

LITERATURE REVIEW

ENGAGEMENT BY EDUCATION FOR ACTION: RECOMMENDATIONS FOR EDUCATIONAL INTERVENTIONS TO PREVENT CONCUSSION IN SPORT

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ABSTRACT

Introduction: The science of traumatic brain injury has evolved into a deep understanding of physiological mechanisms, injury identification, management, and prevention. The Centre for Disease Control and Prevention rates concussion management, and prevention as an epidemic level of importance. In the USA, concussion affects between 1.6 and 3.8 million athletes per year. The primary aim was to provide substantiated recommendations for current best practice educational initiatives. The secondary aim was to determine if education alone as a prevention strategy for decreasing concussion rates in sport is successful. Furthermore, recommendations for future research have been provided.

Method of review: A comprehensive search using eight different search combinations, and a strict inclusion criterion was performed yielding 22 relevant articles that were published between 2001 and 2014.

Review outcomes: A summary of current literature on educational initiatives for concussion in sport has been presented.

Discussion: From this review, it appears a multifaceted educational strategy using videos and presentations, targeting youth, and coaches in high risk sports to be the most effective means of increasing knowledge and understanding of concussions in sport. However, there are many gaps in the literature that need to be addressed in order to identify the learning needs of different demographic groups. Additionally, the standardisation of concussion education through legislation may be beneficial in aiding reductions in related injury. However, there is insufficient evidence to claim that any single education method alone would be successful. Therefore, multiple educational strategies, legislation, and knowledge transfer may be preferable to target and assist those at risk of concussion. This review has highlighted the importance of concussion as a health concern and highlights the importance for health professionals to undertake research in this field.

Keywords: Concussion; Education intervention; Health; Sport; Traumatic brain injury

INTRODUCTION:

Scientific research has resulted in an understanding of physiological mechanisms; injury identification; management; and prevention of traumatic brain injury (TBI). Concussions are a known subset of TBI and are a large health concern, specifically in contact sporting environments^{1,2}. Concussion injuries typically involve a blow to anywhere on the body that results in ‘shaking’ of the brain. When the brain collides with the cranium an injury can be asymptomatic. However if symptoms are present, they may include (but not be limited to): headaches; dizziness; nausea; vomiting; feeling slow; various sleep disorders; fatigue; drowsiness; sensitivity to light or noise; vertigo; dazed; stunned; ringing ears; and double vision¹.

Untreated or unnoticed concussions can quickly progress to severe TBI with long term effects on quality of life. This is a prominent health concern in sporting culture, and currently the best known cure is prevention. One preventative measure may be to better educate those associated in sports where concussion is a risk, for example an understanding of negative outcomes and methods to recognise concussion.

The process of this review was to examine current prevention strategies for concussion in sport, specifically educational interventions. This review has been divided into the following subsections: defining key terms; epidemiology; brief review of prevention strategies; method of review; review outcomes; discussion including critical review of current educational interventions; current guidelines; knowledge transfer (KT) and education; legislation and education; current best practice recommendations; future research recommendations; and conclusions.

The evaluation of educational methods to reduce concussion risk may provide valuable insight into effective prevention strategies specific to sporting demographics. These strategies can then be incorporated into legislative laws in order to be standardised and have a wide-ranging effect. The first step in this process is to determine effective instructive approaches. Therefore, the primary aim

of this review was to provide substantiated recommendations for current best practice educational initiatives for the reduction of the rate of concussion in sport. This was achieved by critically reviewing current interventions. The secondary aim was to determine whether education alone as a prevention strategy for preventing concussions in sport has been successful. Furthermore, recommendations for future research regarding preventative action, specifically educational strategies, have been presented.

DEFINING KEY TERMS:

The 4th International Conference on Concussion in Sport, defined a brain injury that is termed ‘concussion’ as a “*complex pathophysiological process affecting the brain, induced by biomechanical forces*”². The consensus statement released at the Conference offered four defining features to contextualise this definition:

1. *Concussion may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an ‘impulsive’ force transmitted 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 prolonged³.*

The term ‘concussion’ has been incorrectly used interchangeably with ‘mild traumatic brain injury’ (mTBI) in the literature, and sporting culture. The definition (above) for concussion differs from that used for mTBI². Defined by the Centre for Disease Control and Prevention (CDC), and the American Congress of Rehabilitation Medicine, mTBI is a:

*Loss of consciousness for no more than 30 minutes, or amnesia as a result of a mechanical force to the head, and a Glasgow Coma Score (GCS) of 13 to 15*⁴.

