgement.</p> <p>-Independent variables; age, position, recurrent SRC.</p> <p>-Only symptoms that remained consistent from season to season were used during analysis.</p>	<p>-Descriptive univariable and bivariable statistics were used for the IDV and DV.</p> <p>-Average incidence rate was calculated against RTP average.</p> <p>-Time loss cut-point of 10 days was used to distinguish severity.</p> <p>-Linear regression model assisted in identifying potential predictors of time loss.</p>	<p>-559 physician- diagnosed regular in game SRC.</p> <p>-80 per season, game rate of 5.8 concussions per 100 players per season.</p> <p>-Common PCS was 71% headaches, time lost in days increased 2.25 times for every subsequent SRC.</p> <p>-Controlling for age and position, significant predictors of time loss were post-concussion headache (<math>p &lt; 0.001</math>), low energy or fatigue (<math>p = 0.01</math>), amnesia (<math>p = 0.02</math>) and abnormal neurologic examination (<math>p = 0.01</math>). Using a previously suggested time loss cut-point of 10 days, headache (odds ratio [OR] 2.17, 95% CI 1.33-3.54) and low energy or fatigue (OR 1.72, 95% CI 1.04-2.85) were</p>	<p>-Limitations: underreporting, different thresholds for physicians reporting and RTP, no systematic collection of data for practice, exhibition and playoff related SRC.</p> <p>-Suggest that more should be done to educate all involved with the sport about the potential adverse effects associated with continuing to play while symptomatic, failing to report symptoms to medical staff and failure to recognize or evaluate any suspected concussion. Our findings also suggest that more conservative or precautionary measures should be taken in the immediate post-concussion period, particularly when an athlete reports or experiences a post- concussion headache, low energy or fatigue, amnesia, recurrent concussion or many different post-concussion symptoms, or when the athlete has an abnormal neurologic examination.</p>

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			significant predictors of time loss of more than 10 days.	
<p>Caron, J., Bloom, G., Johnston, K., &amp; Sabiston, C. (2013).                  Effects of multiple concussions on retired national hockey league players.  <i>Journal of Sport &amp; Exercise Psychology</i>, 35(2), 168–179.</p>				
<b>Purpose</b>	<b>Methods &amp; Procedures</b>	<b>Analysis</b>	<b>Findings</b>	<b>Discussion/Recommendations</b>
<p>To understand the meanings and lived experiences of multiple concussions in professional hockey players using hermeneutic, idiographic, and inductive approaches within an interpretative phenomenological analysis (IPA).</p>	<p>-Interviewer was an athlete who had suffered multiple concussions.</p> <p>-Participants were five former National Hockey League athletes who retired due to medically diagnosed with severe concussions suffered during their careers.</p> <p>-Each player competed professionally for at least 10 season and who had been retired for at least four seasons.</p> <p>-3 participants played majority of career in the 90's, 1 played equally in the 80's and 90's and 1 played equally in the 1990's and 2000's</p> <p>-Each interview was approximately 45 to 90 min in a mutual agreed upon location in North America.</p>	<p>-Interview guide was established to gather info from participants experience of their 1<sup>st</sup> concussions and how it occurred, the long-term effects.</p> <p>-Open ended interview to help prevent any theoretical and researcher biases.</p> <p>-The interviewer conducted the first three steps.</p> <p>-Coauthors identified and connected themes using interviews journal, analysis notes, and delayed literature searches.</p> <p>-Identified profiles for each of the participants, along with detailed narrative and</p>	<p>-Participants acknowledge they couldn't remember their first concussion.</p> <p>-Short-term: physical symptoms included vision impairments.</p> <p>: psychological repercussions of feeling isolated during their concussion rehab and had withdrawal, feeling of being alone and no one understood their situation. Alienated encouraged by coaches and GM.</p> <p>-Headaches or head pressure.</p> <p>-Vision impairments, reading and memory issues.</p>	<p>-These findings advance research on the long-term post-concussion effects and add to the ever-increasing list of possible outcomes, including chronic traumatic encephalopathy (Stern et al., 2011) and mood disorders and dementia (Gavett, Stern, &amp; McKee, 2011; Stern et al., 2011). This line of research is still in its infancy (McCrory, 2011), and our results demonstrate, through personal accounts of former professional hockey players, the long-term effects of concussions on multiple quality-of-life domains.</p> <p>-Based on our findings, a greater awareness of the physical symptoms that occur both immediately and persist long term can inform management programs to help concussed athletes rehabilitate and avoid returning to play while symptomatic (Safai,</p>

