May Heading in Soccer Result in Traumatic Brain Injury? A Review of Literature

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ABSTRACT

Background: Globally, soccer is the most popular team sport, unifying many fans all around the world. The epidemiological studies so far have confirmed that head playing and hitting the ball with head may cause minor head injuries, which exert their effects in a cumulative way. Methods: Literature search for this review was conducted and data about traumatic brain injury collected from various sources. Results: The consequences of head injury are evident as chronic changes in cognition, including disturbances in concentration and slowing of mental and physical agility. Conclusion: Various recommendations have been issued for the prevention of chronic negative cumulative effects of soccer ball head playing. In addition, the professional soccer players are also exposed to more intense craniocerebral trauma, such as concussions and contusions. These patients require treatment of skilled sports physicians, neurologists and neurosurgeons and some may need long to return to the sport scene again. Keywords: head injury, brain injury, soccer, concussion, head.

1. INTRODUCTION

Globally, soccer is the most widespread and most popular collective sport according to the number of participants and fans. The International Federation of Association Football (FIFA) reports of over 224 million active players, registered at national associations in 204 countries (1). It was already in 1424 when the Scottish king James I. tried to forbid the so-called fute ball, as the young men were more drawn to the game instead of the important medieval fighting sports, such as fencing and archery. As seen, the sport was already popular in those times and probably existed in a certain form much earlier (2).

Playing or hitting the ball with the head comes from the north of England. It became more and more popular a decade after the original rules were adopted by the Football Association in 1863. Soon afterwards in 1872, the association added a new rule forbidding the ball contact with hands (3). Since then, the so-called head playing became the integral part of soccer. It is therefore not unusual that speculations began to be made whether in addition to the already existing dangers of footballers colliding during the play with different body parts against the head or head to head, the possibility of causing short-term and long-term head trauma by hitting or playing with the head exists (4, 5). Further considerations and extensive studies are being conducted to establish to what extent, from which direction and on which side consequences are possible and if these are long-term or whether they are visible immediately (4–6).

Soccer has been known as a typical contact sport with a relatively high level of exposure to head injuries only the last few years (7–16). The American Paediatric Academy postulated soccer as a contact or cohesion sport in the same category as the American football and ice hockey with a comparable frequency of head injuries (17, 18).
3. RESULTS AND DISCUSSION

As a typical contact sport, soccer may result in various injuries. The majority of them affect talocrural joint, knee or inguinal region, however; 4% to 22% of all soccer injuries are related to head injuries with the incidence of 1.7 injuries per 1000 playing hours (7-13). This number refers to all types of head injuries, including facial injuries, concussions, bruises and eyeball injuries. The incidence of concussions is estimated at 0.5 injuries per 1000 competitive soccer playing hours, although it is difficult to provide a more accurate estimation due to inconsistencies in different interpretations of concussions (5, 8, 14, 15).

Mechanisms of injury

Head injuries in soccer may result from two possible mechanisms (5, 19). As in other contact sports, head injuries mostly result from unintentional hits with the head and hits to the head from different body parts of players (head to head, elbow to head), hitting the head against the ground, football goal frame or even hits received by the ball, when the ball flies and hits the unprepared player with great speed (5, 19-21). The other reason for head injuries in soccer includes forces that are below the level required to trigger the symptoms of concussion. In such cases, the terms microtrauma and subconcussive brain trauma are used (5, 22, 23). Such injuries result from intentional bouncing of the ball with the aim of controlling and re-directing or even accelerating its movement towards a target (5, 19). The impact of such subconcussive brain injuries is most probably cumulative and chronic, but less acute. The number of hits with the head is also important. It was found that professional players hit the ball with their head between six to sixteen times per match. The more successful the players, the more exposed they are to high intensity training and higher frequency of matches. For a footballer's professional career, which last up to 20 years, this represents an important cumulative burden of hits with the head (19-21, 25).

Researchers report of four different mechanisms having impact on the development of neuropathological changes in acute brain trauma caused in boxing and other contact sports, as well as in soccer (19, 25, 26). The mechanisms include rotational and angular acceleration, linear acceleration and carotid artery injuries (25, 26). Rotational and angular acceleration injuries are particularly dangerous as they include sudden acceleration of the head with simultaneous rotational movements of the brain inside the skull, which may lead to vessel injuries due stretching and occlusion. This mostly occurs in bouncing the ball with the head (19, 22, 23, 25, 27). In addition, it is very important how the soccer player is capable of limiting the rotational movements with proper contraction of neck muscles and which techniques are used to hit the ball with the head, as specifically pointed out by the Norwegian neurosurgeons (28). Linear acceleration causes focal ischemic brain lesions, which worsen proportionally with the number of microtraumatic subconcussive hits (20, 21, 28).

