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LISTE DES ABBRÉVIATIONS

ACSM : American College of Sport Medicine

AE : Athletic Exposure

Abs : Abstract

Art : Article

ATCD : Antécedent

BESS : Balance Error Scoring System

CAT : Certified Athletic Trainer (USA) ou Certified Athletic Therapist (Canada)

CDC : Centers for Disease Control and Prevention

CDH : Chronic Daily headache

CERNEC : Centre de Recherche en Neuropsychologie et Cognition

CGH : Cervicogenic Headache

CHISG : Cervicogenic Headache International Study Group

CINAHAL : Cumulative Index to Nursing and Allied Health Literature

Dr : Docteur

FB : Feedback

GCS : Glasgow Coma Score

GRAN : Groupe de Recherche sur les Affections Neuromusculosquelettiques

HR : Heart Rate

ICL : Index to Chiropractic Literature

IHS : International Headache Society

IIHF : International Ice Hockey Federation

LHJMQ : Ligue de Hockey Junior Majeur du Québec

LNH : Ligue Nationale de Hockey

LOC : Lost of Consciousness

MRI : Magnetic Resonance Imaging

mTBI : mild Traumatic Brain Injury

N : Nombre

NCAA : National Collegiate Athletic Association

NHL : National Hockey League

NHLPA : National Hockey League Players Association

OHL : Ontario Hockey League

QMJHL : Quebec Major junior Hockey League

PCS : Postconcussion Syndrome

PEDro : Physiotherapy Evidence Database

PRO : Professional

PTH : Post-Traumatic Headache

RTP : Return to play

S/S : Signs and Symptoms

SAC : Standardized Assesment of Concussion

TBI : Traumatic Brain Injury

TCC : Traumatisme Craniocérébral

TCCL : Traumatisme Craniocérébral léger

Tx : Traitements ou Treatments

UQTR : Université du Québec à Trois-Rivières

WAD : Whiplash Associated Disorders

CHAPITRE I. INTRODUCTION

Les traumatismes craniocérébraux légers (TCCL) sont un sujet de plus en plus présent dans les médias depuis quelques années. Des hockeyeurs populaires, tels Sydney Crosby, Paul Kariya et Chris Pronger, on fait les manchettes pour leurs commotions et leurs symptômes qui ont perduré plusieurs mois. Les professionnels de la santé oeuvrant dans le domaine sportif sont à la recherche de protocoles et de remèdes miracles pour tenter gérer cette épidémie silencieuse. Or, les recherches scientifiques sont encore préliminaires et peu d'articles scientifiques proposent des outils concrets pour les praticiens oeuvrant sur le terrain.

Ce mémoire est basé sur un des sujets ayant suscité un intérêt majeur en médecine du sport ces dernières années. Le premier article porte sur l'association entre le mécanisme provoquant une commotion cérébrale et son impact direct au niveau de la colonne cervicale. En pratique, il n'est pas rare pour les praticiens d'associer intuitivement TCCL et cervicalgie, car ils se produisent souvent conjointement lors d'un processus de « whiplash » et les signes et symptômes sont similaires (Hynes et al., 2006; Schneider et al., 2014). Cependant, peu de littérature scientifique traite de ce sujet pourtant commun en clinique. De ce fait, une revue de la littérature était de mise pour mettre à jour les connaissances des praticiens à ce sujet. Les objectifs de cette revue de la littérature étaient de trouver les relations et les similarités entre les signes et symptômes, les mécanismes de blessures et les types d'interventions thérapeutiques pour les commotions cérébrales et les cervicalgies.

En ce sens les professionnels de la santé oeuvrant dans le domaine sportif recherchent souvent des outils pour traiter les commotions cérébrales. Outre le « gold standard » universel qu'est le repos, de nouveaux protocoles et techniques émergent peu à peu dans la littérature scientifique. Conséquemment, le deuxième article présente un projet de recherche qui a été fait sur les commotions cérébrales en collaboration avec des thérapeutes de la Ligue de Hockey Junior Majeure du Québec (LHJMQ). Les objectifs de cette étude sont 1) d'objectiver les caractéristiques des commotions subies par des hockeyeurs d'âge junior, 2) d'analyser les données descriptives concernant le retour au jeu, 3) de recenser les méthodes et techniques d'intervention faites par les différents professionnels de la santé lors de la réadaptation postcommotionnelle et 4) d'étudier l'influence d'une formation continue entre les deux saisons sur les types de traitements utilisés par les thérapeutes. Appuyés par la littérature, les résultats du projet représentent les protocoles et techniques présentement utilisées dans le domaine sportif.

Ces deux articles apportent des aspects nouveaux et aideront au développement des techniques utilisées lors de la réadaptation suit à une commotion cérébrale.

CHAPITRE II. PROBLÉMATIQUE

II.i. LES COMMOTIONS CÉRÉBRALES

Présentement, les commotions cérébrales, ou, en terme médical traumatisme craniocérébral léger (TCCL), sont une des préoccupations les plus importantes auprès des professionnels de la santé à tous les niveaux sportifs (Benson et al., 2013; Broglio et al., 2014). Le Consensus International sur les commotions cérébrales dans les sports de Zurich, tenu en 2012, a défini la commotion cérébrale comme suit:

« Processus pathophysiologique complexe induit par des forces biomécaniques affectant le cerveau. Les aspects cliniques, pathologiques et biomécaniques se rejoignent sur plusieurs caractéristiques communes pour définir la nature de la commotion cérébrale. Il survient lors d'un coup direct à la tête ou lors d'une force transmise indirectement à celle-ci. Une commotion cérébrale résulte habituellement d'une diminution rapide des fonctions neurologiques sur une courte période lors de l'impact et se résout spontanément. Cependant, certains signes et symptômes peuvent durée de quelques minutes à plusieurs heures.»

(Traduction libre, McCrory et al., 2013)

Les commotions cérébrales sont diagnostiquées dans 70 à 90% de l'ensemble des TCC (Kozlowski et al., 2013; McCrory et al., 2013). Selon les données recueillies, il y aurait eu 62% d'augmentation au niveau des consultations aux urgences pour les TCCL entre 2001 et 2009 aux États-Unis (Clay et al., 2013). Une des raisons majeures soutenant cette augmentation de diagnostics de commotions dans les dernières années serait que la population est plus au courant des risques de complications suite à de multiples commotions (Hanson et al., 2014). Statistiques Canada estime que l'incidence annuelle des TCCL est de 600 par 100 000 Canadiens et que les TCC graves sont à un taux de 11,4 par 100 000 habitants (Tator et al., 2007). Aux États-Unis, il est estimé qu'il y a entre 1,6 et 3,8 millions de TCC par année (Benson et al., 2013; Broglio et al., 2014; Johnson et al., 2013). Le groupe d'âge le plus à risque serait les 19 à 29 ans, représentant près du quart de l'ensemble des TCC (Tator et al., 2007). Cependant, près des 50% des commotions cérébrales ne seraient pas rapportés selon Harmon et ses collaborateurs (2013). Le Centre pour le contrôle et la prévention des maladies (CDC) a même décrit les commotions cérébrales comme une épidémie silencieuse (Borich et al., 2013).

II.ii. LES COMMOTIONS CÉRÉBRALES AU HOCKEY

Le hockey sur glace, le football américain ainsi que la crosse sont les sports ayant le plus haut taux d'incidence de commotions tous sports confondus (Hanson et al., 2014; Sullivan et al., 2012). Étant des sports de contact, les commotions sont plus communes dans ces sports, autant chez les hommes que les femmes (Broglio et al., 2014; Pelletier, 2006). Au niveau du hockey sur glace, il y a plus d'un 1 million de jeunes hockeyeurs au Canada et États-Unis combinés, dont 570 000 sont enregistrés avec Hockey Canada (Bonfield et al., 2014; Schneider et al., 2013). Le département des urgences aux États-Unis a décrété un total de 17 008 blessures à la tête en lien avec le hockey sur glace incluant 4820 commotions cérébrales entre les années 1990 à 1999 (Delaney, 2004). Parmi tous les types de blessures, les commotions cérébrales ont la plus grande proportion chez les jeunes hockeyeurs (Schneider et al., 2013).

Les commotions cérébrales sont communes au hockey sur glace (Benson et al., 2011). Le mécanisme le plus commun provoquant une commotion est le contact entre les hockeyeurs, communément appelé la « mise en échec » (Bonfield et al., 2014; Giza et al., 2013; Harmon et al., 2013; Hynes et al., 2006). Selon l'étude de Schneider et al. (2013), la mise en échec est incorporée au jeu au niveau Pee-Wee (11-12 ans) en Alberta et dans la catégorie Bantam (13-14 ans) au Québec. Il y a une évidence scientifique au hockey sur glace que les règlements interdisant les mises en échec dans la catégorie de 11-12 ans (Pee-Wee) sont une stratégie efficace pour la prévention des blessures (Benson et al., 2013). Un article de Benson et ses collaborateurs (2013) mentionne que les hockeyeurs âgés entre 10-13 ans sont plus à risque de subir une commotion cérébrale, plus particulièrement lors de l'introduction des mises en échec légales lors des parties.

Dans le hockey professionnel, il y a plus de 50 000 mises en échec annuellement et plusieurs d'entre elles sont la cause de blessures à la tête (Hackney, 2011). En 2010-2011, 44% des commotions cérébrales provenaient de mise en échec légale, 17% de mise en échec illégale (41% en 2010-2011) et 8% de bagarres (Bonfield et al., 2014). La vitesse de jeu ainsi que le l'aspect agressif et compétitif de ce sport sont des aspects qui augmentent les risques de blessures, plus particulièrement les commotions cérébrales (Bonfield et al., 2014).

La Ligue Nationale de Hockey (LNH) est la première ligue professionnelle à s'être dotée d'une politique officielle sur la prévention, l'évaluation et les traitements des commotions cérébrales (Bonfield et al., 2014). De 1997 à 2004, la LNH et la National Hockey League Players Association (NHLPA) ont mis sur pieds un programme sur les commotions cérébrales pour les examiner d'un point de vue scientifique. L'étude s'est étendue sur une période de sept ans pour un total de 559 commotions cérébrales recensées durant les saisons régulières de cette période (Benson et al., 2011). Donnant une moyenne de 80 commotions cérébrales par saison, ceci représente 5,8% des hockeyeurs de la LNH au total (Bonfield et al., 2014). L'incidence était de 1,8 commotion cérébrale par 1000 joueurs-heures (Bonfield et al., 2014). L'incidence de 5% de commotions cérébrales dans la LNH est similaire à celle retrouvée dans la *Swedish Elite League* (Bonfield et al., 2014). Selon une revue systématique de la littérature parue en 2012, l'incidence des commotions cérébrales dans les sports varierait entre 0,1 à 21,5 par 1000 Athletic Exposure (AE) (Clay et al., 2013). La plus haute incidence se retrouvait dans le hockey junior canadien, mais un haut taux de commotions touchait aussi le football américain considérant le grand nombre de participants (Clay et al., 2013). Dans le programme américain National Collegial Athletic Association (NCCA), le hockey sur glace comprend un des risques de commotions cérébrales les plus élevées tous sports confondus avec un ratio de 0,41 par 1000 AE. D'autres études rapportent des incidences variant entre 0,72 à 3,1 par 1000 AE ce qui fait de la commotion cérébrale l'une des blessures les plus fréquentes dans ce sport. Une étude sur la ligue de hockey universitaire canadienne durant une période de six ans a démontré que les commotions cérébrales représentaient un total de 13% de l'ensemble des blessures répertoriées (Rishiraj et al., 2009). Au Canada, Echlin et al. (2010) a présenté dans son étude une incidence beaucoup plus élevée de 7,5 par 1000 AE chez le joueur de hockey en général et de 21,52 par 1000 EA chez les juniors canadiens. Ces statistiques exposent un risque sept fois plus élevé chez le hockey junior canadien que dans la LNH. Cependant, la publication compare une étude prospective chez des hockeyeurs juniors comparativement à une étude rétrospective avec des questionnaires de symptômes autorapportés pour ceux de la LNH, ce qui pourrait expliquer l'apparent risque sept fois plus élevé.

Durant la saison 2011-2012, la LNH a reporté qu'il y a eu 90 hockeyeurs qui ont du manquer des parties en saison régulière en raison d'un diagnostic de commotion (Bonfield et al., 2014). La majorité des commotions cérébrales (environ 80%) se produisent lors des parties comparativement aux pratiques, en raison de l'intensité du jeu contre les adversaires (Bonfield et al., 2014; Hanson et al., 2014). À tous les niveaux de jeu, les attaquants sont plus à risque de TCCL que les défenseurs et les gardiens, quant à eux, ont la plus faible incidence (Bonfield et al., 2014). Un des problèmes rencontrés lors de la mesure de l'incidence des commotions cérébrales au hockey sur glace est que plusieurs cas ne sont pas rapportés. En effet, les hockeyeurs ont une réputation d'être durs envers leur corps malgré la douleur. Cette idéologie bien ancrée dans ce sport sur glace fait en sorte que plusieurs athlètes continuent de jouer malgré la présence de symptômes et, du fait même, diminuent l'incidence rapportée (Bonfield et al., 2014). Les maux de tête étaient le symptôme le plus commun (Benson et al., 2011; Hecht, 2004; Lucas, 2011; Marshall, 2012; McCrory et al., 2013; Watanabe et al., 2012). Suite à des analyses statistiques, la conclusion de l'étude mentionne que les maux de tête postcommotionnels, la fatigue ou la diminution d'énergie, l'amnésie et les examens neurologiques anormaux sont des signes prédicateurs d'une plus longue convalescence chez les hockeyeurs professionnels (Benson et al., 2011). Le consensus de Zurich, tenu en 2012, mentionne que les symptômes persistants plus de 10 jours sont plus communs chez les hockeyeurs élite ainsi que chez les enfants (McCrory et al., 2013). En effet, les adolescents âgés entre 10 et 18 ans prennent plus de temps à récupérer suite à une commotion que les adultes (Moser et al., 2012).

Un bon nombre de hockeyeurs, comme Paul Kariya, Pat Lafontaine, Éric Lindros Keith Primeau et Marc Savard ont dû prendre leur retraite de façon prématurée en raison de multiples commotions cérébrales (Bonfield et al., 2014). De nombreuses questions ont été aussi soulevées en rapport aux multiples traumas frontaux à la tête qui ont potentiellement mené aux suicides de trois « hommes forts » de la LNH (Derek Boogaard, Rick Rypien et Wade Belak) (Bonfield et al., 2014). De plus, l'apport des médias dans les cas des vedettes comme Sydney Crosby et Chris Pronger a soulevé un débat public en ce qui a trait aux risques de ce sport ainsi qu'aux conséquences de la chronicité des symptômes que plusieurs professionnels retraités vivent quotidiennement (Bonfield et al., 2014). Cette chronicité, appelée le syndrome postcommotionnel, peut s'installer progressivement dans les mois suivants le trauma et son étiologie n'est pas très bien définie dans la littérature (Marshall, 2012; McCrory et al., 2013; Signoretti et al., 2011; Weightman et al., 2010). Retrouvé dans 10 à 15% des cas de commotions cérébrales, ce syndrome est diagnostiqué lorsque les symptômes perdurent plus de 14 jours (Cancelliere et al., 2014; Hecht, 2004; McCrory et al., 2013). Une approche multidisciplinaire est ainsi recommandée pour cette pathologie aux multiples facettes qui est souvent très complexe (Kozlowski et al., 2013; Makdissi et al., 2013; McCrory et al., 2013).

Différentes approches ont été utilisées pour diminuer le risque de commotions cérébrales chez les hockeyeurs. La Ligue Nationale de Hockey (LNH) a introduit depuis quelques années la Règle 48 régulant les coups à la tête, mais l'incidence de commotion chez les hockeyeurs professionnels n'a pas diminué (Donaldson et al., 2013). Cependant, ces changements de règlementation par rapport aux « mises en échec par-derrière » ainsi que les « coups à la tête » au niveau du hockey sur glace ont permis de réduire la gravité des blessures au niveau du cou ainsi que de la sévérité des commotions cérébrales (Biasca et al., 2002; Harmon et al., 2013).

II.iii. LA COLONNE CERVICALE ASSOCIÉE AUX COMMOTIONS CÉRÉBRALES

Le hockey sur glace est un sport rapide où les mises en échec sont permises sur l'ensemble de la patinoire (Bonfield et al., 2014). La nouvelle génération de hockeyeurs est de mieux en mieux entrainée, représentant des gabarits de plus en plus gros et pouvant atteindre des vitesses de 30 miles à l'heure ce qui accroit les contacts à haute vélocité contre les bandes, les buts et les adversaires (Bonfield et al., 2014; Hynes et al., 2006). Ces collisions provoquent de sévères changements de vitesse, comme des mouvements accélérations/décélérations provoquant des blessures (Bonfield et al., 2014; Broglio et al., 2014). Il y a une forte association entre ce phénomène de « whiplash » produisant des blessures cervicales et les symptômes dus à une commotion cérébrale au hockey sur glace (Hynes et al., 2006). Le « whiplash » est défini comme une accélération et/ou une décélération de la tête et du complexe du cou, provoquant des symptômes associés (Hanson et al., 2014; Hynes et al., 2006; Kozlowski et al., 2013; Littleton et al., 2013; Watanabe et al., 2012).

La pathophysiologie des symptômes du patient provient d'une ou plusieurs structures cervicales. L'implication des muscles, ligaments, nerfs, œsophage, articulation temporomandibulaire, disques intervertébraux, articulations zygapophysaires, vertèbres ainsi que le complexe atlanto-occipital crée un défi complexe pour le clinicien voulant intervenir auprès d'un patient avec des douleurs cervicales (Hecht, 2004; Watanabe et al., 2012; Weightman et al., 2010). Reliant ces faits, le mécanisme du « whiplash » peut provoquer des troubles cervicogéniques, une commotion cérébrale ou bien les deux, ce qui complexifie le rôle du praticien.

Différents outils de prévention ont été mis en place sur le marché pour diminuer le risque de commotions cérébrales dans le sport. Parmi les croyances populaires, il n'y a pas d'évidence scientifique confirmant que le port du protège buccal diminue significativement le risque de commotions (Benson et al., 2013). D'un autre côté, une hypothèse suppose que le développement de la musculature cervicale aiderait à diminuer les risques de commotions cérébrales, théorie qui a été renversée par une récente étude chez les hockeyeurs adolescents (Mihalik et al., 2011). Cependant, de nouvelles études ont démontré qu'avec une musculature développée au niveau du cou, les forces transmises au niveau de la tête sont moins grandes et l'anticipation du contact est meilleure (Eckner et al., 2014; Schmidt et al., 2014; Tierney et al., 2005). Or, les résultats n'ont pas démontré que les athlètes avec un cou plus développé ont une diminution de la sévérité de l'impact à la tête (Schmidt et al., 2014). D'un autre côté, Collins et al. (2014) ont conclu dans leur étude incluant 6704 athlètes de niveau secondaire que la mesure de la force du cou peut être un outil intéressant pour évaluer le risque de commotion cérébrale.

II.iv. LES TRAITEMENTS DE LA COMMOTION CÉRÉBRALE

En ce qui concerne les types de traitements, de nombreux professionnels de la santé travaillent avec les patients ayant des symptômes postcommotionnels (Signoretti et al., 2011; Weightman et al., 2010). Avec cette approche multidisciplinaire, de multiples approches sont utilisées pour améliorer la condition du patient symptomatique. Or, selon le dernier consensus international, ayant eu lieu en 2012, le repos posttrauma est le seul traitement reconnu et recommandé dans le domaine médical (McCrory et al., 2013). Depuis ce temps, d'autres approches comme la thérapie manuelle, l'entrainement neurosensorimoteur, l'approche vestibulaire et l'activité physique graduelle sont des techniques qui commencent à faire leur preuve dans la littérature scientifique (Brolinson, 2014; Laker, 2011; Leddy et al., 2012; McCrory et al., 2013; Schneider et al., 2014).

Dans le but d'outiller les professionnels de la santé, une recherche approfondie des dernières publications scientifiques était de mise pour diriger les pratiques cliniques en lien avec les commotions cérébrales. De ce fait, les deux articles suivants permettront, en premier lieu, de mettre en lien les connaissances récentes sur les dysfonctions cervicogéniques associées aux commotions cérébrales dans le but d'en démontrer leur interrelation dans leurs signes et symptômes, leurs mécanismes de blessures ainsi que dans leurs traitements communs à ses deux pathologies distinctes, mais parfois combinées. En second lieu, les objectifs du projet de recherche présentés dans le deuxième article sont 1) d'objectiver les caractéristiques des commotions subies par des hockeyeurs d'âge junior, 2) d'analyser les statistiques concernant le retour au jeu, 3) de recenser les techniques d'intervention fait par les différents professionnels lors de la réadaptation postcommotionnelle et 4) d'étudier l'influence d'une formation continue entre deux saisons complètes sur les types de traitements utilisés par des thérapeutes.

CHAPITRE III. ARTICLE 1

CERVICAL SPINE INVOLVEMENT IN MILD TRAUMATIC BRAIN INJURY: A REVIEW

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Le premier auteur, Michael Morin, a établi avec Dr Philippe Fait les critères d'inclusions et d'exclusions et a ensuite élaboré le protocole de recherche des articles ciblés dans la littérature et fait la collecte de données. M Morin a sélectionné, analysé et synthétisé les articles pour la revue de la littérature. Suite à l'écriture de l'article, le Dr Philippe Fait et Monsieur Pierre Langevin ont révisé le manuscript. Les trois auteurs ont finalisé le papier en collaboration et ils ont élaboré des étapes pour la publication.

ABSTRACT

BACKGROUND: Post-concussion syndrome and rehabilitation for mild traumatic brain injured (mTBI) patients is challenging for health care professionals. The evidence of involvement of the cervical spine in mTBI is preliminary, but usually clinically accepted. There is a lack of scientific evidence in the present literature on this subject.

OBJECTIVE: This article is a review bringing together the evidence of the involvement of the cervical spine in mTBI symptoms, the injuriy's mechanism and the efficient of therapy for cervical spine with symptoms related to concussion.

METHODS: A search with keywords was conducted on PubMed, Index to Chiropractic Literature (ICL), SportDiscus, Physiotherapy Evidence Database (PEDro), Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Cochrane library databases for articles, available in English and French, published between 1990-01-01 and 2015-05-19. The following keywords: concussion, neck, traumatic brain injury, treatment, cervical, chiropractic, physiotherapy, athletic training, manipulation guideline, physical therapy, manual therapy and mTBI were used. The reference lists of articles meeting the criteria (original data articles, literature reviews and clinical recommandations) were also searched in the same databases.