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	<p>-Interviews were audio recorded as well as transcribed verbatim and safely stored.</p> <p>-Players discussed their physical and psychological symptoms they had experienced as a result from the concussions they sustained and how the symptoms affected their professional careers, personal relationships, and QoL.</p>	<p>interpretation of their experiences.</p> <p>-Each participant was assigned a pseudonym.</p> <p>-The profiles established were used with a delayed literature review to identify emergent themes and to connect themes within and across the players who volunteered.</p> <p>-Coding sheet was designed in order for the interviewer to reflect on the findings from his own perspectives.</p>	<p>-QoL: participants suggest that their multiple concussions have affected their abilities to perform daily tasks.</p> <p>-Depression and emotional rollercoaster and effected their families.</p> <p>-Thoughts of suicide due to depression, physical pain, feelings of isolation, and anxiety.</p> <p>-Wives had to basically be the single mother due to participant being able to not be affected by symptoms. (Divorce)</p>	<p>2003), and also increase awareness at a societal level to reduce the burden of male athletes' living up to hegemonic masculinity standards.</p> <p>-Calls for researchers to implement longitudinal approaches to gain a more thorough understanding of the implications of this injury.</p>
<p>Engström, Å., Jumisko, E., Shahim, P., Lehto, N., Blennow, K., Zetterberg, H., &amp; Tegner, Y. (2020).          Losing the identity of a hockey player: the long-term effects of concussions.  <i>Concussions</i>, 5(2), CNC74-CNC74.</p>				
<b>Purpose</b>	<b>Methods &amp; Procedures</b>	<b>Analysis</b>	<b>Findings</b>	<b>Discussion/Recommendations</b>
<p>To describe what suffering multiple concussions meant for former semi-professional or professional hockey players who were</p>	<p>-9 former Swedish hockey players who played on national or professional teams.</p> <p>- Forced to quit due to multiple SRC.</p> <p>- Interviews.</p> <p>-Narratives</p>	<p>- Hermeneutic phenomenology</p> <p>-Themes were established</p>	<p>-Being limited in everyday life</p> <p>-Returning to the hockey stadium as soon as possible</p> <p>-Forming a post career identity</p>	<p>- Limitations: small number of participants, interviews were long (80 minutes).</p> <p>-There is a debate how to decrease the risk for concussions has to continue.</p>

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<p>forced to end their career.</p>			<p>-Lacking understanding and support</p> <p>-Preventing injuries by respecting other players.</p>	<p>-The effects has to be known by all involved and what there is that can be done for those affected.</p>
<p>Gard, A., Lehto, N., Engström, Å., Shahim, P., Zetterberg, H., Blennow, K., Marklund, N., &amp; Tegner, Y. (2020).                  Quality of life of ice hockey players after retirement due to concussions.  <i>Concussion</i>, 5(3), CNC78.</p>				
<b>Purpose</b>	<b>Methods &amp; Procedures</b>	<b>Analysis</b>	<b>Findings</b>	<b>Discussion/Recommendations</b>
<p>Assessed the post-concussive symptom burden, quality of life and post-traumatic stress in former Swedish professional ice hockey players with prior concussions.</p>	<p>-All players ended careers due to history of multiple concussions, fear of additional concussions or symptoms that prevented further play.</p> <p>-Swedish ice hockey players who retired because of SRC.</p> <p>-Study info was sent to medical staff of the 400 ice hockey clubs in Sweden consisting of 50,000 players.</p> <p>-Athletes were recruited for the study between 2014-2019.</p> <p>-76 players assessed, on average of 5 years after their most recent SRC.</p>	<p>-Questionnaire addressing athletic career and concussions sustained during sports.</p> <p>-Included level of play, # years, reason for terminating hockey career, # concussions, age first concussion, last concussion, age retirement, hospitalized from concussion, etc.....</p> <p>-Sport Concussion Assessment Tool (SCAT)- evaluates 22 different symptoms in 7 rankings on a Likert scale. (Self-administered)</p> <p>-Short Form Health Survey, QoL (SF-36)- 36 questions measuring health domains,</p>	<p>-Outcomes in terms of QoL and PTSD is worse in players ending their careers due to a high symptom burden.</p> <p>- Retired hockey players that have a history of concussions had a lower quality of life and high post-traumatic stress.</p> <p>- 58% of participants retired due to post concussive symptoms. (gCS)</p> <p>- 42% of participants retired due to concern of additional concussions. (gCC)</p>	<p>-Results suggest that it is important to continually evaluate symptom burden to guide the decision and that it may be favorable to retire earlier when the symptom burden is reduced, to avoid developing persistent post-concussive symptoms leading to a lower QoL.</p> <p>-Other factors, such as biomarkers, neurocognitive assessment, refined neuroimaging and anti-inflammatory drugs need to be further studied to evaluate if these can predict or aid SRC recovery.</p>

