Systematic Review

ANNALS OF MEDICINE & SURGERY

OPEN

Prevention of sports-related concussion in soccer: a comprehensive review of the literature

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Introduction: Concussion is a common complaint among adult and adolescent athletes around the world and poses a safety risk in competitive, recreational, and noncontact sports. It is estimated that concussions occur at a rate of 0.5 per 1000 playing hours; however, the precision of this estimate is uncertain due to variations in the interpretation and reporting of concussions. Athletes with a history of concussions are more likely to sustain additional concussions, which can result in cognitive decline, depression, and early degenerative change. In order to lessen the likelihood of future difficulties, this study compiles the research on preventing sports-related concussion in soccer and presents a summary of the findings.

Material and Methods: We performed a literature search on PubMed, EBSCO (Elton B. Stephens Company), DOAJ (Directory of Open Access Journals), and Cochrane for the past 20 years. The search strategy was using Boolean terms based on any of the search terms of sports-related-concussion, soccer, and prevention. The studies were included based on inclusion and exclusion criteria.

Results: This research identified three systematic reviews, seven literature reviews, five cross-sectional studies, one randomized controlled trial, three prospective studies, and one retrospective study. As concussion prevention measures in soccer, several strategies can be implemented, including concussion education, rule/regulation changes, proper heading technique, behavioral skills training, vision training to improve sensory and anticipation, the use of supplements to prevent severe concussion and accelerate recovery, as well as prevention in youth sports and head impact detection.

Conclusion: Good education, good technique, good training, and a good strengthening program can be implemented to prevent concussions in soccer. To determine the relationship between prevention and concussion, however, additional research is required.

Keywords: prevention, soccer, sports-related-concussion, recommendation

Introduction

Globally, adult and adolescent athletes regularly report sports-related concussions (SRCs), which pose a safety concern at the competitive and recreational levels of contact and noncontact sports[1]. A concussion may result from a collision, blow, or shock to the head or body that causes the head and brain to move rapidly back and forth. These rapid movements may cause the brain to bounce or spin inside the skull, which can alter its chemical properties[2].

Head/neck injuries account for 4–22% of all soccer injuries at a rate of 1.7 per 1000 playing hours. The rate of concussions in sports is believed to be 0.5 per 1000 playing hours, although its accuracy is limited by differences in the diagnostic criteria and documentation of head injuries. Faude *et al.* evaluated injuries to young soccer players (ages 5–19) and found that 5% of all injuries in these age groups were to the head. In a more recent online survey of 8104 youth soccer teams with 101 699 players aged 7–14 years old, the overall concussion incidence rate was 0.85/1000 athlete exposures (AEs). Games were 5.7 times more likely than practices to result in concussions (1.73/1000 AEs vs. 0.27/1000 AEs)[1].

The effects of concussions on an athlete's memory, reaction time, and balance are well established from a clinical standpoint. Furthermore, athletes with a history of concussions are more likely to sustain subsequent concussions, which can result in cognitive decline, depression, or early degenerative change, such as chronic traumatic encephalopathy[1]. This in-depth analysis summarizes the research on SRCs, including suggestions for avoiding future problems.

HIGHLIGHTS

- Sports-related concussion due to ball heading in soccer.
- Using headgear and proper training, such as proper heading technique and neck strengthening, could prevent concussions in soccer.
- Education and restrictions on heading could reduce the incidence of future soccer-related concussions.

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Annals of Medicine & Surgery (2023) 85:365–373