RESULTS: After the search, 4,854 records were screened and 81 abstracts were eligible for review. Finally, 59 articles were selected, including original data studies (n=21), reviews (n=36)

and clinical recommandations (n=2). Those articles were used to describe different subjects such as: mTBI's signs and symptoms, mechanism of injury and treatments.

CONCLUSIONS: Evidence regarding cervical spine involvement in mTBI is preliminarily clear, but there is a lack of sound evidence in the literature. The hypothesis of cervical spine involvement in post-mTBI symptoms and in PCS is supported by increasing evidence and largely accepted. For the mTBI management and treatment, few articles in the literature are available, but decent studies showed interesting results about manual therapy (cervical, vestibular) and exercises as an efficient tools for health care practicioners.

Abbreviations used in this paper: mild traumatic brain injured (mTBI), Chiropractic Literature (ICL), SportDiscus, Physiotherapy Evidence Database (PEDro), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Centers for Disease Control and Prevention (CDC), traumatic brain injured (TBI), Postconcussion syndrome (PCS), Magnetic Resonance Imagings (MRIs), Whiplash-Associated Disorder (WAD), International Headache Society (IHS), post-traumatic headache (PTH), cervicogenic headache (CGH), Glasgow Coma Score (GCS), the Standardized Assessment of Concussion (SAC), the Balance Error Scoring System (BESS).

INTRODUCTION

Mild traumatic brain injury (mTBI) is commonly known as concussion (Tator et al., 2007). In a recent study, Statistics Canada estimated mTBI annual incidence to be 600 per 100,000 persons and 11.4 per 100,000 inhabitants for traumatic brain injured (TBI). The pediatric TBI population is the sub-group of patients who consulted the most often in the emergency room (Tator et al., 2007). An estimated 1.6 to 3.8 million sport- and recreation-related brain injuries occur in the United States annually, and up to 75% are classified as mild (Borich et al., 2013). The mild severity is diagnosed in 70 to 90 per cent of all TBI cases and the symptoms usually resorb in between 7 to 10 days (Kozlowski et al., 2013; McCrory et al., 2013). However, as many as 50% of concussions may go unreported (Harmon et al., 2013). In an epidemiologic study, Tator et al. (2007) demonstrated that the highest age group incidence for TBI is between the ages of 19 and 29 years old, representing approximately one quarter of all patients with TBI. The Centers for Disease Control and Prevention (CDC) describes mTBI as a silent epidemic (Borich et al., 2013).

Concussion in sports was defined in 2013 at the international consensus on concussion in sport, held in Zurich as:

> *"Concussion is a brain injury and is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces. Several common features that incorporate clinical, pathologic and biomechanical injury constructs may be utilised in defining the nature of a concussive head injury. This is caused by a direct blow to the head, face,*

neck or elsewhere on the body with an "impulsive" force transmitted to the head. Concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, symptoms and signs may evolve over a number of minutes to hours. Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies" (McCrory et al., 2013).

The number of concussions has increased in recent years for multiple reasons. First, recent studies showed an increased awareness in the population of the potential for complications following concussion and repeated trauma (Hanson et al., 2014). Secondly, health professional are more involved in sports and in the concussions follow-up (Brolinson, 2014). However, for 10 to 33 per cent of cases, the symptoms may persist longer than 10 days (Makdissi et al., 2013). This clinical picture of the symptoms persisting for a few weeks to more than six months is defined in the literature as the postconcussion syndrome (Makdissi et al., 2013).

Postconcussion syndrome (PCS) is a complex medical subject that few articles and studies in the scientific literature dwell on concretely (McCrory et al., 2013). Considering this pathology as a multi-facetted injury, many signs and symptoms complicate its diagnosis. Various possibilities of impairments are known as being a part of this condition such as cognitive, vestibular, cervical, physical and psychological dysfunctions (McCrory et al., 2013). Therefore, with a multitude of clinical theories already existing in the literature, it is difficult to determine

PCS's clinical guidelines for practitioners. A consensus is clear at this level and a multidisciplinary approach is essential to the progress of the patient suffering from PCS (McCrory et al., 2013).

One of the major challenges in the medical management of concussion is that there is no "gold standard" for assessing and diagnosing the injury (Guskiewicz et al., 2013). It has been showed by Schneider et al. (2014) that a combination of cervical and vestibular physiotherapy decreased time to medical clearance for the return to sport in a cohort of 31 patients (12-30 years old) with persistent symptoms of dizziness, neck pain and/or headaches following a sport-related concussion. However, little research has been published on this topic.

PROBLEM

The problem targeted by this review of literature is the lack of data regarding the association between the mTBI and cervicogenic impairment. The majority of the scientific publications focus on the diagnosis of mTBI and there is little evidence on the possible involvement of the cervical region (McCrory et al., 2013). Cervical spine investigation after a cranial trauma is essential, but the association between symptoms and mTBIs is poorly described in the literature. From these facts, a literature review will improve the medical knowledge of all medical professionals and help the diagnosis and treatment of mTBI.

GOALS

The aim of this review was to target scientific articles describing mTBI and combining them with studies involving cervicogenic headache cases in order to look at the connections and similarities between these two types of injuries. The specific goals of this article is (1) to determine the common signs and symptoms of mTBI (including PCS) and cervical dysfunctions, (2) to describe the mechanism of cranial trauma injury and to link it up with the impact on the cervical spine, and (3) to give an update on the various types of effective treatments for these conditions.

METHODS

A critical review strategy was used for an analysis of the articles selected and a data synthesis was built to arrive at a final product and conclusion. The following electronic resources were searched from 1990-01-01 to 2015-05-19: *PubMed, Index to Chiropractic Literature (ICL), SportDiscus, Physiotherapy Evidence Database (PEDro), Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Cochrane library databases*. The following keywords were used in different combinations: *concussion, neck, TBI, mTBI, cervical, physiotherapy, physical therapy, athletic training, treatment, chiropractic, manipulation, manual therapy* and *guideline*. For the complete list of combinations, see Table 1. Three data collection were done at different dates: 2014-02-16, 2014-05-15 and 2015-05-19. Reference lists of articles meeting the selection criterias were also collected. All abstracts in English and French that dealt with our subject, the neck involved in a concussion, were selected for a full reading of article. A total of 4,854 abstracts were found on the search engines. Following this search, the articles were selected according to three main topics:

1) mTBI's and PCS symptoms related to the cervical spine.
2) Mechanism of injury
3) Therapies of the cervical spine with symptoms related to mTBI.

Inclusion criterias, based on the pre-cited keywords, were: original data articles, literature reviews and clinical recommandations, available in English and French, based on the objectives of this research. Exclusion criterias were: foreign languages papers other than English and French, case studies, magazine articles, expert and editorial comments were rejected of this review. The selection of articles is showed in Figure 1 and combinations are explained in Table 1.

RESULTS

After a careful sceening of 4,854 data entries, 81 abstracts met the inclusion criterias of our research and were reviewed. All these articles were read and analysed. Twenty-Three articles were excluded, because the main topic did not match the three topics of this study (n=18) or were study cases (n=2), magazine articles (n=2) and expert comment (n=1). Finally, of the remaining 59 papers used for this literature review, 21 were original data research, 36 were reviews of the literature and 2 were clinical recommandations based on daily practice. Each selected article is described in table 2 (see Appendix A). These articles were analysed and split into the different main topics discussed in this paper: 1) the association between cervical spine sprain and mTBI signs and symptoms, 2) mechanism of injury and 3) interventions and treatments. Results are represented in Figure 1 and Table 1.

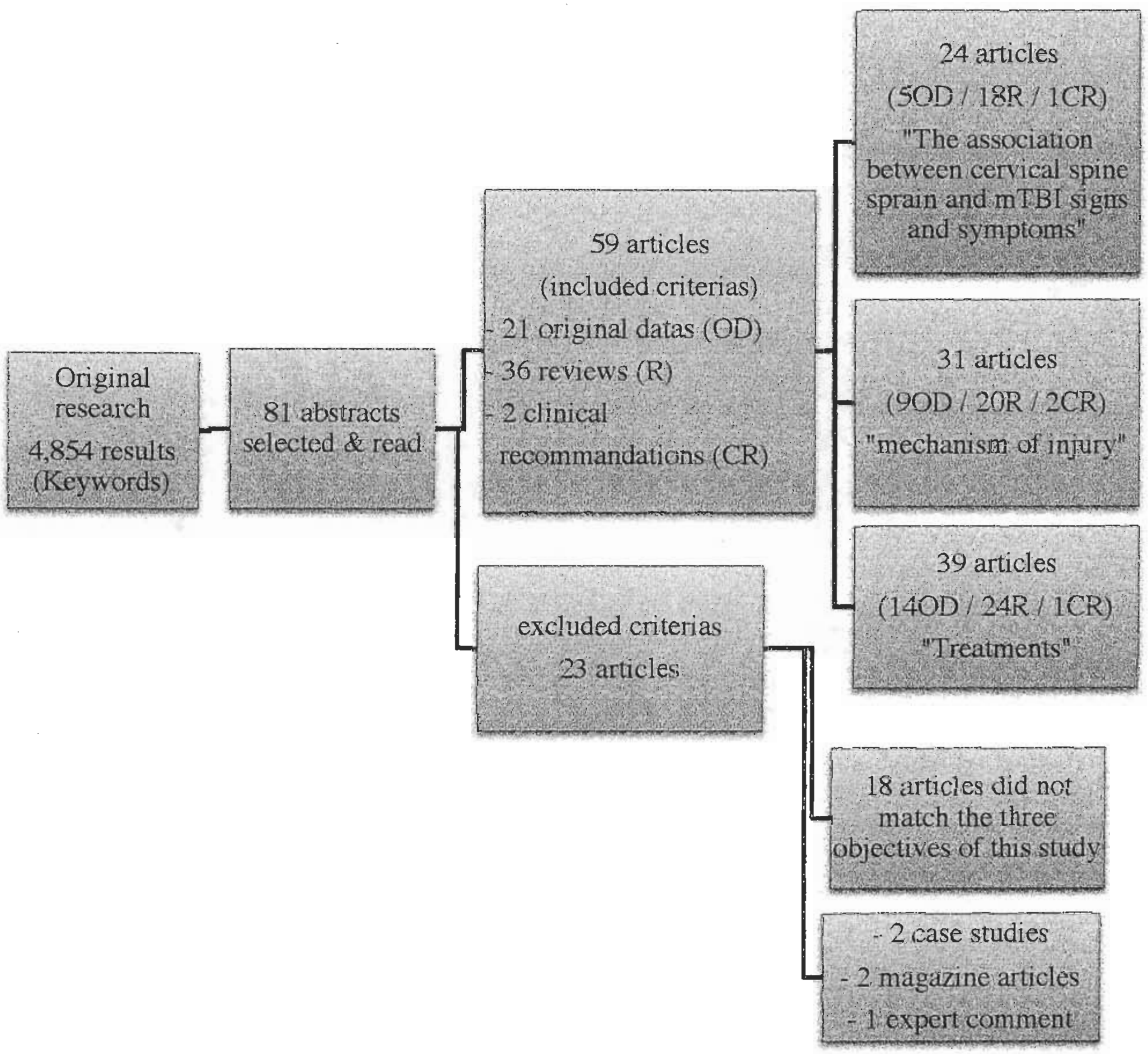

Figure 1: Research method for this review

Table 1

Preliminary search of Literature
(Total Results / Abstracts (Abs) selection / Articles (Art) for review)

Date		1990-01-01 to 2014-02-16			2014-02-16 to 2014-05-15			2014-05-15 to 2015-05-19		
Resources	Key words	Total	Abs	Art	Total	Abs	Art	Total	Abs	Art
Pubmed	Concussion, Neck	180	12	12	10	0	0	21	5	2
Pubmed	TBI, Neck, Treatment	56	0	0	0	0	0	7	2	2
Pubmed	TBI, Cervical	83	0	0	33	0	0	17	0	0
Pubmed	Concussion, Chiropractic	12	4	1	2	0	0	2	0	0
Pubmed	Concussion, Physiotherapy	53	2	2	3	0	0	12	2	1
Pubmed	Concussion, Physical Therapy	-	-	-	138	4	3	38	6	1
Pubmed	Concussion, Athletic Training, Cervical	30	2	2	0	0	0	6	1	1
ICL	Concussion	32	2	2	0	0	0	4	1	1
SportDiscus	Concussion, Neck	144	0	0	7	0	0	10	4	2
SportDiscus	TBI, Neck, Treatment	5	0	0	0	0	0	0	0	0
SportDiscus	Concussion, Neck, Treatment	15	1	1	4	1	0	3	1	1
SportDiscus	Concussion, Cervical	65	1	1	3	0	0	3	2	1
SportDiscus	Concussion, Chiropractic	9	2	1	0	0	0	2	0	0
SportDiscus	Concussion, Physiotherapy	34	2	2	0	0	0	7	2	1
SportDiscus	Concussion, Athletic Training, Cervical	13	1	1	0	0	0	1	1	1
CINAHL	Concussion, Manipulation	3	3	2	0	0	0	2	1	1
CINAHL	Concussion, Guideline	19	0	0	1	0	0	7	0	0
Cochrane	Concussion	4	1	1	0	0	0	1	1	1
PEDro	Concussion, Physical Therapy	2285	11	7	0	0	0	0	0	0
PEDro	mTBI, Physical Therapy	215	1	1	0	0	0	0	0	0
PEDro	mTBI, Manual Therapy	99	0	0	0	0	0	0	0	0
PEDro	Concussion, Manual Therapy	1132	2	2	0	0	0	0	0	0
PEDro	Concussion, Chiropractic	22	0	0	0	0	0	0	0	0
Total		4510	48	40	201	5	3	143	29	16

DISCUSSION

I. The association between cervical spine sprain and mTBI signs and symptoms

Following a head impact, the clinician must make a comprehensive assessment to determine the diagnosis. Loss of consciousness is not a representative symptom of the trauma severity (Littleton et al., 2013; Marshall, 2012; McCrory et al., 2013). In post-trauma physical examination, it is always important to keep in mind "*Red Flags*" associated with the cranial trauma to avoid medical wrongdoing that can even cause death. Any intervener must refer to an emergency departement for a complete follow-up when the patient presents a worsening of a headache, advanced drowsiness, unconsciousness, an inability to recognize the place or the people, an unusual change in personality, convulsions, vomiting, an increase of confusion or irritability, weakness or numbness in the arms or legs, inarticulate language and/or pain in the neck (Hanson et al., 2014; Marshall, 2012; McCrory et al., 2013; Pelletier, 2006). The subject's relatives must keep watch over him/her for a period of 24 hours post-trauma to ensure that there is no emergence of late red flags (Guskiewicz et al., 2013; McCrory et al., 2013).

Post-trauma cervical vascular injuries and the inadequacy of the vertebro-basilar arterial system pose a challenge to many clinicians. It is important to remember the red flags with respect to injury of the vertebral artery. The presence of a headache accompanied by the "*5 Ds*" – dizziness, diplopia, dysarthria, dysphagia and "drop attacks" is a contraindication for manual therapy and requires a complete medical investigation (Bradley, 2004).

The 2012 Zurich consensus on concussion in sports lead by McCrory et al. (2013) define a list of common symptoms of mTBI: headache, pressure in head, neck pain, nausea/vomiting, dizziness, blurred vision, balance problems, sensitivity to light, sensitivity to noise, feeling slowed down, feeling as if in a fog, "not feeling right", difficulty concentrating, difficulty remembering things, fatigue/low energy, confusion, drowsiness, difficulty falling asleep, more emotional, nervous/anxious, irritable, and/or sad. These symptoms can be divided into 4 categories as described in Table 3 (Marshall, 2012; McCrory et al., 2013; Pelletier, 2006). If one or more of these signs and/or symptoms are present after a trauma, the clinician must suspect a mTBI, and a rigorous protocol must be carried out before the athlete can return to play (McCrory et al., 2013).

As mentioned in the introduction, the majority of the mTBIs (80-90%) are resolved in 7 to 10 days (Fowler Kennedy, 2013; McCrory et al., 2013; Signoretti et al., 2011). However, in 10 to 15% of cases, the symptoms may persist more than 10-14 days, and even several months post-trauma (Cancelliere et al., 2014; Hecht, 2004; McCrory et al., 2013). The diagnosis for this clinical picture is known as PCS and the etiology in the literature for PCS is not well defined (Fowler Kennedy, 2013; Marshall, 2012; Weightman et al., 2010).

The most common lasting symptoms are headaches, dizziness, slower reaction time, sleep disorders, depressions, emotional disorders, visual dysfunctions and memory disturbance (Cancelliere et al., 2014; Clay et al., 2013; Lucas, 2011; Martinez, 2011). Dizziness following the mTBI can be a predictive sign of a late recovery (Cancelliere et al., 2014; Littleton et al., 2013).

In addition, cognitive difficulties when processing information and headaches reported by the subject post-trauma are also predictive of prolonged symptoms (Littleton et al., 2013).

Table 3:

Most common symptoms of mTBI according to their categories.

References	Cognitive	Somatic Physical	Affective Emotional	Sleep Disturbance
Marshall, 2012 Hanson et al., 2014 Hynes, 2006 Scorza et al., 2012 McCrory et al., 2013	- Confusion - Retrograde Amnesia - Anterograde Amnesia - Loss of consciousness - Disorientation - Feeling foggy (in a fog) - Vacant stare - Inability to focus - Delayed verbal reponses - Delayed motor reponses - Slurred - Incoherent speech (slurred) - Excessive drowsiness	- Headache - Dizziness - Balance Disruption - Nausea - Vomiting - Visual Disturbances - Phonophobia	- Emotional Lability - Irritability - Fatigue - Anxiety - Sadness	- Trouble falling asleep - Decreased sleep - Increased sleep
Hanson et al., 2014	- Feeling slowed down - Difficulty concentrating - Difficulty remembering - Forgetful of recent information - Confused about recent events - Answers questions slowly - Repeats Questions	- Balance problems - Visual problems - Fatigue - Sensitivity to light - Sensitivity to noise - Dazed - Stunned	- Nervousness	- Drowsiness
Hynes, 2006	- Dysphagia - Seeing Stars	- Deafness - Ringing in the ears - Temporomandibular		
Scorza et al., 2012	- Disorientation - Stunned - Vacant stare	- Blurred vision - Convulsions - Light-Headedness - Numbness - Tingling - Tinnitus	- Clinginess - Depression - Personality changes	

As mentioned previously, the most common symptoms in subjects post-mTBI is post-traumatic headache (PTH) (Lucas, 2011; Pelletier, 2006). Their incidence of headaches following a mTBI varies between 5 to 90% (Hecht, 2004; Watanabe et al., 2012). Their prevalence in children with mTBI is from 73 to 93 % (Lucas, 2011). These headaches are classified according to a mnemonic hint COLDER & FAT (Pelletier, 2006) :

Character (including severity and whether there is more than one type of pain)
Onset (insidious or sudden)
Location (what part of the neck and/or head)
Duration
Exacerbating factors
Relieving factors
Functional activities affected
Associated symptoms (such as Aura in migraines – visual, auditory, gustatory)
Time of day or associations with time of month (such as the menstrual cycle)

One of the theories explaining the origin of a post-mTBI headache is the brain neurometabolic cascade initiated minutes after the trauma. The s acceleration-deceleration forces caused by an impact provoke the brain to suffer a "mechanical shake" stress (Signoretti et al., 2011). This shock is defined as a "neurometabolic cascade" intrinsic to a cellular process, described by a complex cascade of ionic, metabolic and pathophysiological events often associated with microscopic axonal injury (Giza et al., 2001; Harmon et al., 2013; Signoretti et al., 2011). This disturbance in the brain may take a few days to several weeks to be resolved.

The diagnosis of PTH can be difficult to address in subjects with history of pre-existing headaches. However, if these symptoms have the tendency to increase in intensity or to become more frequent post-trauma, the PTH syndrome may be put forward (Lucas, 2011). PTH is defined as a headache that occurs within 1 week after regaining consciousness or within 1 week of head trauma (Weightman et al., 2010). Usually, the majority of PTH are resolved between 6 and 12 months and are mostly due to cervical muscular tension and bad posture (Weightman et al., 2010). It is really important to take headaches into consideration post-mTBI, because it is one of the major causes of morbidity in mTBI subjects (Watanabe et al., 2012). The clinicians must be alert to warning signs during a patient evaluation. (see table 4)

Table 4

Warning Signs in head pain (Goadsby et al., 2002).

Fever
Pronounced change in pain character or timing
Neck Stiffness
Pain associated with cognitive dysfunction
Pain associated with neurological disturbance, such as clumsiness or weakness
Pain associated with local tenderness, such as of the temporal artery

Biologically, the neurometabolic cascade disorder is usually resolved 7 to 10 days post-trauma in adults (Giza et al., 2001; Moser et al., 2012). As a result, the symptoms related to PCS are non-specific to the mTBI and professionals must consider other pathologies (McCrory et al., 2013; Weightman et al., 2010). On the other hand, a recent study suggests that at even 1 month or more post-concussion, the cerebral blood flow is decreased in 36% of subjects aged between 11 to 15 years old who suffered a mTBI compared to the non-concussed control group (Maugans et al., 2011). Further studies are needed to clarify this phenomenon.

The persistent symptoms of PCS would be related to a brain dysfunction problem rather than a structural problem (Signoretti et al., 2011). This would explain the negative results on much of the medical imaging prescribed in emergencies (Signoretti et al., 2011). In addition, a Norwegian study of 348 participants found that headaches occuring more than 3 months post-trauma, and diagnosed as PCS, are often related to a musculoskeletal pathology. In other words, the head or brain injury does not cause it (Stovner et al., 2009). These results show the importance of the cervical aspect in patients with a mTBI even greater (Fowler Kennedy, 2013; Hecht, 2004; Kent et al., 2013; Martinez, 2011; McCrory et al., 2013; Weightman et al., 2010).

