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EVIDENCE BRIEF

Risk Factors for Concussion

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Key Messages

- Concussions are the most common form of head injury and represent a significant burden of injury to Ontarians. In 2018, the former Ministry of Health and Long-Term Care (MOHLTC) in Ontario included concussions as a topic of consideration in their injury prevention guidelines.
- To inform a program of public health intervention, we reviewed the literature on concussion risk factors across ages and injury mechanisms.
- There is sufficient evidence to support playing in a sporting match over practice, having sustained a previous concussion, and playing at lower altitude increase the risk of concussion. There is some evidence to suggest that adverse childhood experiences also increase concussion risk.
- Evidence is mixed for other risk factors including sex, age, and attention deficit hyperactivity disorder (ADHD).

Issue and Research Question

Concussions are the most common form of head injury and can be caused by either direct impact or forceful motion of the head or other part of the body that results in rapid movement of the brain within the skull.[1]

In Ontario, emergency department visits for concussions has increased significantly over time, from 63.7 visits per 100,000 in 2003, to 242.5 per 100,000 in 2018.[2] This may reflect a true increase in incidence, an increase in awareness and reporting, or a combination of the two. In either case, this increase identifies an opportunity for prevention.

Much of the current action on concussions in Canada pertains to concussion awareness and identification, post-concussion management and guidelines for returning to school, work and sports. This, then, identifies a gap for public health organizations to focus on concussion prevention. In 2018, the former Ministry of Health and Long-Term Care (MOHLTC) in Ontario included concussions as a topic of consideration in their injury prevention guidelines.[3] This document specifies the requirement for a program of public health intervention to address risk factors for various injuries including concussions in order to reduce their population burden. This includes the need to assess the evidence on concussion risk factors in order to inform these potential public health interventions.

As a result, we conducted a rapid review of the literature in order to answer the following research question: What are the risk and protective factors for concussion?

Methods

A rapid review of published literature was conducted to synthesize the existing research evidence on risk and protective factors for concussion, across all age groups and populations. Systematic searches were conducted in November 2019 in order to identify all relevant evidence on this topic. Public Health Ontario Library Services conducted a search in Medline, Embase, CINAHL, PsycINFO and SPORTDiscus using relevant vocabulary and subject headings. All database results were integrated and duplicates were removed. The search strategy is available upon request.

English-language peer-reviewed review-level papers were eligible for inclusion if they: examined the effect of a risk or protective factor on concussion risk and were published within the last 10 years. Papers were excluded if they did not have concussion outcomes, scored weak on the quality appraisal, or did not include reproducible search methods.

One reviewer screened all of the titles and abstracts and a second reviewer screened a random selection of titles and abstracts. Full-text versions of all papers for inclusion were reviewed by two reviewers. For all relevant papers, one PHO staff extracted relevant data and summarized content.

Quality appraisal was conducted for each included review using the Healthevidence.org Quality Assessment Tools for Review Articles.[4] Two reviewers independently appraised each included article and any discrepancies were resolved by discussion. The study results are summarized below by risk factor.

Main Findings

The peer-reviewed literature search identified 954 articles, 79 were included for full text review and a final 10 met the inclusion criteria. Of the included reviews, one was a review of reviews[5] two were systematic reviews and meta-analyses,[6,7] five were systematic reviews,[8-12] and two were scoping reviews.[13,14]

Using the Healthevidence.org Quality Assessment Tool for Review Articles,[4] the reviews were rated as strong,[5,6] moderate,[7-14] or weak on methodological quality; reviews rated as weak were excluded (n=4).

Previous Concussion

> Currently, there is substantial scientific evidence to suggest that sustaining an initial concussion increases the risk of sustaining a subsequent concussion.