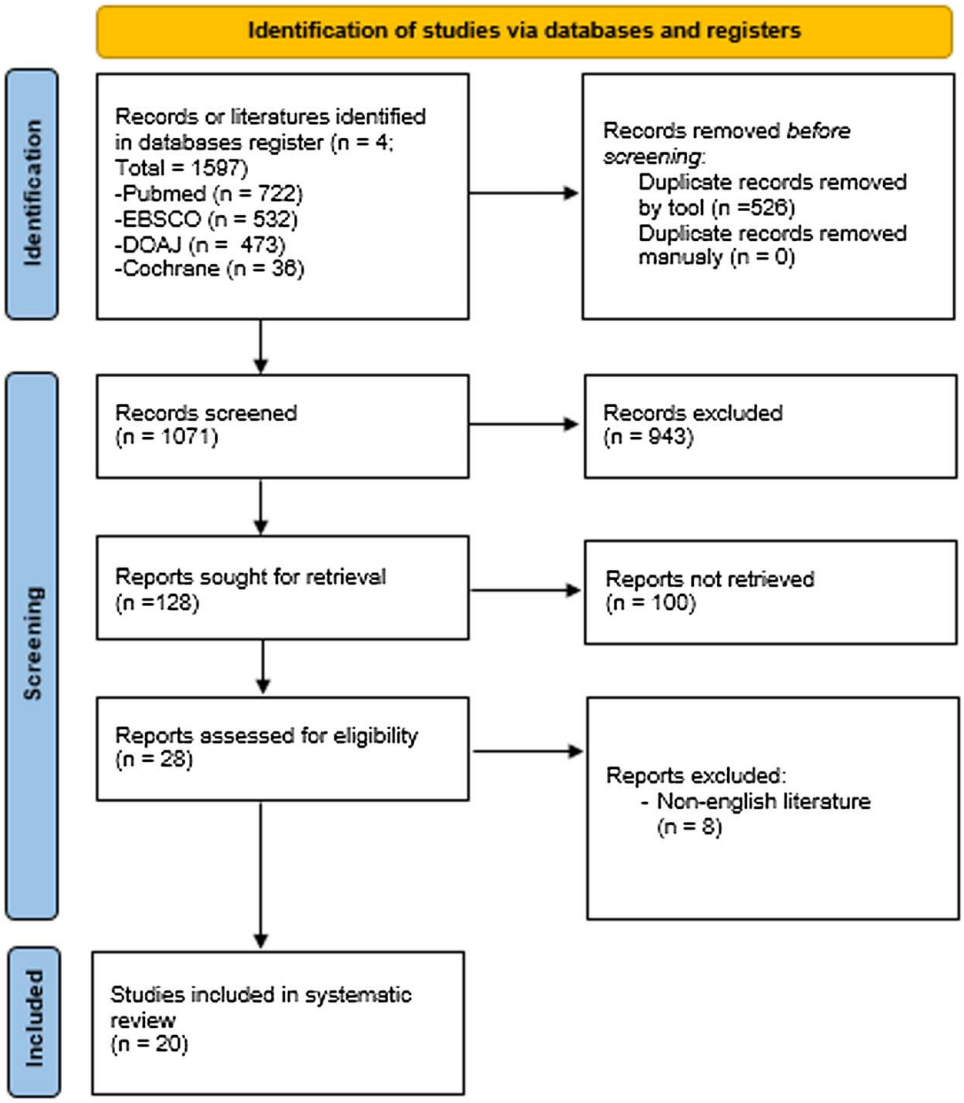
Received 24 September 2022; Accepted 26 January 2023

Published online 24 March 2023

http://dx.doi.org/10.1097/MS9.0000000000000268

Table 1

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) of included studies



Materials and methods

Search strategy

This study used search strategy based on the guideline of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020, as shown in Table 1[3]. Articles were retrieved from PubMed, EBSCO (Elton B. Stephens Company), DOAJ (Directory of Open Access Journals), and Cochrane databases from 2000 to 2022. The keywords used were based on the terms 'prevention' AND 'sports-related-concussion' AND 'soccer'.

Eligibility criteria

The lead author (S Indharty) manually assessed the applicability of each paper, with the consent of all other study authors. The articles that met the following criteria were selected for a comprehensive evaluation.

Inclusion criteria

The selected publications included randomized controlled trials, prospective research, retrospective research, descriptive, and review that were published in English. The sport assessed in this review is soccer.

Exclusion criteria

Case series and case reports were omitted from this analysis.

Critical appraisal

A thorough evaluation of the selected studies was the next step. Articles with critical issues unrelated to the prevention of SRC in soccer are excluded if they do not meet the inclusion criteria.