II. Mechanism of injury

Neck pain is the third most reported symptom in the athlete population (Schneider et al., 2013). The prevalence of neck injury in sports is usually associated with direct contact with an opponent, the athlete's age, the athlete's gender as well as his/her playing position on the field (Clay et al., 2013; Scorza et al., 2012). Recent studies correlate the phenomenon of mTBI with the occurence of whiplash (Fernandez et al., 2005; Hecht, 2004; Hynes et al., 2006; Leslie et al., 2013). Furthermore, Schneider et al. (2013) demonstrated in a prospective study with 3 832 male ice hockey players (11-14 years old) that the presence of headache and neck pain in a preseason evaluation increases the risk of concussions during the season. Consequently, a neck examination should be part of the postconcussion follow up in addition to the neurological screening examination (Hanson et al., 2014). If cervical spine injury is present or suspected, primary care is essential. The emergency department will be able to manage the cervical trauma, including advanced neurological and musculoskeletal imaging (Harmon et al., 2013).

Whiplash is defined as a mechanism of acceleration-deceleration transferred to the cervical spine (Hanson et al., 2014; Leddy et al., 2015; Watanabe et al., 2012). With its large range of motion, the upper cervical spine is the most mobile part of the vertebral column. During a whiplash motion, cervical structures are stressed at their end of range of motion and this can explain why neck injuries happen (Kristjansson et al., 2009). The impact produces stresses and injuries in the bones and soft tissues of the cervical region thus causing clinical manifestations (Fernandez et al., 2005). Among those, whiplash symptoms include neck pain, cervicogenic headaches, chest pain, memory and concentration disturbances, muscle tension, sleep disturbances, dizziness, fatigue, cervical range of motion restricted, irritability, tinnitus and visual disturbances (Fernandez et al., 2005; Hynes et al., 2006; Leslie et al., 2013; Watanabe et al., 2012; Weightman et al., 2010). Studies have demonstrated that impacts at low velocity between 4-12 km/h can provoke neck and head injuries thus causing dysfunctions and pain (Hynes et al., 2006). These clinical conditions are often similar to those listed for mTBI, which leads to confusion for the medical corps (Fowler Kennedy, 2013; Hecht, 2004; Hynes et al., 2006; Leslie et al., 2013).

Table 5

Summary table of the Whiplash-Associated Disorder (WAD) classifications and concussion symptoms that can manifest themselves in any grade of WAD (Hynes et al., 2006; Spitzer et al., 1995).

WAD classification	Symptoms
0	No neck complaints
I	Complaint of neck pain, stiffness or tenderness
II	Neck complaint with musculoskeletal signs
III	Neck complaint, musculoskeletal signs and neurological signs
IV	Fracture and/or dislocation

The pathophysiology related to the patient's symptoms originates from one or several structures of the cervical spine. After a trauma involving the cervical region, the involvement of muscles, ligaments, arteries, nerves, the oesophagus, the temporomandibular joint, intervertebral discs, zygapophysial joints, vertebrae and the atlanto-occipital complex in the cranio-cerebral stabilization creates a real complex challenge for clinicians (Hecht, 2004; Watanabe et al., 2012; Weightman et al., 2010).

One of the hypotheses raised in the literature for the origin of neck pain is the involvement of the cervical zygapophysal joints (Bogduk, 2011). They have been shown to be the source of neck pain, headaches, visual disturbances, tinnitus and dizziness in patients who have sustained whiplash (Fernandez et al., 2005; Fowler Kennedy, 2013; Leslie et al., 2013). In this following order, the C1-C2, C2-C3, C0-C1, C3-C4 levels are the most often described to be associated with cervical symptoms following a mTBI (Fernandez et al., 2005; Hecht, 2004; Schneider et al., 2013; Treleaven et al., 1994). More specifically, the cervical zygapophysal joints pain is expressed by a sensory hypersensitivity and hyperexcitability of the spinal cord reflexes, causing an increase of the nociceptive process in the central nervous system, the origin of post-trauma pain (Smith et al., 2013). The cross-sectional study of Smith et al. (2013) renforces this hypothesis with their project involving 58 adults (18-52 years old) who sustained a whiplash disorder divided in two groups (experimental group receiving a facet block, control group). Theiy concludedthat patient with chronic Whiplash-Associated Disorder (WAD) who respond and who do not respond to facet blocks show similar sensory disturbances, motor dysfunction and psychological distress. Another study published by Treleaven et al. (1994) supports the implication of the cervical region in12 patients suffering of persistent postconcussion headache. These examples enhanced the importance of the cervical assessment post-mTBI (Treleaven et al., 1994; Weightman et al., 2010; Whiteside, 2006).

Following a whiplash, the cervical spine is often the source of a patient's pain. The neck received the transmitted force of the impact and the same acceleration-deceleration mechanism can produce a mTBI. This association between the cervical spine and mTBI during the whiplash process can be a cause of cervicogenic symptoms (Schneider et al., 2014). Neck problems are also associated with mTBI because of the similarities of their symptoms (Lucas, 2011). One common symptom in post-trauma subjects is headache. Also, cervicogenic headache is a well-known condition (Lucas, 2011; McCrory et al., 2013; Scorza et al., 2012). In fact, if those neck impairments, usually in the upper cervical spine, are not well managed, symptoms can become chronic and may cause prolonged postconcussion headaches (Schneider et al., 2014).

Cervicogenic headache are common after a whiplash injury (Becker, 2010; Hecht, 2004). Different studies showed that 3 to 4.6% of patients will develop chronic daily headache post whiplash and 2% will be permanently disabled (Becker, 2010). The first publication that discussed the association between cervical dysfunctions and the origin of headaches was published by Hilton in 1860 (Becker, 2010; Hecht, 2004). Since 1983, this affection is known under the name of cervicogenic headache (CGH). The upper cervical spine pain can arise from various anatomical structures such as muscles, joints, ligaments, nerves and more (Becker, 2010). The large occipital nerve is hypothetised to be a pain generators and was introduced by Hunter and Mayland in 1949 as a potential source of CGH (Hecht, 2004). Tensions in the cervical muscles (trigger points), a part of IHS, is the most common diagnosed type of headache (Hecht, 2004; Stovner et al., 2009). Becker (2010) explained that headache related to cervical spine disorders (CGH) remains one of the most controversial areas of headache medicine.

Dysfunctions of the cranio-cervical zygapophysial (C0 to C4) joints can also cause headaches (Bogduk, 2011; Hecht, 2004). After a whiplash injury, if the patient complains about a headache, dysfunctions of the C2-C3 zygapophysial joint are highly prevalent, particulary if there is also tenderness over the C2-C3 facet joint (Becker, 2010). Cervicogenic headache may be unilateral or bilateral with the dominance depending on one or more of the structures that are affected (Hecht, 2004). Pain location usually begins in the occipital region of the neck. Clinically, at least 50% of neck pain after a whiplash injury has zygapophysial joints as the single most common source of pain. Futhermore, facet joints appear to be the most common source of pain in the neck with or without headache. King et al. (2007) showed in their retrospective study inclunding 173 patients that manual examination had a high degree of sensitivity during zygapophysial joint pain evaluation, but a low specificity. Tension in the cervical muscles has the effect of reducing neck movement and generate local pain (Hecht, 2004; Pelletier, 2006). The ergogenic posture, physical activities and the position while sleeping can provoke irradiated pain to the head (Lucas, 2011). In 2013, the Cervicogenic Headache International Study Group (CHISG) developed the diagnostic criteria for CGH. (see table 6)

One of the marked improvements of SCAT3 and Child SCAT compared to the SCAT2 is the introduction of the cervical assessment in the post-trauma evaluation (McCrory et al., 2013). Knowing that the mechanism of a mTBI is an external force transmitting energy to the head, it is possible that the neck, supporting the head, can also be traumatized during such an external force (Hecht, 2004; Hynes et al., 2006; Marshall, 2012).

Table 6

Summary table of the Cervicogenic Headache (CGH) diagnostic criteria

(Headache Classification Committee of the International Headache Society, 2013).

Cervicogenic Headache (CGD) diagnostic criteria
Unilaterality of pain, although it is recognized that bilateral cervicogenic headache may occur
Restriction in range of motion in the neck
Provocation of usual head pain by neck movement or sustained awkward neck positions
Provocation of usual head pain with external pressure over the upper cervical or occipital region on the symptomatic side
Ipsilateral neck, shoulder, or arm pain, usually of a vague nonradicular nature, occasionally radicular.

In conclusion, post-traumatic headaches are a serious contributor to disability following cranial, cerebral, and cervical injury. While there are a variety of different posttraumatic headaches, clinicians must be aware of all potential presentations including those produced from acervical spine dysfunction and its affiliated structures (cervicogenic) (Hecht, 2004). Following on from this, it is recommended to evaluate the cervical upper region after a head trauma to limit morbidity and to look for International Headache Society (IHS) cervicogenic characteristics (Headache Classification Committee of the IHS, 2013). The Zurich consensus for concussion in sports (2012) recommended a multidisciplinary approach for patients who suffer PCSsymptoms, such as a headache, lasting longer than 6 weeks (McCrory et al., 2013; Harmon et al., 2013; Weightman et al., 2010).

III. Treatments

Currently, the majority of articles in the literature focus on the diagnosis of mTBI, but few are dedicated to management and treatments (Brolinson, 2014). Several health professionals such as family physicians, neurologists, physiotherapists, athletic therapists, psychologists, neuropsychologists, occupational therapists, chiropractors, osteopaths, acupuncturists, social workers, psychiatrists and nurses regularly work on post-mTBI rehabilitation with patients (Signoretti et al., 2011; Weightman et al., 2010). This demonstrates the importance of a whole medical staff working together to optimize their patients' treatment by Purtzki et al. (2012). The 2012 Zurich consensus on concussion in sport suggested physical and cognitive rest until the end of the acute symptoms post-trauma, and multidisciplinary approach involving experienced health care professionals when treating mTBI (Littleton et al., 2013; Martinez, 2011; McCrory et al., 2013). Moser et al. (2012) did a retrospective analysis with 49 high school and collegiate athletes (mean = 15.0 years old) and suggested that a period of cognitive and physical rest may be a useful mean of treating concussion-related symptoms. Sleep is a form of physical rest and it is not always recommended post-mTBI (Littleton et al., 2013). Previous advice including frequent awakening of the concussed athlete to 'make sure they are okay' is no longer recommended (Harmon et al., 2013). Usually, sleep should not be interrupted as it is helping the recovery. The only questionable case is if the level of consciousness is unclear; in this instance, the athlete should be imaged and observed in a hospital until the doctor gives clearance (Harmon et al., 2013). The American Medical Society for Sport Medicine recommends that it is advisable to let the athlete sleep for recovery (Harmon et al., 2013). This recovery time allows for a period of 7 to 10 days before the athlete returns to competition (Borich et al., 2013). During this period, the symptoms would have to be evaluated daily and all activities that increase these symptoms would have to be stopped (Littleton et al., 2013). A Cochrane study published by Gravel et al. (2013) mentioned that, based on present literature, no intervention initiated acutely has been clearly associated with a positive outcome for patients who sustain mTBI. When follow-up interventions are considered, little evidence may be associated with better results post-concussion (Gravel et al., 2013). Scientific evidence has shown that personalised treatments (manual spinal therapy, physiotherapy and neuro-sensorimotor retraining) allow a quicker recovery and allow athletes to return to their sports faster than after a program of rest and graduated exercises (Brolinson, 2014; Laker, 2011).

Once the symptoms disappear, the integration of gradual physical activity can promote an acceleration in recovery (Borich et al., 2013; Hynes et al., 2006; Leddy et al., 2012). During the active recovery program, the occurence or increasing level of any postconcussion symptoms will stop the return to activity program. The athlete should wait 24 hours after the end of symptoms before returning to the previous asymptomatic level and restarting his active recovery program (Bonfield et al., 2014). An early return to play or a too aggressive rehabilitation could compromise the healing process, increase risk of repeated concussion and create longer-term issues (Harmon et al., 2013; Laker, 2011; Master et al., 2014).

A study by Leddy et al. (2012) showed that a lightweight level of exercise can be beneficial for subjects with a slow rehabilitation. Kozlowski et al. (2013) published recently a cross-sectional study about the exercice impact on 34 patients with PCS and a control group of 22 patients. Conclusions showed that patients with PCS had a symptom-limited response to exercise, and the treadmill test was a potentially useful tool to monitor the recovery from PCS (Kozlowski et al., 2013). Other physiotherapy treatments, such as vestibular rehabilitation, visual training, cardiovascular training and the treatment of cervical dysfunctions have shown some promising avenues (Fowler Kennedy, 2013; McCrory et al., 2013; Schneider et al., 2014; Watanabe et al., 2012; Weightman et al., 2010). Return-to-play is allowed when athletes are symptom-free at rest, able to do a full practice with contact without symptoms, no longer taking any medications, and cleared regarding his/her baseline levels of cognitive functioning and postural stability (Hanson et al., 2014).

A lot of tools are available, but the inclusion of the cervical assessment in SCAT3 and Child SCAT3 is a progression of SCAT2 for the evaluation and treatment of mTBI (McCrory et al., 2013). SCAT3 and Child SCAT3 include clinical tests known to the scientific community and are used regularly by sports therapists (McCrory et al., 2013; Pelletier, 2006; Scorza et al., 2012). The SCAT3 is used on the field to help clinicians diagnose concussions and is recognized as a standardized method for evaluating injured athletes (age >13 years) for concussion (Bonfield et al., 2014; McCrory et al., 2013). The SCAT3 child is a new tool adapted for children from 5 to 12 years old. Including the Glasgow Coma Score (GCS), the Standardized Assessment of Concussion (SAC), the Maddocks questions, and the Balance Error Scoring System (BESS), these questionnaires are global and are helpful for a quick return-to-play decision (Bonfield et al., 2014; Giza et al., 2013). They also include scale symptom evaluation, cognitive assessment and memory, neck examination, and coordination examination (Bonfield et al., 2014). The evaluation of the cervical region has been included as a new part of the SCAT3 / SCAT3 child and a full clearance is essential before a return to play (Bonfield et al., 2014; McCrory et al., 2013). The post-mTBI subjects must have no pain in the neck, full mobility and an adequate bilateral general force to restart their sporting activities (Hynes et al., 2006; Scorza et al., 2012).

The specific databases of vertebral manipulation are originally from Kovacs' works in 1955 (Hecht, 2004). Evidence-based studies demonstrate that the physical status of individuals with neck pain is improved with an exercise program that combines manipulation, proprioceptive neuromuscular facilitation, acupressure on trigger points, and range-of-motion exercises, along with exercises to improve head relocation accuracy compared to a control neck pain group of similar patients treated with information and advice (Kristjansson et al., 2009). Some treatments, such as vertebral manual therapy, cervical tractions, manipulations and exercises can relieve neck pain (Hecht, 2004; Miller et al., 2010; Martinez, 2011). Treatment of the cervical spine (sustained natural apophyseal glides) has been demonstrated effective in 17 individuals with suspected cervicogenic dizziness compared to a control group (17 adults) (Reid et al., 2008). Treatment of the cervical spine and the vestibular system in the presence of persistent dizziness, neck pain and/or headaches may facilitate functional and symptomatic improvements and shorten recovery in post-mTBI subjects (Brolinson, 2014; Kent et al., 2013; Schneider et al., 2014). Brolinson & al. (2104) have demonstrated that interventions of spinal manual therapy, physiotherapy and neuromotor/sensorimotor training are more effective for mTBI recovery compared to a programme of rest and exercise over a period of 8 weeksSchneider et al. (2014) demonstrated that a significantly higher proportion of post-mTBI individuals (more than 3 weeks post-trauma) were medically cleared to return to sport within 8 weeks of initiating treatment if they were treated in physiotherapy with cervical spine and vestibular rehabilitation compared to a control group. Another study published by Leddy et al. (2015) compared PCS and cervicogenic/vestibular symptoms with a questionnaire in 128 adults patients. Their results were not statistically significant to distinguish both type of patients, but they conclude that clinicians should consider specific testing of exercise tolerance and perform a physical examination of the cervical spine and the vestibular/ocular systems to determine the etiology of postconcussion symptoms and to consider treating these accordingly. (Leddy et al., 2015)

Regarding the cervical muscular system, several changes can be produced following a trauma such as mTBI or whiplash. The ability of the neck to control and resist the external forces and the physiological changes, such as fat infiltration in the muscles, may result in increased head acceleration during the impact, which should increase the risk of mTBI. There is still nonempirical support that greater strength in the neck could reduce the risks of mTBI on the field (Benson et al., 2013; Marshall, 2012; Mihalik et al., 2011). In fact, Mihalik et al. (2011) evaluated the effect of cervical strenght on head impact with 37 hockey players (average 15 years old) and they conclued that the hypothesis of neck strenght decreases head acceleration was not supported. Recent publications have tended to show the impact of neck musculature in the prevention of concussions. Two hypotheses are presently under debate in the literature. The potentially modifiable risk factors for concussion are neck strength and impact anticipation (Eckner et al., 2014). Tierney et al. (2005) demonstrated that males have a better head–neck segment dynamic stabilization than females when angular acceleration si sustained by the head in a study including 20 males and 20 females. Futhermore, a descriptive study demonstrated that greater neck strength and anticipatory cervical muscle activation (bracing for impact) can reduce the magnitude of the head's kinematic response in a population of 46 contact sport athletes (male and female) aged between 8 and 30 years old (Eckner et al., 2014). Another group showed on a group of 49 football players (high school/collegiate) that with better cervical strength and less angular displacement after a shock, the odds of sustaining higher magnitude head impacts are reduced. However, their findings did not show that stronger and larger neck muscles in players decreased head impact severity (Schmidt et al., 2014). On the other hand, Collins et al. (2014) concluded, with their study including 6704 high school athletes, that neck strength can be an interesting screening tool to prevent concussion. Further research is needed to clarify these hypotheses and the real role of neck strength in reducing brain risk.

PTH are a complex process and different studies have difficulties targeting the problem due to the many causes and effects that produce the pain. There is little evidence in clinical trials for treating PTH. Studies have shown that physiotherapy treatments will decrease the pain and increase the cervical range of motion compared to the control group in a cervical collar for a period of 6 and 12 weeks post-trauma (McCrory et al., 2013; Watanabe et al., 2012). The physiotherapy programmes consisted of active and passive mobilisations, postural strengthening, the application of ice and exercises that are efficient for PTH. Another study by Jensen et al. (1990) has presented a decreased level of pain among the group of 23 subjects who underwent cervical manipulation over a period of 5 weeks compared to the control group. However, much of this effect is lost in the post-8 weeks re-evaluation.

CONCLUSION

In conclusion, mTBI is a complex injury and needs to be taken care of by different medical specialists working together toward the same goal – recovery (McCrory et al., 2013; Purtzki, 2012). The evidence of cervical spine involvement in mTBI is starting to become evident, but there is a lack of sound evidence in the literature (Leslie et al., 2013). Our findings have implications for further research. The hypothesis of cervical spine involvement in post-mTBI symptoms and in PCS is supported by increasing evidence and largely accepted. Health professionals should consider assessing the cervical spine of patients affected by a mTBI. Some original data articles support this theory and showed that persistent headache and post-concussion syndrome are often related to musculoskeletal pathology, as cervical spine. For the mTBI management and treatment, few articles in the literature are available, but decent studies showed interesting results about manual therapy (cervical, vestibular) and exercises as an efficient tools for health care practicioners. Further studies are needed to establish an adequate evaluation and determine guidelines for treatments. The evaluation and treatment of the cervical region is a major step to improve mTBI rehabilitation.

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CHAPITRE IV. ARTICLE 2

ANALYSIS OF THERAPEUTIC INTERVENTIONS RECEIVED AFTER SPORT CONCUSSIONS IN JUNIOR-AGED ELITE HOCKEY PLAYERS

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Le premier auteur, Michael Morin, a participé à toutes les étapes de l'élaboration de cet article, en collaboration avec son directeur de recherche, Dr Philippe Fait. Ils ont participé à la prise de données et aux collections d'information. L'auteur principal a synthétisé, effectué les analyses statistiques et écrit l'article.

ABSTRACT

BACKGROUND: Ice hockey is a popular sport played worldwide at high speed and at high risk of injury. Body checking is legal at a certain level and is the primary cause of concussions in this sport. Recent articles found a strong association in ice hockey between this "whiplash" phenomena and head/neck injuries, such as concussions. There is a lack of scientific evidence in the present literature on how therapists work during the post-concussion recovery.

OBJECTIVE: The purposes of this study was to analyze 1) the different characteristics of concussions over two seasons in junior hockey, 2) the return to play descriptive data, 3) the different therapies experimented by therapists during a post-concussion rehabilitation and 4) how a 1-day workshop held between the first and the second hockey season can influence the management of concussions within the Quebec Major Junior Hockey League's (QMJHL).

METHODS: A descriptive study was conducted to examine the effects of a workshop teaching cervical evaluation following a sport concussion. Injury surveillance reports were analyzed for 18 Canadian major junior hockey teams which included male subjects between the ages of 16 and 20 years (average = 18.34 years old). Based on a review of data from each team, the variables were studied over the 2013-2014 and 2014-2015 seasons. Data included concussions sustained in practice and game situations during regular seasons only. Pre-season and playoffs were not compiled.

RESULTS: A total of 69 concussions occurred during 2013-2014 and 75 concussions occurred during the 2014-2015 season. The most current cause of concussion was “Collision with an Opponent” and the most common reported symptom was “headache”. The symptoms resolved within an average of 9.57 days, athletes were out of school for an average of 3.06 days and they were able to return to play in an average of 19.39 days. After the concussion workshop, physiotherapists were more involved in the professional follow-up post-concussion (27.31%) and treatments (22.84%) ($p < 0.05$). Incidence of concussions in the QMJHL is 0.87/1000 AEs, 12.35 concussions per 100 players, and 5.64 concussions per 100 QMJHL regular season games.

CONCLUSIONS: In conclusion, it is difficult to compare the post-concussion follow up with the literature, because this study is probably the first one to focus on this topic. One major point that needs to be more researched is the return to school protocol, which seems to be a problem in the post-concussion recovery. This study revealed that future research is needed to better manage the return to school and how an early comeback can slow down recovery. Athletic therapists and physiotherapists are effective for the post-concussion follow-ups, cervical evaluations and a variety of treatments. Long-term studies are needed to understand and fully appreciate the best recovery protocol post-concussion.

Abbreviations used in this paper: Athlete exposure (AE), Antecendent (ATCD), Games played (GP), International Ice Hockey Federation (IIHF), National Hockey League (NHL), Ontario Hockey League (OHL), Proprioceptive Neuromuscular Facilitation (PNF), Quebec Major Junior Hockey League (QMJHL), Return-to-play (RTP), Signs and Symptoms (S/S).