Clinical and diagnostic findings

Norwegian researchers report of electroencephalographic (EEG) abnormalities and an increased incidence of brain atrophy in active and former professional soccer players compared to persons who do not play soccer actively. Cognitive and emotional symptoms, typical for postcommotional syndrome, are also more frequent (28-30). One third of active and former professional soccer players had a minor to moderately altered EEG recordings. It is interesting that less EEG abnormalities were found in soccer players, who characterized themselves as typical players with the head (28, 31). This paradox probably points to better endurance, training and experience of such players and superior technique of playing with the head compared to others. Defence players were more burdened than other players. EEG abnormalities were much more expressed in younger soccer players and may be attributed to neuronal injury of still developing brain, caused by subconcussive injuries (19, 27-30).

On the other hand, studies that included the recordings of the head with computer tomography and magnetic resonance did not show any reliable correlation between postcontusional or postcommontional symptoms and signs of possible encephalopathy (32). A correlation between morphological changes and previous brain injuries in soccer players has been established (19, 30). It was concluded that repeated microtrauma caused by hitting the ball with the head and other less intensive blows to the head are not clinically significant (27, 29, 31, 33, 34). Modern literature questions the findings of these older studies due to many methodological imperfections, such as lack of data on the condition prior to injuries, subjectivity of researchers, insufficient control (35) ... This should be further investigated. A large share of injuries described by Tysvaer may explain the possibility of brain damage caused by alcohol which displays a similar image, however; this possibility was not excluded in the study (28, 36).

Certain prospective controlled studies, which also included the subject’s clinical status, neuropsychological testing and imaging, exclude the correlation between the cognitive disorders and soccer playing (32, 34, 37, 38). On the other hand, certain other studies established a statistically significant poorer performance of neuropsychological tests in soccer players compared to rugby players and sportsmen from non-contact sports at non-professional level (27, 35). These studies undoubtedly establish a correlation between the cumulative effect of bouncing the ball with the head and poorer neuropsychological test results (27, 35, 39). Interestingly, some reports describe a clear correlation between increased serum concentration of biochemical markers, typical for brain trauma, such as S-100B and neuron-specific enolase and the intensity of playing with the head or bouncing the ball with the head during soccer (40-43). Serum concentration increases of these two markers are transient, however; statistically significantly increased in soccer players after a match compared to serum levels prior to
the match (42-43). The studies and scientific evidence are summarised in Table 1.

**Recommendations for the game**

Regarding the above mentioned, The Canadian Academy of Sport Medicine has laid down recommendations with the purpose to decrease the frequency of head injuries in soccer players, including concussions (44). These recommendations are: soccer is a contact sport where concussions are possible and severe head injuries as well; the players should avoid dangerous actions; all participating in soccer have to acquainted with the signs and symptoms of head injuries and proper training needs to be carried out prior to soccer season; all players with suspected concussions have to be examined and treated by specially trained physicians; soccer balls and their size has to be adjusted according to age and properly inflated. The smallest soccer ball size, number 3, is recommended for children under the age of 10, number 4 for children between 10 and 14 years, and the biggest, number 5, for players above 14 years. Children should strictly avoid hitting the ball with the head, especially repeated hitting, due to so far unclear short and long-term effects of bouncing the soccer ball with the head. It is important to teach the players the right technique with minimum traumatizing effect; the soccer goal frame should be firmly ingrained and padded if possible; goalkeepers, who are the most exposed to potential brain trauma, have to be extra protected against the players’ offense play. During the game the goalkeepers have to wear mouth guard. Wearing a special head guard is not obligatory so far, as it is not known yet whether its use is beneficial in all cases (16, 19, 21, 35, 44-47).

**4. CONCLUSION**

European Soccer is undoubtedly recognized as a contact sport with statistically comparable frequency of cranioencephalic injuries as in American football and hockey (5, 6). The injuries may be severe and include skull fractures and in rare cases also contusions and hematomas. Head trauma is assessed according to a special sport-specific definition. The mildest level is a simple concussion, which does not require any other measures than a rest. In a complicated concussion, the symptoms last longer and manifest themselves as the disturbance of consciousness and long-lasting cognitive disorders. Such patients require the treatment of specially trained sport physicians and cannot expect to return to the field any time soon. To avoid the possibility of chronic cumulative negative effect of bouncing the ball with the head, different recommendations were created and the playing technique must be correct.

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- **Authors contributions:** Gorazd Bunc and Janez Ravnik designed the study and collected the literature, Tomaz Velnar designed the study, was scientific advisor and reviewed the work.

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