Table 2

Studies enrolled in this systematic review

Study	Year	Participants/ studies/ events	Study type	Study name	Summary	Reference
Cooney*et al.*	2022	22 studies	Systematic review	Head and neck characteristics as risk factors for and protective factors against mild traumatic brain injury in military and sporting populations: a systematic review	Neck characteristics, such as neck strength and head and neck size, are associated with protection from mild traumatic brain injury (mTBI/ concussion). Variable head–neck strength and size occasionally with protection against mTBI events and reduced kinematics	[5]
Makovec Knight *et al.*	2021	8 studies	Systematic review	Soft-shell headgear, concussion and injury prevention in youth team collision sports: a systematic review	Headgear use was not associated with decreased SRC incidents or superficial head injury in young athletes.	[6]
Tjønndal and Austmo Wågan	2021	18 studies	Literature review	Athletes' and coaches' attitudes toward protective headgear as concussion and head injury prevention: a scoping review	The use of headgear is believed to prevent concussion. However, there is still a difference between what is beliefs and its implementation	[7]
Jeffries *et al.*	2020	223 participants	Cross-sectional	Concussion-prevention strategies used in National Collegiate Athletic Association Divisions I and II women's soccer	Cervical-strengthening programs are believed to be a good strategy to prevent concussion, but their implementation is still lacking compared to the use of headgear which is not believed to reduce concussion. The use of a mouthguard cannot reduce the risk of concussion but can protect the teeth and mouth after head impact. Approaches through nutritional intervention are believed to be able to reduce postconcussion adverse effects, which still require further research	[8]
Feiss *et al.*	2020	13 studies	Systematic review	A systematic review of the effectiveness of concussion education programs for coaches and parents of youth athletes	Concussion education programs increase concussion knowledge among coaches and parents and promote behavioral changes among coaches that can reduce the prevalence of concussions in high school sports	[9]
Daugherty *et al.*	2020	2047 participants	Cross-sectional	Concussion experiences in New England private preparatory high school students who played sports or recreational activities	Much effort needs to be made to develop strategies to improve knowledge, attitudes, and behaviors related to concussion. This can be done by increasing knowledge about the risks and dangers of concussion in order to increase awareness, guiding athletes to follow the rules when competing, this can be assisted by referees and sports officials in enforcing safe standards of play when competing	[2]
Kung *et al.*	2020	NA	Literature review	The effects of anticipation and visual and sensory performance on concussion risk in sport: a review	Anticipation of head impact has been shown to help reduce linear and rotational head acceleration, particularly for head impacts of mild to moderate severity, but less so for severe head impacts. Visual and sensorimotor performance and oculomotor behavior have an influence on reducing the risk of concussion	[10]
Lalji *et al.*	2020	7496 cases	Cross-sectional	The 2015 US Soccer Federation header ban and its effect on emergency room concussion rates in soccer players aged 10–13	Regulations regarding the prohibition of headings in soccer games at the age of 10–13 years may not reduce the incidence of concussion in this population. However, this is likely to be increased by the increase in reporting of concussion cases as a result of increased concussion education	[11]
Mooney *et al.*	2020	64 studies	Literature review	Concussion in soccer: a comprehensive review of the literature	There have been several attempts to reduce the prevalence of soccer-related concussions through the use of headgear, heading restrictions, strength training and player education, and limiting athlete contact during soccer practice and play	[12]
McGuine *et al.*	2020	2766 participants	RCT	Does soccer headgear reduce the incidence of sport-related concussion? A cluster, randomized controlled trial of adolescent athletes	Soccer headgear does not reduce the incidence of SRC in the overall sample of high school football players	[13]
Waltzman and Sarmiento	2019	18 studies	Literature review	What the research says about concussion risk factors and prevention strategies for youth sports: a scoping review of six commonly played sports	Regulations to limit player-to-player contact can help prevent concussions and other injuries. Regulations regarding the prohibition of tackling and kickoffs in football can also reduce the risk of concussion. In addition, increased education about concussion and basic playing techniques can also help prevent concussion	[14]
Quintero *et al.*	2020	5 participants	Prospective	Reducing risk of head injury in youth soccer: An extension of behavioral skills training for heading	BST increases the percentage of correct moves for each player based on an analysis of heading assignments. BST can increase the ability of correct heading from the beginning/basics. A good and correct heading technique can reduce the incidence of concussion	[15]
Beaudouin *et al.*	2019	NA	Retrospective	Head injuries in professional male football (soccer) over 13 years: 29% lower incidence rates after a rule change (red card)	After the rule change that introduced red cards in 2006, the overall number of head injuries decreased. Most head injuries in professional men's soccer are caused by head-to-head and elbow–head contact. After the rules changed, the incidence rate for elbow–head incidents decreased	[16]
Press and Rowson	2017	26 participants	Prospective	Quantifying head impact exposure in collegiate women's soccer	Head impact measurement data using accelerators must be careful when interpreting head impact sensor data in the field	[17]
Caccese and Kaminski	2016	18 studies	Literature review	Minimizing head acceleration in soccer: a review of the literature	Headgear can decrease head acceleration during high impact, but this can cause the athlete to hit the ball harder and play more dangerously	[18]
Catenaccio *et al.*	2016	48 participants	Prospective	Validation and calibration of HeadCount, a self-report measure for quantifying heading exposure in soccer players	HeadCount as a self-administered questionnaire, for long-term exposure assessment headings can be used to index exposure in study populations and, once generalizable safe exposure thresholds have been delineated, can be disseminated to monitor exposure and minimize risk	[19]
Faude *et al.*	2013	32 studies	Literature review	Football injuries in children and adolescent players: are there clues for prevention?	There are three main areas that are particularly relevant for future injury prevention. Prevents injury during matches, reduce the risk of falling while playing, and influences of physical maturation status and growth spurts	[20]
Niedfeldt	2011	NA	Literature review	Head injuries, heading, and the use of headgear in soccer	Headgear has not been shown to be effective at reducing ball impact but may help reduce impact forces that are not associated with the ball to the head	[21]
Naunheim *et al.*	2003	NA	Cross-sectional	Brief Reports: Does soccer headgear attenuate the impact when heading a soccer ball?	Headgear currently available for soccer headings demonstrates some ability to absorb impacts during soccer heading simulations	[22]
Babbs	2001	NA	Cross-sectional	Biomechanics of heading a soccer ball: implications for player safety	Heading is usually safe but sometimes can be dangerous, this depends on the main characteristics of the player and the ball	[23]

BST, Behavioral Skill Training; mTBI, mild traumatic brain injury; NA, not applicable; RCT, randomized control trial; SRC, sports-related concussion.