INTRODUCTION

Ice hockey is a popular sport worldwide, with more than 1 million young players in North America, including 570 000 participants in Canada only (Bonfield et al., 2014; Schneider et al., 2013). This sport is played at high speed (more than 30 miles/hour), with sticks, pucks, rigid boards and hard ice (Bonfield et al., 2014; Hynes et al., 2006; Smith et al., 2015). Body checking is legal at a certain level and is the primary cause of injuries in this sport (Smith et al., 2015). One of the most common injuries of collision between players with potentially serious consequences is concussion (Benson et al., 2011; Bonfield et al., 2014; Giza et al., 2013; Harmon et al., 2013; Hynes et al., 2006; Smith et al., 2015).

In November 2012, the 4th International Conference on Concussion in Sport held in Zurich came up with an international definition of what is a sport concussion:

> *Concussion is a brain injury and is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces. Several common features that incorporate clinical, pathologic and biomechanical injury constructs that may be utilised in defining the nature of a concussive head injury include:*
>
> *1. Concussion may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an ''impulsive' force transmit- ted to the head.*
>
> *2. Concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, symptoms and signs may evolve over a number of minutes to hours.*
>
> *3. Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies.*

> *4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course. However, it is important to note that in some cases symptoms may be prolonged.* (McCrory et al., 2013)

Studies showed that rules changes such as severe sanctions against "check from behind" and "head checking" helped to decrease the number of concussions and neck injuries (Biasca et al., 2002; Harmon et al., 2013). One of the main problems about concussions in hockey is the non-reported injuries, or the lack of knowledge about this injury (Bonfield et al., 2014). In fact, the International Ice Hockey Federation (IIHF) report revealed that before 2012, 11.5% of the players diagnosed with a concussion returned to play during the same game (Tuominen et al., 2015). With the 2012 Zurich Consensus on concussion in sport, guidelines and protocols are clear about any suspected concussed players: they are not allowed to return to play in the same game or practice (McCrory et al., 2013; Tuominen et al., 2015). The NHL was the first professional league to get a policy about concussion prevention, evaluation and treatments (Bonfield et al., 2014). Since, the NHL introduced the "Rule 48", regulating body checking to the head, but the concussion incidence among NHL hockey players has not decreased (Donaldson et al., 2013). ''Collisions on ice'' in professional hockey happen at high speed and create an acceleration/deceleration movement without a head impact (Bonfield et al., 2014; Broglio et al., 2014). Hynes et al. (2006) found in their prospective study, which included 183 players (15-35 years old), a strong association in ice hockey between this « whiplash » phenomena and head/neck injuries, such as concussions. Players are more at risk for concussions during games than practice for most sports (Hanson et al., 2014). Clay et al. (2013) explained that the risk of a concussion during a game is from 3 to 14 times higher than practice across a variety of sports and for both sexes. In other words, athletes have 68.5% more chance of concussions during competition than a practice.

This study examined concussions during two regular seasons, 2013-2014 and 2014-2015. The goals of this study were to analyze 1) the different characteristics of concussions over two seasons in junior hockey, 2) the return to play statistics descriptive data, 3) what kind of the different therapies used by therapists during their post-concussion rehabilitation and 4) how a 1-day workshop day held between the first and the second hockey season can influence the management of concussion management within the Quebec Major Junior Hockey League's (QMJHL). Our hypotheses were:

1) The QMJHL's concussion incidence will be similar to the one described in the literature;
2) Signs and symptoms average duration will be similar to the ones described in the literature.
3) Return to play protocol will include proper return to school management.
4) The QMJHL's therapists will change their practice after attending the concussion workshop between the two seasons.

METHODS

A descriptive study was conducted to examine changes following the implementation of a workshop teaching cervical evaluation following a sport concussion. Injury surveillance reports were reviewed for 18 Canadian major junior hockey teams. The data contained in each injury report were reported by each health care professional working full time with a hockey team. Data was reported over the course of two entire regular seasons. The data were prospectively collected and retrospectively reviewed. Based on a review of data from each team, the number of concussions that occurred over the 2013-2014 and 2014-2015 seasons, including those sustained in practice and game situations, was determined for each team. Informed consent was obtained from all participants, and the QMJHL allowed to share legally all anonymous information for this project. The QMJHL's commissioner signed an agreement to support this project. The Université du Québec à Trois-Rivières Ethics Review Board approval was obtained before the start of the data collection. Each health care professional had to consent before collecting data.

Participants:

All participants included in this study were males between the ages of 16 and 20 years (average = 18.34 years old) who were officially on a QMJHL team roster with their respective team for the 2013-2014 and 2014-2015 seasons.

Injury Definition:

A concussion was defined as an injury that occurred as a result of participation in an organized hockey practice or game, that required medical attention by a health care professional, that resulted in removal of play for one or more calendar day after injury, and that was documented in the injury report by the health care practitioner as a concussion. The concussion management plans from all 18 teams were compared, to evaluate their evaluation, treatments, return to play protocols (rest, return-to-school, physical activity with and without contact). A cervical screening and evaluation was done when a neck injury was suspected.

Procedure:

When the player was able to return to play (cleared by physician, neuropsychologist and head team therapist), the therapist in charge of his rehabilitation had to complete a return to play questionnaire (Appendix B and C) on a secured website. The computerized form was automatically sent to the QMHJL main office with the team's name, while another anonymous form was sent to the head physician of the league, the medical supervisor of the league and the director of the research group. A QMHJL supervisor followed up the recovery of all concussions on a monthly fashion, and monitored if the return to play questionnaire was completely filled in by the therapists.

The return to play questionnaire was available in English and French (See Appendix B and C). The first part of the questionnaire contained the player information (age, position, academic level, past concussion information), the description of the current concussion (date of injury, neurocognitive ImPACT tests, symptoms ended, return to play) and the number of missed games. The second part presented a list of signs and symptoms and the mechanism of injury. The third part was dedicated to the professional follow-up. It asked which health care professionals were involved in the first evaluation post-concussion, the number of missed school days and if the neck was evaluated and screened. In the case of a full neck evaluation, all information related with the health care professionals involved in the first assessment and all treatments were required. In addition, the number of treatment sessions per week, all types of therapies used and the locations of the appointment were collected in order to help draw a picture of the recovery process. Finally, the team's therapist in charge of the athlete rehabilitation had to sign the form to give consent and to confirm that all the information filled were complete and true. All new questionnaires coming in were reviewed monthly. Any missing data was recorded and sent to the QMJHL supervisor to recover the information directly from the team's therapists.

Workshop:

The purpose of this 1-day workshop held between the 2013-2104 and 2014-2015 seasons was to teach the latest scientific literature updates about management of sport concussions. During the 8-hour long class, 3 hours were devoted to a lecture about theoretical literature update and 5 hours were devoted to hands-on practice and feedback provided by an independent physiotherapist (Fellow of the Canadian Academy of Manipulative Physiotherapy) teaching the workshop. All therapists learned a variety of evaluations (cervical, cranial nerves, oculomotor, stability, and temporomandibular, vestibular system) and practiced different type of manual therapy treatments such as cervical mobilizations, tractions, active release techniques, triggers points, proprioceptive neuromuscular facilitation (PNF), oculomotor and massages. Seventeen of the 18 therapists attended the whole workshop. The therapist who missed the workshop received all the theoretical information later. With comparing professional follow-up, cervical evaluation, treatments and techniques for both hockey seasons, we could see the impact of the workshop on therapists work and their statistically significant differences.

Statistics analysis:

Descriptive analyses were computed using Microsoft Excel (Microsoft Corp., Redmond, WA) and analyzed with SPSS Statistics Program 20 (IBM Corp., Armonk, NY). Non-parametric tests were used. Chi-square test (χ^2) was used for analyzing the variables that presented frequencies. The level of statistical significance was set at 0.05.

RESULTS

A regular QMJHL's season represents a total of 612 games and an average of 150 practices during 32 weeks. During the first hockey season of this study (2013-2014), a total of 69 concussions were reported. Five reports were rejected because they were incomplete, or because the players did not come back to play before the end of the data collection. For the first season analyzed, a total of 64 concussions were included for a total of 577 players.

During the regular 612 games of the second season of the data collection (2014-2015), a total of 75 concussions were reported. Eight reports were rejected because they were incomplete, or because the players did not come back to play before the end of the study. A total of 67 concussions were included for the second season analyzed, for a total of 593 players. No statistical difference in the total number of concussions were observed between both years (χ^2 = 0.01; $p = 0.91$).

For the current study, a total of 144 concussions were diagnosed in 2 seasons of 68 games and 150 practices. With 21 players per team, and a total of 18 teams, incidence of concussion in the QMJHL is 0.87/1000 AEs.

Another way to calculate the incidence is the rate of concussion per 100 players. The QMJHL data revealed a total of 577 players were involved with a team in 2013-2014, for a ratio of 12.04 concussions per 100 players and a ratio of 12.65 concussions per 100 players in 2014-2015, for a total of 593. The difference between both years was not statistically significant (χ^2 = 172; $p = 0.19$).

The literature mentions another method to calculate the concussion incidence. During both season, a total of 1,224 regular season games were played. The ratio for the 2013-2014 season was 5.64 concussions per 100 QMJHL regular season games, and 6.13 concussions per 100 QMJHL regular season games in 2014-2015. The difference between both years was not statistically significant ($\chi^2 = 2.17$; $p = 0.14$).

Table 1

Total players by position compared to the number of concussion for the 2013-2014 and 2014-2015 seasons (68 games played)

Position	Total	Concussions	% Concussions
2013-14			
Forward	337	41	12.17
Defense	185	21	11.35
Goalie	55	2	3.64
Total	577	64	11.09
2014-15			
Forward	343	43	12.54
Defense	192	21	10.94
Goalie	58	3	5.17
Total	593	67	11.30

When looking at concussion occurrence per position, forwards had the highest percentage of concussions for both years, but it was not statistically significant for the first season ($\chi^2 = 0.08$; $p = 0.78$) nor the second season ($\chi^2 = 0.30$; $p = 0.58$). In 2013-2014, 12.17% of all forwards sustained a concussion, comparatively to 12.54% during season 2014-2015 ($\chi^2 = 0.02$; $p = 0.88$). For the first year, defensemen (11.35%) had a higher percentage of risk than goaltenders (3.64%), but not statistically significant during the first season ($\chi^2 = 2.91$; $p = 0.09$). During the second season, defensemen (10.94%) still had a higher proportion than goalies (5.17%), but it was not statistically significant ($\chi^2 = 1.71$; $p = 0.19$). When comparing all players pooled, the probability of concussion for a defenseman was similar, but not statistically significant, in 2013-2104 with 11.35%, and in 2014-2015 with 10.94% ($\chi^2 = 0.02$; $p = 0.90$). Goalies had a low incidence of concussion with 3.64% during 2013-2014 season and 5.17% during 2014-2015 season ($\chi^2 = 0.16$; $p = 0.69$).

When concussion incidence by age is analyzed, QMJHL's players aged 18 and 19 years old presented a higher percentage of concussions than others players for both years, but the difference with other age groups was not statistically significant for 2013-2014 ($\chi^2 = 0.89$; $p =$ 0.35) nor for 2014-2015 ($\chi^2 = 1.20$; $p = 0.27$). Table 2 shows the average games played by age.

The average academic level for concussed players was 11.42 school years [min=9; max=13] in 2013-2014 and 11.97 school years [min=9; max=14] in 2014-2015. If the number 10 is considered a grade 12 in high school (English program) and secondary 5 (French program), the average age of players who got a concussion represents their second college year.

Table 2

Total number of players by age compared to the number of concussion for the 2013-2014 and 2014-2015 seasons (68 games played (GP))

Age	Total	Concussions	% Concussions	Average GP (68)
2013-14				
16 years old	79	3	3,80	22.33
17 years old	151	9	5,96	30.00
18 years old	150	25	16,67	39.00
19 years old	138	21	15,22	43.33
20 years old	59	6	10,17	48.00
Total	577	64	10,17	36.53
2014-15				
16 years old	67	4	5,97	24.33
17 years old	151	14	9,27	30.00
18 years old	159	21	13,21	36.00
19 years old	149	26	17,45	39.67
20 years old	67	2	2,99	49.67
Total	593	67	11,30	35.93

Those academic results are linked to the average age of players who suffered concussion. The highest incidence was around 18.3 years old [16;20] during the first year and 18.1 years old [16;20] during the second year. Lower incidence affected the 20-year-old group in 2014-15, but it was not statistically significant ($\chi^2 = 0.70$; $p = 0.40$).

Table 3

Top 10 Concussion's cause(s) during 2013-2014 and 2014-2015 seasons

Ranking	Cause(s) of Injury	Concussions	% Concussions*	% Cause(s)
2013-14**				
1	Collision with opponent	30	46.88	26.79
2	Blind-siding	11	17.19	9.82
3	Fall on ice	9	14.06	8.04
4	Collision on open ice	8	12.50	7.14
5	«Whiplash»	8	12.50	7.14
6	Collision with boards	7	10.94	6.25
7	Rotation mechanism	7	10.94	6.25
8	Collision with net	6	9.38	5.36
9	Fight	6	9.38	5.36
10	Others	6	9.38	5.36
2014-15***				
1	Collision with opponent	34	50.75	27.42
2	Collision with boards	21	31.34	16.94
3	Blind-siding	15	22.39	12.10
4	Checked from behind	10	14.93	8.06
5	Fight	9	13.43	7.26
6	Fall on ice	7	10.45	5.65
7	Collision on open ice	5	7.46	4.03
8	Rotation mechanism	5	7.46	4.03
9	Others	5	7.46	4.03
10	«Whiplash»	4	5.97	3.23

* more than one cause can be documented for a single event
**2013-14: A total of 64 mTBI and a total of 112 causes
*** 2014-15: A total of 67 mTBI and a total of 124 causes

A total of 16 possible mechanisms of injury were listed in a section of the data collection form. It must be noted that more than one cause can be documented for a single event. The three main mechanisms of injury were the same for both seasons. In the top 10, we found the same 9 causes for both years.

The most reported cause was "Collision with an Opponent", in 46.88% of all cases during 2013-2014 season ($\chi^2 = 12.95$; $p < 0.001$), and in 50.75% of the cases during 2014-15 season ($\chi^2 = 5.21$; $p = 0.02$); it is statistically significant for both years.

The second most common cause of concussion during the 2013-2104 season was "Blind Siding", with 17.19% of all cases of concussion. It was the third occurrence with 22.39% during the 2014-2015 season. This was the same for the two seasons observed ($\chi^2 = 0.56$; $p = 0.46$).

"Fights" were reported as the cause of a concussion for the first season with a percentage of 9.38% of all concussion and, for the second year, the percentage went higher with 13.43% of all causes ($\chi^2 = 0.53$; $p = 0.47$). Concussions had been caused by a "Checked from Behind" in 6.25% of all concussions for the 2013-2104 season and increased to 14.93% during the second season ($\chi^2 = 2.58$; $p = 0.11$).

By comparing the percentage of players who had suffered one or more concussions before the concussion reported in this study, we find that 40.6 % (2013-2014) and 37.3 % (2014-2015) of all hockey players had a history of concussions ($\chi^2 = 0.33$; $p = 0.56$).

Table 4

Antecedents (ATCD) of concussion for the two seasons

Antecedents	2013-14	2014-15	χ^2 ($p < 0.05$)
Average (total)	0.70	0.53	
Players (ATCD >1)	26	25	0.15 ($p = 0.70$)
Average (ATCD >1)	1.73	1.40	
% = players (ATCD >1) / total	40.63	37.31	0.33 ($p = 0.56$)

Table 5

Description of post-concussion durations (average and total days/games for two seasons)

Description	2013-14 (average)	2014-15 (average)	2013-14 (total)	2014-15 (total)
End of S/S (days)	9.23	9.90	591	663
Return to play (days)	18.81	19.96	1,204	1,337
Games missed	5.58	5.85	357	392
School missed (days)	3.06	2.54	196	170

The total symptomatic days after concussions were 591 for 64 athletes on the first year, and 663 for 67 athletes on the second year. Signs and symptoms resolved at the same rate for both seasons, within an average of 9.23 days in 2013-2014 compared to 9.90 in 2014-2015 ($\chi^2 = 0.06$; $p = 0.81$).

Even though sign and symptoms resolved after around 9 days, athletes were able to return to play in an average of 18.81 days (2013-2014) when engaged into the return-to-play protocol

(RTP). The RTP average was similar on the following year with 19.96 days before a full clearance ($\chi^2 = 0.03$; $p = 0.87$). A total of 1,204 days were missed after concussions during the 2013-14 season, during which the rehabilitation proceeded, compared to 1,337 days in the 2014-2015 season.

During this amount of time, players missed an average of 5.58 games after a concussion, for a total of 357 games missed during the first season. The second season was similar, with an average of 5.85 games missed per player with concussion, for a total of 392 missed games during the second season ($\chi^2 = 0.46$; $p = 0.50$).

During this same period, while they were out-of-play and still symptomatic, the players were out of school for an average of 3.06 days (2013-14) and 2.54 days (2014-15). When combining all these missed school days, the total is 196 missed days for the first season and a total of 170 school-missed days for the next year ($\chi^2 = 0.55$; $p = 0.46$).

A total of 23 signs and symptoms (S/S) were listed on the data collection form. The S/S checklist showed the same top eight S/S for both seasons. Moreover, the exact same five S/S were in the six most reported ones for both seasons. The average of S/S per player with concussion was 7.28 [min=2; max=15] for the 2013-2104 season and 6.48 [min=1; max=19] for the 2014-2015 season. (see table 6)

Table 6

Concussion's signs and symptoms (top 8) for the 2013-2014 and 2014-2015 seasons

Ranking	Signs / Symptoms	Total	% Concussions	% S/S
2013-14	*			
1	Headache	57	89.06	12.23
2	Does not feel Right	42	65.63	9.01
3	Feeling Slowed Down	36	56.25	7.73
4	Dizziness	32	50.00	6.87
5	Head Pressure	30	46.88	6.44
6	Neck Pain	27	42.19	5.79
7	Fatigue / Low Energy	25	39.06	5.36
8	Difficulty to Concentrate	24	37.50	5.15
2014-15	**			
1	Headache	59	88.06	13.53
2	Dizziness	40	59.70	9.17
3	Feeling Slowed Down	33	49.25	7.57
4	Neck Pain	30	44.78	6.88
5	Head Pressure	28	41.79	6.42
6	Difficulty to Concentrate	28	41.79	6.42
7	Does not feel Right	26	38.81	5.96
8	Fatigue / Low Energy	26	38.81	5.96

* 2013-14: A total of 64 mTBI and a total of 466 S/S
** 2014-15: A total of 67 mTBI and a total of 436 S/S

Headache was the most reported symptom, being present in 89.06% (2013-2014) and 88.06% (2014-15) of all concussion reported in this study. It was not statistically different for both seasons ($\chi^2 = 0.05$; $p = 0.82$). That represents 12.23% of all S/S for the first year, and 13.53% for the second one.

Another symptom that was frequently reported was neck pain, in 42.19% of all concussion. For the second year, 44.78% of all athletes with concussions presented neck pain. It was not statistically different for both seasons ($\chi^2 = 0.18$; $p = 0.67$).

Table 7

Professional follow-up after a concussion for the 2013-2014 and 2014-2015 seasons

Ranking	Professional Follow-Up	Total	% Concussions	% Professionals
2013-14	*			
1	Athletic Therapist	47	73.44	37.01
2	Doctor	33	51.56	25.98
3	Physiotherapist	15	23.44	11.81
4	Osteopath	13	20.31	10.24
5	Neuropsychologist	10	15.63	7.87
6	First Responder	8	12.50	6.30
7	Others	1	1.56	0.79
8	Chiropractor	0	0.00	0.00
2014-15	**			
1	Athletic Therapist	42	62.69	29.79
2	Physiotherapist	34	50.75	24.11
3	Doctor	33	49.25	23.40
4	Neuropsychologist	17	25.37	12.06
5	Osteopath	8	11.94	5.67
6	First Responder	5	7.46	3.55
7	Others	2	2.99	1.42
8	Chiropractor	0	0.00	0.00

* 2013-14: A total of 64 mTBI and a total of 127 professionals
** 2014-15: A total of 67 mTBI and a total of 141 professionals

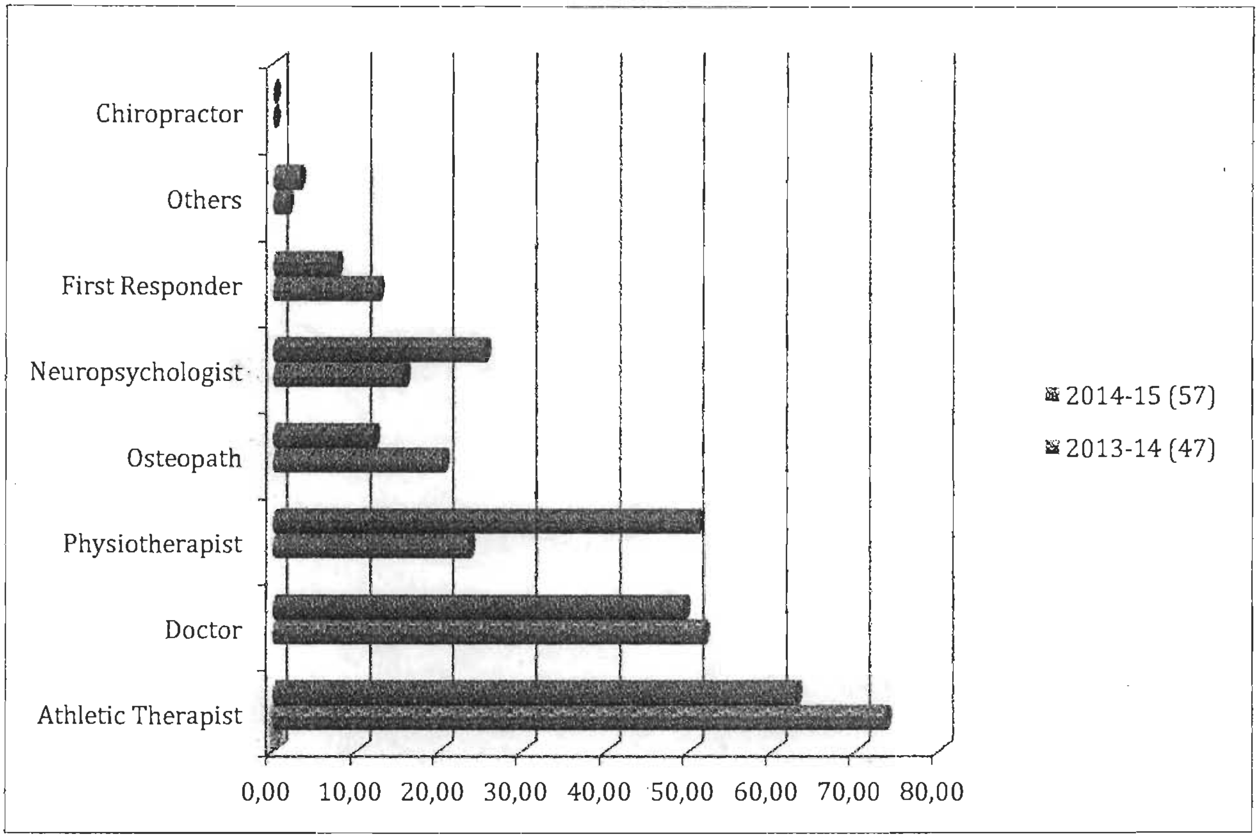

Figure 1. Professional follow-up after a concussion for both seasons

Professional follow-up represents the health care professionals involved during the initial evaluation of a sport concussion. The numbers of professionals working full time with a hockey team during the 2013-2014 season was: 14 athletic therapists, 3 first responders and 1 physiotherapist. The 2014-2015 season was slightly different, with a proportion of 12.5 athletic therapists, 3 first responders and 2.5 physiotherapists (this is due to the fact that a physiotherapist replaced an athletic therapist at mid-season).