If mTBI symptoms worsen, the injury can quickly turn into a TBI. In contrast to mTBI, concussion is a transient state typically characterised by short lived neurological disturbances, opposed to actual pathophysiological injury². Loss of consciousness connected the two definitions in the past, however the current understanding is that concussion can occur with, or without loss of consciousness. Therefore the terms ‘concussion’ and ‘mTBI’ have differing health concerns, each referring to distinct characteristics of similar pathophysiological alterations. In this document, concussion will be the term used. When addressing prevention strategies, note that preventing concussion may additionally influence the prevention of mTBI, and TBI respectively.

EPIDEMIOLOGY:

The importance of addressing concussion in sport is obvious when examining epidemiological findings from the past five to ten years. The CDC rates concussion management and prevention at an epidemic level of importance, as it affects between 1.6 and 3.8 million athletes per year in the United States⁵. Sport is the second highest cause of concussion, only automotive accidents have higher incidences. These rates may also be increasing due to the increasing participation rate of sports. Approximately 20% of concussions reported annually are sport related, with this number estimated to be higher due to underreporting⁶. Furthermore, athletes are approximately three times more likely to be concussed if they have already been exposed to a previous concussive injury. The highest risk sports for concussion are sports that induce blows to the body or head including: boxing and combat sports; all football codes; ice hockey; field hockey; volleyball; wrestling; basketball; baseball; and softball⁷⁻⁹.

A major concern is the danger to youth athletes who participate more frequently in sport, and thus

have higher rates of concussions¹⁰. Youth athletes account for 65% of sport related TBI in the USA¹¹. From this population, athletic injury rates show that concussions account for 90% of the estimated 300,000 injuries to the head annually in high schools⁷. Additionally, incidences in concussion injury have seen a 4.2 fold increase in the USA over 11 years and between 1997 and 2007 emergency departments reported the tripling of visits by youths with concussion^{2,6}. The age bracket of emergency department concussion visits is dominated by youth aged ten to 14 years old, followed by those aged 15 to 19 years old¹². Furthermore, there tends to be less medical support at younger competitive level competition, with responsibilities of prevention and management being placed on regional coaches and teachers. Taking into account the increasing rates amongst youths, concussion prevention and management is an important health concern to address. It stands to reason that prevention has beneficial effects on various demographics and organisations. This can be at the elite professional end of the sporting spectrum, through to college and school sports, as well as grass-roots level of community and junior competitions. Furthermore, it is possibly the environments away from the elite level where these strategies should be focused due to difficulties in assisting the “mums and dads” coaches typically found volunteering at local junior level sports, where they may not necessarily be aware of the seriousness of concussion that would be expected within a professional organisation. Needless to say, scientific communities have a role to play in providing evidence of effective measure to educate people in all areas of sporting endeavour to assist address this potentially serious health issue.

PREVENTION STRATEGIES:

The most effective treatment for any health concern is prevention. There are many strategies aimed at preventing concussion. However, understudied risk factors and a varied population knowledge base remain obstacles in standardising effective prevention strategies. Current multifaceted

prevention initiatives are recommended by governing bodies that include: protective equipment; enforcing rule changes; identifying risk factors; professional technique modifications (e.g. coaching style, referee conduct, and athletic movement efficiency); strength training; athlete conduct; knowledge transfer; legislation; and education^{2,13}.

Previously, protective equipment, specifically helmets have had mixed outcomes for athlete safety in general³. Within boxing, protective equipment has been reported as an effective tool to reduce the risk of injury^{9,14}. However, the current understanding suggests that helmets are designed to prevent severe acute injuries (i.e. TBI and skull fractures) and do not assist in preventing shearing and rotational forces that cause concussion¹. Similarly, mouthguards have been proposed to decrease the severity of concussions by decreasing the force and trauma transmitted to the brain from an impact. Unfortunately, no research conclusively supports the use of mouthguards to decrease concussion. However, mouthguards have been reported as providing increased protection from dental fractures, and avulsions, ocular, and facial injury¹. For this point alone, athletes should be encouraged to wear mouth protection when competing or exercising. Another strategy to reduce risk of concussion is strength training.