Data extraction

Data extraction is the procedure by which all relevant findings that meet the selection criteria are compiled to form a body of evidence pertaining to the stated research issue. Based on A MeaSurement Tool for Assessment of multiple systematic Reviews (AMSTAR) 2[4], we stated the level of compliance was moderate.

Result

We found 1597 articles after searching the PubMed, EBSCO, DOAJ, and Cochrane databases. After title and abstract screening, there were 128 articles left. Following full-text screening, 20 studies were selected for inclusion in this study. This research identified three systematic reviews, seven literature reviews, five cross-sectional studies, one randomized controlled trial, three prospective studies, and one retrospective study (Table 2). The research identified studies on education, regulations/rules, use of headgear, anticipation, heading restriction, cervical-strengthening programs, visual–sensory–motor training programs, future injury prevention in young players, and head impact detection, particularly in soccer[24].

Even though great progress has been made in detecting and treating concussions, less is known about their primary prevention. Basic concussion prevention strategies must be investigated in greater depth to protect the health and safety of high-risk groups. The risk of concussions is especially high in contact sports like American football, soccer, and hockey[24–26].

General prevention

The use of helmets/headgear, proper heading technique, proper tackling technique, limiting contact training during training, enforcing rules that prohibit collisions with the head and other potentially unsafe behavior, changing to regulations, fair play, cervical spine strengthening, and neuromuscular training are some of the precautions that can be taken[6]. Mooney *et al*. assert that it is unclear how headgear, heading restrictions, strength training, and player education affect concussion rates. Mastoid sensors, rangefinders, and other cutting-edge technologies will be used in the future for more precise monitoring of concussion severity and frequency. This will enable us to better comprehend them and, ultimately, prevent soccer concussions. For example, limiting an athlete's contact during soccer practice may have a greater impact on concussion rates than limiting the heading of the ball[12].

Good education about SRC in soccer

Good concussion education can reduce the risk of concussions[14]. This escalating health issue can be mitigated through targeted measures if the underlying cause is understood[27]. A number of concussion education initiatives have been created to increase athlete safety. These activities generally include presentations by medical professionals, fact sheets, or videos[28]. In order to receive treatment and reduce the risk of long-term consequences, it is essential to be aware of the symptoms and signs of concussion and to notify parents, coaches, and medical professionals of any potential injuries[29]. Additionally, concussion education programs help parents and coaches learn more about the condition and encourage coaches to modify their behavior, both of which can help reduce the incidence of concussions in high school sports[9]. To develop methods for enhancing concussion-related knowledge, attitudes, and behaviors will require considerable effort. This can be accomplished by increasing awareness of the risks and dangers of concussion and guiding athletes to follow the rules when competing. Referees and sports officials can assist in enforcing safety standards of play when competing[2].

Regulations to limit player-to-player contact

In order to prevent concussions in sports, it is essential to promote strategies that have been shown to reduce this risk. Two examples of concussion prevention measures for sports include implementing contact restrictions that reduce collisions and altering rules to make the sport safer[29]. To reduce the risk of concussion among young athletes, training rules must be modified to restrict player-to-player contact[30]. Limiting player-to-player contact can aid in preventing concussions and other injuries. In football, regulations prohibiting tackling and kickoffs can also reduce the risk of concussion[29]. The overall number of head injuries decreased after the introduction of red cards. In professional men's soccer, head-to-head and elbow-to-head collisions are the most common causes of head injuries. The incidence of elbow–head incidents decreased after the rules were modified[16]. According to a study conducted by Lalji *et al*., regulations prohibiting headers in soccer games for children ages 10–13 may not reduce the incidence of concussions in this population. However, this may occur for a number of reasons, including the increased reporting of concussion cases as a result of increased concussion education[11].

Cervical-strengthening programs

According to the study by Jeffries *et al*., cervical-strengthening programs are a good strategy for preventing concussions, but their implementation is lagging behind that of headgear, which is not believed to reduce concussions. A mouthguard cannot reduce the risk of concussion, but it can protect the teeth and mouth after a head impact. It is believed that nutritional interventions can mitigate the negative effects of postconcussion syndrome. This difference may be attributable to the length of time required for the cervical-strengthening program to demonstrate results, as well as the history of previous concussions[8].