When looking at health care professionals working full time with a team, certified athletic therapists represented 77.78% (2013-2014) and 69.44% (2014-2015) of all health care professionals. It was not statistically different for both seasons. ($\chi^2 = 2.08$; $p = 0.15$). In between seasons, the different teams' staff changed, and athletic therapist decreased by 8.34%. Full time first responders stayed the same for both years at 16.67%. The number of physiotherapists increased in between both seasons, going from 5.56% to 13.89%, an 8.34% increase, but that was not statistically significant, even though we can see a tendency ($\chi^2 = 3.56$; $p = 0.06$).

Certified athletic therapist were involved in the management of 73.44% of all concussion for the first year, and in 62.69% of them for the second year ($\chi^2 = 1.74$; $p = 0.19$). Physiotherapist were more included in the first professional follow-up during the 2014-15 season, increasing from 23.44% to 50.75%, which is significant ($\chi^2 = 10.43$; $p = 0.001$). The neuropsychologists' participation also increased, going from 15.63% to 25.37% between both season, but it is not significant ($\chi^2 = 1.90$; $p = 0.17$).

During the 2013-2014 season, 47 cervical evaluations were conducted on 64 athletes with concussions, representing 73.4% of all the cases. During the 2014-2015 season, this percentage increased at 85.1% (57 evaluations/67 cases of concussions) for an increase of 11.7% between both years ($\chi^2 = 2.71$; $p = 0.10$).

A higher percentage of physiotherapists were involved in postconcussions cervical evaluations during the second year of this study. However, this 11.2% increse between both seasons is not statistically significative ($\chi^2 = 1.32$; $p = 0.25$). Physicians also had a higher percentage involvement in postconcussive neck evaluations, increasing from 14.89% to 21.05% for the last season of this study, but it is not statistically significative ($\chi^2 = 0.65$; $p = 0.42$).

Table 8

Professionals involved in cervical evaluation after a concussion during 2013-2014 and 2014-2015 seasons

Ranking	Cervical - Evaluation	Total	% Concussions	% Professionals
2013-14	*			
1	Athletic Therapist	37	78.72	48.68
2	Physiotherapist	17	36.17	22.37
3	Osteopath	13	27.66	17.11
4	Doctor	7	14.89	9.21
5	First Responder	1	2.13	1.32
6	Neuropsychologist	1	2.13	1.32
7	Others	0	0.00	0.00
8	Chiropractor	0	0.00	0.00
2014-15	**			
1	Athletic Therapist	33	57.89	40.74
2	Physiotherapist	27	47.37	33.33
3	Doctor	12	21.05	14.81
4	Osteopath	8	14.04	9.88
5	Neuropsychologist	1	1.75	1.23
6	First Responder	0	0.00	0.00
7	Others	0	0.00	0.00
8	Chiropractor	0	0.00	0.00

*2013-2014: A total of 47 mTBI and a total of 76 professionals
** 2014-2015: A total of 57 mTBI and a total of 81 professionals

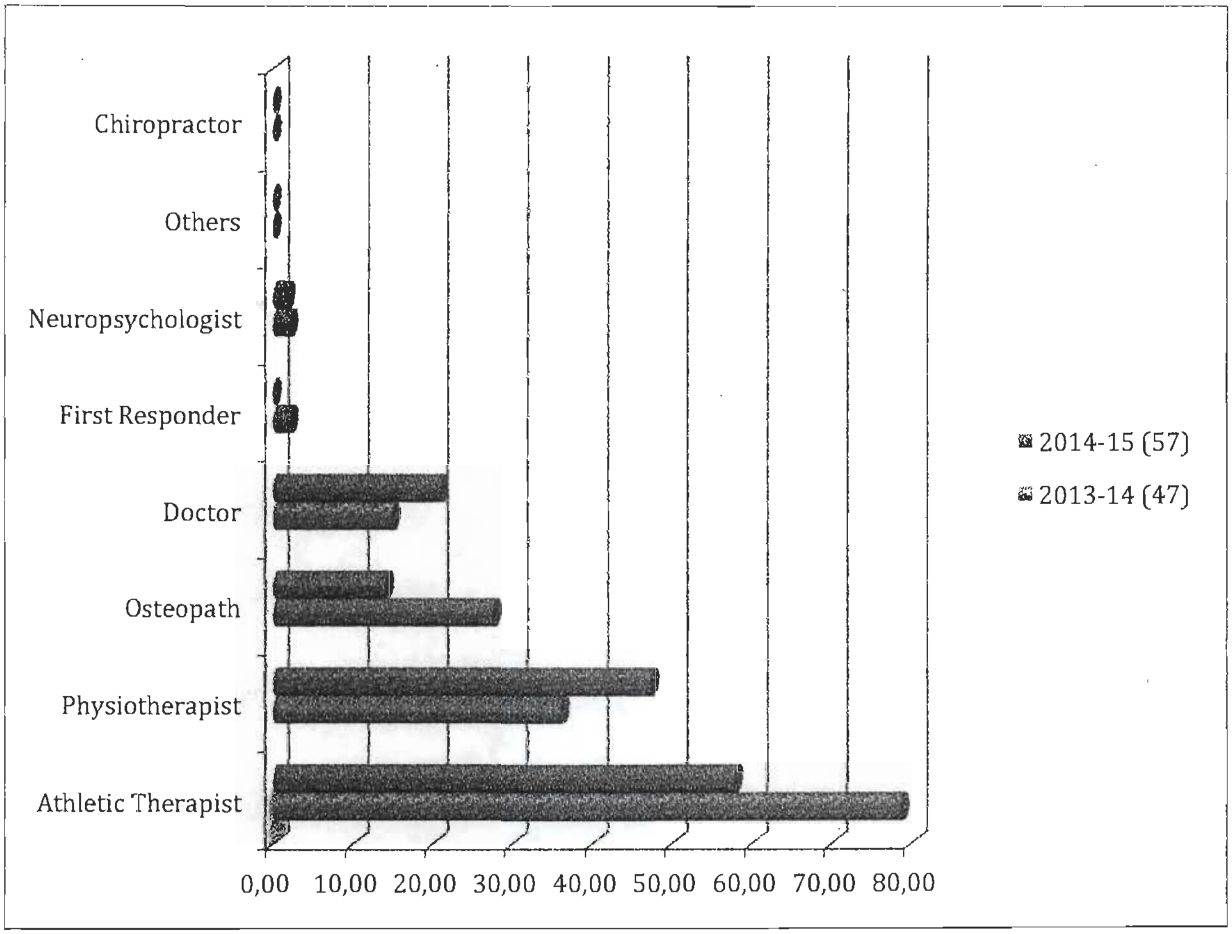

Figure 2: Professionals involved in cervical evaluations after a concussion for both two seasons

The average treatments for concussion was 2.93 days per week for the first year, and 3.09 for the second one. Physiotherapists were more involved in treating concussions during the 2014-15 season (52.63%) than in 2013-2014 (29.79%) ($\chi^2 = 5.51$; $p = 0.02$) which is statistically significant.

Table 9

Professionals involved in cervical post-concussion treatments during the 2013-2014 and 2014-2015 seasons

Ranking	Cervical - Treatment	Total	% Concussions	% Professionals
2013-14	*			
1	Athletic Therapist	37	78.72	48.05
2	Physiotherapist	14	29.79	18.18
3	Osteopath	11	23.40	14.29
4	Doctor	7	14.89	9.09
5	Neuropsychologist	4	8.51	5.19
6	First Responder	2	4.26	2.60
7	Others	2	4.26	2.60
8	Chiropractor	0	0.00	0.00
2014-15	**			
1	Physiotherapist	30	52.63	36.14
2	Athletic Therapist	28	49.12	33.73
3	Doctor	9	15.79	10.84
4	Neuropsychologist	7	12.28	8.43
5	Osteopath	7	12.28	8.43
6	First Responder	1	1.75	1.20
7	Others	1	1.75	1.20
8	Chiropractor	0	0.00	0.00

*2013-2014: A total of 47 mTBI and a total of 77 professionals
** 2014-2015: A total of 57 mTBI and a total of 83 professionals

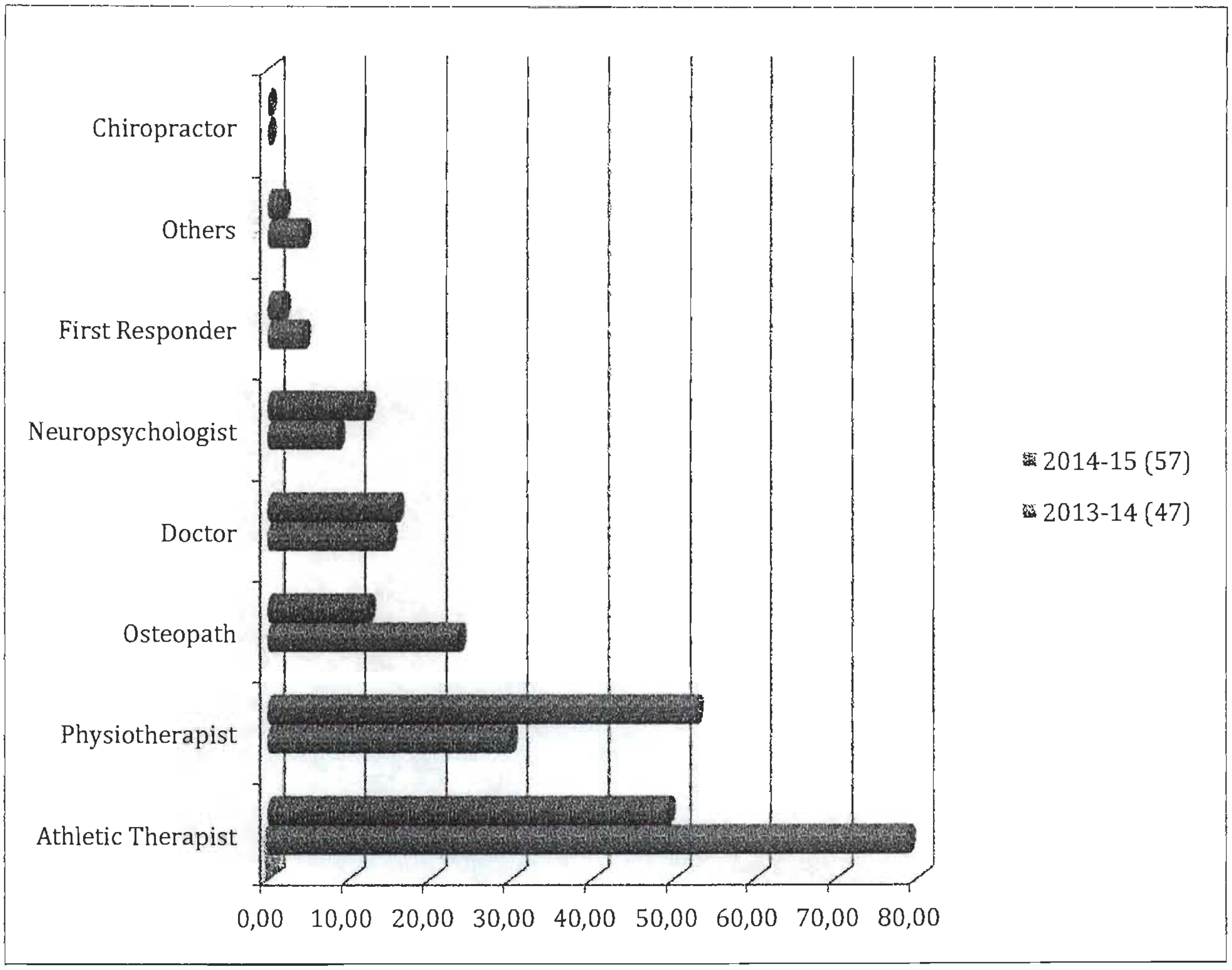

Figure 3: Professionals involved in cervical treatments after a concussion for both seasons

A total of 183 treatments sessions have been provided to 47 athletes with concussions during the first season, for an average of 3.89 different treatments per athlete with concussion. For the second year, the reports showed a total of 234 treatments for 57 athletes with concussions, for a total of 4.11 treatments per concussion. Twelve types of treatments were listed on the data collection questionnaire.

Table 10

Cervical post-concussion treatments during 2013-2014 and 2014-2015 seasons

Ranking	Cervical - Treatments	Total	% Concussions	% Treatments
2013-14 *				
1	Rest	47	100.00	25.68
2	Massage	26	55.32	14.21
3	Passive mobilizations	25	53.19	13.66
4	Traction	18	38.30	9.84
5	Manipulation	14	29.79	7.65
6	Active Release	14	29.79	7.65
7	Osteocranial	11	23.40	6.01
8	Trigger Points	11	23.40	6.01
9	Vestibular	6	12.77	3.28
10	Oculomotor	4	8.51	2.19
11	PNF	4	8.51	2.19
2014-15 **				
1	Rest	57	100.00	24:36
2	Massage	32	56.14	13.68
3	Passive mobilizations	31	54.39	13.25
4	Traction	30	52.63	12.82
5	Active Release	22	38.60	9.40
6	Trigger Points	17	29.82	7.26
7	Oculomotor	10	17.54	4.27
8	Manipulation	9	15.79	3.85
9	Osteocranial	8	14.04	3.42
10	Vestibular	6	10.53	2.56
11	PNF	5	8.77	2.14

*2013-2014: A total of 47 mTBI and a total of 183 treatments

** 2014-2015: A total of 57 mTBI and a total of 234 treatments

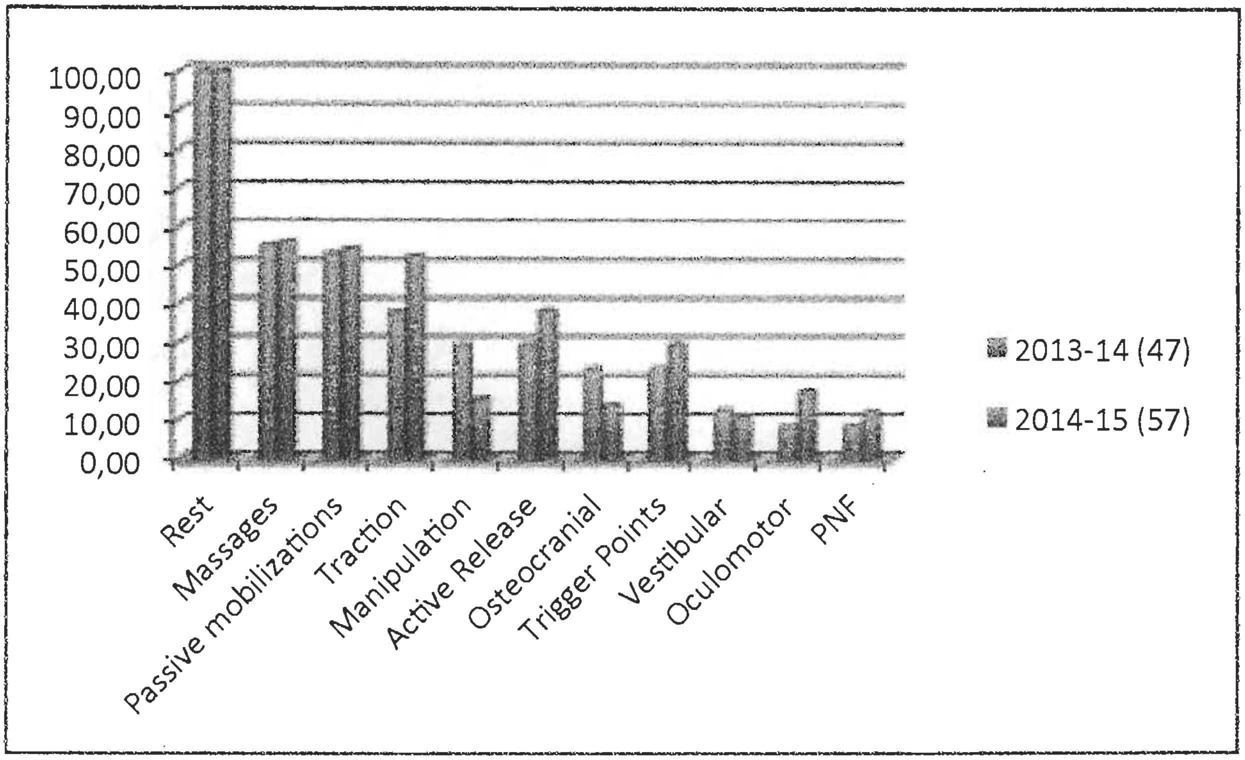

Figure 4: Cervical post-concussion treatments for both seasons

Rest was reported as the most popular treatment, and was used in 100% of concussion cases. As shown in table 10, the four most provided treatments were the same for both years. They were, in order of the most to the less provided: rest, used in 100% of the cases for both years, massages were used in 55.32% of the cases for the first year and 56.14% of the for the second year ($\chi^2 = 0.007$; $p = 0.93$), passive mobilizations were used in 53.19% of the cases in 2013-2014 and in 54.39% of the cases in 2014-2015 ($\chi^2 = 0.01$; $p = 0.90$) and tractions were used 38.30% in first season and in 52.63% of the cases in second one ($\chi^2 = 2.13$; $p = 0.14$).

Four types of treatments increased between the two seasons analyzed. Traction therapy augmented from 38.30% to 52.63% ($\chi^2 = 2.13$; $p = 0.14$), Active Release techniques increased from 29.79% to 38.60% ($\chi^2 = 0.88$; $p = 0.35$), Trigger Points Inhibition increased from 23.40% to

29.82% (χ^2 = 0.54; p = 0.46) and Oculomotor rehabilitation raised from 8.51% to 17.54% (χ^2 = 1.80; p = 0.18), but none of these results is statistically significant.

DISCUSSION

In the literature, the most commonly used method to show the sport concussion incidence is called Athlete Exposures, and it includes games and practices (Echlin et al., 2010). For the current study, the incidence of concussion in the QMJHL was 0.87/1,000 AEs. The NHL reported an incidence from 1.81 per 1,000 AE in 1998-1999 which decreased to 1.04 per 1,000 AE in 2005-2006 (Echlin et al., 2010). College-level male hockey players had a ratio between 0.41 and 0.72/1,000 AE compared to 0.54/1,000 AE in high school males players (Clay et al., 2013). At the university level, the National Collegiate Athletic Association (NCAA) Division 1 university hockey players reported an incidence rate of 3.1 per 1,000 AE.

On the other hand, the QMJHL data revealed a ratio of 12.04 concussions per 100 players in 2013-2014, and a ratio of 12.65 concussions per 100 players for a total of 593 in 2014-2015. In 2011, Benson et al. (2011) presented an average NHL percentage of 5.8 concussions per 100 players for 7 seasons between 1997-98 and 2003-04. This difference can be explained by the knowledge about concussions at this time, the players' experience, the self-report questionnaire inconsistencies and the fact that not all concussions were declared (Bonfield et al., 2014). Secondly, the proportion of players per team 32.5 in the QMJHL for this study compared to an average of 47 players in the NHL.

During both season, a total of 1,224 regular season games were played. The ratio during the 2013-2014 season was 5.64 concussions per 100 QMJHL regular season games, and 6.13

concussions per 100 QMJHL regular season games in 2014-2015. The literature showed that the total concussion incidence over 3 seasons analyzed was 5.23 per 100 NHL regular season games, versus 5.05 per 100 Ontario Hockey League (OHL) regular season games (Donaldson et al., 2013). The QMHJL ratio was probably higher, because the concussion awareness was different between seasons 2009-10 to 2011-12 (Donaldson's study) compared to the current study, which took place in 2013-14 and 2014-15.

Eighteen and nineteen years old players have a higher percentage of concussions compared to other ages, but not statistically significant. Those players are usually playing more time on ice than 16 and 17 year-olds. Table 2 shows that the 18 to 20 year-olds play more games than 16-17 years-olds. On the other hand, 20 year-olds had a lower percentage of concussions than 18-19 years-olds, but not statistically significant. One hypothesis is that older players have more game experience and are more mature physically and consequently less at risk for such injuries.

Depending on sports, certain positions and individual playing styles have a greater risk of concussion (Harmon et al., 2013). In this study, forwards had the highest percentage of concussion with an average of 12.3% for both seasons compared to 11.1% for defensemen and 4.4% for goalies. The IIHF exposed player's position risk of concussion, and centers were about twice as much exposed that defensemen and wingers (Tuominen et al., 2015). A recent study by Hutchison et al. (2015) exposed too that forwards got more concussions than expected compared to other players. This can be caused by the facts that forwards play at a higher speed and open ice contact happened often. Conversely, the OHL and NHL defensemen were found to be at a higher risk of suffering a concussion than other players. Their explanation are based on sequences that concussed defensemen were turning their back to retrieve pucks along the boards, which left them vulnerable (Donaldson et al., 2013).