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<p>-70 male and 6 females.</p> <p>-Retired due to either high burden of symptoms that made it impossible to play, or due to concerns of sustaining additional concussions.</p> <p>-Pro, Semi &amp; Amateur ice hockey players.</p>	<p>where low score means poorer QoL.</p> <p>-Uses 8 subscales with 4 scales relating to functional outcomes, 3 scales relating to well-being and one over-all health scale.</p> <p>-Functional scale- physical function, role physical, social functioning, role emotional.</p> <p>-Well-being scale- bodily pain, fatigue, mental health.</p> <p>-Impact of Event Scale-Revised, PTSD (IES-R)- self reporting PTSD.</p> <p>-Classified traumatic event as having to give up hockey due to SRC.</p> <p>-22 questions- 3 subscales: intrusion, avoidance and hyperarousal.</p>	<p>- 82% of the participants subjectively experienced and increase susceptibility to attain additional concussion injuries following a SRC.</p> <p>-86% of the participants indicated suffering from nervousness or anxiousness as most frequent symptom.</p> <p>- gCS differed significantly in all domains of QoL. gCC differed significantly in role physical, general health, vitality, social functioning, role-emotional and mental health.</p> <p>-Found that each correlation was significant and even stronger: symptom severity and SF-36, # of symptoms and SF-36, symptom severity and IES-R, and # of symptoms and IES-R</p> <p>-gCS had correlations between symptom severity</p>
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			and SF-36, # of symptoms and SF-36, symptom severity and IES-R, and # of symptoms and IES-R. -gCC had significant correlations between symptom severity and SF-36, and # of symptoms and SF-36, but not between symptom severity and IES-R or # of symptoms and IES-R.	
<p>McFarlane, L. H., Burles, F., Yeates, K. O., Schneider, K., &amp; Iaria, G. (2020).                  A Pilot Study Evaluating the Effects of Concussion on the Ability to Form Cognitive maps for Spatial Orientation in Adolescent Hockey Players.  <i>Brain Injury, 34(8)</i>, 1112-1112.</p>				
<b>Purpose</b>	<b>Methods &amp; Procedures</b>	<b>Analysis</b>	<b>Findings</b>	<b>Discussion/Recommendations</b>
<p>To investigate the impact of SRC on the ability to form cognitive maps, mental representations of the environment that critical for spatial orientation and navigation.</p>	<p>-18 adolescent hockey players suffering from a SRC and 19 hockey players with no history of concussions.                      -Age, sex and handedness was organized when matching players with and without a SRC.                      -A trained medical staff member administered the Sport Concussion Assessment Tool 5<sup>th</sup> Edition (SCAT5) to players who suspected to have sustained a SRC.</p>	<p>-A one-way analysis of covariance (ANCOVA) was performed to compare the number of correct responses and response time between the groups.</p>	<p>-Athletes with concussion (<math>M = 42.61, SD = 7.22</math>) performed significantly worse than those without concussion (<math>M = 48.32, SD = 8.27</math>) in terms of accuracy, with a medium to large negative effect, <math>F(1, ) = 5.82, p = .021, d = -0.72</math>.                      -This confirms that there is a negative effect of SRC on the ability to form cognitive maps.</p>	<p>-SRC may affect the ability to familiarize with a spatial surrounding and orient within it.                      -No previous studies have examined the effects of a SRC on the ability to form cognitive maps for orientation.                      -Limitations: small sample size, only studied on one single computerized task.</p>

