TIER 1A: ENVIRONMENTAL SCAN

Stream I - Current Landscape of Sport Concussion in Children and Youth and Existing Injury Prevention Strategies: Literature Review and Best Practices

Stream III – Web Scan/ Asset Summary

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**BACKGROUND**

Traumatic brain injuries (TBI) are among the most devastating of catastrophic injuries, with twice the death rate of injuries overall (Zygun et al., 2005). A brain injury can permanently change the way a child or youth talks, walks, learns, works and interacts with others. Evidence exists that children and adolescents take longer than adults to recover following a concussion (Guskiewicz & Valovich McLeod, 2011). This is why prevention and appropriate return to play is so important for team sports, particularly in the pediatric and adolescent populations. Frequent coverage in the mainstream media has provided significant recent attention to the prevalence of concussion in sports, particularly with respect to the potentially devastating consequences.

As part of the environmental scan, the literature review (Stream 1) and web scan (Stream 3) identify the best available evidence and surveillance data to be used in developing the national team sport-brain injury prevention project. It determines areas of opportunity for sports, age-specific and targeted approaches to capacity building, engagement, education and training. It unveils good practices that can be leveraged in these areas demonstrating that interventions such as protective sports equipment, safe play environments, enforcement of policy, true sport attitudes and education can work together in combination to create safer sports in Canada. The issue of sport concussion is considered in the context of First Nations, Inuit, Metis, rural and remote communities while also exploring gendered targets. The product is based on the 3 E’s perspective and will be updated over the course of the project, through collaboration with the Tier 1A partners.

**Objectives**

The objectives of the literature review are to:

- a) understand the current landscape of sport-related concussion among children and youth aged 18 years or younger;
- b) identify interventions and injury prevention programs; and
- c) identify areas where improvements can be made; gaps in the literature

**METHODOLOGY**

**Sources**

Applicable peer-reviewed research and review papers were identified through a search of the following research databases: MEDLINE, PubMed, PsycInfo, CINAHL, and Sport Discus. The search was limited to articles published after the year 1988 (to capture over 20 years of publication), in both the English (GS) and French (SB) languages. Reference lists from the high quality studies were reviewed for relevant articles. Due to the current surge of interest in concussion injuries, a hand-search of key journals was also conducted to ensure capture of all articles published in the last year. The more recent issues of the following journals were

**Study Selection**

The search is international, using published research that is considered for inclusion according to study methodology and quality. Keywords and the synonyms used by respective databases were utilized in an extensive literature search. The following search strategy was used:

**Broad Search (** or $ dependent on database protocol):**

**Concussion**$ OR **Head Injur**$ OR **Brain Injur**$

AND

**Athlete**$ OR **Sport**$ OR **Team Sport**$ OR **Hockey** OR **Football** OR **Lacrosse** OR **Baseball** OR **Rugby** OR **Ringette** OR **Soccer**

AND

**Child**$ OR **Youth**$ OR **Pediatric** OR **Adolescen**$ OR **Young People** OR **Teen**$

**Targeted Searches: (Add these terms to the broad search strategy using “AND”)**

**Targeted Search A:**

**Injur**$ **Prevention** OR **Knowledge Transfer** OR **Prevent**$ OR **Tool**$ OR **Program**$ OR **Resource**$ OR **Strateg**$ OR **Education**

**Target Search B:**

**Gender**$ OR **Age** OR **Aboriginal**$ OR **First Nation**$ OR **Rural** OR **Northern**

**Table 1: Electronic databases and original search strategies**

<table>
<thead>
<tr>
<th>Database</th>
<th>Search Strategy</th>
<th>Results (broad search only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medline (Ovid version) (1988-2012)</td>
<td>Broad search</td>
<td>692</td>
</tr>
<tr>
<td>PsycInfo (Ebscohost version) (1988-2012)</td>
<td>Broad search</td>
<td>84</td>
</tr>
<tr>
<td>CINAHL (Ebscohost version)</td>
<td>Broad search</td>
<td>439</td>
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</table>
After careful consideration, it was determined that we would limit the search to articles published after the year 2000, such that the International Classification of Disease (ICD) -10 coding would be in place.

**Inclusion criteria**

*Population/participants:* Participants must be children or youth; 18 years of age and under; who have incurred or are at risk of incurring a sports-related concussion injury

*Intervention:* Any type of intervention to prevent sports-related concussion in children and youth; could involve education, engineering, enforcement, or additional interventions

*Comparison (study design/methods):* All randomized controlled trials (RCT) (where they exist) comparing concussion frequency/rates, or child/youth/athlete/coach/parent/healthcare provider knowledge or skill, before and after an intervention were included. In the absence of RCT, quasi-experimental, case-control, before/after, or cohort studies that report or describe interventions were included. Studies must include data from a regional, national, or international database.