Strengthening of the neck muscles has been a proposed theory to limit rotational and linear motion resulting from an impact blow, and thus reducing brain loading¹⁵. However, Benson et al reported that theoretical links between strength training, concussion rates and severity has shown no supportive or conclusive evidence. Strengthening of neck muscles may not necessarily lessen any forces imparted on contact. A blow that impacts directly to the head, there appears to be little opportunity for the force to be absorbed, unlike loads encountered from activities such as running. When making contact with the ground, the shock from the impact is attenuated through the musculotendinous units of sequential body segments with less shock at the head compared to the loading shock at ground contact¹⁶. It is this shock absorbing function of

multiple segments of the lower limbs and spine that contribute to reducing the impact forces on the brain. When taking these factors into account, perhaps strength training of neck muscles may not be an effective measure against concussion due to direct impact to the head resulting in effectively no opportunity for shock attenuation.

Rule changes have been extensively researched to limit the exposure to contact which may cause concussion. Removing body checking from youth ice hockey; limited interchange rules in rugby; and compulsory awareness programs have reduced concussion rates and have been successful concussion prevention strategies¹⁵. While rule changes are effective, there is a slow process to implement through sporting associations, and leagues. Further research is needed to validate this prevention strategy.

Legislation is another major tool used for preventing concussions. The Lystedt Law in the USA remains the most prominent legislation. The law was named in honour of Zackery Lystedt. Lystedt was an athlete who suffered a concussion during a football game and even though this occurred, he was allowed to return to play¹⁷. After the game, the athlete was airlifted to hospital and underwent brain surgery. Lystedt barely survived with severe neurologic injuries and residual disabilities. The Lystedt legislation formed a partnership between the CDC and the Brain Injury Association of America who provided tools based on current knowledge to standardise concussion prevention and management¹⁷. This initiative has been seen as a long needed first step in the direction of concussion prevention. While many states have this law implemented, to make a significant impact, legislation needs to expand to the whole of the USA¹⁵. This may lead to other countries considering the implementation of similar programs and laws.

The above prevention strategies have been extensively researched through implementation, and evaluation. In addition, often overlooked in concussion literature is the use of educational initiatives as a prevention strategy. Many educational initiatives exist, and all consensus statements recommend the use of education for preventing

concussion^{1, 3, 13, 18-20}. These recommendations are based on evidence outside concussion literature, and current knowledge gaps exist due to no normalisation of educational resources, and limited evaluations of currently existing education initiatives. Further research into these prevention strategies is warranted.

METHOD OF REVIEW:

A search compiled the literature on educational concussion initiatives in sport. The process was limited to English language literature from online databases. Eight different combinations of search terms were utilised, with considerable overlap. The search terms included:

1. 'Concussion' *or* 'traumatic brain injury';
2. 'Sport';
3. 'Education' *or* 'safety' *or* 'prevention' *or* 'knowledge'.

A strict inclusion and exclusion criteria were followed. These criteria ensured the specificity of chosen studies accurately represented the aims and objectives of this review. The inclusion and exclusion criteria were as follows:

1. Titles examined first to eliminate irrelevant articles.
2. Full articles were then read if abstracts presented any possibility of the topic of education being included.
3. Any evaluations of educational interventions were included.
4. Primary targets of interventions or strategies must have included concussion, or traumatic brain injury, and education.
5. Any educational intervention studies not including an evaluation were included.
6. Any current source inclusive of the years: 2001 to 2014.
7. Online database search only, in the English language.
8. Research involving animals was excluded.
9. Studies with no educational intervention were excluded.
10. Articles primarily targeting protective equipment education strategies were only

included if there was an educational component targeting concussions.

Using the specified search terms as well as inclusion and exclusion criteria, 2052 total original sources were found. The total of 2052 sources yielded 384 articles with relevant titles, from which 41 abstracts were accepted. Nineteen articles were excluded after analysing the full texts. This was due to a lack of educational strategies or no significant reference to concussion in the body of the text. Therefore leaving a total of 22 total articles included in this systematic review.

Practicality for readers was considered important and the key messages from the included articles were organised into Table's 1 & 2. The tables have been organised into chronological order of most recent publication first and include: date of publication; first author and reference number; relevant sport; type of educational intervention; and a brief summary of the results. The tables will serve as an easy means for readers to summarise current literature on concussion education initiatives.