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<p>-The spatial configuration task was specifically designed to measure the ability to form a mental representation of the spatial surroundings.</p> <p>-The task was performed 60 times on a computer screen that shows a virtual environment that simulates outer space and four objects.</p> <p>-Accuracy and reaction time were measured for this test.</p>			<p>-Further studies should investigate the possible differences in athletes spatial orientation abilities in their everyday lives.</p> <p>-The lack of pre-injury data, have no baseline.</p>
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Nyberg, G., Mossberg, KH., Lysholm, J., & Tegner, Y. (2015).  
 Subsequent traumatic injuries after a concussion in elite ice hockey: A study over 28 years.  
*Curr Res Concussion*, 2(3),109-112.

Purpose	Methods & Procedures	Analysis	Findings	Discussion/Recommendations
<p>To analyze whether athlete who have sustained a concussion are at an increased risk for subsequent traumatic injuries.</p>	<p>-Investigated all concussions that occurred in one Swedish elite hockey club over 28 seasons.</p> <p>-From the SHL, from the 1984-1985 season until the 2011-2012 season.</p> <p>-264 SHL players over 28 seasons; 1700 games and 6185 practices.</p> <p>-A computerized injury registration form (ISIS) was used.</p> <p>-First 15 seasons, data was recorded on paper and then later put into ISIS.</p>	<p>-Subjects were divided into two groups, players who sustained a concussion and players who experienced knee injuries (MCL tear or knee distortion).</p> <p>-Knee injury was chosen due to a similar RTP as a concussion.</p> <p>-Both groups were followed for 42 days after being cleared to RTP.</p> <p>- From these two groups, two more were created; occurred in game or occurred during game and practices.</p>	<p>-Over 28 seasons, 2003 injuries occurred, 148 were concussions.</p> <p>-Consisted of 81 players, 50 of them only sustained one concussion.</p> <p>-No statistical significance from a player who suffered a concussion compared to a knee injury in relation to sustaining subsequent injury.</p>	<p>-Was not able to confirm that players who RTP after a concussion were at a higher risk than normal to sustain additional traumatic injuries.</p> <p>-It is unclear why a player who sustains more than 1 concussion is possibly at an increased risk for sustaining another injury.</p> <p>-Sample size is too small in order to accurately assess research question.</p>

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	<p>-For all 28 seasons, same team physician was responsible for all diagnoses.</p> <p>-Concussions were diagnosed according to the guidelines of; Congress of Neurological Surgeons (85-86 season), guidelines proposed by Cantu were introduced to SHL in 1986, 2004 McCrory guidelines used.</p>	<p>-If another concussion occurred during the 42 RTP time period, that second concussion was regarded as a subsequent injury.</p> <p>-Follow up time was divided into three groups; 0-7 days, 0-21 days and 0-42 days post RTP.</p> <p>QlikView version 8.5, Qlik, Sweden database analysis program was used.</p> <p>-Calculations of statistics were calculated using SPSS version from IBM corporation, using a X2 test or Fisher's exact test.</p>	<p>-However, there was a tendency for more players who had more than one concussion to experience a subsequent injury in a game or practice within 42 days when compared to those with knee injury.</p> <p>-Players with a concussion that missed more than 28 days of playing, had a more severe injury within 21 days after RTP when compared to players with a knee injury.</p>	
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Pedersen, H., Ferraro, F., Himle, M., Schultz, C., & Poolman, M. (2014).  
 Neuropsychological Factors Related to College Ice Hockey Concussions.  
*American Journal of Alzheimer's Disease & Other Dementias*, 29(3), 201–204.