Ice hockey is a high-speed, high-contact sport and, unfortunately, body checking is expected to increase the risk of head injury (Giza et al., 2013). In our study, "Collision with an opponent" was the most common mechanism of concussion, with its presence in 46.88% (2013-2014) and 50.75% (2014-2015) of all cases reported. This is consistent with the literature, where we can find that the most common mechanism of a concussive injury is by checking or by a player-to-player contact (Harmon et al., 2013). Hutchison & al. (2015) showed with NHL data that 80% (n=158/197) of diagnosed concussions involved a "collision with an opponent" (Hutchison et al., 2015b). New studies are exposing this injury mechanism and suggest new guidelines rules for equipment, player-to-player contact sports and sex-specific conditioning (Clay et al., 2013).

When speaking of concussions, one can specifically think of hits to the head. This mechanism is usually included within the "collision with an opponent" category. The NHL penalty statistics revealed that "check to the head" was called 11.8% of the time, while other aggressive penalties accounted for 44.1% and non-aggressive penalties for 11.8% (Donaldson et al., 2013). In this study, "Blind-siding" and "collision on open ice" were included in the "head checking" category. "Blind-siding" was the second most common cause, with 17.19% of all concussion during the 2013-2104 season and was the third occurrence with 22.39% in 2014-2015. On the other hand, "collision on open ice" was in 12.50% (2013-2104) and 7.46% (2014-2015) of all concussions cases. For the past couple years, mentality in ice hockey has been changing, and new rules, such as "head checking", should reduce concussions in the future (Biasca et al., 2002).

In our study, "Collision with boards" was the third most common cause for the 2014-2015 season with 31.34% of all cases of concussions and was the sixth occurrence with 10.94% in 2014-2015. The study of Tuominen & al. (2015) exposed that the majority of concussions occurred without board contact (55.8%) during the IIHF tournaments.

"Fights" and "checked from behind" were two of the most usual dangerous causes of injuries in the past. However, severe spinal injuries are decreasing with prevention strategies, and new "Fair Play Rules" (Biasca et al., 2002). The 2013-15 QMJHL data represent well this improvement with 6.25% of all concussions being caused by a "check from behind" during the season 2013-2104 and 14.93% during the following season. On the other hand, "fights" lead to concussions in about one in ten concussions (9.38% for 2013-2014 and 13.43% for 2014-2015). This is similar of the NHL, where 8.12% of diagnosed concussions are a result of fighting (Hutchison et al., 2015b). Again, the new rules about "fights" on the ice are effective. Donaldson et al. (2013) wrote that the most common penalty called in the NHL, with 32.3%, was fighting. The OHL showed the same statistics with "fights" and "check to the head" as their most common penalties with 36.4% each (Donaldson et al., 2013).

In the previous NHL data, it is notable that "fights" and "bodychecking" were causing secondary contact of the head with the boards or ice, causing more concussions than blindsiding; these incidents are not covered by head checking rules in the league (Donaldson et al., 2013). The Ice Hockey Summit II held at the Mayo clinic (Rochester, MN) yield some high priority actions for the hockey player's future: 1) eliminate head hits from all levels of ice hockey, 2) change body checking policies, and 3) eliminate fighting in all amateur and professional ice hockey (Smith et al., 2015).

The international panel of experts present at 2012 Zurich consensus on concussion in sport agreed with the fact that the majority of sport concussions resolve in a period of 7-10 days and most studies report that 80-90% of athletes have symptom resolution by the 7th day following their injury (Harmon et al., 2013; Marshall, 2012; McCrory et al., 2013). Signs and symptoms can remain between a few minutes to a couple months and years (McCrory et al., 2013). In this study, signs and symptoms resolved within an average of 9-10 days (9.23 days in 2013-2014 and 9.90 for 2014-2015), and athletes were able to return to play in an average of 19 days (18.81 days for 2013-2014 and 19.96 for 2014-15) following the RTP protocol. These numbers show that those athletes took more time to RTP than the reported international average. McCrory et al. (2013) mentioned that the recovery time frame might be longer in children and adolescents. Another hypothesis is that although physical symptoms are gone, the full recovery is not always indicating a complete cognitive recovery, because neuropsychological deficits can still problematic (Harmon et al., 2013; McFadyen et al., 2009).

The gold standard for managing concussion is physical and cognitive rest (Borich et al., 2013; Broglio et al., 2014; Giza et al., 2013; Marshall, 2012; McCrory et al., 2013). A physical activity (including sport) break is needed in the acute symptomatic period following injury (24-48h) for the brain to recover until the acute symptoms resolve (McCrory et al., 2013). During our study, all QMJHL team therapists were aware of the International Zurich consensus on concussion in sport protocol for RTP. An interesting fact in this study is that, during the period where players were out-of-play and still symptomatic, they were out of school for an average of only 2.8 days (3.06 days for 2013-2014 and 2.54 days for 2014-2015). In fact, these data show that some players were returning at school full time, even though their symptoms were still present. To our knowledge, there are no international standardized guidelines for returning athletes to school (Harmon et al., 2013). Recent studies are focusing their research in this field and papers are starting to come out. Concussed students need cognitive rest and may require academic accommodations such as decreased class hours, reduced workload and extended time for tests while recovering (Harmon et al., 2013). An asymptomatic athlete returning to school too early can reproduce the signs and symptoms with cognitive stress, fatigue, exterior factors (noise, lights, etc.). As described earlier, some athletes have persistent neurocognitive deficits following a concussion, despite being symptom free (Harmon et al., 2013; Moser et al., 2012). Multidisciplinary resources are usually needed to help impaired students (Harmon et al., 2013). Recently, DeMatteo et al. (2015) published a post-concussion return-to-school paediatric protocol. Interestingly, this study involved teenagers and young adult between 16 and 20 years old. Purcell et al. (2013) have also proposed a return-to-school protocol as part of the updated Canadian Paediatric Society statement on concussion. It is agreed in the literature that the brain get to maturity between 20-30 years old, usually at the average age of 25 (Lebel et al., 2008;

Tamnes et al., 2010). Should groups of major junior hockey players be looked at as a paediatric groups? Future researches are needed in that matter and will help to understand and optimized the return-to-school process post-concussion in students-athletes.

When looking at symptoms after a concussion, it is clear in the literature that headache is the most commonly reported symptom (Harmon et al., 2013; Littleton et al., 2013; Lucas, 2011; McCrory et al., 2013; Scorza et al., 2012). This is consistent with our results, where headache was the most reported symptom with 89.06% (2013-2014) and 88.06% (2014-15) of all cases of concussion. The NHL statistics between 1997-2004 revealed that 70.9% of 533 players who had sustained a concussion suffered of headache (Benson et al., 2011). In the same way, a study of over 1,000 high school sport-related concussions mentioned headache as the most common symptom, with 94.3%, followed with dizziness/unsteadiness in the second place with 75.5% (Marshall, 2012). Tables 10 and 11 show dizziness being present in 50.00% of all concussions during the first season and 59,70% during the second one. This is consistent with the NHL data, where dizziness was involved in 34% of all concussions (Benson et al., 2011).

Another symptom that was frequently reported was neck pain (42.19% of all reported cases of concussion during 2013-2104 and 44.78% for 2014-15). This can be explained in part by Hynes et al. (2006), who showed an association between whiplash-induced neck injuries and the symptoms of concussion during a hockey season for player's aged 15-35. More research is required to explain the injury mechanism and to improve treatments when the neck in involved post-concussion.

Between seasons 2013-2104 and 2014-2105, the QMJHL medical committee decided to give a concussion workshop during the June summer entry draft. The objective of this activity was to upgrade the team therapists' knowledge and skills, in order to improve their concussion management. In general, the top 4 treatments used are the same for both years, but numbers showed an higher percentage in treatments by traction (14.33%), oculomotor rehabilitation (9.03%), active Release techniques (8.81%) and trigger points inhibition (6.42%), but that was not statistically significant. Another interesting fact is described in the last table. Statistics revealed that treatments were more provided at the rink (9.85%) than in an outside clinic or at the hospital. Those records show the importance of continuing education and the efficiency of the 2014 summer concussion workshop.

On the health professionals' side, the only type of clinicians that increased their percentages after the workshop are physiotherapists. In fact, they were more involved in professional follow-up with a progression of 27.31%, as well as a raise of 11.2% for the neck evaluation. We also observed a raise of 22.84% for neck treatments between both years. These progressions are statistically significative for the follow-up and treatments. Athletic therapy is still the profession which is the most involved in the three components, but we have to take into consideration that the majority of the QMHJL's therapists are athletic therapists. Limitations of this study were that no control group was involved in this project, the control of the learning process with the workshop, the self-report consistency and the fact that maybe not all concussions were reported. We can conclude that athletic therapists and physiotherapists are important players in post-concussions rehabilitation, particularly when the cervical spine is injured.

CONCLUSION

In conclusion, the incidence of concussion in the QMJHL is 0.87/1,000 AE, 12.35 concussions per 100 players and 5.64 concussions per 100 QMJHL regular season games. These numbers are similar to high-level leagues' statistics such as the NHL and the OHL. Signs and symptoms average duration was longer for the QMJHL players, and it took more time to RTP than the reported international average. Hypotheses suggested were that the recovery time frame might be longer in children and adolescents, and that although physical symptoms are resolved, the full physical recovery is not always indicating a complete cognitive recovery, because neuropsychological deficits can still be problematic. An interesting fact uncovered in this study was that, while players were out-of-play and still symptomatic, they still returned to school full time. Finally, the workshop helped therapists to develop concussion's management and to use different tools to optimize post-concussion rehabilitation.

It is, however, difficult to compare the post-concussion follow up with the literature, because this study is, to our knowledge, the first one on that matter. Furthermore, three other limitations of this study are 1) the measure of the learning process with the workshop, 2) the self-report consistency and 3) the fact that maybe not all concussions were reported. One major aspect that needs more research is the return-to-school protocol that looks like a problem in the post-concussion recovery. This study revealed that future studies are needed to better manage return-to-school and look at how an early return-to-play could slow down total recovery. In practice, health professionals need to be more involved in the post-concussion follow-up and consider an association between an early return to school and longer-lasting symptoms. Long-term studies are needed to understand and fully appreciate the best post-concussion recovery protocols.

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CHAPITRE V. DISCUSSION GÉNÉRALE

Comme mentionné précédemment, les recherches récentes sur les TCCL portent majoritairement sur le diagnostic de celles-ci que sur leur traitement possible. Les projets de recherches effectués dans le cadre de ce mémoire ont permis d'élucider certaines tendances sur le terrain et de préciser des hypothèses en se basant sur des évidences dans la littérature scientifique.

Le projet de recherche en collaboration avec la LHJMQ amène un grand nombre de données sur la réadaptation postcommotionnelle des les hockeyeurs élites d'âge junior. En général, les données sur l'incidence de ce type de blessure dans ce projet de recherche sont semblables aux ratios retrouvés dans les autres ligues élites, comme la LNH par exemple. Le point concernant les positions de jeu les plus à risque des hockeyeurs soulève une mésentente entre les différentes études recensées dans la littérature. En effet, l'incidence des TCCL chez les attaquants serait plus élevée en raison que leur style de jeu est plus rapide et, qu'ainsi, les collisions sont provoquées à plus grande vélocité (Donaldson et al., 2015). L'envers de la médaille est que les défenseurs sont plus à risque, car ils présentent souvent leur dos à l'adversaire pour protéger la rondelle (Donaldson et al., 2015). L'étude en collaboration avec la LHJMQ montre un pourcentage plus élevé de commotion chez les attaquants que les défenseurs pour les deux années étudiées, mais ces résultats ne sont pas statistiquement significatifs. L'ensemble des études démontre que la mise en échec permise est la cause première des commotions cérébrales au hockey. Il y a une diminution marquée du nombre de combats, de mise en échec par-derrière et de coups à la tête selon les statistiques récoltées dans ce projet de recherche. La littérature va dans ce sens. En effet, ces changements de règlementation par rapport aux « mises en échec par-derrière » ainsi que les « coups à la tête » au niveau du hockey sur glace ont permis d'améliorer la gravité des blessures au niveau du cou ainsi que de la sévérité des commotions cérébrales (Biasca et al., 2002; Harmon et al., 2013). Des recherches comprenant un suivi longitudinal seront primordiales pour évaluer l'efficacité de cette nouvelle règlementation pour la protection des hockeyeurs.

En général, les signes et symptômes postcommotionnels disparaissent après quelques jours de repos et nécessitent peu ou pas de traitements particuliers. Cependant, selon la littérature, si les symptômes perdurent plus de 2-3 semaines, le diagnostic de syndrome postcommotionnel est posé et le pronostic est dur à établir pour les spécialistes dans le domaine (Cancelliere & al., 2014; Hecht, 2004; McCrory & al., 2013). Notre étude auprès des hockeyeurs juniors a démontré que les signes et symptômes disparaissaient en moyenne après environ 9 jours et que les hockeyeurs étaient prêts pour un retour complet après grossièrement 19 jours. La vitesse du jeu et la force des impacts sont probablement une des causes qui expliquerait la différence entre nos résultats et la littérature. Une autre hypothèse est le fait que les hockeyeurs juniors, âgés entre 16 et 20 ans, ne devraient pas être comparés à des adultes, mais bien à la clientèle pédiatrique en raison que leur cerveau n'a pas atteint leur pleine maturité. Il serait intéressant d'analyser le temps de récupération par âge et par type de sport pour voir les différences au lieu de généraliser.

Le retour à l'école ou à l'apprentissage lors de la réadaptation est aussi un point qui a suscité une réflexion lors de ces recherches. En effet, il est clair que le repos est actuellement le «gold standard» pour optimiser la récupération et il est logique de penser que l'école, étant un stimulus, doit être diminuée ou arrêter pour une meilleure récupération. Or, notre étude auprès de thérapeutes expérimentés démontre qu'il y a une problématique à ce niveau. En lien, peu d'articles scientifiques discutent de ce sujet et les protocoles de retour progressif sur les bancs de classe sont quasi inexistants. Cette réalité est donc problématique et les professionnels de la santé doivent se pencher sur ce terrain ambigu question de diminuer le temps de convalescence en optimisant la réadaptation des commotions cérébrales. De futures recherches sont primordiales sur ce sujet et une restructuration du protocole de retour au jeu est de mise pour les prochaines années.

Le syndrome postcommotionnel (SPC) est un autre casse-tête pour les praticiens. À ce niveau, la littérature est peu détaillée et les protocoles pour ciblés d'où proviennent les symptômes ne font que commencer à émerger. Le cou, le système vestibulaire et le contrôle oculomoteur sont des exemples de causes qui pourraient être impliquées dans les SPC. Plusieurs cliniciens font présentement une évaluation sommaire de la colonne cervicale lorsqu'une commotion cérébrale est suspectée. C'est en 2013 que l'outil d'évaluation SCAT3 a ajouté une portion à son questionnaire portant sur les douleurs au cou posttrauma. Un TCCL se produit lors d'un mouvement d'accélération et de décélération du cerveau dans la boite crânienne. Il est donc logique de penser que si le crâne fait un mouvement de va-et-vient (whiplash), la colonne cervicale est directement affectée par ce mécanisme de blessure. De plus, le tableau clinique peut être confondant pour le clinicien, car le phénomène de «whiplash» peut provoquer des blessures à plusieurs structures dont le cou et le cerveau, et que les symptômes, comme les maux de tête, peuvent provenir autant de la commotion cérébrale elle-même que d'une dysfonction cervicale. La revue de la littérature présentée dans ce mémoire explique en détail la complexité de ces pathologies conjointes. De plus, le projet de recherche sur le terrain a révélé qu'environ 43% des hockeyeurs commotionnés ont ressenti des douleurs au cou.

Pour mettre à jour les connaissances des thérapeutes en matière de traitements des commotions cérébrales, les dirigeants de la LHJMQ ont décidé de présenter une formation théorique et pratique sur le sujet entre les saisons 2013-2014 et 2014-2015. Les statistiques de l'étude ont démontré que suite à la journée de développement, il y a eu une augmentation d'un peu plus de 11% au niveau des évaluations cervicales et plusieurs nouveaux types de traitements ont été utilisés dans la réadaptation des hockeyeurs en convalescences. Quelques études dans la littérature démontrent que la thérapie manuelle et les exercices sont efficaces pour traiter les commotions cérébrales associées à des problèmes cervicogéniques (Brolinson, 2014; Hecht, 2004; Laker, 2011; Martinez, 2011; Miller & al., 2010). Cliniquement, l'hypothèse que le cou peut être impliqué dans les symptômes suivant une commotion et lors d'un syndrome postcommotionnel est évidente pour les professionnels de la santé. Or, les évidences scientifiques expliquant la combinaison entre ses deux types de blessures est quasi inexistante. De futures recherches permettront d'approfondir ces types de blessures « au haut du corps ».

Pour terminer, les futures recherches permettront d'approfondir les connaissances sur les TCCL, communément appelés, commotions cérébrales. En pratique, les professionnels de la santé doivent continuer de s'impliquer dans le suivi posttrauma et dans les projets de recherche sur ce sujet. En effet, une des limites de ce mémoire est en fait le manque de littérature concrète sur ces sujets. D'un autre côté, le projet de recherche avec la LHJMQ comprenait plusieurs athlètes de haut niveau, mais l'absence d'un groupe contrôle ainsi qu'une possibilité que les commotions cérébrales n'aient pas toutes nécessairement été déclarées apportent certaines limites à ce mémoire.

Une des conclusions de ce mémoire porte sur l'importance de l'évaluation cervicale postcommotionnelle et du choix de traitements considérant les dysfonctions et les symptômes associés. De plus, les résultats du projet de recherche signalent qu'il faut porter une attention toute spéciale sur le retour à l'école précoce lors de la réadaptation post-TCCL. En bref, l'avenir est prometteur, car l'intérêt est grand à ce sujet et il concerne l'ensemble de la population.

CHAPITRE VI. CONCLUSION

En conclusion, la revue de la littérature a permis de supporter scientifiquement l'implication de la colonne cervicale dans les commotions et dans le syndrome postcommotionnel. Quelques études ont démontré qu'une proportion des céphalées posttraumatiques persistantes ainsi que certains syndromes postcommotionnels auraient des origines musculosquelettiques, telle que la colonne cervicale. D'autres études ont étudié le mécanisme de blessure et associent le phénomène de « whiplash » à celui provoquant les commotions cérébrales. En ce qui à trait aux types de traitement décrits dans la littérature, peu d'articles sont actuellement disponibles, mais quelques-uns récents décrivent d'intéressants résultats à propos de la thérapie manuelle (cervicale, vestibulaire) combinée aux exercices comme étant des outils utiles pour les praticiens. L'évaluation et le traitement de la région cervicale sont des étapes importantes dans la réadaptation postcommotion. En lien, le projet de recherche de cette maitrise en collaboration avec la LHJMQ appuie cette théorie de douleurs cervicales posttraumatiques représentant près de 43% des cas de commotions cérébrales répertoriées.

Le projet de recherche avec les équipes de hockey de niveau junior majeur a aussi démontré que l'incidence des commotions cérébrales est similaire aux autres ligues de haut niveau, comme la LNH et la OHL. En ce qui a trait à la durée des signes et symptômes postcommotionnels des hockeyeurs de la LHJMQ, ils dureraient plus longtemps et ils prendraientt plus de temps pour un retour au jeu complet que les moyennes mentionnées dans le consensus international de Zurich sur les commotions cérébrales dans les sports (2013). Les hypothèses suggérées pour expliquer ce phénomène sont le fait que les hockeyeurs juniors peuvent être classés dans la catégorie pédiatrique (plus longue convalescence) ou bien que, même si les symptômes physiques sont disparus, les déficits neuropsychologiques peuvent rester présents et repousser le retour au jeu. Une autre conclusion intéressante de ce projet de recherche est que le retour à l'école se fait de façon trop hâtive dans le processus récupération, et que même certains hockeyeurs retournent à temps plein à l'école même s'ils sont toujours symptomatiques. Finalement, la formation continue suivie entre deux saisons complètes a permis aux thérapeutes de perfectionner leurs traitements tout en leur donnant des outils de références pour optimiser leur réadaptation. Malgré les diverses limites de l'étude, de futures recherches permettront de peaufiner le protocole de retour au jeu, particulièrement au sujet du retour à l'école postcommotion.

En résumé, les deux articles de ce mémoire sont à la base des futures recherches dans le domaine et permettront le développement de nouveaux projets d'envergure pour mieux comprendre ce qui se fait sur le terrain tout en précisant le rôle de la colonne cervicale lors de l'impact. En bref, la présente littérature évoque seulement la pointe de l'iceberg concernant nos connaissances des commotions cérébrales.