REVIEW OUTCOMES:

A summary of the 22 articles was created to accommodate brief overviews of the literature included in this review (Table 1, Table 2). Article publication dates range from 2001 to 2014. Sport specific educational initiatives included two rugby (Union)^{24, 25}; three soccer^{5, 8, 35}; six ice hockey^{8, 10, 23, 27, 33, 34}; one basketball⁵; and one snowboarding intervention³¹ respectively. Participants partaking in education interventions included a mix of young children less than 8 years of age²⁸, youth eight to 18 years of age^{8, 11, 12, 21, 26, 27, 28, 33, 35, 36}, students^{31, 32, 35, 36, 37}, and trained professionals^{11, 12, 21, 22, 24, 26, 37}. Trained professional refers to anyone educated previously on concussions including coaches, athletic directors, and physicians. Nineteen articles evaluated an intervention and from these 17 articles reported significantly positive trends of increasing knowledge post intervention. Two articles reported negative or mixed results when evaluating educational interventions. Only one article

evaluated the impact education had on concussion rates, and the cost of injuries. Three articles presented interventions with no follow up evaluation. No studies that focused on helmet use, with a concussion component were found, as helmet studies primarily focused on TBI and not concussion. The most popular educational strategy was films (12 articles), followed by presentation classes (seven), fact sheets (four), computer modules (four), online education (three), brochures (three), checklists (one), and video games (one) respectively. Most interventions utilised two or more educational strategies, with the CDC's 'Head's Up' initiative being the most recognised intervention (three articles).

DISCUSSION:

The aim of this review was to provide recommendations for current best practice educational initiatives to reduce the rate of concussion in sport. Furthermore, a secondary aim was to determine whether education alone as a prevention strategy for preventing concussions in sport is successful. An interesting point to highlight early in this discussion is that no educational strategies were found during this review's literature search that was associated with boxing or similar combat type sports. This was a surprising outcome as it may be considered that these sports would be likely to benefit if education strategies were an effective method of reducing

Table 1: A chronological (2014 – 2012) summary of current literature on educational initiatives for concussion in sport.

Date	Author	Sport	Type of Intervention	Summary of Results
2014	Cusimano, et al ¹⁰	Ice hockey.	Educational video.	Significant short term memory retention following education programme. However, a decrease over time.
2014	Kroshus, et al ²³	Ice hockey.	Institution determined concussion education.	Varied results from several media sources. Video were shown to provide greater understanding of concussion.
2013	Esquivel, et al ⁸	Various sports.	Online survey aimed at 4 target groups.	Majority of interviewees stated their organisation made information available for concussion education.
2013	Provvidenza, et al ⁴⁰	Various sports.	Review of knowledge transfer applied to sport concussion.	Clear links between greater understanding and decreases in concussion.
2013	Miyashita, et al ⁵	Soccer and basketball.	Educational power point lecture.	Athletes showed an improvement on knowledge for concussions. Preseason intervention had an impact on knowledge retention.
2012	Viljoen, et al ²⁴	Rugby.	BokSmart Rugby Safety workshops and materials.	Ongoing education programme for rugby officials. Continual and regular updating process.
2012	Ahmed, et al ²²	Various sports.	Evaluation of sports medicine site concussion education.	Reported many websites lacked adequate information. Often too complex for the general public to understand.
2012	Covassin, et al ¹¹	Various sports.	Survey of CDC's Heads Up intervention.	High outcomes from participants learning about concussion and also being able to identify the injury.
2012	Bagley, et al ³⁶	Various sports.	Curriculum using interactive presentations.	Many participants (especially females) increased concussion knowledge after education programme.
2012	Bramley, et al ³⁵	Soccer.	Survey on concussion reporting rates.	Reported that participants would likely self report concussion after the education intervention.
2012	Falavigna, et al ³²	Various sports.	Educational intervention with a video and lecture.	An initial increase in knowledge was found after a single lecture. This diminished after five months.

Table 2: A chronological (2012 – 2001) summary of current literature on educational initiatives for concussion in sport.

Date	Author	Sport	Type of Intervention	Summary of Results
2012	Sullivan, et al ³⁷	Various sports.	Lecture using best practice concussion knowledge.	A highlighted a lack of trainee's understanding of cognitive rest in concussion management.
2011	Koh ³¹	Snowboarding.	Snowboard-related concussion safety education.	The mean score of snowboard-related concussion knowledge proved possible.
2010	Sarmiento, et al ²⁶	Various sports.	Tool kit for high school coaches.	Coaches reported a benefit from the kit and used it to educate athletes on concussion.
2010	Sawyer, et al ²¹	Various sports.	CDC "Head's Up" toolkit.	Majority of users indicated that toolkit materials could be used to improve their school's concussion plan.
2010	Glang, et al ¹²	Various sports.	Use of Interactive Video.	Differences between treatment and control participants for understanding and managing concussion.
2010	Echlin, et al ³³	Ice hockey.	DVD and computer based concussion education project.	Increases over time for those participating concussion education.
2007	Gianotti, et al ²⁵	Rugby.	Educational video and concussion check tool.	Improvements over several measures with a financial benefit seen as a key outcome.
2006	Goodman, et al ²⁷	Ice hockey.	Educational video game.	Playing a video game increased participant identification of concussion.
2003	Cook, et al ³⁴	Ice Hockey.	Educational injury prevention video.	Identification of causes and mechanisms of concussion increased after use of video based information.
2003	Wesner ²⁹	Various sports.	Schools presentation and video.	Improved self reported knowledge; use of protective gear; and a positive trend toward correct responses.
2001	Gresham ²⁸	Various sports.	Curriculum integrating math, literacy, & science objectives.	Improvement scores in knowledge about the brain and spinal cord safe behaviours to prevent traumatic injury.