A systematic review and meta-analysis by Reneker et al. examined the association between previous concussion and subsequent injury risk among both military service members and athletes. Seven studies including 36,400 total participants reported odds ratios (ORs) to estimate the association between previous and subsequent concussion. They estimated that those with a previous concussion had more than three times the odds of sustaining a secondary concussion (OR=3.73, 95%CI: 2.41, 5.78),[6] compared to those with no concussion history. In five studies that included athletes only (n=33,627) the summary odds estimate of sustaining a concussion among those who reported a previous concussion was over four times greater than those who did not report a previous concussion (OR=4.44, 95%CI: 2.90, 6.79).[6]

In the same review by Reneker et al. a further three studies including 26,015 athletes reported rate ratios to estimate the association between concussion history and subsequent concussion risk. In this sample, those with a previous concussion had almost twice the rate of a subsequent concussion compared to those without a previous concussion(RR=1.97, 95%CI: 1.47, 2.63).[6]

A systematic review by Lasry et al. of individuals from the general population reported an increased risk of subsequent traumatic brain injury (TBI) after initial TBI (adjusted hazard ratio (HR) estimates ranging from HR=1.62, 95%CI: 1.08, 1.54 to HR=3.39, 95%CI: 1.32, 8.72.[8] A second systematic review by Abrahams et al. also supported the conclusion that a previous concussion increases the risk of a subsequent concussion.[9]

Finally, a scoping review of concussion risk factors concluded that football players who had sustained a concussion in the previous 12 months had a higher risk of suffering another concussion compared to those who had not sustained a concussion in the previous 12 months (HR= 1.96, 95%CI: 1.40, 2.73).[14]

Match Play vs. Practice

> Currently, there is substantial scientific evidence to support that there is an increased risk of sustaining a concussion in match play compared to in practices.

A systematic review by Abrahams et al. concluded that there was an increased risk of concussion in match play compared to in practices. This finding was consistent across the 29 studies which included athletes participating in a wide range of sports such as soccer, football, basketball, lacrosse and ice hockey at the amateur, collegiate and professional levels.[9] As a result of some studies having very low concussion incidence in practices, the precision of the relative risk estimates across the studies varied greatly. All of the 29 studies found an increased risk of concussion in games compared to practices, supporting match play as a concussion risk factor.

Attention Deficit Hyperactivity Disorder (ADHD)

> Currently, the scientific evidence on the association between ADHD and TBI risk is inconclusive. While some studies have demonstrated an association between the two variables, few have established that an ADHD diagnosis preceded a head injury and therefore limits the ability to establish risk. Additionally, the literature does not currently assess concussion as an outcome independent from other TBIs.

In a meta-analysis by Adeyemo et al. that examined the association between ADHD and mild traumatic brain injury (mTBI), only two studies specified that the ADHD exposure preceded an incident mTBI outcome. In these two studies (n=3,668), the relative risk of mTBI among those with ADHD was 0.98 (p=0.97), suggesting that the evidence does not support ADHD as a risk factor for mTBI.[7] An additional five studies in this review demonstrated an association between ADHD and concussion,[7] however these studies did not specify that an ADHD diagnosis preceded an incident concussion so the effect of ADHD on mTBI risk could not be established.

In a systematic review by Horris et al. examining the relationship between ADHD and TBI, two studies (n=168), one cross-sectional and one retrospective, found an increase in concussion incidence in those with ADHD compared to those without.[12] While the two studies were not prospective, participants specified that their ADHD diagnosis preceded their TBI.

Altitude

Two reviews examined the association between altitude at which sports were being played and concussion incidence, finding similar results.[11,14] The scoping review by Waltzman et al. found that among a sample of high school athletes, the risk of concussion was 31% lower in those playing at higher altitudes.[14] Similar results were observed in a review by Yengo-Kahn et al. of NFL players where the odds

of sustaining a concussion were 30% lower when playing at higher altitudes (OR=0.70, 95%CI: 0.53, 0.94).[11]

Adverse Childhood Experiences (ACES)

> Currently, the review-level literature examining the effect of ACEs on concussion risk is limited to one systematic review, however it consistently found that ACEs increase the risk of TBI in various high risk populations.

A scoping review by Ma et al. examined the association between adverse childhood experiences (ACEs) and concussion risk.[13] ACEs are defined in this review using the seminal definition of "psychological, physical or sexual abuse, or exposure to household dysfunction such as substance abuse, mental illness, spousal violence and criminal behaviours of a household member experienced during the first 18 years of life."[15] The review included six studies that used any component of this definition. Populations in the review included incarcerated persons, individuals with a high risk of psychosis, individuals with severe mental illness and homeless persons.

The included studies measured ACEs differently, ranging from examining individual components of ACEs to using a composite ACEs score. In some cases, studies dichotomized participants to exposed and unexposed groups or assessed the effect of an increasing number of ACEs. The review included studies that used any TBI as the primary outcome without assessing concussion specifically and separately from other traumatic brain injuries.