*Outcome:* Studies are included if any of the following were recorded as outcome measures: number of concussions; concussion rate; frequency of concussions; reduction of concussions; change in child/youth/athlete/coach/parent/healthcare provider knowledge, behaviour or skill, regarding sport-related concussion prevention.

**Exclusion criteria**

Studies were excluded if they did not involve: children/youth ages 18 years or under; sports-related concussion injuries; an intervention geared at preventing sport-related concussion; a reported outcome measure.
Figure 1. Search strategy and selection of articles for review

Data Collection and Analysis

Study identification and selection

Eligible studies were selected from the search outputs. The reviewer scanned the abstracts and titles of articles retrieved by the electronic and hand-searches for eligibility, based on the inclusion and exclusion criteria outlined previously. Full copies of all those deemed eligible, were reviewed for closer examination. In any instance in which it was difficult to make a selection decision on the basis of the title and abstract alone, the full article was retrieved for screening. All studies that initially appeared to meet inclusion criteria, but upon closer inspection did not, were excluded.

Inclusion data extraction

Inclusion data was extracted from each eligible study using a standardized inclusion criteria form. Inclusion data was extracted based on the type of population, type of intervention, type of study (comparison) and type of outcome.

Assessment of study quality

Quantitative studies

We have selected the Effective Public Health Project Quality Assessment Tool 2003 (Effective Public Health Practice Project, 2003) which indicates overall component ratings as strong, moderate, or weak for each study. This tool contains component ratings for selection bias, allocation bias, confounders, blinding, data collection methods, withdrawals and drop-outs,
analysis and intervention integrity, as well as checklists for reporting of statistical tests, sample size calculation, measurement of confounding, adjustment of confounding and follow-up. It should be noted that based on the broad inclusion criteria for study design, many of the studies may result in an overall rating of weak.

Qualitative studies

We have selected the following three questions posed by Mays and Pope (2000) to assess the quality of the qualitative studies included in the review.

1. Adequate description: Is sufficient detail given of the theoretical framework informing the study and the methods used? Is the description of the context for the study clear? Is there an adequate justification and description of the sampling strategy? Is the description of the fieldwork clear?
2. Data analysis: Are procedures for analysis clearly described? Has the analysis been repeated by more than one researcher? Are findings from quantitative research used to ‘test’ qualitative findings? Is there evidence that the researchers have looked for contradictory observations?
3. Link to theory: Is the study design and sampling strategy theoretically grounded? Does the link to theory inform the analysis and any claims for generalisability? Is sufficient original evidence provided to support a relationship between interpretation and evidence?

Data extraction and synthesis

Description of studies

All studies were described using a narrative summary, specific to the following intervention categories: Educational; Engineering/Technological; Enforcement/Policy; Clinical; Neuropsychological; Physical.

FINDINGS

The aim of this review was to gain a comprehensive understanding of the current landscape of sport-related concussion in children and youth by identifying interventions and injury prevention programs. In order to achieve our aim we searched for various fields for a variety of intervention types.

Narrative Summary

Based on the large number of studies found in our search, it was determined to report on a subset of the findings, specifically those published in the years 2000 to 2012. The year 2000 was chosen as the limit, since it follows the implementation of ICD-10 coding. The search identified:

- 31 educational interventions
- 37 engineering/technological interventions
- 31 enforcement/policy interventions
- 43 clinical interventions
- 55 neuropsychological interventions
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- 20 physical interventions
- 68 reviews, summaries, or commentaries on the topic
- 103 epidemiological/descriptive, did not include an intervention

Educational Interventions (31)

Educational interventions include any type of information or knowledge that can be acquired and learned by children/youth/athletes, coaches, parents, healthcare providers, school/organization officials, etc. Thirty-one articles (14.29% of included references (31/217)) were categorized as educational interventions. The search provided some key educational interventions including those related to the examination of:

- Educational interventions and better preventive and educational strategies for players including increasing awareness and reporting of concussion and its associated symptoms (Echlin et al., 2010; Mitka, 2010; Cusimano, 2009)
- Increasing players’ knowledge by providing concussion education and informing coaches, parents, etc., of suspected concussion (Bramley et al., 2011; Sye et al., 2006; McCrea et al., 2004)
- Coaches’ knowledge and general understanding or misunderstanding of concussion among their players (Bramley et al., 2012); including inconsistency of concussion management and return to play relative to published expert guidelines (Faure & Pemberton, 2011); the effects of having a certified athletic trainer (Guilmette et al., 2007); and misconceptions regarding recognition, treatment and referral of concussions (Valovich McLeod et al., 2007)
- Knowledge translation, through formal and informal sources, among coaches, including the efficacy of toolkits for use by coaches (Mrazik et al., 2011; Koester & Mangus, 2005; Weber, 2005)
- Physician-observed ice hockey concussions (Echlin, 2010)
- Knowledge and management among nurses (Knight et al., 2006), doctors (Demorest et al., 2005; Bazarian et al., 2001) and athletic trainers (Rains & Robinson, 2010; Boyd, 2010)
- Attitude and opinion of neurosurgeons regarding helmets for winter sports (Jung et al., 2012)
- Consensus among neurosurgeons (McCrary & Davis, 2005)
- Promoting the use of bicycle helmets during primary care visits (Clements, 2005); office based approach to mild and traumatic brain injury (Witt, 2005)
- Parents’ knowledge and awareness of concussion and accurate reporting (Coghlin et al., 2009; Sullivan et al., 2009)
- An injury and illness surveillance program for children and staff: Improving the safety of youth settings (Ercg et al., 2009)
- Implicit learning as a design strategy for learning games: Alert Hockey (Ciavarrro et al., 2008)
- Pediatric concussions in sports: a simple and rapid assessment tool for concussive injury in children and adults (Hayden et al., 2007)
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- Evaluation of the ThinkFirst Canada, Smart Hockey brain and spinal cord injury prevention video examining effects on knowledge transfer and behavioural outcomes (Cook et al., 2003)
- Evaluation of the Center for Disease Control’s concussion initiative for high school coaches: Heads Up: Concussion in High School Sports, examining effects on knowledge, attitudes and practices for the prevention and management of concussions (Sarmiento et al., 2010; Theye & Mueller, 2004)

Engineering/Technological Interventions (37)

These types of interventions include any form of protective equipment and/or the technology associated with that equipment. Thirty-seven articles (17.05%) were themed as engineering/technological interventions (37/217). The search provided some key studies examining engineering-related interventions including:

- Impact tests on helmets (Bartsch et al., 2012; Hoshizaki et al., 2012)
- Head impact exposure (Daniel et al., 2012; Reed et al., 2010; Broglio et al., 2009; Schnebel et al., 2007; Koh et al., 2004; Naunheim et al., 2000) or biomechanics (Mihalik et al., 2012; Broglio et al., 2010)
- Mouthguard utilization (Raaii et al., 2011) or efficacy (Singh et al., 2010; 2009; Mihalik et al., 2007; Finch et al., 2005)
- Helmets for preventing head and facial injuries in bicyclists (Thompson et al., 2000)
- Helmets for snow sports (Juang et al., 2010; Alexander & Raub, 2003)
- Head acceleration measurement system (Hanlon & Bir, 2010; Lewis et al., 2001)
- Efficacy and protective benefits of protective headgear for soccer (Gray et al., 2009; Delaney et al., 2008; Finch et al., 2003), and whether padded headgear for rugby is beneficial (McIntosh et al., 2009; 2003; Petterson, 2002; Finch et al., 2001; McIntosh & McCrory, 2001)
- The potential for brain injury on selected surfaces used by cheerleaders (Shields & Smith, 2009)
- The effects of competitive intensity represented by field location, time in competition, and phase of play on injury severity in high school football (Yard & Comstock, 2009)
- The efficacy of computer based testing as a tool for return to play of youth hockey players with concussions (Brooks, 2007)
- The beneficial effects of newer helmet technology on concussion rates and return to play in high school football players (Collins et al., 2006)
- The efficacy of the use of video games to promote concussion knowledge acquisition (Goodman et al., 2006; Slobounov et al., 2006)
- Comparative performance of playground surfacing materials including conditions of extreme non-compliance (Gunatilaka et al., 2004)
- Incidence, causes, and severity of high school football injuries on field turf versus natural grass: a 5-year prospective study (Meyers & Barnhill, 2004)
- Survey analysis to assess the effectiveness of the bull tough helmet in preventing head injuries in bull riders: a pilot study (Brandenburg & Archer, 2002)
- A comparison of facial protection and the incidence of head, neck, and facial injuries in Junior A hockey players: a function of individual playing time (Stuart et al., 2002)

**Enforcement/Policy Interventions (31)**

Enforcement/policy related interventions can include any type of legislation, bill, policy statement, rule, or guideline to prevent or reduce the risk of sport-related concussion. Thirty-one articles (14.29%; 31/217) fell into the category of enforcement/policy interventions. The search provided key documentation and studies including:

- Return to play guidelines (Johnson, 2012; Fjordbak, 2011; Echlin et al., 2010; Foreman, 2010; McLeod, 2009; Purcell, 2009; Yard & Comstock, 2009; Pangillinan & Hornyak, 2007; Smurawa & Congeni, 2007; Kissick & Johnston, 2005; Asplund et al., 2004; Stevenson, 2003; Goodman & Gaetz, 2002)
- Efficacy of thorough return to play examinations for head and neck injuries in young athletes (Kraft, 2003)
- Effects of infractions on the severity of head impacts (Pearsall, 2012; Mihalik et al., 2010)
- Effects of bodychecking in hockey (Cusimano et al., 2011; Emery et al., 2011; 2010; Macpherson et al., 2006; Ross, 2004; Marchie & Cusimano, 2003)
- Risk of injury and concussion associated with team performance and penalty minutes in competitive youth ice hockey (Emery et al., 2011)
- Guidelines for youth sports safety (Robinson et al., 2011)
- Proceedings from the ice hockey summit on concussion: a call to action (Smith et al., 2011)
- Effect of a lockout of professional ice hockey players on injuries among minor league players (Keays et al., 2010)
- Legal issues (Wilson, 2010)
- When the rules of the game are broken: What proportion of high school sports-related injuries are related to illegal activity? (Collins et al., 2008)
- AAP statement on bicycle helmets (AAP, 2001)
- AAP Clinical Report: Sport-related concussion in children and adolescents (Halstead & Walter, 2010)
- Policy Statement – Boxing participation by children and adolescents (Purcell, 2011)

**Clinical Interventions (43)**

Clinical interventions are those interventions based in medical theory, practice, and procedures. Forty-three articles (19.82%) were considered clinical interventions (43/217). The search revealed several promising areas including:

- MRI studies to assess alteration of brain function (Johnson et al., 2012; Slobounov et al., 2010; Vagnozzi et al., 2010)
- The recognition and detection of concussion and the need to be asymptomatic prior to activity, thereby avoiding second impact syndrome (McCory et al., 2012; Cantu & Gean, 2010); or post-concussion syndrome (Gunstad & Suhr, 2001)
- Use of EEG for detecting abnormalities (Cao & Slobounov, 2011; 2010; 2009; Cao et al., 2008)
- Diffusion tensor imaging to assess the severity and recovery of function after concussion (Cubon et al., 2011)
- Cumulative impact effect/ effects of multiple concussions (Eckner et al., 2011; Schatz et al., 2011; Slobounov et al., 2007; Iverson et al., 2006; Gaetz et al., 2000)
- The efficacy of the administration method (self-report vs interview) of a concussion assessment tool on athlete reporting of symptoms (Krol et al., 2011)
- Assessment and management of clinical symptoms including the effects of medical provider type on timing of return to play, frequency of imaging, and frequency of neuropsychological testing (Meehan et al., 2011); the use of outcomes scales to assess health-related quality of life, depression and anxiety (Valovich McLeod & Register-Mihalik, 2011); the efficacy of neuropsychological testing together with structured symptom rating scales (Gioia et al., 2009); clinical course of postconcussion symptom resolution (Erlanger et al., 2003); the gap between knowledge about brain injuries and their treatment in the office vs the field (Landry, 2002)
- Role of neuroimaging (Prabhu, 2011)
- Role of occupational therapy in sport-related concussion (Reed, 2011)
- Role of the speech pathologist in concussion management (Salvatore & Fjordbak, 2011; Duff, 2009)
- Role of the school nurse (Piebes et al., 2009)
- Evaluation of the standardized assessment of concussion in a pediatric emergency department (Grubenhoff et al., 2010)
- Role of concussion history (Colvin et al., 2009) or preparticipation screening (McLeod et al., 2008; Tucker & Grady, 2008; Valovich McLeod et al., 2008; Koester, 2003)
- The reliability of the modified balance error scoring system (Hunt et al., 2009; Valovich McLeod et al., 2004; Valovich et al., 2003) and additional graded system scales (Mailer et al., 2008)
- Residual deficits from concussion as revealed by virtual time-to-contact measures of postural stability (Slobounov et al., 2008)
- The use of computerized neuropsychological screening evaluations within 72 hours of injury, to predict recovery patterns (Iverson, 2007)
- Traumatic brain injury-induced hypopituitarism in adolescence (Baldelli et al., 2005)
- The clinical factors associated with return to play - When is it safe to let a child play after a head injury? (Cross, 2004)
- Mandatory admission after isolated mild closed head injury in children: is it necessary? (Adams et al., 2001)
- Persistent prolongation of simple reaction time in sports concussion (Bleiberg et al., 2001; Goodman et al., 2001)