<b>Purpose</b>	<b>Methods &amp; Procedures</b>	<b>Analysis</b>	<b>Findings</b>	<b>Discussion/Recommendations</b>
<p>To present six years-worth of archival data collected on neuropsychological factors related to men's college ice</p>	<p>-74 male collegiate ice hockey players with a mean age of 23.</p> <p>-6 years period.</p>	<p>-ImPACT neuropsychology test battery was used in order to analyze the data.</p> <p>-This computer-based test measures multiple aspects of</p>	<p>-Significant decrease in performance and delayed memory when compared to baseline.</p>	<p>-Players who sustained one concussion were affect in performance of memory functioning, delayed and immediate memory for verbal and non-verbal</p>

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<p>hockey players concussions.</p>	<p>-Beginning of season, each player had a baseline established using the ImPACT.</p> <p>-When a player had contact to the head, concussive symptoms, and the symptoms did not clear up within 15 minutes, the ImPACT was re-administrated.</p>	<p>cognitive function including learning, immediate and delayed memory, focused attention, concentration, working memory, reaction time, response inhibition, visual processing speed, and visual-motor speed.</p> <p>-Provides composite scores assessing verbal memory, visual memory, reaction time, processing speed, and impulse control. The specific tests include Word Memory, Design Memory, Xs and Os, Symbol Match, Color Match, and Three Letters.</p>	<p>-Immediate recall was reduced for both words, <math>t_{13} = 2.24</math>, <math>P &lt; .05</math>, and designs, <math>t_{13} = 2.72</math>, <math>P &lt; .05</math>.</p> <p>-Delayed recall was also reduced.</p> <p>-Individuals were less able to remember target words, <math>t_{13} = 2.67</math>, <math>P &lt; .05</math>, and designs, <math>t_{13} = 3.12</math>, <math>P &lt; .01</math>, at the delayed condition. They were also less able to identify distracter words, <math>t_{13} = 2.18</math>, <math>P &lt; .05</math>, at the delayed condition.</p> <p>-When a second sport-related concussion was sustained (<math>n = 4</math>), significant decreases in performance were observed on multiple cognitive domains when compared to baseline performance, including reductions in visual-motor speed (Visual Motor Composite, <math>t_3 = 3.12</math>, <math>P &lt;</math></p>	<p>information was affected in a negative way.</p> <p>-Players who sustained two concussion showed a reduction of immediate recall of nonverbal information, had more difficulty in tasks requiring visual processing and visual discrimination.</p> <p>-The current study found that many important cognitive functions needed continually throughout the lifespan (immediate memory, delayed memory, reaction time, and visual processing / discrimination) can all be negatively affected by concussions experienced by division 1 college ice hockey players.</p> <p>-Although small sample size, data from this study should be looked at due to the data patterns and the potential late-life consequences and the impact the consequences have on those more vulnerable including college hockey players.</p>
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			.01), increased errors on tasks of visual processing discrimination (Xs and Os; $t_3 = -3.36, P < .05$ ), and more errors on immediate recall of designs, $t_3 = 3.60, P < .05$ .	-College athletes need to be made aware how they may be affected after a SRC especially additional ones of the potential short- and long-term (possible CTE) consequences.
<p>Siman, R., Shahim, P., Tegner, Y., Blennow, K., Zetterberg, H., &amp; Smith, D. H. (2015).                  Serum SNTF Increases in Concussed Professional Ice Hockey Players and Relates to the Severity of Post-concussion Symptoms.  <i>Journal of neurotrauma</i>, 32(17), 1294–1300.</p>				
<b>Purpose</b>	<b>Methods &amp; Procedures</b>	<b>Analysis</b>	<b>Findings</b>	<b>Discussion/Recommendations</b>
To evaluate serum spectrin terminal fragment (SNTF) as a diagnostic and prognostic biomarker for concussion in a prospective cohort study involving professional ice hockey players in the Swedish Hockey League.	-288 participants which derived from 24 players from each 12 teams. -Each physician from each team documented signs and symptoms of concussions and performed the physical exam. -Diagnosis of a SRC were made according to the latest guidelines on SRC.	-Blood samples were extracted at 1, 12, 36 and 144 hours after concussion happened, as well as on the date of RTP.  -Before the start of the season, two of the teams players were sampled for baseline serum biomarker level, in addition, players from one of these teams provided blood samples 1 and 12h after a training game without a sustaining a concussion.  -SNTF was quantified by a deidentifying sera which used an electrochemiluminescence-	-Of the 28 players who sustained a concussion during this study/season, and the 45 players evaluated during preseason, serum SNTF levels increased at 1 hour after concussion and it remained significantly elevated from 12 hours to 6 days before it declined to baseline.  -8 players symptoms went away after a few days. -20 players were withheld for 6 days or longer and their serum SNTF levels increased from 1 hour to 6 days, and between 12 and 36	-Prior to this study, SNTF had not been evaluated as a blood biomarker for SRC.  -Links serum SNTF to the incidence and severity of SRC, and SNTF is a mechanism-based blood biomarker for the diffuse axonal injury (DAI) underlying brain functional impairment after a mTBI.  -Further investigation on the vulnerability of concussed athletes to develop a progressive neurodegenerative condition in the chronic postinjury time period.