Three studies examined the association between overall exposure to any ACEs and TBI. One reported that the odds of a TBI among those who had exposure to any ACEs was over twice the odds of those who were not exposed (OR=2.26, 95%CI: 1.04, 5.02).[13] The remaining two reported a dose-response relationship between increasing numbers of ACEs and presence of head injuries ($p < 0.05$).[13] The review also found that childhood physical abuse was associated with an increased odds of head injury without loss of consciousness (OR=2.13, 95%CI: 1.19, 3.87), that childhood psychological abuse was associated with an increased odds of TBI (OR=1.95, 95%CI: 1.09, 3.51), and that the incarceration of a household member also increased the odds of a TBI (OR=2.67, 95%CI: 1.11, 6.46).[13]

Sex

> Currently, the scientific evidence on sex as a risk factor for concussion is mixed, with some studies reporting a higher risk of TBI among females and others reporting a higher risk among males. The literature largely does not assess concussions independently from other TBI outcomes.

One systematic review by Merritt et al. found that females were more likely to sustain a concussion in soccer, basketball and baseball/softball compared to males in studies where both sexes were represented across the included sports.[10] In sports where both sexes were not equally represented such as lacrosse and ice hockey, the findings were less conclusive. Some studies reported higher rates among males, some reported higher rates among females and other studies reported no significant differences. Outside of a sports setting, most studies combined concussion with other TBI outcomes, reporting that males were more likely to sustain a TBI compared to females; however, concussions were not independently assessed.[10]

In a systematic review of risk factors for a recurrent TBI in the general population by Lasry et al., eight studies examined sex as a risk factor.[8] Males had a statistically significantly higher risk of a recurrent TBI in three out of the eight studies that examined sex, with the other five reporting no statistically significant effect. Notably, the three studies that did report a significantly higher risk of concussions among males also had the three largest sample sizes and the most precise estimates out of the eight studies. These three produced relative risk estimates ranging from RR=1.31, 95%CI: 1.03-1.66 to RR=1.64, 95%CI:1.32-2.04.[8]

These findings suggest that females may have a higher risk of TBI in a sports context and males are more likely to sustain a TBI outside of sports. These estimates represent all TBI outcomes however, and concussions should be specifically assessed in future studies.

Age

> Currently, the scientific evidence on age as a risk factor for concussion is limited, with some studies suggesting an increased risk associated with older age, and others reporting inconclusive results.

A systematic review by Lasry et al. found that each 10-year increase in age was associated with a an 11% increased odds of TBI (OR=1.11, 95%CI: 1.00, 1.34); however, the other included study that examined age reported no significant effect.[8] The review of reviews by Donnan et al. found that youth between the ages of 5 and 16 were at higher risk of mTBI compared to those ages 0-1.[5]

Discussion and Conclusions

While many potential risk factors for concussion such as sex, age and ADHD still require more research to determine their association with concussion risk, there is substantial evidence to support the effect of other risk factors.

In a sporting context, there is currently strong evidence to support that playing in a match compared to practice, having sustained a previous concussion and playing at a lower altitude increase the risk for suffering a concussion. Additionally, in a non-sporting context, there is some evidence to support that adverse childhood experiences also increase concussion risk.

Implications for Practice

The identification of concussion risk factors can support the development of targeted interventions in line with the MOHLTC 2018 Injury Prevention guidelines. These efforts, along with working with local community groups and other stakeholders, can reduce the population burden of concussions in Ontario.

Additionally, identifying the gap in conclusive evidence supporting other potential risk factors can guide future research. Efforts to fill these knowledge gaps and continuously support concussion prevention are needed.

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Specifications and Limitations of Evidence Brief

The purpose of this Evidence Brief is to investigate a research question in a timely manner to help inform decision making. The Evidence Brief presents key findings, based on a systematic search of the best available evidence near the time of publication, as well as systematic screening and extraction of the data from that evidence. It does not report the same level of detail as a full systematic review. Every attempt has been made to incorporate the highest level of evidence on the topic. There may be relevant individual studies that are not included; however, it is important to consider at the time of use of this brief whether individual studies would alter the conclusions drawn from the document.

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