athlete risk of concussion. Furthermore, 22 articles directly related to education as a preventative strategy out of the 384 articles whose titles matched the inclusion/exclusion criteria.

Implementing an effective health prevention strategy requires determining key stakeholders. Results specifically targeted sports with a higher risk of concussion, namely all football codes, ice hockey and snowboarding^{7, 8}. Within these high risk sports, the most represented groups were youth (nine of 22 articles) and trained professionals, specifically coaches (seven of 22 articles). This may be due to youth being at the highest risk of receiving a concussion in sport¹¹, and coaches being responsible for educating others and incorporating

policies²¹. The results suggest that those participating in high-risk sports, youth and coaches are the most important stakeholders to provide with educational interventions. Therefore, importance should be placed on future best practice strategies tailored specifically to these groups. Other demographics and sports must also be considered, however results suggest the priority, and the most promising means of having the largest preventative impact is educational interventions specifically designed for these identified stakeholders.

Not all results demonstrated positive trends or evaluated interventions, such as one article, which evaluated online sports medicine sources of education²². Ahmed et al. concluded that the

content of online information, quality of information, and readability varied, often lacking in information quality, or being presented in a format difficult to comprehend for the intended audience. Not all online sources received similar criticism, and the benefits of online knowledge transfer, including social media may provide the most effective means of increasing awareness, and educating at a population level²². The benefits of online prevention and awareness strategies are still underrepresented in literature and Ahmed et al state that there is a need for further research in this field. This highlights the importance of addressing learning needs such as language used, and the need to standardise concussion information to ensure the quality of information transferred. Kroshus et al. reported mixed results when evaluating knowledge from 146 division one ice hockey athletes' pre, and post education. No significant changes to attitude, reporting norms or behaviour were attributable to education interventions, and results were widely varied for pre and post measures²³. Kroshus et al. reported that results were untrustworthy due to educational interventions being determined by institutions (primarily, colleges), not the governing body: The National Collegiate Athletic Association. This indicates that no consistent method for concussion education is being applied to the sport across the USA, let alone internationally. The National Collegiate Athletic Association's ice hockey legislation states that institutions have to provide concussion education. However, there are no rules on content or delivery methods²³. This research demonstrates the problem with current legislation, which supports education and awareness, yet does not provide guidelines for effective implementation. Therefore changes to legislation may be required to standardise the quality of education and assure effective implementation of prevention strategies in sporting organisations.

Three articles^{8, 23, 24}, presented educational interventions or strategies that were not evaluated. Kroshus et al. focused on knowledge transfers potential to influence the success of education. The authors present a strong argument that KT is an

important concept to consider as a tool to use in concussion education. This highlighted importance at least part of the reason for a brief review of KT and concussion education to be included in this review, with the section titled: "KT and concussion education". The study by Esquivel et al. (2013) demonstrated the differences in concussion education between sports, and identified football codes played in the USA and ice hockey as key sports where prevention is most needed. The major limitation of this research was only including these sports, all of which were already known to include concussion education, and to be high-risk sports. The study could possibly be strengthened by comprehensively analysing educational provision in other sports, age divisions, and regions. The third, and most relevant article by Viljoen & Patricios (2012) presents a joint initiative between the South African Rugby Union and the Chris Burger/Petro Jackson Players Fund titled: 'Boksmart', a national rugby safety program. The three articles were the only publications found in the current scientific literature. It appears that the organisations supporting the three studies are leading a proactive role against concussion in sports, primarily through educational programs. *Note: These initiatives are reviewed shortly.* The Viljoen & Patricios (2012) article reports on a program that is based on the most current concussion information from consensus statements, and uses a multifaceted approach to preventing concussions in South African rugby union, from grassroots to a professional level⁸. 'Boksmart' tailors education toward the rugby landscape in South Africa to maximise the programs adoption, and impact. This evidence based, nationwide approach is a potential means to provide real outcomes, however no evaluation of 'Boksmart' was found, and the impact remains unknown. The authors also highlight that even substantiated evidence based initiatives do not guarantee compliance, or assure the successful prevention of injury. Currently, 'Boksmart' appears to be the most recognised intervention in South Africa, however future research is needed to evaluate the impact of the 'Boksmart' initiative and whether there is merit in transferring its principles

to other sports.