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		<p>based sandwich that was analyzed by an experimenter blinded to the data on PCS severity and serum levels of the other biomarkers.</p> <p>-The t-test was used to compare biomarker levels after a concussion or training to preseason or pretraining levels.</p> <p>-The Mann-Whitney's U test was used for comparison of longitudinal biomarker levels between participants with RTP in less than 6 days and 6 days or greater.</p>	<p>hours differed significantly from the less serve concussed players.</p> <p>-Results can suggest that blood SNTF, could be used for the diagnosis and prognosis for SRC and could be used to guide a neurobiological informed decision on RTP.</p>	<p>-Limitations: small sample sizes, and an incomplete assessment between serum SNTF concentrations with brain structure and the long-term functional changes following a SRC.</p> <p>-Pre-season blood samples weren't taken from ALL SWH players.</p> <p>-Further research for the use of serum SNTF to detect brain injuries on other neuronal injuries for behavioral, neuroradiological, and physiometric assessments.</p>
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Tapper, A., Gonzalez, D., Roy, E., & Niechwiej-Szwedo, E. (2017).  
 Executive function deficits in team sport athletes with a history of concussion revealed by a visual-auditory dual task paradigm.  
*Journal of Sports Sciences, 35(3), 231-240.*

<b>Purpose</b>	<b>Methods &amp; Procedures</b>	<b>Analysis</b>	<b>Findings</b>	<b>Discussion/Recommendations</b>
To examine executive functions in team sport athletes with and without a history of concussion.	<p>-29 intercollegiate varsity ice hockey players. 15 females aged 19.1 +/- 1.26 years, and 14 males aged 22.25 +/- .9 years.</p> <p>-18 had history of concussions and 11 had no concussion history.</p> <p>-Participants completed two health history questionnaires in order to</p>	<p>-2 computer systems used to collect data. E-prime software (v1.2) and Microsoft Excel (MS Office 2013).</p> <p>-Corsi block target coordinates and the participants target response selection were exported from E-prime. These</p>	<p>-Examined two important attributes of executive functions. Visuospatial working memory and divided attention.</p> <p>-There were no differences when a task was completed by itself.</p>	<p>-Because athletes had a more difficult time dividing attention between the two task, the results suggest that a decrease in central executive function could be explained b concussions.</p> <p>-The sport-specific examination can be more useful than previous</p>