Neck strength as well as head and neck size are head and neck physical characteristics associated with protection against mild traumatic brain injury (mTBI)[5]. mTBI protection and altered impact kinematics are occasionally associated with head–neck size and strength variations. According to a correlation between size and neck strength, a one-pound increase in neck strength reduces the risk of mTBI in high school athletes by 5%[31]. When comparing the sexes, neck strength significantly reduces the angular acceleration and displacement of the head during a disturbance[5].

The use of headgear/helmet

Regarding its effectiveness in preventing concussions, the use of protective equipment such as headgear is still a matter of debate. A study conducted by Tjønndal and Austmo Wågan.[7] stated that even though there are still differences between belief and implementation, headgear can prevent concussions. Another

study conducted by Caccese and Kaminski[18] stated that headgear could reduce head acceleration during high impact. However, McGuine *et al*.[5]. and Makovec Knight et al.[32]. found that headgear did not diminish the incidence of concussion. In addition, the use of headgear is believed to encourage reckless play. Another study conducted by Niedfeldt[21] and Naunheim *et al*. also found that the headgear could not reduce the impact but could help reduce the severity of the impact.

Heading restrictions

Heading restrictions are another effort to reduce the incidence of future SRCs[12]. Unintentional or unprepared heading of the ball can result in a head injury[16]. To prevent concussion, it is necessary to learn the proper heading technique, one of which is Behavioral Skill Training (BST), because this method is more acceptable and memorable. Based on an analysis of heading assignments, BST raises the proportion of correct moves made by each player. BST is regarded as an effective method for learning soccer-specific skills. A proper heading technique can reduce the incidence of concussions[15]. According to Babbs, heading is generally safe but can occasionally be hazardous, depending on the player and the primary characteristics of the ball. It depends on the fundamental qualities of the player and the ball. When a player heads the ball with a greater effective body mass, which is influenced by the player's size, strength, and technique, the level of safety is significantly enhanced. Even with today's youth-sized balls, smaller, younger players are more susceptible to potentially dangerous headers due to their lower body mass[5].

Visual and sensorimotor training programs

According to a study by Kung *et al*., there may be a correlation between visual performance, oculomotor behavior, and anticipation, especially in highly talented athletes, and the frequency and severity of head injuries. Vision training can therefore be a useful method for enhancing eye control, gaze behavior, and visual and sensorimotor performance in order to enhance anticipation to prevent collisions and reduce the risk of concussions. Anticipation and the capacity to rapidly integrate visual cues and generate appropriate responses are predicted to be advantageous in reducing the risk of direct head contact. Improved visual–motor control and oculomotor performance enable players to anticipate head collisions, which appears to reduce the severity and frequency of head impacts. Improved visual–motor control and oculomotor performance enable players to anticipate collisions, which appears to reduce the severity and frequency of head hits. Sports vision training is a promising strategy for enhancing visual–motor control and eye speed, which may help reduce the risk of concussion. The effectiveness of a visual and sensorimotor training program can reduce the risk of concussion in a variety of sports[10].

Future injury prevention in youth soccer

In addition, Faude *et al*. identified three crucial areas for future research on injury prevention in young soccer players. Priority should be given to the number of severe contact injuries sustained during a match. By enforcing game rules and promoting fair play, injuries resulting from risky play or cheating may be reduced. The high incidence of fractures among younger athletes is a further cause for concern. Implementing specific preventive training that emphasizes improving balance, coordination, or neuromuscular performance could be one way to reduce the risk of falling. The influence of physical maturity and growth spurts should be the third focus area. In youth soccer, players with varying stages of biological maturity but the same age typically play together. Consequently, some athletes lack the physical maturity of their more experienced teammates and competitors. The influence of relative age on the talent selection procedure has been discussed ad nauseam. This effect refers to the asymmetry in the birth date distribution of the teams, which favors players born earlier in the election year. Although this problem has been known for some time, there is no solution. In addition to talent selection and performance, it is plausible to assume that the relative age effect influences injury risk and player characteristics[20].

Head impact detection

In a study by Press and Rowson, head impact exposures were measured in soccer players using a linear accelerometer sensor worn on the mastoid and compared to video-recorded impact exposures. It was discovered that the total number of impacts detected by the sensors was significantly greater than those identified by video analysis. Future improvements in the sensitivity and specificity of monitoring technology may permit the early detection of probable head impacts during competition. This test is performed to determine the correlation between acceleration and head injury. This future measurement is anticipated to be able to detect head injuries and assess the risk so that they can be avoided[17]. Additionally, it is essential for monitoring heading behavior. This requires a method for testing the behavior of headings, specifically HeadCount. HeadCount can be self-administered as a questionnaire for evaluating long-term exposure. Once generalizable safe exposure limits have been established, HeadCount can be distributed to monitor and reduce exposure[19].