Of the 19 articles that demonstrated positive trends for implementing concussion education, only one article evaluated the impact of an intervention. Gianotti & Hume (2007) evaluated the impact of a New Zealand initiative titled: 'RugbySmart' by analysing concussion claims over two years. The 'RugbySmart' intervention is similar to 'Boksmart' from South Africa, in that it uses a multifaceted prevention strategy (including videos and toolkits) at a nationwide level. 'RugbySmart' is shown to 99% of New Zealand rugby coaches and referees due to a compulsory requirement to view it annually²⁵. This indicates that legislation can greatly increase the adoption and awareness of prevention strategies. The results demonstrate that since the implementation of 'RugbySmart', there was an approximate 11% decrease in concussion injury health claims have been made. At the same time of this investigation, athlete numbers playing the sport increased almost 14%. Furthermore, during this period, reported concussion in the general population increased by approximately 17% and in other sports by almost 25%. This suggests in relative terms, a decrease in concussion rates, correlated to the implementation of the rugby intervention. However, correlation does not necessarily indicate causation, and knowledge differences were not evaluated. Many external factors may have contributed to these results, and further research to evaluate the interventions impact on knowledge, injury rates, and external influences on concussions are needed. This is the only known study that has evaluated impact, and the method of analysing concussion claims could be replicated in other interventions to evaluate impact factor.

The third most promising intervention that currently exists, and the most cited (three of 22 articles), is the CDC's 'Heads Up' initiative in the United States of America. This initiative was founded in response to the rise of approximately 31 US states issuing laws mandating concussion education, removing concussed athletes from play, and requiring a healthcare professional's clearance before return to play was allowed¹¹. These laws

greatly increased awareness, yet failed to include specific prevention strategies. The CDC's "Heads Up: Concussion in Youth Sports" initiative aims to resolve this issue, by providing a multifaceted concussion prevention kit for coaches. The tool kit includes a coach's guide, videos, clipboard stickers, wallet cards, fact sheets, and a CD ROM, all downloadable for free²⁶. This initiative also increased awareness, and provides evidence based education and guidelines that anyone can access.

Evaluations of the 'Heads Up' initiative have shown increases in coach knowledge, that coaches value the material, and the majority would use it to educate others through implementing concussion policies, or incorporating it into an existing one²¹. There is no evidence suggesting this intervention has an impact on concussion rates, and future research should be carried out to evaluate this gap for validation. This campaign may have great potential, but it puts ownership on coaches to implement policies and educate others. While the educational tool kit may be successful, at times accomplishments typically last as long as the coach administering the intervention remains in their position. This limitation highlights the importance of legislation to incorporate a tool kit, educational strategies, or guidelines in order for interventions to be standardised and long lasting.

All other results found in the literature indicated positive trends (17 articles), suggesting that education alone is an effective means to increase knowledge; however the educational strategies utilised varied. Two novel strategies, which require validation are educational video games, and e-learning through interactive videos^{12, 27}. These concepts both demonstrated a significant impact on increasing concussion knowledge, and may provide a fun alternative to learning for youth, and those with shorter attention spans. Therefore, a free online website including e-learning through interactive games may present an effective strategy tailored for youth. This strategy could also be incorporated into school curriculum, which has been shown to be an effective means of increasing concussion knowledge in young children, grades one to three²⁸. The process of changing school

curriculums can be challenging. That said, currently this is the only substantiated strategy of increasing concussion knowledge in young children. Thus, curriculum, or school-based interventions should be considered when targeting young children.

The remaining ten articles not included in those already reviewed, present similar educational strategies, most of which included a video, or presentation in some format. Strategies differed in terms of target audience, and the number of educational strategies used, with the majority using a multifactorial approach. Nevertheless, the articles all demonstrated significant improvements in concussion knowledge post intervention^{5, 10, 29-36}. This suggests that videos and presentations may be effective at increasing knowledge of concussion in sport, regardless of the intended audience. Currently, videos and presentations appear to be the most successful educational strategies, due to the method being validated singularly, with no other strategies or factors contributing to results^{5, 10, 31, 33, 34, 37}. Other educational strategies include: guides; fact sheets; cards; brochures; and advertisements. However, these strategies have not been validated alone and typically form part of a bigger multifaceted intervention. Therefore on current evidence, videos and presentations are the most effective method to increase knowledge and understanding of concussion in sport.