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ANNEXE A

Table 2

Included studies description

Mémoire (programme 3407)

Table 2

Included studies description

Authors/Sections	Study objective	Population	Methods	Main outcomes / findings
Original Data				
Collins et al. (2014)	Develop and validate a cost-effective tool to measure neck strength in a high school setting. Determine if anthropometric measurements captured by ATs can predict concussion risk.	6,704 high school athletes in boys' and girls' soccer, basketball, and lacrosse	Feasability study Pilot Study	- Differences in overall neck strength may be useful in developing a screening tool to determine which high school athletes are at higher risk of concussion. Once identified, these athletes could be targeted for concussion prevention programs.
Eckner et al. (2014)	The purpose of this study was to determine the influence of neck strength and muscle activation status on resultant head kinematics after impulsive loading.	46 contact sport athletes 24 male; 22 female aged 8 to 30 years	Descriptive laboratory study	- Neck strength and impact anticipation are 2 potentially modifiable risk factors for concussion. Interventions aimed at increasing athletes' neck strength and reducing unanticipated impacts may decrease the risk of concussion associated with sport participation. - The results of this study suggest that greater neck strength attenuates the head's dynamic response to external forces.
Hecht et al. (2004)	This article reviews the literature on management of posttraumatic headaches, presents an approach to the assessment and treatment of individuals with headaches following TBI that appear to be cervicogenic, focuses specifically on identifying occipital neu ralgia, and discusses the technique of occipital nerve blocks.	7 males (18-42 yo) 3 females (22-64 yo)	Retrospective Review & Report of Ten Patients	- Following the injection, 8 patients (80%) had a 'good' response and 2 (20%) had a 'partial' response. - While there are a variety of different posttraumatic headaches, clinicians must be aware of all potential presentations including those emanating from the cervical spine and its affiliated structures (e.g., cervicogenic) - Injury to these structures (innervated by afferent fibres of the 3 sup. cervical roots) - These include but are not limited to muscles, ligaments, vessels, somatic and sympathetic nerves,

				oesophagus, temporomandibular joint, discs, zygapophyseal joints, cervical vertebrae, and the atlantoaxial complex. - 'whiplash syndrome' may be the primary factor in many postconcussive headaches. - 9 categories of headache attributed to head and brain injury as well as neck injury. - Post-traumatic vertebral basilar insufficiency: This presents with headache and the 4 Ds of dizziness, diplopia, dysmetria, and drop attacks.
Hynes et al. (2006)	Examine the relationship between the occurrence of whiplash-associated disorders and concussion symptoms in hockey players.	High school, College/university, Ontario Hockey League and men's recreational teams. (15–35 yo) 20 teams	Prospective study	- 183 players were registered for this study; 13 received either a mechanical whiplash injury or a concussion injury. - Initial injuries ranged from WAD I to WAD III and all subjects reported concussion symptoms. - Only three subjects reported full resolution of both WAD and concussion symptoms at the 7–10 day follow-up evaluation. - There is a strong association between whiplash-induced neck injuries and the symptoms of concussion in hockey injuries. - Acceleration and deceleration of the head and neck complex occurs in sports and can potentially create injuries similar to those incurred in low velocity motor vehicle accidents, as stated in a recent literature review focused on whiplash-associated disorders. - It is important for the clinician treating a patient or athlete for WAD to evaluate for symptoms of concussion and for the team therapist/ clinician to be

				cognisant of conducting a thorough cervical evaluation when dealing with concussed players.
Jensen et al. (2009)	The purpose of this study is to find out if specific manual therapy on the neck could reduce the headache.	23 patients with post-traumatic headache (one year after head trauma)	Clinical controlled trial	- It is concluded that the type of manual therapy used in this study seems to have a specific effect in reducing post-traumatic headache. - The result supports the hypothesis of a cervical mechanism causing post-traumatic headache and suggests that post-traumatic dizziness, visual disturbances and ear symptoms could be part of a cervical syndrome.
King et al. (2007)	The objective was to determine the sensitivity, specificity, and likelihood ratio of manual examination for the diagnosis of cervical zygapophyseal joint pain.	173 patients with neck pain in whom cervical zygapophyseal joint pain was suspected	Retrospective Study	- Manual examination had a high sensitivity for cervical zygapophyseal joint pain, at the segmental levels commonly symptomatic, but its specificity was poor. - The present study found manual examination of the cervical spine to lack validity for the diagnosis of cervical zygapophyseal joint pain.
Kozlowski et al. (2013)	To assess exercise intolerance in male and female patients with PCS.	34 patients (PCS) 17 males, 17 females Age = 25.9 ± 10.9 22 uninjured individuals	Cross-sectional study.	- Little is known about exercise intolerance or the utility of an exercise evaluation in patients with postconcussion syndrome (PCS). - Up to 33% of individuals with concussions have postconcussion syndrome (PCS), with up to 30% continuing to meet criteria for PCS 6 months postinjury. - Patients with PCS had a symptom-limited response to exercise, and the treadmill test was a potentially useful tool to monitor the recovery from PCS.
Leddy et al. (2015)	The objectve was to compare symptoms in patients with physiologic postconcussion	128 adults	Retrospective Review Questionnaire	- Clinicians should consider specific testing of exercise tolerance and perform a physical examination of the cervical spine and the

	disorder (PCD) versus cervicogenic/vestibular PCD.			vestibular/ocular systems to determine the etiology of postconcussion symptoms. - Concomitant injury to the cervical spine resembling whiplash may occur as a result of the acceleration–deceleration forces sustained in concussive trauma. - Structural and functional injury to the cervical spine can be associated with prolonged symptoms such as head- ache, dizziness, blurred vision, and vertigo.
Maugans et al. (2011)	The goal of this investigation was to explore cerebral blood flow fluctuation after pediatric sport-related concussion.	Twelve children ages 11 to 15 years Control group	Clinical study	- Statistically significant alterations in cerebral blood flow were documented in the sport-related concussion group, with reduction in cerebral blood flow predominating. Improvement toward control values occurred in only 27% of the participants at 14 days and 64% at >30 days after sport-related concussion. - Pediatric sport-related concussion is primarily a physiologic injury, affecting cerebral blood flow significantly without evidence of measurable structural, metabolic neuronal or axonal injury.
Mihalik et al. (2011)	The objective was to evaluate the effect of cervical muscle strength on head impact biomechanics.	37 volunteer ice hockey players age = 15.0 ± 1.0 years,	Prospective cohort study	- The hypothesis that players with greater static neck strength would experience lower resultant head accelerations was not supported. - There is still nonempirical support for the role neck musculature may play in reducing the risk of mild TBI that is worthy of investigation in a young at-risk sample.
Moser et al. (2012)	The objective of this article is to evaluate the efficacy of cognitive and physical rest for the treatment of concussion.	High school and collegiate athletes (N = 49) range = 14-23 yo mean = 15.0 yo 67% male	Retrospective analysis	- Participants showed significantly improved performance on Immediate Post-Concussion Assessment and Cognitive Testing and decreased

		33% female		symptom reporting following prescribed cognitive and physical rest. - These preliminary data suggest that a period of cognitive and physical rest may be a useful means of treating concussion-related symptoms, whether applied soon after a concussion or weeks to months later.
Reid et al. (2008)	This study aimed to determine the efficacy of sustained natural apophyseal glides (SNAGs) in the treatment of this condition.	34 adults 17 SNAGs 17 Placebo	Double-blind randomised controlled clinical trial	- Balance with the neck in extension improved and extension range of motion increased in the SNAG group. No improvements in balance or range of motion were observed in the placebo group. - The SNAG treatment had an immediate clinically and statistically significant sustained effect in reducing dizziness, cervical pain and disability caused by cervical dysfunction.
Schmidt et al. (2014)	The purpose of this study was compare the odds of sustaining higher magnitude in-season head impacts between athletes with higher and lower preseason performance on cervical muscle characteristics.	49 high school and collegiate American football players	Cohort study	- The study findings showed that greater cervical stiffness and less angular displacement after perturbation reduced the odds of sustaining higher magnitude head impacts; however, the findings did not show that players with stronger and larger neck muscles mitigate head impact severity. - Male athletes also exhibit greater stiffness and capacity to store elastic energy compared with female athletes. (Cervical Strength)
Schneider et al. (2014)	The objective of this study was to determine if a combination of vestibular rehabilitation and cervical spine physiotherapy decreased the time until medical clearance in individuals with prolonged	18 males 13 females 12–30 years	Randomised controlled trial	- A combination of cervical and vestibular physiotherapy decreased time to medical clearance to return to sport in youth and young adults with persistent symptoms of dizziness, neck pain and/or headaches following a sport-related concussion. - The cervical spine is cited

	postconcussion symptoms.			as a source of pain in individuals with whiplash. - The upper cervical spine can cause cervicogenic headaches. - A combination of manual therapy and exercise has been shown to be more effective than passive treatment modalities in individuals with neck pain.
Schneider et al. (2013)	The objective of this study was to determine the risk of concussion in youth male hockey players with preseason reports of neck pain, headaches, and/or dizziness.	3832 male Ice hockey players (11-14 yo) 280 teams	Prospective study	- Preseason reports of neck pain and headache were risk factors for concussion. - Dizziness was a risk factor for concussion in the Pee Wee nonbody checking. - A combination of any 2 symptoms was a risk factor in the Pee Wee nonbody checking cohort and the Bantam cohort. - Male youth athletes reporting headache and neck pain at baseline were at an increased risk of concussion during the season. The risk associated with dizziness and any 2 of dizziness, neck pain, or headaches depended on age group and body checking. - Neck pain is the third most commonly reported baseline symptom in varsity athletes
Smith et al. (2013)	This preliminary study examined a sample of individuals who did and did not respond to facet block as well as healthy controls to determine whether there were differences in their physical and psychological features once the effects of the blocks had abated and symptoms had returned.	58 Adults (18–65 yo) Calgary, Canada	Cross-sectional study	- Following FB procedures, both WAD groups demonstrated generalized hypersensitivity to all sensory tests, decreased neck ROM and increased superficial muscle activity with the CCFT compared to controls ($p < 0.05$). There were no significant differences between WAD groups (all $p > 0.05$). Both WAD groups demonstrated psychological distress (GHQ-28; $p < 0.05$), moderate post-traumatic stress symptoms and pain catastrophization. The WAD_NR group also

				demonstrated increased medication intake and elevated PCS scores compared to the WAD_R group ($p < 0.05$). - Chronic WAD responders and non-responders to Feed Back (FB) procedures demonstrate a similar presentation of sensory disturbance, motor dysfunction and psychological distress. Higher levels of pain catastrophization and greater medication intake were the only factors found to differentiate these groups.
Stovner et al. (2009)	A main object of this study was to assess the validity of this diagnosis by studying the headache pattern of concussed patients that participated in one historic (n = 131) and one prospective cohort (n = 217) study	200 patients (18–67 yo) Trauma involving LOC of <15 min. Kaunas, Lithuania	Questionnaires study (Post-3m. & -1y.)	- No difference in any headache category (diagnosis, attack frequency, symptoms) was found one or more years after the trauma, except that photophobia was somewhat more prevalent amongst the concussed patients. - Existence of pre-traumatic headache was a predictor of post-traumatic headache, although pre-traumatic headache seems to have been underreported amongst the concussed patients. - There was a significant negative correlation between the duration of unconsciousness and the headache. - This negative correlation, and the lack of specificity indicates that headache occurring 3 months or more after concussion is not caused by the head or brain injury. - Rather it may represent an episode of one of the primary headaches, possibly induced by the stress of the situation.
Tator et al. (2007)	This report is intended to improve understanding of the	Adult Children	Statistical Report	- Cerebral concussions are commonly known as mild traumatic brain injury

	epidemiology of neurological conditions and the economic impact on the Canadian health care system and society.	Canada		(mTBI). - By contrast, Statistics Canada estimated in recent studies that the annual incidence for mTBI is 600 per 100,000 persons and 11.4 per 100,000 inhabitants for a traumatic brain injury (TBI). - However, the highest age group incidence is between 19 and 29 years of age, representing approximately one quarter of patients with cranial trauma.
Tierney et al. (2005)	The purpose was to determine whether gender differences existed in head–neck segment kinematic and neuromuscular control variables responses to an external force application with and without neck muscle preactivation.	20 females 20 males Adult	Cohort study	- Gender differences existed in head–neck segment dynamic stabilization during head angular acceleration. - Females exhibited significantly greater head–neck segment peak angular acceleration and displacement than males despite initiating muscle activity earlier (SCM only) and using a greater percentage of their maximum head–neck segment muscle activity.

Treleaven et al. (1994)	This study measured aspects of cervical musculoskeletal function in a group of patients (12) with postconcussional headache (PCH) and in a normal control group.	8 Males (15-48 yo) 4 Females (20-44 yo)	Retrospective study	- 159 potentially suitable subjects. 91 persons who were contacted by telephone, 42 reported PCH. Twelve of the 15 eligible patients consented to enter the study. - The most frequent major symptomatic segments were C1-C2, C2-C3, C0-C1, C3-C4. Signs of cervical articular and muscular dysfunction distinguished the PCH group from the control group. - As upper cervical joint dysfunction is a feature of cervicogenic causes of headache, the results of this study support the inclusion of a precise physical examination of the cervical region in differential diagnosis of patients suffering persistent headache following concussion.
Original data	- Poster			
Purtzki et al. (2012)	To prospectively characterize an adolescent patient population after a concussion and to trial an interdisciplinary service delivery model.	36 Adolescents ages 12-19	Poster	- There was a high incidence of multiple concussions. - There was a significant need for school reintegration and education of school staff. - A significant need for clinical rehabilitation services in the adolescent population was noted. - The results warrant further research into rehabilitation needs and the merit of early interdisciplinary rehabilitation.
Review				
Becker et al. (2010)	This review was developed as part of a debate, and takes the	Adult	Literature Review	- Clinical treatment trials involving patients with proven painful disorders of

	"pro" stance that abnormalities of structures in the neck can be a significant source of headache.			upper cervical zygapophysial joints have shown significant headache relief with treatment directed at cervical pain generators. - Headache related to cervical spine disorders (cervicogenic headache and chronic headache attributed to whiplash injury) remains one of the most controversial areas of headache medicine. - Diagnostic criteria for cervicogenic headache have been developed by the CHISG.
Benson et al. (2013)	To critically review the evidence to determine the efficacy and effectiveness of protective equipment, rule changes, neck strength and legislation in reducing sport concussion risk.	Adult	Literature Review Electronic databases, grey literature and bibliographies were used to search the evidence using Medical Subject Headings and text words.	- No new valid, conclusive evidence was provided to suggest the use of headgear in rugby, or mouth guards in American football, significantly reduced players' risk of concussion. No evidence was provided to suggest an association between neck strength increases and concussion risk reduction. - There was evidence in ice hockey to suggest fair-play rules and eliminating body checking among 11- to 12-years-olds were effective injury prevention strategies. - The effect of helmet/headgear use on concussion risk is still inconclusive in rugby, football (soccer), ice hockey, American football and rodeo. - No evidence was provided to suggest an association between neck strength and concussion risk reduction on the playing field. - A multifactorial approach is needed for concussion prevention. Future well-designed and sport- specific prospective analytical studies of sufficient power are warranted.
Bogduk	Summarize the	Adult	Narrative	- Clinical studies have

(2011)	evidence that implicates the cervical zygapophysial joints as the leading source of chronic neck pain after whiplash.		Review Data were retrieved from studies that addressed the postmortem features and biomechanics of injury to the cervical zygapophysial joints, and from clinical studies	shown that zygapophysial joint pain is very common among patients with chronic neck pain after whiplash - The fact that multiple lines of evidence, using independent techniques, consistently implicate the cervical zygapophysial joints as a site of injury and source of pain, strongly implicates injury to these joints as a common basis for chronic neck pain after whiplash.
Bonfield et al. (2014)	Review the incidence, evaluation, treatment, return- to-play protocol, and prevention efforts related to concussion in ice hockey.	Adult	Litterature Review	- SCAT3 includes the Glasgow Coma Score (GCS), Standardized Assessment of Concussion (SAC), Maddocks questions, and the Balance Error Scoring System (BESS) - Worrisome signs and symptoms that require medical attending include worsening headache, excessive drowsi- ness, inability to recognize people or places, repeated vomiting, confusion, erratic behavior, increased irritability, seizures, reports of weakness or numbness in arms or legs, unsteadiness, and slurring of speech. - Care for patients with prolonged symptoms (>10 days) can be difficult. It requires a multidisciplinary approach in a coordinated center with special expertise.
Borich et al. (2013)	In this special interest article, we discuss the definition and risk factors associated with concussion, summarize and high-light some of the most widely used assessment tools, and critique the evidence for current principles of concussion	Adult	Literature review	- Disease Control and Prevention describes *mild traumatic brain injury* (mTBI; which includes concussion) as a silent epidemic. - Sustaining multiple or recurring concussions (≥3) increases the risk of long-term effects such as significant cognitive

	management.			impairment. - 'Rest' in the form of delaying return to competitive sports may be better served by a universal period of 7 to 10 days than by symptom monitoring, primarily to prevent the potential for reinjury. - Intermediate levels of activity may not be harmful and could potentially accelerate recovery during a graded return to physical activity protocol.
Bradley (2004)	Neurology in clinical practice (review)	Adult	Book	- "*5 Ds*" – dizziness, diplopia, dysarthria, dysphagia and "drop attacks"
Brolinson et al. (2014)	To systematically review the evidence for rest, treatment and rehabilitation after sport-related concussion.	Sports Adult Pediatric	Systematic Review PubMed, Cochrane Central Register of Controlled Trials, Sport Discus, and Web of Science	- From 749 articles evaluating rest and 1,175 evaluating treatment, 2 studies met criteria for the effect of rest and 10 abstracts met criteria for treatment. Three further treatment articles were identified by the authors. - Light exercise, or daily exercise after a 2-week baseline period, appeared to encourage return to physical activity in children and adults. - Interventions included manual spinal therapy, physiotherapy, and neuromotor and sensorimotor retraining compared with rest and graduated exercise, for up to 8 weeks. - Studies of management of concussion were so poor that conclusions that rest was not helpful or that exercise might be beneficial are premature. Better evidence showed that individualized treatment of long-standing symptoms may allow earlier return to sport than rest and exercise alone.
Cancelliere et al. (2011)	Synthesize the best available evidence on	Male football players	Systematic review	- After 77,914 records were screened, 52 articles were

	prognosis after sport concussion.	High school, collegiate, and professional levels.	Modified SIGN criteria	eligible for this review, and 24 articles (representing 19 studies) with a low risk of bias were accepted. - The evidence concerning the course and prognosis of sports concussion is very preliminary, and there is no evidence on the effect of return-to-play guidelines on prognosis. - Well-designed, confirmatory studies are urgently needed to understand the consequences of sport concussion, including recurrent concussion, across different athletic populations and sports.
Clay et al. (2010)	The purpose of this study was to summarize sport concussion incidence data, identify sports that present higher injury frequency, reveal the degree of risk in some lesser-known sports, and outline specific details within the sports literature.	Athletes (boxing or other martial arts sports were excluded)	A systematic literature review PubMed	- Two hundred and eighty-nine articles were screened, and 62 articles were reviewed. - The overall incidence of concussion in sport ranged from 0.1 to 21.5 per 1,000 athletic exposures. - Concussion incidence was highest in Canadian junior ice hockey, but elevated incidence in American football remains a concern because of the large number of participants. - 21.52/1000 AEs in junior hockey is 7 times higher than previously reported in the NHL. - - An increase in concussions reported across all sports and sexes in 2005 to a 50% increase in Certified Athletic Trainer (CAT) coverage.
Fernández et al. (2005)	The aims of the present paper are to detail a manual approach developed by our research group, to help in future studies of the management of the sequels to whiplash injury, and to suggest explanations for the mechanisms of this protocol.	Adult	Literature Review	- The clinical syndrome of whiplash injury includes neck pain, upper thoracic pain, cervicogenic headache, tightness, dizziness, restriction of cervical range of motion, tinnitus, and blurred vision. - Spinal manipulation/mobilization, and soft tissue mobilization, techniques

				are manual therapies commonly used in the management of neck disorders. - Upper cervical spine performs a hyperextension motion during the first phase of the whiplash injury. - The biomechanical analysis of a rear-end impact justifies some of the manipulative techniques: upper cervical manipulation, dorsal manipulation, cervicothoracic joint manipulation, and pelvic girdle manipulation. - MTrPs in trapezius muscles, suboccipital muscles, scalene muscles and sternocleidomastoid muscles, commonly play an important role in the treatment of people suffering from post-whiplash symptoms
Giza et al. (2013)	Assessed evidence for quality and synthesized into conclusions using a modified Grad- ing of Recommendations Assessment, Development and Evaluation process.	Adult	Systematic Review	- Diagnostic tools to help identify individuals with concussion include graded symptom checklists, the Standardized Assess- ment of Concussion, neuropsychological assessments, and the Balance Error Scoring System. - Risk factors for recurrent concussion include history of multiple concussions, particularly within 10 days after initial concussion.
Giza et al. (2001)	The goal of this paper is to underlying pathophysiologic processes of concussive brain injury and relate these neurometabolic changes to clinical sports-related issues such as injury to the developing brain, overuse injury, and repeated concussion.	Adult	Review	- The pathophysiologic cascade following concussive brain injury include abrupt neuronal depolarization, release of excitatory neurotransmitters, ionic shifts, changes in glucose metabolism, altered cerebral blood flow, and impaired axonal function.

Goadsby et al. (2002)	The purpose of this review is to describe chronic daily headaches (CDH) and their treatments.	Adult	Review	- It is not pathophysiological since there is no clear evidence for splitting the infrequent and frequent forms of primary headache. The common types of primary daily headache in clinics are chronic tension type headache (15%) and chronic migraine (78%). In general practice these figures are reversed with chronic tension type headache (55%) being more common than chronic migraine (33%). - Warning signs in head pain
Gravel et al. (2013)	This systematic review investigated the effectiveness of interventions initiated in acute settings for patients who experience mTBI.	Adult	Systematic Review MEDLINE, Embase, PsycINFO, CINAHL, and Cochrane Cochrane's Risk of Bias assessment tool.	- From a potential 15,156 studies, 1,268 abstracts were evaluated and 120 articles were read completely. Of these, 15 studies fulfilled the inclusion/exclusion criteria. - According to the published literature, no intervention initiated acutely has been clearly associated with a positive outcome for patients who sustain mTBI, and there is little evidence suggesting that follow-up interventions may be associated with a better outcome. - There is a paucity of well-designed clinical studies for patients who sustain mTBI. The large variability in outcomes measured in studies limits comparison between them.
Guskiewick et al. (2013)	Review the current literature to identify the most sensitive and reliable concussion assessment components for inclusion in the revised version—the SCAT3	Adult	Literature review PubMed, MEDLINE, Psych Info and Cochrane. different Keywords	- The initial search terms of 'concussion' and 'athletics' yielded 1,126 articles. When these terms were refined using the term 'assessment' the total was 254 articles. 77 articles were used in the current evidence review. - It is widely accepted as one of the best predictors of outcome following more

				moderate to severe injury and as such is appropriate for identification of more severe injury. (Glasgow) - Balance deficits or instability are often observable in patients following concussion and the presence of these deficits may be an indicator of vestibular disruption.
Hanson et al. (2014)	The purpose of this article is to review the current literature in the management and prevention of concussion.	Pediatrics	Review	- The rise in the number of concussion diagnoses may be due, in part, to increased awareness regarding the potential for complications of concussions and sequelae of multiple concussions, as opposed to an actual increase in the incidence of concussion alone. - Typical Signs and Symptoms of Concussion.
Harmon et al. (2013)	To provide an evidence-based, best practises summary to assist physicians with the evaluation and management of sports concussion. To establish the level of evidence, knowledge gaps and areas requiring additional research.	Adult Children	Statement of the American Medical Society for Sport Medicine Review	- Sports medicine physicians are frequently involved in the care of patients with sports concussion. - The primary concern with early RTP is decreased reaction time leading to an increased risk of a repeat concussion or other injury and prolongation of symptoms. - Headache is the most commonly reported symptom with dizziness, the second most common. - Most studies report that 80–90% of athletes have symptom resolution by 7 days following their injury.
Headache Classification Committee of the International Headache Society (IHS) (2013)	The International Classification of Headache Disorder may be reproduced freely for scientific, educational or clinical uses by institutions, societies or individuals.	Adult Children	Review Guideline	- Cervicogenic headache from 1.Migraine and 2.Tension-type headache include side-locked pain, provocation of typical headache by digital pressure on neck muscles and by head movement, and posterior-to-anterior radiation of pain.