Discussion

All athletes are susceptible to concussions as sports injuries, irrespective of their skill level. The 5th International Conference on Concussion in Sport defined SRC as a traumatic brain injury caused by biomechanical stresses to the head or body, which ultimately results in functional impairment and temporary neurologic deficits[33]. Concussions have been connected to a wide range of characteristics, such as prior head trauma, age, education, competitive level, attitude, gender, unexpected collision, neck stiffness, emotional risks, cervical strength, and cervical circumference[2].

Concussion awareness, understanding, and reporting behaviors arise as a result of concussion-related knowledge, perception, and external psychosocial aspects. On the basis of previous research, it has been determined that additional efforts are required to develop strategies to improve concussion-related knowledge, attitudes, and behaviors. While high school students and athletes, particularly adolescent athletes, have a high level of awareness and knowledge of concussions, additional research has revealed that adolescent athletes tend to 'underestimate' the danger and impact of concussions. Therefore, it is essential that athletes fully understand the negative effects that concussions can have on their physical, academic, emotional, and social health[2]. Although knowledge and awareness of concussions have

increased among both athletes and nonathletes in recent years, additional measures are necessary to reduce the risk of concussion among young athletes, such as rule modifications and a reduction in player-to-player contact during training. This preventive measure will be especially beneficial for young athletes who engage in contact or collision sports such as soccer, ice hockey, and American football. By identifying and evaluating these preventive measures, concussions can be avoided[30].

In 2006, the International Football Association Board amended the game's rules so that intentional and direct 'elbows to the head' were punished with a red card. This modification was made in response to an analysis of the injury mechanism underlying FIFA World Cup head injuries (1998–2004). With the introduction of red cards in 2006, the total number of head injuries decreased by ~29%, lacerations/abrasions decreased by 42%, concussions/traumatic brain injuries by 29%, bruises by 18%, and facial fractures by 16%. The mechanism of elbow–head injury dropped significantly by 23%. The most common cause of head injuries is physical contact with other players (as opposed to contact with the ground, posts, etc.). The incidence rate of head injuries decreased after the rule change, while the proportion of contact-related injuries remained high. It is likely that there was more contact for fair play during header duels after the rules were changed, but because player contact is such an integral part of soccer, it is impossible to minimize or eliminate it. Before and after the game shift, head-to-head contact is the most common method, followed by elbow–head and foot–head contact[16,33].

This contradicts the findings of research conducted by Lalji *et al*. Following the rules prohibiting heading in soccer games between the ages of 10 and 13, the incidence of concussions in this age group was not reduced. However, this is likely to increase as a result of the rise in concussion cases reported as a result of increased concussion education. Also consider that prohibiting headings may not necessarily reduce soccer contact significantly because other types of contact besides headings can occur and increase the risk of concussion[24]. Brain trauma may result from both direct and indirect contact with the head. Concussions are a prevalent occurrence in a variety of sports, with athletes' collision (particularly tackling) being a leading cause. Physical altercations between athletes are an inevitable part of contact and crash sports. Therefore, conducting a study into how to avoid accidents is crucial. Changing the rules of youth sports could have the biggest impact on public health by reducing the number of concussions that occur in these games[24].

The use of protective headgear has been suggested as a means of reducing the force exerted on the head and thereby reducing the risk of concussion. Although it has not been demonstrated that headgear can effectively reduce the impact of the ball, it may be able to reduce the impact of other forces. The widespread use of headgear is feared to provide players with a false sense of security, encourage more aggressive play, and increase the risk of injury[21]. It has been suggested that the capacity to withstand forces delivered directly or indirectly to the head could serve as a preventative measure against concussions and traumatic brain injury[24]. Unpredictable ball contact and head-to-head impact generate the highest head-to-head acceleration. High-velocity ball collisions have the potential to be hazardous. The risk of concussion can be reduced by wearing protective headgear[18]. Despite the widespread belief that headgear can prevent concussions, there are still a significant number of athletes who do not wear it. This is due to the inconvenient and unattractive nature of wearing headwear. This demonstrates that there are differences between beliefs, athlete behavior, and coach behavior regarding the recommendation of protective headgear. Although most athletes in the majority of the researched literature believe that headgear protects against concussions and other head injuries, relatively few athletes admit to wearing this headgear unless competition regulations require it[7]. While many believe that wearing a helmet prevents concussions, some studies contradict this belief. In previous studies, most coaches and officials believed that protective equipment, such as helmets, could prevent SRC. According to previous research, coaches who had received concussion education were less likely to believe that headgear could prevent SRC. Additional research has shown that protective equipment such as helmets and mouth guards can prevent superficial head injuries but do not reduce the relative risk of SRC[33]. In the study conducted by Withnall *et al*., who evaluated three types of headgear concluded that none of the three headgear tested appeared to be very effective in reducing the impact of ball contact, whether intentional or unintentional. In some instances, wearing headgear yields slightly inferior results compared to going without. This is due to the fact that the ball is deformed by more than ten times the thickness of the tested headgear. The headgear modifies the head's radius, which increases the head's moment of inertia and the moment of the spherical arm. When placed between two rigid objects, headbands can reduce head injuries by up to 33%, according to the study. In light of this, it can be asserted that headgear can be advantageous in collisions involving individuals who are not carrying a ball, such as elbows to the head with improper objects[21,34].