Neuropsychological Interventions (55)

Neuropsychological interventions are a subset of clinical interventions, however based on their status and magnitude in the literature, they are described here as a separate section.
Neuropsychological testing is an intervention used to reveal the differences in concussed versus non-concussed athletes. Fifty-five articles (25.35%) included neuropsychological interventions (55/217). The search revealed an abundance of literature surrounding this topic area including:

- Neuropsychological and neurophysiological assessment of sport concussion (Baillargeon et al., 2012; Broglio et al., 2011; Johnson et al., 2011; Ross et al., 2011; Stephens et al., 2010; Broglio et al., 2009; 2009a; Lau et al., 2009; Iverson et al., 2006; van Kampen et al., 2006; Stephens et al., 2005; Gioia et al., 2004; Iverson et al., 2004; Lovell et al., 2004; McCrea et al., 2002; Johnston et al., 2001)
- Role of neuropsychologists in the evaluation and management of sport-related concussion (Echemendia et al., 2012)
- Computerized neurocognitive testing for the management and evaluation of sport-related concussions (Meehan et al., 2012; Kontos et al., 2011; Lau et al., 2011; McCrea et al., 2010; Pardini et al., 2010; Schatz et al., 2010; Kaminski et al., 2008; Brown et al., 2007; Segalowitz et al., 2007; Erlanger et al., 2003; Barr & McCrea, 2001; Erlanger et al., 2001)
- Representative baseline values on the sport concussion assessment tool 2 (SCAT2) in adolescent athletes vary by gender, grade and concussion history (Valovich McLeod et al., 2012; 2006; Schneider et al., 2010)
- Reliability and/or validity of ImPACT (Elbin et al., 2011; Covassin et al., 2009; Tsushima et al., 2008; Schatz et al., 2006; Iverson et al., 2005; Iverson et al., 2003)
- The relationship between psychological distress and baseline sports-related concussion testing (Bailey et al., 2010)
- Investigating baseline neurocognitive performance between male and female athletes with a history of multiple concussion (Covassin et al., 2010; Kirkwood et al., 2009; Fazio et al., 2007; Bleiberg et al., 2004; Collins et al., 2003)
- Emotional response to sport concussion compared to ACL injury (Mainwaring et al., 2010)
- Age-related differences (Hunt & Ferrara, 2009)
- Psychometric support for the acute concussion evaluation (Gioia et al., 2008)
- Prolonged recovery of memory functioning (Sim et al., 2008)
- Reliability and normative data for the post-concussion scale (Lovell et al., 2006)
- Comparability, reliability and practice effects on alternate forms of the digit symbol substitution and symbol digit modalities tests (Hinton-Bayre & Geffen, 2005)
- Concussion in sports: relationship of activity level after concussion to post-concussive symptoms and neurocognitive performance (Majerske et al., 2004)
- On-field predictors of neuropsychological and symptom deficit following sports-related concussion (Collins et al., 2003a)
- Psychological aspects in the competitive athlete (Putukian & Echemendia, 2003)
- Recency and frequency of soccer heading interact to decrease neurocognitive performance (Webbe & Ochs, 2003; Witol & Webbe, 2003)
- Important markers of sports-concussion severity: retrograde and anterograde amnesia (McKeag et al., 2002)
- Standardizing mental status testing on the sideline after sport-related concussion (McCrea, 2001)

**Physical Interventions (20)**

Physical interventions are those in which a physical change is made in order to reduce the risk of sport-related concussions. Twenty articles (9.22%) were themed as physical interventions (20/217). The search provided physical intervention studies including those examining:

- Physical contact as a mechanism of injury (Darling et al., 2011; Stuart, 2005); secret locker room game (Moulton, 2005)
- Participation in leisure activities during brain injury rehabilitation (Fleming et al., 2011); active rehabilitation (Gagnon et al., 2009; McClincy et al., 2006)
- On-field signs and symptoms as predictors (Lau et al., 2011)
- Head impact can be affected by cervical muscle strength (Mihalik et al., 2011), collision type, player anticipation (Mihalik et al., 2010)
- Preseason symptoms as risk factors (Schneider et al., 2011)
- Pathophysiology of concussions (Shrey et al., 2011)
- Sex differences in self-reported symptoms after aerobic exercise in non-injured athletes: implications for concussion management programmes (Gaetz & Iverson, 2009); effect of exercise on balance (Schneiders et al., 2012)
- Effects of a symptom-free waiting period on clinical outcome and risk of reinjury after sport-related concussion (McCrea et al., 2009)
- Posttraumatic migraine characteristics in athletes following sports-related concussion (Mihalik et al., 2005)
- Effect of heading on postural control (Broglio et al., 2004); evaluation of cumulative effects of soccer heading (Janda et al., 2002; Kirkendall et al., 2001)
- Activity restrictions as part of discharge management (Swaine & Friedman, 2001)

**Summaries (68)**

Although summaries were not considered part of the inclusion criteria for the search, it is interesting to note that 68 articles fall into this category as summaries, reviews or commentaries concerning sport-related concussion. This represents 17.53% of the abstracts that were reviewed (68/388).