Kristjansson et al. (2009)	The purpose is to review : Dizziness in Neck Pain: Implications for Assessment and Management	Adult	Review	- Diagnostic criteria - Disturbances to the afferent input from the cervical region in those with neck pain may be a possible cause of symptoms such as dizziness, unsteadiness, and visual disturbances, as well as signs of altered postural stability, cervical proprioception, and head and eye movement control.
Laker et al. (2011)	A 3-step model for return-to-play medical decision making was recently published and, in the current paper, undertook a systematic review of the literature to determine the level of evidence in support of this model.	Adult Sports	Systematic Review PubMed, Web of Science, and CINAHL electronic databases.	- We reviewed 148 articles that met the criteria for inclusion. - Of the 148 articles in total, only 13 focused on RTP as the main subject and the remaining 135 mentioned RTP anecdotally. Of these 13 articles, 5 were reviews, 4 were editorials, and 4 were original research. - The appropriate level of aggressiveness in returning the athlete to sport remains controversial as is aggressive rehabilitation and early return to competitive activity without compromising healing or long-term functional outcomes. - There is some resistance in the medical literature toward attempts to standardize the RTP medical decision-making process. The most common statement relating to RTP recommendations in sport is for each recommendation to be ''individualized''.
Leddy et al. (2012)	This review focus on rehabilitation of Concussion and Post-concussion Syndrome	Adult Children	Review	- Rest is the primary treatment for the acute symptoms of concussion. - Early education, cognitive behavioral therapy, and aerobic exercise therapy have shown efficacy in certain patients but have limitations of study design. - The cervical spine should be carefully assessed for

				tenderness, spasm, and range of motion. Precipitation of headaches, dizziness, or vertigo should direct therapy to address a cervical injury.
Leslie et al. (2013)	Based on the current medical evidence, we would suggest that the constellation of symptoms presently defined as concussion does not have to involve the brain.	Adult	Editorial - Comment	- Concussion symptoms can emanate from the cervical spine. - Whiplash mechanisms of injury are identical to the "impulsive forces" described in con- cussive injuries. - The symptoms of concussion and WAD display remarkable similarity. Notably, symptoms such as headache, neck pain, disturbance of concentration or memory, dizziness, irritability, sleep disturbance, and fatigue, have been described in both concussion and whiplash patients. - Cervical zygapophysial joints have been implicated as generators of headache and dizziness, with diagnostic and therapeutic anaesthetic blocks in whiplash patients. If the headache associated with concussion can potentially be of cervical spine origin, we would suggest that there is no certainty that any of the common concussion symptoms are specific to brain injury. - The overlap with neck/whiplash injuries is evident.
Littelton et al. (2013)	This article outlines various aspects of sport-related concussion management, including preparation/planning, education, evaluation, management, return to play decisions, and the long term effects of	All levels of athletic participation.	Literature review	- Clinicians should make sure that they are staying up to date with their knowledge of concussion prevention, evaluation, management, and return to play decisions, and be sure to educate their athletes, coaches and parents about the prevention, reporting

	concussion.			and long-term consequences of concussion. - If an individual is exhibiting symptoms that are associated with a prolonged recovery, their clinician may consider using a more conservative management approach. - Loss of consciousness and/or amnesia have not been linked to prolonged recovery or long-term consequences, these cases should be carefully monitored and return to play decisions should be more conservative.
Lucas (2011)	This article reviews the literature on headache management in concussion and mTBI	Adult Pediatric United States	Literature Review	- Reports of headache after concussion or mTBI in children ranged from 72%-93%. - Headache is one of the most common symptoms after TBI and PTH may be part of a constellation of symptoms that is seen in the postconcussive syndrome.
Makdissi et al. (2013)	The objectives of the current paper are to review the literature regarding difficult concussion and to provide recommendations for an approach to the investigation and management of patients with persistent symptoms.	Adult Sport	Qualitative review MEDLINE and Sports Discus	- Cases of concussion in sport where clinical recovery falls outside the expected window (ie, 10 days) should be managed in a multidisciplinary manner by healthcare providers with experience in sports-related concussion. - Important components of management, after the initial period of physical and cognitive rest, include associated therapies such as cognitive, vestibular, physical and psychological therapy, assessment for other causes of prolonged symptoms and consideration of a graded exercise programme at a level that does not exacerbate symptoms.
Marshal et al. (2012)	This paper is a review of recent literature on the topic of concussion, consisting	Athletes United States	Narrative review	- Clinicians should not expect every examination procedure to be significant in order to make a

	of: biomechanics, pathophysiology, diagnosis and sideline management.			diagnosis. Any sign and/or symptom of neurological dysfunction following an impact meets the diagnostic criteria of a concussion and should be treated as such. - Impact may, or may not, result in a loss of consciousness and, in fact, it has been demonstrated that 90% of concussions do not result in a loss of consciousness. - The cervical spine is not only a potential source of injury that we must be aware of, but it is also implicated as a factor in the concussion itself. - *Signs and Symptoms of Concussion from the Assocition of Sport College of Medecine (ACSM) updated consensus statement*
Martinez (2011)	This overview of the current status of sport-incurred concussion describes major signs and symptoms of concussion, provides an example algorithm to assess concussion, and discusses treatment and prevention.	United States Adult (Sport, military) Pediatric	Literature Review	- Research and understanding of concussion are still in their infancy. - 20 percent of head injuries may cause prolonged disorientation, loss of short-term memory, slower thinking, headaches, dizziness, sleep disturbances, fatigue, and impulsive and disruptive behavior. - A concussion is considered 'complex' when LOC exceeds a minute, cognitive impairment is persistent or prolonged, and there is a history of multiple concussions.
Master et al. (2014)	The content of this review is drawn from the clinical information and education resources about concussions	Adult Children	Review Guideline	- Indirect forces transmitted to the head from an impact to the body (for example, whiplash) may be sufficient to cause concussion. - The Sport Concussion Assessment Tool 3 (22) has incor- porated this test and a modified Balance Error Scoring System as components of its sideline

				balance evaluation.
McCrory et al. (2012)	The new 2012 Zurich Consensus statement is designed to build on the principles outlined in the previous documents and to develop further conceptual understanding of this problem using a formal consensus-based approach.	International Consensus - Adults - Pediatric	International Consensus Sport Concussion	- An initial period of rest may be of benefit. - Multimodal physiotherapy treatment for individuals with clinical evidence of cervical spine and/or vestibular dys- function may be of benefit. - Multidisciplinary Approach - Persistent symptoms (>10days) are generally reported in 10–15% of concussions. In general, symptoms are not specific to concussion and it is important to consider other pathologies. - PCS should be managed in a multidisciplinary manner by healthcare providers with experience in sports concussion.
Miller et al. (2010)	This cervical overview group systematic review update assesses if manual therapy combined with exercise improves pain.	Adult	Systematic Review	- Low quality evidence suggests clinically important long-term improvements in pain, function/disability, and global perceived effect when manual therapy and exercise are compared to no treatment. - High quality evidence suggests greater short-term pain relief than exercise alone, but no long-term differences across multiple outcomes for (sub)acute/chronic neck pain with or without cervicogenic headache.
Pelletier (2006)	The purpose of this paper is to present a review of the diagnosis and treatment of the potentially catastrophic neck and head injuries caused by spearing in Canadian amateur football.	Amateur football United States Canada	Literature review PubMed – MeSH (NCBI), ICL and Google Scholar	- From a total of 697 references, 63 were retained. - The trend in adopting the new guidelines seems to be ever growing, particularly in collision and contact sports including football, hockey, lacrosse, soccer, wrestling, diving, rugby and boxing. - Associated cervical trauma with concussion may include one or several

				of neck pain, reduced cervical range of movement, cervicogenic headache, cervicogenic vertigo and occipital neuralgia. - Contrary to popular belief, loss of consciousness (LOC) does NOT have to be present and it is expected that the resolution of the clinical and cognitive symptoms will follow a chronological course. - Several manual techniques for the treatment of post traumatic concussion syndrome have been described as either 'direct' or 'indirect'
Scorza et al. (2012)	Current Concepts in Concussion.	Children Adolescents	Literature review	- Initial evaluation involves eliminating cervical spine injury and serious traumatic brain injury. - There are no specific treatments for concussion. - Neuropsychological tests are designed to identify subtle cognitive deficits. - For obvious head and neck injuries, assessment begins at the site of injury and focuses on evaluating the cervical spine. In unconscious persons, cervical spine injury must be assumed. - Selected Symptoms of Concussion - Neurological Examination Findings Suggesting Severe Injury in Patients with Suspected Concussion
Signoretti et al. (2011)	The following review represents the authors' effort to piece together the current concepts and the most recent findings about the complex basic physiology underlying the injury processes of this particular type of brain trauma and to emphasize the nuances	European Countries United States Adult	Literature Review	- Postconcussive symptoms may be prolonged in a small percentage of cases, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury, which usually is confirmed by the absence of abnormalities on standard neuroimaging studies.

	involved in conducting research in this area.			- Although concussion certainly is blended into the vast world of mTBI, by definition, concussion should be considered a discreet and distinct entity because not all cases of mTBI are truly 'concussive'; thus the 2 terms refer to different constructs and should not be used interchangeably. - More problematically, within days after a simple blow to the head, this intricate biochemical derangement can result in a dangerous state for the brain, generating a situation of metabolic vulnerability to the point that if another equally mild injury were to occur, the 2 concussions would show the biochemical equivalence of a severe brain trauma.
Watanabe et al. (2012)	The specific goals of this review include (1) determination of effective interventions for PTH (2) development of treatment recom-mendations (3) identification of gaps in the current medical literature regarding PTHA treatment (4) suggestions for future directions in research to improve outcome for persons with PTHA.	Adult Child	Literature Review PubMed, CINAHL, PsycINFO, ProQuest, Web of Science, and Google Scholar. The level of evidence : American Academy of Neurology criteria	- After reviewing the abstracts, 64 of the 812 articles appeared to meet the inclusion criteria. 36 of the 64 articles met the final criteria. - Head pain may be related to direct damage to the skull or brain tissue; muscular, tendinous, and/or ligamentous injury to the cervical spine; and injuries to peripheral nerves. Other nervous system injuries, such as visual and vestibular system damage, also may contribute to headache syndromes. - Biologically based interventions included a variety of biofeedback mechanisms, physical therapy and manual therapy, immobilization devices, ice, and injections. - Immobilization in a cervical collar is less effective than either 'act as usual' or a multimodal physical therapy program

				of ice, active and passive mobilization, postural (strength and isometric) exercises, and advice. - Although a number of interventions are used to treat PTHA, no well-designed studies of recent publication (1985-2009) have evaluated the efficacy of these various treatments. - Outcomes should be more standardized and include not only measures of pain severity but also measures of comorbidities and the impact on activity and participation.
Weightman et al. (2010)	The purpose of this article is to provide a summary of the development process and to share specific recommendations for PT practice with Service members who sustain MTBI.	Military and civilian populations	Literature Review MTBI-related, evidence-based reviews and guidelines	- The 4-month project resulted in a draft document, titled *Clinical Practice Guidance: Occupational Therapy and Physical Therapy for Mild Traumatic Brain Injury*, that was updated in June 2009 (version 2) with the addition of guidelines or pertinent research that had been released in the interim. - Determine the disability and its severity related to the neck, jaw, and headaches. - Physical therapy interventions with the strongest evidence in the treatment of PTH include a multimodal approach of specific training in exercise and postural retraining, stretching and ergonomic education, and manipulation and/or mobilization in combination with exercise.
Whiteside (2009)	The goal in this article is to review assessing neck injuries to detect concussions, spinal cord injury and the potential for such injury resulting from instability of the cervical spine.	Children Adolescents	Clinical Review	- The presence of loss of consciousness (LOC) does not correlate with the severity or outcome of a concussion. - Helmet and other protective gear in place, and such equipment should not be removed.

				- Neuropsychological testing - there is no agreement on a cutoff point for 'abnormal' that would minimize missed concussions or unnecessary play restrictions. - Athletes with memory loss, imbalance, or symptoms reported 15 minutes after the injury should be restricted from play for the rest of the day. - Athletes with neurologic symptoms persisting longer than 30 minutes - particularly those with prolonged LOC or any focal neurologic sign - should be monitored closely and may require transport to an emergency department.
Clinical Recommandations				
Fowler Kennedy (2013)	This document is intended to provide the user with instruction and direction in the rehabilitation of PCS.	Ontario Hospital Canada Adult	PSC & Treatment Guidelines: - Cervicogenic - Autonomic - Vestibular - Visuon - Education	- Anatomically, the cervical spine is closely linked to structures that can cause many of the same symptoms as concussion. - PCS treatment has traditionally consisted of rest, education, neurocognitive rehabilitation and anti-depressants with limited effectiveness. - Balance deficits and postural instability are commonly reported post-concussion.
Spitzer et al. (1995)	The purpose was to expose the Clinical Classification of Whiplash Associated Disorders	Adult	Guideline	- Grade 0 to 4 (Clinical Presentation)

ANNEXE B

Questionnaire version française

Questionnaire descriptif suite au retour au jeu après un traumatisme craniocérébral

Mémoire (programme 3407)

QUESTIONNAIRE DESCRIPTIF SUITE AU RETOUR AU JEU APRÈS UN TRAUMATISME CRANIOCEREBRAL

- Âge de l'athlète : [ ]
- Niveau Scolaire : [ ] (secondaire 5 = niveau 10)
- Position : ☐ Attaquant ☐ Défenseur ☐ Gardien
- Est-ce que cet athlète a déjà subi un TCC ? ☐oui ☐non
  - Si oui, combien ? [ ]
  - Dates: #1 __/__/__ #2 __/__/__ #3 __/__/__
  - Nombre de jours d'arrêt? #1 [ ] #2 [ ] #3 [ ]

- Date du TCC : __/__/__
  - Première date du test ImPACT : __/__/__
  - Autres test ImPACT: #1 __/__/__ #2 __/__/__ #3 __/__/__ #4 __/__/__ #5 __/__/__
  - Date de la fin des symptômes : __/__/__
  - Date de retour au jeu : __/__/__
  - Nombre de parties manquées [ ]

- Listes des symptômes (tous) : (SCAT3)

☐ Maux de tête	☐ Pression intracrânienne	☐ Douleur au cou	☐ Nausée/vomissement
☐ Étourdissement	☐ Vision embrouillée	☐ Problème d'équilibre	☐ Sensible à la lumière
☐ Sensible aux bruits	☐ Se sentir au ralenti	☐ Se sentir dans la brume	☐ «Ne se sent pas bien»
☐ Difficulté à se concentrer	☐ Difficulté à se souvenir	☐ Fatigue/Peu d'énergie	☐ Confusion
☐ Somnolence	☐ Difficulté s'endormir	☐ Plus émotionnel	☐ Irritable
☐ Triste	☐ Nerveux/anxieux	☐ Autres : ____________	

- Raison de la blessure (toutes) :

☐ Frapper par une rondelle	☐ Collision avec un adversaire	☐ Collision contre la bande	☐ Collision avec le filet
☐ Frapper par un bâton	☐ Mise en échec par derrière	☐ Chute sur la glace	☐ Coup de côté (aveugle)
☐ Bataille	☐ Collision au centre de la glace	☐ Blessure sans-contact	☐ «Wiplash»
☐ Mécanisme de rotation	☐ Hyperflexion latérale	☐ Compression vertébrale	☐ Autres: ____________

Suivi professionnel

- Quel type de professionnel(s) a suivi le joueur durant sa convalescence ? (tous)

☐ Thérapeute Athlétique	☐ Physiothérapeute	☐ Premier Répondant	☐ Neuropsychologue
☐ Médecin	☐ Ostéopathe	☐ Chiropraticien	☐ Autres: ____________

- Médications : ____________________________
- Arrêt de l'école : ☐ oui ☐ non
  *Si oui, nombre de jours d'arrêt ? [ ]
- Évaluation complète du cou : ☐ oui ☐ non
  Si *OUI, qui a fait l'évaluation :

☐ Thérapeute Athlétique	☐ Physiothérapeute	☐ Premier Répondant	☐ Neuropsychologue
☐ Médecin	☐ Ostéopathe	☐ Chiropraticien	☐ Autres: ____________

*Qui fait les suivis/traitements (tous):

☐ Thérapeute Athlétique	☐ Physiothérapeute	☐ Premier Répondant	☐ Neuropsychologue
☐ Médecin	☐ Ostéopathe	☐ Chiropraticien	☐ Autres: ____________

*Combien de fois par semaine (Moyenne) : [ ]
*Où sont faits les traitements ?

☐ Aréna	☐ Hôpital	☐ Clinique privée	☐ Autres : ____________

*Quels types de thérapies sont utilisés ? (toutes)

☐ Traction	☐ Manipulation	☐ Mobilisations Passives	☐ Massages	☐ Active Release
☐ Oculomoteur	☐ Osteocranial	☐ Trigger Points	☐ Vestibulaire	☐ Repos
☐ Proprioceptive Neuromuscular Facilitation (PNF)		☐ Autres : ____________		

- Combinaison avec électrothérapies ? ☐ oui ☐ non
  *Si oui, quels types d'électrothérapies sont utilisés ? (tous)

☐ Ultrason	☐ TENS	☐ Courant-interférentiel	☐ Autres : ____________

Suite à chaque traitement (dates), notez l'évolution de 0/10 à 10/10 pour les signes/symptômes :

Traitement #1 : /10 __/__/__	Traitement #2 : /10 __/__/__	Traitement #3 : /10 __/__/__
Traitement #4 : /10 __/__/__	Traitement #5 : /10 __/__/__	Traitement #6 : /10 __/__/__
Traitement #7 : /10 __/__/__	Traitement #8 : /10 __/__/__	Traitement #9 : /10 __/__/__
Autres : ____________		

Je, ____________, consent à participer à cette étude et confirme que toutes les informations sont représentatives des traitements donnés. ***Signature :*** ____________ ***Date :*** __/__/__

ANNEXE C

Questionnaire version anglaise

Descriptive questionnaire after return-to-play athlete sustaining a mTBI

Mémoire (programme 3407)

Descriptive questionnaire after return-to-play athlete sustaining a mTBI

- Age of athlete : ☐
- Academic level: ☐
- Position : ☐ Forward ☐ Defenceman ☐ Goalie
- Did he ever had a mTBI ? ☐ yes ☐ no
  - If Yes, how many ? ☐
  - Dates: #1 __/__/__ #2 __/__/__ #3 __/__/__
  - How many missed days ? #1 ☐ #2 ☐ #3 ☐

- Date of mTBI : __/__/__
  - First ImPACT test (date) : __/__/__
  - Other ImPACT tests : #1 __/__/__ #2 __/__/__ #3 __/__/__ #4 __/__/__ #5 __/__/__
  - Date when symptoms ended : __/__/__
  - Return to play : __/__/__
  - Number of missed games : ☐

- List of symptoms (all): (SCAT3)

☐ Headache	☐ Pressure in head	☐ Neck pain	☐ Nausea/Vomiting
☐ Dizziness	☐ Blurred vision	☐ Balance problem	☐ Sensitivity to light
☐ Sensitivity to noise	☐ Feeling slowed down	☐ Feeling like «in a fog»	☐ «Don't feel right»
☐ Difficulty concentrating	☐ Difficulty remembering	☐ Fatigue/low energy	☐ Confusion
☐ Drowsiness	☐ Trouble falling asleep	☐ More emotional	☐ Irritability
☐ Sadness	☐ Nervous/Anxious	☐ Others : ______	

- Cause of injury (all):

☐ Hit by a puck	☐ Collision with boards	☐ Non-contact injury	☐ Collision on open ice	☐ Fall on ice
☐ Hit by a stick	☐ Checked from behind	☐ Collision with opponent	☐ Blind-siding ☐ Fight	☐ Collision with net
☐ «Wiplash»	☐ Rotation mechanism	☐ Spine compression	☐ Lateral hyperflexion	☐ Others: ______

Professional follow-up

- What professional(s) conducted a follow-up on the recovering player ? (all)

☐ Athletic Therapist	☐ Physiotherapist	☐ First Responder	☐ Neuropsychologist
☐ Physician	☐ Osteopath	☐ Chiropractor	☐ Others: ______

- Medication : ______
- Missed School: ☐ yes ☐ no
  - *If yes, how many missed days ? ☐
- Complete neck evaluation: ☐ yes ☐ no
  - ***If** ***YES***, who did the evaluation ?

☐ Athletic Therapist	☐ Physiotherapist	☐ First Responder	☐ Neuropsychologist
☐ Physician	☐ Osteopath	☐ Chiropractor	☐ Others: ______

*Who did the follow-ups ? (all):

☐ Athletic Therapist	☐ Physiotherapist	☐ First Responder	☐ Neuropsychologist
☐ Physician	☐ Osteopath	☐ Chiropractor	☐ Others: ______

*How many times a week ? (Average) : ☐

*Where are the treatments given?

☐ Rink	☐ Hospital	☐ Private Clinic	☐ Autres : ______

*What therapies are being used ? (all)

☐ Traction	☐ Manipulation	☐ Passive Mobilisations	☐ Massage	☐ Active Release
☐ Oculomotor	☐ Osteocranial	☐ Trigger Points	☐ Vestibular	☐ Rest
☐ Proprioceptive Neuromuscular Facilitation (PNF)		☐ Others : ______		

- In conjunction with electrotherapy ? ☐ yes ☐ no
  - *If yes, what kind ? (all)

☐ Ultrasound	☐ TENS	☐ Interferential therapy	☐ Others : ______

Following each treatment, asses the evolution from 0/10 à 10/10 for signs/symptoms :

Treatment #1 :	/10	__/__/__	Treatment #2 :	/10	__/__/__	Treatment #3 :	/10	__/__/__
Treatment #4 :	/10	__/__/__	Treatment #5 :	/10	__/__/__	Treatment #6 :	/10	__/__/__
Treatment #7 :	/10	__/__/__	Treatment #8 :	/10	__/__/__	Treatment #9 :	/10	__/__/__
Others : ______								

I, ______________, fully consent to participate in this study and I confirm that that all the information provided is consistent with the treatments given. *Signature*: ______________ __/__/__