In soccer, players can deliberately direct the ball with their heads, a technique known as 'heading.' Normal ball heading is associated with altered brain structure, increased biochemical markers of brain injury, and diminished neuropsychological function. Others argue that this deficit is the result of undetected and misdiagnosed head injuries among soccer players[18]. Depending on the player and ball's primary features, heading is typically safe but also can be dangerous[21]. Player-to-player contact remains the leading cause of concussions in youth soccer. This suggests that prohibiting heading the ball may not have a significant effect on reducing contact in soccer[11]. Athletes should be taught proper heading techniques in a safe environment using well-planned skill development[18]. Recent research demonstrates that BST is an effective method for teaching soccer-specific skills. BST training results in the robust acquisition of the trained behavior, followed by the behavior's long-term maintenance. According to a 14-step task study, the increase in the total percentage of correct steps to execute the correct header demonstrates that BST is an effective technique for enhancing the correct heading technique. The primary investigator taught the 14-step task analysis using the BST for each step. Before reading and discussing in depth each step of the task analysis with each player, the researcher provided verbal instructions at each stage of the task analysis[15].

When a player heads the ball with a greater effective body mass, which is influenced by the player's size, strength, and technique, the level of safety is significantly enhanced. Younger, smaller players are more susceptible to potentially dangerous headers than adults, even when using today's youth-sized balls, due to their lower body masses. A lower ball inflation pressure reduces the probability of dangerous head acceleration. Additionally, low-pressure balls have superior 'touch' and

'playability,' which are determined by the duration and area of contact between the foot and the ball during a kick. By emphasizing the teaching of proper technique, adapting balls for young players with reduced weight and inflation pressures, and avoiding head contact with rising, quickly kicked balls from close range, the risk of concussion can be significantly reduced[23]. The majority of SRCs are caused by heading. According to research, the greatest risk for concussion is not necessarily associated with heading the ball (i.e., the impact when the ball hits the head), but rather with the possibility of colliding with another athlete in midair or from an aerial position. The degree of concussion associated with a heading may also be affected by variations in ball characteristics, such as ball mass and pressure[29].

Reducing linear and angular acceleration is the initial step in mitigating damage risk. This review provides several recommendations for reducing linear and angular acceleration, which may be crucial for adolescents and athletes recovering from head injuries sustained in competitive soccer. These recommendations include improving head–neck–torso alignment, enhancing follow-up, preventing unintentional head-to-head and ball-to-head collisions, increasing the strength of the neck flexors and extensors evenly, and improving neuromuscular control. Younger athletes, especially those with a greater head-to-body ratio, must avoid heading the ball at all costs. Both their lack of a neck and their small head size are notable[18].

For increased sport specificity, head acceleration has also been measured during training for tackling and heading the ball. As teeth clenching activates the greater masseter muscle, which is thought to promote neck and head stability, these studies utilize teeth clenching as a type of anticipation[10]. Balance and postural control are essential for preventing soccer injuries. Higher postural control was found to be one of the most influential factors on technical skill performance under the pressure of competitors and rapidly changing situations. In order to enhance branch-specific technical skills and increase the success rate of their performance in the game, it is recommended that balancing training be performed in addition to their use in injury prevention[35]. Due to their strength, these athletes are at risk for brain damage. To practice a targeted heading technique with a light ball under minimal pressure, athletes should have the ball thrown at them slowly if they wish to head the ball, regardless of their size-related risk factors. Finally, while a helmet can lessen the impact of head-to-head collisions, it may also encourage players to take greater risks by giving them a sense of more confidence in their protection[18].

Neck stiffness and latency of neck muscle contraction have been identified as modifiable factors that provide dynamic head and neck stabilization, thereby reducing the risk of concussion[10]. Collins *et al.* discovered a significant correlation between neck strength and size in the prevention of mTBI in high school athletes, indicating that the risk of mTBI decreased by 5% for every pound of increased neck strength[31]. Neck strength significantly reduces head angular acceleration and disturbance displacement[5]. Reduced head kinematic response to external forces is associated with increased neck strength and anticipatory cervical muscle activation, which may aid in the prevention of concussions. Women have greater acceleration and angular displacement of the head–neck region, despite appearing before men[12]. Athletes with a low head–neck segment mass are more likely to experience excessive head acceleration, but head–neck–torso alignment during heading and postcontact follow-up can mitigate this effect. Increased neuromuscular neck stiffness and symmetrical strength of the neck flexors and extensors may also reduce head acceleration[18]. The increased cervical strength and circumferences of adults may make them less susceptible to the consequences of concussion during traumatic events[24].