One strategy that may assist in effective learning is to ensure any video or presentation format be kept to small volume. In the education literature it has been reported that student attention decreases after approximately ten minutes of information provision³⁸. Providing a series of short videos with separate topics that highlight components of concussion may have a greater effect on knowledge retention rather than an information overload that might occur with the whole issue being addressed in a single video. This may fit well with the suggested educational and interactive video game concepts. Addressing this issue may also overcome limitations highlighted by Goodman et al. (2006) to avoid the creation of games that become boring and subsequent loss of interest and Glang et al. (2010) the need for short communicative video

tools.

Results from 19 of the 22 articles suggest that education alone can increase knowledge of concussion in sport, particularly in youth, and coaches involved with high risk sports. This may in turn lead to a decrease in concussion rates, increasing concussion identification, and improving concussion management. However, this cannot be conclusively stated due to only one article suggesting that as a result of the intervention, an increase in knowledge on concussion and at the same time showing a reduction of incidences²⁵. Therefore, education as the sole prevention strategy to decrease concussion in sport cannot be recommended. Due to the lack of validated educational strategies, the current literature suggests that a multifaceted intervention is the most promising method to cater for different learning needs. The existing literature is not diverse enough to determine specific demographic learning needs, and therefore a multifaceted initiative would provide a platform to validate specific educational strategies.

CURRENT RECOMMENDATIONS:

When considering a best practice educational intervention, all factors must be considered. Recommendations must be based on literature evaluating current educational prevention strategies, as well as the current prevention guidelines from key sporting bodies, and by addressing other successful prevention strategies such as legislation, and knowledge transfer. The most recognised current guidelines for concussion education come from the 4th International Conference on Concussion in Sport and the American Medical Society for Sports Medicine. Both sources suggest a multi-factorial approach to educational strategies by also recognising the importance of knowledge transfer strategies, and legislation³.

Guidelines include providing evidence based best practice educational initiatives with KT strategies to educate key parties (coaches, athletes, parents, officials, schools, and healthcare providers), to improve concussion recognition; management; and

prevention¹³. However, no specific or conclusive suggestions were made as to which educational strategies or knowledge transfer models should be utilised, only that education should be tailored to specific groups.

LEGISLATION AND CONCUSSION EDUCATION:

Education alone may never be able to increase widespread awareness, or normalise practice. The current guidelines recommend incorporating legislation as a prevention strategy, which may lead to the standardisation of educational interventions, and the culture of sports concussion. This is an important first step to increase the effectiveness of education. One of the most well known legislations is the Lystedt Law, which provides concussion guidelines and authorises return to play medical clearance for all concussions received on public fields⁶. Following this legislation, many other states in the US have passed similar laws, however few have been evaluated for effectiveness.

The Lystedt law brought about partnerships between numerous sporting bodies with some of the prominent members being: The Brain Injury Association; CDC; National Collegiate Athletic Association; National Federation of State High School Associations; USA Football; and USA Lacrosse¹⁷. The law and the collaboration of these organisations undoubtedly increased concussion awareness and standardised return to play guidelines in Washington³⁹. The success of this law warrants the inclusion of similar efforts in all countries. When similar laws exist, then long-term educational policies can also be incorporated to normalise best practice education. Currently education alone has demonstrated inconsistencies and knowledge deficiencies, with varied understanding and policies for individual institutions, and professionals¹⁷. The first step in remedying this issue is to implement, validate and evaluate laws alongside education.

KNOWLEDGE TRANSFER AND CONCUSSION EDUCATION:

Similar to legislation, KT has been recommended by the 4th consensus statement on concussion in sport as an effective prevention strategy³.

Knowledge transfer is defined as:

The exchange, synthesis and ethically sound application of knowledge within a complex system of interactions among researchers and users to accelerate the capture of the benefits of research; improved health, more effective services and products, and a strengthened healthcare system³⁹.

Knowledge transfer refers to providing the correct and most up to date information to the right people, in a format specifically adapted for those people, in order to effectively increase knowledge and influence decisions⁴¹. Knowledge transfer relates closely with education and focuses on educational strategies that work specific to different groups. Target audiences for education benefit from different strategies, and KT can help in identifying knowledge gaps, developing appropriate strategies, evaluating strategies and facilitating desired outcomes³. There is currently insufficient appropriate KT in society and the learning needs and policies for physiotherapists, athletic trainers, coaches, student athletes and other stakeholders are not uniform, or being addressed appropriately².