**Epidemiological/Descriptive (no intervention) (103)**

Although this was an exclusion criterion in the search, it is prudent to mention that the majority of studies were epidemiological in nature, merely stating the prevalence of sport-related concussions in a variety of populations. This included 26.55% of the total number of abstracts reviewed (103/388).
DISCUSSION

Although concussion has become a hot topic in academic research and in the media, the research examining the efficacy of prevention interventions for children and youth is not as robust as would be expected. A large body of the research is purely descriptive/epidemiological and simply discusses the prevalence of sport-related concussion in children and youth, not interventions associated with preventing sport-related concussion. It is recognized that baseline data on the number and rate of concussions in children and youth is required in order to develop interventions; therefore the utility of this research is acknowledged. However, there exists a gap in how to proceed in preventing these injuries through various types of interventions. Much of the research focuses on interventions based in neuropsychology and baseline/pre-participation questionnaires and exams. The neuropsychological and clinical realms are highly researched areas.

When considering the implications of this review, a number of limitations can be discussed. The broad search strategy allowed for an abundance of studies that did not meet our inclusion criteria. The grey literature found in the Google search may not have been peer-reviewed and critically assessed. No qualitative studies were found in the search.

Gaps in the Literature/ Opportunities for improvements?

We have identified several areas that require improvement. Firstly, the search did not identify any articles directly referencing sport-related concussion in First Nations/Inuit/Metis youth. This is a major gap in the literature since much of the research indicates that First Nations/Inuit/Metis youth are considered vulnerable populations. In addition, very few articles were found regarding sex/gender differences. This may be due in part, to higher participation rates by males in team sports, and sports where the risk of concussion is increased.

There also exists a lack of evaluation of interventions. While in many cases, interventions have been developed, rigorous evaluation has not been conducted to ensure their efficacy, specifically within the pediatric population. The educational interventions tend not to include outcome studies and evaluative effects (Guskiewicz & Valovich McLeod, 2011). Hospital emergency departments, school nurses and athletic trainers continue to be unaware of concussion guidelines; therefore, implementation, evaluation and outcome studies are required (Schatz & Moser, 2011).

In this same vein, prospective examination of intrinsic and extrinsic risk factors in an effort to develop evidence-based preventative mechanisms is required. Prospective study design is the key to informed research.
In terms of data, or concussion surveillance, many studies use high schools as their data source, yet a database of provincial, national or international cases would greatly increase the quality and representativeness of the research.

Although there is an abundance of studies examining neuropsychological interventions, there is limited information regarding the efficacy of these tools to shed light on recovery patterns (such as symptom checklists, neuropsychological tests, balance tests, SCAT2) in younger athletes with concussion (Guskiewicz & Valovich McLeod, 2011).

The development of age-specific return-to-play guidelines for pediatric, high school and collegiate athletes are required, as these populations are unique in their cognitive and physical development. The development of youth-specific neuropsychological screening measures and establishment of psychometric properties by researchers other than manufacturers would be beneficial.

In terms of policy and return-to-play guidelines, athletes should not return to play based solely on self-reported symptoms. There are return-to-play guidelines such as those developed through the Lystedt Law (Zachery Lystedt Law, House Bill 1824, Washington, DC, 2009), however implementing policy and establishing practice guidelines is a constant challenge.

**Conclusion**

This literature review has identified the current landscape of sport-related concussion in children and youth, through the categorization of the various types of interventions for prevention since the year 2000. Gaps in the literature and areas where improvements can be made were ascertained.
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Educational Interventions


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TIER 1A: ENVIRONMENTAL SCAN


Epidemiological/Descriptive (No Intervention)


TIER 1A: ENVIRONMENTAL SCAN


TIER 1A: ENVIRONMENTAL SCAN


Stream III – Web Scan/ Asset Inventory

OBJECTIVES
The overall objective of the web scan is to supplement the literature review in order to gain an understanding of the current landscape of sport-related concussion in children and youth. The goal of the scan is to collect recent information about, and examples of prevention programs identified through the literature review. In accessing the unpublished or grey literature, we will gain a more complete and current understanding of concussion injury prevention program interventions.