Vision training can be an effective strategy for preventing SRC because it improves an athlete's ability to scan the visual field for approaching objects or opponents, allowing him or her to anticipate head impacts. Vision training can therefore be a useful method for enhancing eye control, gaze behavior, and visual and sensorimotor performance in order to enhance anticipation to prevent collisions and reduce the risk of concussions. By precisely anticipating impact, athletes can either prepare for collision or attempt to avoid it. It has been demonstrated that anticipating a head impact can help reduce linear and rotational head acceleration, particularly for mild to moderate head impacts, but less so for severe head impacts. Inconsistent data exist regarding the relationship between oculomotor behavior, visual and sensorimotor function, and concussion risk. More research is required to determine how visual and sensorimotor performance influences concussion prevention and anticipation, particularly in sports where helmets do not impede vision[10].

Youth who participate in sports have the opportunity to develop their leadership and teamwork skills, as well as to improve their physical and mental health and academic performance. In addition to these benefits, exercise can put teenagers at risk for harm, including concussions[29]. Teenagers experience a growth spurt between the ages of 10 and 14, which increases their risk for sports-related injuries. It has been demonstrated that changes in limb length, mass, and body composition are the primary causes of damage[11]. Younger players may sustain more concussions from heading the ball due to their smaller stature, underdeveloped muscles, lower skill level, and technical deficiencies. Therefore, initiatives to encourage young soccer players to use the correct size soccer ball and to receive instruction from experienced personnel who are familiar with techniques for heading the ball in order to reduce the force exerted on the skull should aid in reducing the incidence of concussions in children[21].

One strategy for preventing concussion is measuring head impact exposure in soccer players using a linear accelerometer sensor worn on the mastoid and comparing recorded impact exposure. This measurement is intended to predict the occurrence of concussions so that they can be avoided in the future. However, according to a study conducted by Press and Rowson, sensors reported a significantly higher total number of collisions than video analysis. Effective monitoring technology requires increased sensitivity and specificity, which can lead to early identification of potential head impacts during competition. This test is performed to determine the correlation between acceleration and head injury[30]. Additionally, it is essential for monitoring heading behavior. This requires a method for testing the behavior of headings, specifically HeadCount. HeadCount, as a self-administered questionnaire, for long-term exposure assessment, headings can be used to index exposure in study populations, and once generalizable safe exposure thresholds have been established, HeadCount can be disseminated to monitor exposure and reduce the risk[19].

The use of supplements can also contribute to preventing more severe concussions. This popular dietary supplement is an omega-3 docosahexaenoic acid derived from algae that is said to improve heart, brain, and eye health. *N*-acetylcysteine has anti-inflammatory and antioxidant properties that may support the immune system and cardiovascular health, according to reports. It is believed that this supplement prevents severe concussions and accelerates recovery[12].

This study has the advantage of incorporating multiple studies and summarizing them to provide more accurate results for preventing concussions in soccer. Due to the substantial heterogeneity of clinical and methodological data, however, a meta-analysis cannot be conducted. We were aware of the potential for deception in narrative review, making it the most significant limitation of our study.

Conclusion

To protect the health and safety of high-risk groups, fundamental concussion prevention strategies must be investigated in greater depth. Although significant progress has been made in the diagnosis and treatment of this disorder, less is known about the primary prevention of concussions. Several strategies can be implemented to prevent concussions in soccer, particularly soccer, including concussion education, rule changes, proper heading technique, the BST method, vision training to improve sensory and anticipation, the use of supplements to prevent severe concussion and accelerate recovery, prevention in youth sports, and head impact detection. Numerous contradictory studies exist regarding the effectiveness of headgear in preventing concussions; therefore, additional research is necessary.

Ethical approval

Since this is a systematic review, there is no need for ethical approval.

Sources of funding

This is a self-funded paper.

Author contribution

R.S.I.: did a review of the full papers retrieved, synthesized the data, and wrote the manuscript. AMPS: Concept the manuscript, do the initial review, write the manuscript. R.R.: Review full papers retrieved, synthesis the data, write the manuscript. S.T.: Review full papers retrieved, synthesis the data. M.S.: Review full papers retrieved, synthesis the data. M.R.: Concept the manuscript, review the final version of manuscript. The final version of the manuscript is read and approved by all authors.

Conflicts of interest disclosure

There are no conflicts of interest in this paper.

Research registration unique identifying number (UIN)

We did not register this study.

Guarantor

Andre Marolop Pangihutan Siahaan.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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