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<p>assess the reliability of self-reported concussion history and symptoms.</p> <p>-1<sup>st</sup> questionnaire was the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT), 2<sup>nd</sup> was the University of Waterloo health history questionnaire.</p> <p>-A 22 question symptom checklist using a six-point Likert scale was also used for determining symptoms such as; somatic (headache, foginess), cognitive (memory, concentration) and emotional (sadness, nervous).</p> <p>-Concussions were diagnosed as a complex neurological disturbance affecting the brain, resulting from a direct or indirect impact to the head.</p> <p>-Concussion and non-concussion groups were formed for the participants.</p> <p>-Of the 18 participants in the concussed group, a range of 2 to 98 months from a concussion was established.</p>	<p>coordinates were used to determine the participants recall accuracy.</p> <p>-Tone test tested accuracy response to tone during the second administration of tones.</p> <p>-Tone discrimination accuracy was the main outcome used to compare performance between the single and dual-task conditions. Tone discrimination accuracy was also used to determine auditory task cost, which was defined as the difference in performance between tone discrimination accuracy in the single-task condition compared to tone discrimination accuracy in the dual-task condition.</p> <p>-A dual task cost equation was used to evaluate the performance of each task. (D represents performance accuracy in the dual task condition; S represents performance accuracy in the single task condition).</p>	<p>-Athletes who had a history of concussions, had a significantly worse performance on the tone discrimination task during the dual testing.</p> <p>-Athletes with a history of concussions had a increased difficult time with sharing attention between the two tasks when compared to non-concussed athletes.</p>	<p>studies because the measures tested correlates with the executive functions that an athlete must have in order to play a team sport, furthermore, ice hockey players must use executive functioning to process visual and auditory information more quickly than in other sports.</p> <p>-Even though there is a range in when the concussed athlete sustained a concussion (months to years), history of concussions can still be a contributing factor to impairing executive functioning of the athlete and the lower abilities shown in this dual-task test can suggest that.</p> <p>-These results may have implications when athletes are placed in contact sport environments where they are required to attend to teammates' voices, which is a more complex cognitive process, and process complex visuospatial information. It is possible that a previously concussed athlete may have trouble</p>
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	<p>-9 of these athletes had suffered only 1 concussion, 7 with 2, and 2 with 3 previous concussions.</p> <p>- A single auditory tone discrimination task: recognition of either a high tone or a low tone. 7 levels total and two attempts per level.</p> <p>- A single visuospatial working memory task: The Corsi block test: E-prime computer software was used for this test.</p> <p>- A combination of both tasks.</p> <p>-Lastly, auditory tone discrimination task again, but started at the level the participant achieved during the dual testing phase.</p> <p>-All lasted 15 to 20 minutes.</p> <p>-Participants had to use both hands for the test, neither tasked stressed speed or accuracy, which eliminates any concern for a focus on handedness.</p>	<p>DTC= D – S/S</p> <p>-Used a 2-way mixed ANOVA test with the tone discrimination accuracy in percentage as the dependent variable.</p>		<p>accurately processing their environment, which may increase the probability of sustaining another injury. Therefore, cognitively demanding tasks testing executive functions may provide more insight into the potential long-term effects of concussions.</p> <p>-Limitations: unbalanced design for concussions, a small sample size and a cross-sectional design.</p>
<p style="text-align: center;">Todd, R., Bhalerao, S., Vu, M., Soklaridis, S., &amp; Cusimano, M. (2018).          Understanding the psychiatric effects of concussion on constructed identity in hockey players: Implications for health professionals.  <i>PloS One</i>, 13(2), e0192125.</p>				
<b>Purpose</b>	<b>Methods &amp; Procedures</b>	<b>Analysis</b>	<b>Findings</b>	<b>Discussion/Recommendations</b>