METHODOLOGY
Sources
Searches of Google (http://www.google.ca) and Google Scholar (http://www.google.ca/scholar) were conducted. Key word searches using the same word categories, or a combination of key words, as described in the search strategy for the literature review were conducted. Ten pages of hits for each key word search were screened. Reference lists for all included documents were scanned for related articles.

Inclusion criteria
Information from a website was included if:
- it includes a sport-related concussion prevention strategy/intervention
- the intervention is geared toward children and youth (aged 18 years and under)
- it is from a reputable organization such as a sport governing body/ agency/ national sport organization/ provincial sport organization, not-for-profit, sport therapy/ health-related, prevention-related, or government-related, or academic institution
- pharmaceutical companies were only included where they have been sponsors of a program/initiative which has been led by one of the included organizations
- it is linked to a regional national or international dataset

Exclusion criteria
Information from a website was excluded if:
- it does not include a sport-related concussion prevention strategy/intervention
- the intervention is not geared toward children and youth
- it is a non-reputable organization or a for-profit business
- it is pharmaceutical website that is not a sponsor for an included organization
Google (first 10 pages were screened):

The following search terms were used in a search of Google in order to supplement the searches from Google Scholar and the database review: “Concussion OR Head Injury OR Brain Injury AND athlete OR sport OR Team Sport AND youth OR child OR pediatric OR adolescent OR teen.” This search strategy resulted in a total of 66,800,000 hits on April 9th, 2012. The internet search generated 63 websites containing relevant concussion information. These websites included: academic research centres (9); organizations (21); Hospitals/Foundations (11); media sites/news (15); government (2); other (5).

Google Scholar (since 1993) (first 10 pages were screened):

The following search terms were used in a search of Google Scholar in order to supplement the database review: “Concussion OR Head Injury OR Brain Injury AND athlete OR sport OR Team Sport AND youth OR child OR pediatric OR adolescent OR teen.” This search strategy resulted in a total of 19,700 hits on April 9th, 2012. Eighty-seven relevant articles were retrieved from the first 10 pages of the Google Scholar search. All articles found in the Google Scholar search were also found in the database review. This demonstrates the value of Google Scholar as an academic search tool.

FINDINGS

Google Search (April 9th, 2012)

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<tr>
<th>Website/Organization</th>
<th>Name/Description of Initiative/Resource</th>
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<td><strong>ACADEMIC RESEARCH CENTRES</strong></td>
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<td>American Association of Neurological Surgeons</td>
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<td>BC Injury Research and Prevention Unit</td>
<td>Sport, Recreation and Leisure</td>
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<td>Canadian Medical Association (CMA) Policy</td>
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<td><strong>Sports Medicine Research: In the Lab and in the Field</strong>&lt;br&gt;<a href="http://sportsmedresearch.blogspot.ca/2012/04/time-to-subsequent-head-injury-from.html">http://sportsmedresearch.blogspot.ca/2012/04/time-to-subsequent-head-injury-from.html</a></td>
<td>Time-to-subsequent Head Injury from Sports and Recreation Activities</td>
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<td><strong>The Franklin Institute</strong>&lt;br&gt;<a href="http://www.fi.edu/learn/brain/head.html">http://www.fi.edu/learn/brain/head.html</a></td>
<td>The Human Brain – Protect – Watch Your Head</td>
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<td><strong>ORGANIZATIONS</strong></td>
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<td><strong>Brain Injury Alliance of Colorado</strong>&lt;br&gt;<a href="http://biacolorado.org/public-policy/sports-concussion/">http://biacolorado.org/public-policy/sports-concussion/</a></td>
<td>Youth Sports Concussion</td>
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<td><strong>Canadian Paediatric Society</strong>&lt;br&gt;<a href="http://www.cps.ca/english/statements/HAL/HAL12-01.htm">http://www.cps.ca/english/statements/HAL/HAL12-01.htm</a></td>
<td>Evaluation and management of children and adolescents with sports-related concussion</td>
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<td><strong>Closed Brain Injury – Closed Head Injury</strong>&lt;br&gt;<a href="http://www.closedbraininjury.com/?p=101">http://www.closedbraininjury.com/?p=101</a></td>
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**TIER 1A: ENVIRONMENTAL SCAN**