The action cycle is a KT model, which has seven steps in preparing suitable educational strategies for stakeholders⁴⁰. The authors explain that the action plan KT framework has been used to determine optimal educational plans for physiotherapists and athletic therapists, including evidence-based practice, socialisation and peer-assisted learning; as well as coaches who learn best from reflective processes. Therefore KT frameworks and strategies should be incorporated with educational interventions to ensure the learning needs of different demographic groups are met, so that desired outcomes are achieved.

LIMITATIONS

There is a severe lack of literature in this field, with only 19 of 22 articles evaluating education interventions to prevent, or increase knowledge of concussion in sport, between 2001 and 2014. The major limitation is that only English language databases were comprehensively searched. Perhaps expanding the search to libraries, other language databases, and the World Wide Web would yield more evaluations relevant to this review. It is unlikely however that further sources would significantly influence results due to the scarcity of literature. Due to insufficient literature, it is difficult to conclusively present an effective best practice intervention for each sporting demographic. It is possible however to report on positive current trends, and present guidelines to achieve a current best practice intervention to incorporate into future research, where validation and impact evaluation are needed.

RECOMMENDATIONS FOR IMPLEMENTING EDUCATIONAL STRATEGIES:

From this review of the literature, the following recommendations are proposed guidelines to use when implementing an educational prevention strategy for concussion in sport. These points are based off the most up to date guidelines from key sporting bodies, current intervention evaluations, and external prevention strategies which may improve the impact of education. The guidelines are intended to create, and implement a current best practice educational prevention strategy for concussions in sport:

1. Target key stakeholders including youth athletes and healthcare professionals, specifically coaches.
2. Target those involved in high risk sports, in particular football codes, and ice hockey.
3. Use the action plan KT framework when designing an intervention.
4. Tailor the program to individual, or group learning needs.
5. Incorporate a multifaceted intervention including

- a range of educational strategies.
6. Strategies should include video education, and some form of presentation.
7. Incorporate a means to validate the effectiveness of the intervention, for knowledge and injury rate outcomes.
8. Use injury claims to evaluate changes in injury rates.
9. Implement standardised institutional and individual policies for long lasting impacts.
10. Intervene prior to, or at the commencement of the sporting season for greatest benefits.
11. Regularly review and update the intervention based on the most recent advances of scientific literature.

FUTURE RESEARCH RECOMMENDATIONS:

It is clear that evidence based practice for concussion education practices is far from conclusive. The following are recommendations for future research to fill literature gaps, and provide effective prevention strategies working towards decreasing concussion rates in sport:

1. Strengthen results from this review by expanding the search, and completing a meta-analysis of current literature.
2. Implement interventions specifically targeted to different sports, age groups and demographics.
3. Comparative research to evaluate individual educational strategies.
4. Follow up current knowledge outcome evaluations with concussion rates, impact and cost evaluations.
5. Evaluate the incorporation of KT, and legislation into educational interventions.
6. Validation of South Africa's 'Boksmart' initiative and the CDC's 'Heads up' initiative.
7. Incorporate the CDC's 'Heads up' initiative into legislation.

CONCLUSION:

Considering the level of concern for concussion in sport, it is surprising that during the review of current literature there were only 22 research articles found that report preventative scientific endeavours to overcome this health issue. This concern is especially poignant when the Centre for Disease Control states that sport related concussion rates are epidemic. Furthermore, no published research was found for investigations into concussion education in boxing and similar vein (combative) sports. This indicates the possibility of future research into education interventions for hitting sports.

This review considers what was found in the literature regarding all current scientific information surrounding educational prevention to provide information that should lead to best practice guidelines to incorporate successful interventions. The indication is that educational interventions are an effective strategy to increase concussion knowledge in sport. However using education alone to decrease concussion rates cannot be recommended due to insufficient scientific evidence. Therefore, multifaceted initiatives incorporating multiple educational strategies, legislation, and knowledge transfer targeted toward individuals involved in high risk sports, specifically youth athletes and coaches is recommended to provide a platform to validate the outcome effectiveness of such initiatives. Furthermore, future research recommendations have been provided to fill identified gaps in the literature. It must be highlighted that initiatives do not necessarily guarantee compliance that results in injury prevention. Successful evidence based interventions that change the culture of sports concussions by becoming standard practice would increase chances of reducing this health issue. By highlighting this and making others aware, an engagement by education for action will underline the importance of this health concern, and influence health professionals to undertake research in this field.

CONFLICT OF INTEREST:

The authors declare no conflict of interest.

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