## EFFECTS OF CONCUSSIONS TO ICE HOCKEY PLAYERS

<p>To investigate the effect of concussion and psychiatric illness on athletes and their caregivers.</p>	<ul style="list-style-type: none"> <li>- Used qualitative research method with a grounded theory approach.</li> <li>- Understandings and experiences of the participants.</li> <li>- Through a theoretical perspective gained an in-depth knowledge of what concussed hockey players experience without imposing any of their preconceived notions onto those experiences.</li> <li>- Participants varied levels of ice hockey experience (minor to professional).</li> <li>- 3 woman and 17 men: 16 years of age or older.</li> <li>- At least ten years of ice hockey experience through their profession, volunteering or family.</li> <li>- Analyzed transcriptions of 20 video-taped semi structured interviews using grounded theory.</li> <li>- Interviews were at minimum 30 min. conducted by the same two male interviewers, a psychiatrist and a psychiatric resident.</li> </ul>	<ul style="list-style-type: none"> <li>- Data was open coded into themes and then categories.</li> <li>- The two investigators were the primary coders, done independently.</li> <li>- Second step consisted of axial coding, in order to group specific codes that were related to each other. Grouped together by certain phenomenon, conditions of a phenomenon, actions related to a phenomenon, or consequences of a phenomenon.</li> <li>- Last stage was selective coding, primary codes.</li> <li>- NVIVO 10, a qualitative software program was used to store and organize.</li> </ul>	<ul style="list-style-type: none"> <li>- Short-term: dizzy, nauseous, isolation, stuck in dark room, no one understanding what they were going through, feeling alone.</li> <li>- Some participants were able to conquer the short-term symptoms, but not the long-term (post-concussion).</li> <li>- Long-term: post-concussion depression, anxiety, and PTSD. Mental illness, suicide.</li> <li>- “When asked about reasons that mental illness and concussions were different from other physical sport injuries, twelve of the participants used the word “weak” as a way that individuals may be perceived”.</li> <li>- Some players suggested that they went through a</li> </ul>	<ul style="list-style-type: none"> <li>- Most important finding is that care-providers and family can intervene effectively, to help the process of construction, disruption and deconstruction and then reconstruction. Natural development process.</li> <li>- Must understand the psychological trajectory of concussions in hockey players can help health care providers to recognize and address these issues along with the physical symptoms of a concussion.</li> <li>- This research was able to present that caregivers are able to help athletes who sustain concussions with their new identity, by highlighting their strengths and personhood outside of the game of hockey.</li> <li>- Limitations: broad number of perspectives covered, researchers would like to have been able to recruit more coaches and parents of hockey players.</li> <li>- Were unable to talk to players that refused medical care after</li> </ul>
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	<p>-At participants home and/or work place.</p> <p>-Five primary questions were asked during interview, in addition, participants were encouraged elaborate on their experiences and stories.</p>		<p>biographical deconstruction when they experienced post-concussive mental illness.</p> <p>- These biographical disruptions can lead to a change in the athletes self-identity and their QoL.</p> <p>-The support of family and peers helped many of the players to recover mentally.</p>	<p>sustaining a concussion or players that were still dysfunctional due to persistent concussion symptoms.</p>
<p>Wright, A., Jarrett, M., Vavasour, I., Shahinfard, E., Kolind, S., van Donkelaar, P., Taunton, J., Li, D., &amp; Rauscher, A. (2016). Myelin Water Fraction Is Transiently Reduced after a Single Mild Traumatic Brain Injury – A Prospective Cohort Study in Collegiate Hockey Players. <i>PloS One</i>, 11(2).</p>				
Purpose	Methods & Procedures	Analysis	Findings	Discussion/Recommendations
<p>To observe changes in myelin water fraction, relative to baseline, at acute, sub-acute, and chronic post-mTBI time points in a group of individuals at high-risk of sustaining an SRC.</p>	<p>-25 male and 20 female collage age amateur ice hockey players (mean age 21.2 +/- 3.1 years), from two ice hockey teams.</p> <p>-All players at beginning of season, had a MRI scan of their brain as well as a neuropsychological test (Sport Concussion Assessment Tool version 2 (SCAT2))</p> <p>-Concussions were diagnosed by an independent physician based on the guidelines of the 3<sup>rd</sup> Consensus Statement on Concussion in Sport.</p>	<p>-Myelin water fraction MRI images were compared from each athletes baseline who sustained a SRC to their 72 hour, 2 week, and 2 month images.</p> <p>-Data was analyzed through Voxelwise statistical system using tract-based spatial statistics (TBSS), and the Functional MRI of the Brain Software Library which created a white matter skeleton of each participants brain.</p>	<p>-Results demonstrated a reduction in myelin water fraction at 2 weeks post-injury in several brain areas relative to preseason scans, including the splenium of the corpus callosum, right posterior thalamic radiation, left superior corona radiata, left superior longitudinal fasciculus, and left posterior limb of the internal capsule.</p> <p>-Myelin water fraction recovered to pre-season</p>	<p>-Transient reductions in the myelination status of axons could suggest that the athlete’s brain is more sensitive and vulnerable to additional head injuries during the recovery time.</p>

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	<p>-11 players sustained a SRC.</p> <p>-Following diagnosis, scans and testing happened 72 hours, 2 weeks, and 2 months after SRC.</p> <p>-MRI data was collected using a Phillips Achieva 3T scanner equipped with Quasar Dual Gradients and eight-channel SENSE head coil.</p>		<p>values by 2 months post-injury.</p> <p>-These results may indicate transient myelin disruption following a single mTBI, with subsequent remyelination of affected neurons</p>	
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