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<td><strong>ABC News</strong>&lt;br&gt;<a href="http://abcnews.go.com/Health/WellnessNews/basketball-concussions-head-injuries-rise-teen-sports/story?id=11603847">http://abcnews.go.com/Health/WellnessNews/basketball-concussions-head-injuries-rise-teen-sports/story?id=11603847</a></td>
<td>Basketball and Concussions: How to Protect Your Teen</td>
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<td><strong>Bloomsberg Businessweek</strong></td>
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<td>Experts Report – 8,000 kids are treated in ERs daily, trainers' association says</td>
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<td>Brain Injury News and Information Blog</td>
<td>AYSO (American Youth Soccer Organization) Concussion Management Recommendations Leave a lot to be Desired</td>
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<td>CBC News</td>
<td>Concussion should be termed brain injury: study</td>
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<td>Players, grieving mom back youth head injury protection bill</td>
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<td>Routine hits may injure teen athlete’s brain</td>
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<td>OregonLive.com</td>
<td>Concussions, an injury rising among teen athletes, more profound and enduring than previously known</td>
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<td>Teen Brain Takes Biggest Sports Hits</td>
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<td>What you should know about concussions in sports</td>
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<td>How common is head injury when cycling?</td>
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<td><strong>Comer Children’s Hospital – The University of Chicago</strong>&lt;br&gt;<a href="http://www.uchicagokidshospital.org/online-library/content=P01650">http://www.uchicagokidshospital.org/online-library/content=P01650</a></td>
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<td><strong>The Dana Foundation</strong>&lt;br&gt;<a href="http://www.dana.org/media/detail.aspx?id=25076">http://www.dana.org/media/detail.aspx?id=25076</a></td>
<td>Sports Concussions and the Immature Brain – Young athletes may be more vulnerable to mild brain injury</td>
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<tr>
<td><strong>Knowledge Centre – The Council of State Governments</strong></td>
<td>Concussions in Sports: Protecting Youth from Brain Injury</td>
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<td><a href="http://knowledgecenter.csg.org/drupal/content/concussions-sports-protecting-youth-brain-injury">http://knowledgecenter.csg.org/drupal/content/concussions-sports-protecting-youth-brain-injury</a></td>
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<tr>
<td><strong>Washington State Legislature RCW 28A.600.190</strong></td>
<td>Youth sports – Concussion and head injury guidelines – Injured athlete restrictions – Short title</td>
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<td><strong>Brain Injury Law Center</strong></td>
<td>Youth and Pro Sports: Baseline Test Lessens Concussion Injury</td>
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<td><strong>Brain Injury Professional</strong></td>
<td>Ten Steps and Commitments for an Effective Youth Sports Concussion Program</td>
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<td><strong>New Jersey Youth Soccer</strong></td>
<td>Head Injury Instructions for Coaches</td>
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<tr>
<td><strong>Sports Pro Community Network</strong></td>
<td>Concussion and Traumatic Brain Injury in Youth Athletics: An Overview of Causes, Symptoms, Treatment and Prevention</td>
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<tr>
<td><strong>The School District of Philadelphia – Athletics Office of Academic Enrichment and Support</strong></td>
<td>Care and Prevention of Sport’s Injuries</td>
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<td><a href="http://webgui.phila.k12.pa.us/offices/a/athletics/programs--services/sports-injuries">http://webgui.phila.k12.pa.us/offices/a/athletics/programs--services/sports-injuries</a></td>
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**Google Scholar Search (April 9, 2012)**

The search revealed the same articles as retrieved from the academic electronic database review. The first ten articles in the Google Scholar search results are presented below, in their order of appearance.


http://www.msscentershop.info/content/44/3/188.abstract

http://jama.ama-assn.org/content/303/22/2265.short


http://journals.lww.com/acsm-esser/Abstract/2011/01000/Biomechanics_of_Sport_Concussion__Quest_for_the.3.aspx

9.) Gagnon I, Galli C, Friedman D, Grilli L, Iverson GL. Active rehabilitation for children who are slow to recover following sport-related concussion. Brain Inj, 2009; 23(12): 956-64.  

http://pediatrics.aappublications.org/content/126/3/597.short

DISCUSSION

The aim of this review was to gain a comprehensive understanding of the current landscape of sport-related concussion in children and youth by identifying interventions and injury prevention programs. The Google Scholar search provided the same search results as the academic electronic database review, demonstrating the utility and quality of Google Scholar in literature reviews. The Google search supplemented the database review through the addition of grey literature from relevant websites, most of which was educational in nature.

Conclusion

This review examined the available peer-reviewed and grey literature concerning sport-related concussions in children and youth. This summary and inventory has enabled us to identify gaps
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in the literature and areas where improvements can be made for the prevention of sport-related concussions in children and youth.

ACKNOWLEDGEMENTS

We would like to acknowledge the Public Health Agency of Canada and the ThinkFirst Foundation of Canada for funding this environmental scan as an initiative to support Canada’s children and youth in living active and safe lives.