Acta Clin Croat 2014; 53:430-436 Review

SPORTS AND HEALTH: EQUIVALENCE OR CONTRARIETY

Borislav Radić[1], Petra Radić[2] and Din Duraković[3]

[1]Clinical Department of Neurology, Zagreb University Hospital Center; [2]School of Medicine, University of Zagreb, Zagreb; [3]School of Medicine, University of Rijeka, Rijeka, Croatia

SUMMARY – Playing sports is a widely known method of health promotion. Balanced exercise and diet are keys to healthy life. However, sports activities can cause different injuries, from joint to head injuries. Although head injuries cause a variety of acute and chronic disorders, they are often undertreated. There are 1.6 million injured people examined at emergency departments throughout Europe every year. In sports like boxing, football, soccer, hockey, handball, basketball and bicycling, head injuries occur at a frequency of 4% to 22%. Particularly significant are chronic difficulties that occur after recurrent head injuries, i.e. cognitive deficits and changes in electroencephalogram. Qualifications of professional personnel are insufficient for professional evaluation and treatment of head injuries. The best way for sports to become an important link in health and disease prevention is to go back to sports basics while using acquired scientific knowledge.

Key words: *Athletic injuries – prevention and control; Athletic injuries – complications; Craniocerebral trauma – prevention and control; Sports medicine*

Introduction

Playing sports is a widely known method of health promotion. It is also a powerful instrument for social skill promotion and plays an important role in all areas of human life. Physical activity has a positive effect on the healthy lifestyle adoption, health improvement and quality of life betterment. Today, sport is a medium through which the message of peace, equality and friendship among people is being spread. Regular physical activity is one of the key factors for healthy life. It is impossible to enumerate all the positive effects of physical activity, but no doubt some of them are improving health and quality of life, increased life expectancy and risk reduction for noncommunicable diseases such as cardiovascular disease, diabetes, malignancy, etc. Positive aspects of regular physical activity reflect in physical and mental health, as well as in psychosocial development. It is never too early to start adopting healthy habits and learning about the importance of physical activity. Studies show that most children who are involved in sports and are physically active in childhood maintain these habits in adulthood. Sport has a positive effect on personality development; when children are engaged in sporting activity from an early age, they develop work habits and self-discipline. It has a positive role in the emotional development of children through facilitation of socialization. The association of sport, physical activity and health has been recognized by the World Health Organization, which adopted a document in 2004 on the global strategy on healthy eating, physical activity and health as the Resolution on Health Promotion and Healthy Lifestyles.

A healthy body requires balanced exercise through sports that include activity of muscles and other organs such as heart and lungs. To be absolutely healthy, a person should walk, play sports and have a healthy and balanced diet. However, not all exercises and sports are good for our health. For example, while lifting weights in the gym increases your muscles, "Flash

Correspondence to: *Borislav Radić, MD, PhD*, Clinical Department of Neurology, Zagreb University Hospital Center, Kišpatićeva 12, HR-10000 Zagreb
E-mail: boris.radic105@gmail.com

Received August 6, 2014, accepted November 4, 2014

Game" does not help the most important human muscle, the heart. On the other hand, running does wonders for the cardiovascular and respiratory systems, but ignores the muscles of the upper body, and can cause joint injuries. Athletes find these injuries most disturbing and annoying because they prevent them from playing sports. The injury is any disturbance in the structure and functionality of a particular part of the body that was inflicted in a specific and limited time either by physical (electricity and heat), chemical (acids, alkalis) or mechanical (blow, fall, stab) cause, which, to a greater or lesser extent, reduces the ability to perform daily activities. Sports are also included in these daily activities that are essential and laudable way to improve and maintain "healthy lifestyle"[1]. It is important to distinguish injury from damage. Damage is considered to be the pathoanatomical substrate that is not evident from history, while a professional or amateur athlete is not aware of it or does not remember damage occurrence[2]. Thus, the distinguishing feature is acuteness of injury occurrence, while damage has a chronic character. Damage is usually the result of a series of consecutive microtraumas[3]. We can distinguish acute and chronic injury.

Acute injuries occur by a relatively strong action of force (in contact or force of own muscular contractions) on the part of the body within short time. Chronic injuries result from the effect of repeated force of less intensity (overuse syndrome). Sports injuries are those injuries that occur during sports or exercise activities and they are usually mechanical[4]. Up to 80% of sports injuries affect the locomotor system[3]. The resulting injury is in most cases traumatic (sprain, dislocation, rupture, fracture, avulsion, etc.)[5]. Sports activities include all forms of sports (football, basketball, hockey, athletics, etc.) and all levels, i.e. recreational or competitive, amateur or professional.

Most sports injuries affect the locomotor system and accordingly greatest attention is paid to their prevention and treatment. This approach underestimates other types of injuries, such as head injuries that are less frequent, even though they can carry by far greater consequences, both at the time of occurrence and in the following period. Head injuries account for 4% to 22% of all sports injuries. When it comes to head injuries in sports, we have to stress out a problem of "silent" head injuries, their prevention and treatment. We think that these injuries make an essential distinction between health and sports. They also indicate that modern sports carry a significant amount of head injury that can result in possible disability or even death. The seriousness of these injuries indicates that the motto "sport is health" is no more true and that modern sports, especially professional, can significantly impair health.

Epidemiology

Every year, there are 1.6 million casualties in European hospitals due to traumatic brain injury (TBI)[6], 1.7 million in the U.S.[7], in Sweden 105 inhabitants/year, Scotland 83 to 105 inhabitants/year[6], in the United States 130 *per* 100 000 population/year[7]. Adolescents and adults are the age groups most commonly affected by TBI. Data on those affected and disabled by TBI are not easy to collect ("silent epidemic"), thus they are results of an assessment. Many TBI cases remain unrecorded since people affected often do not seek professional help. It is believed that over 5.5 million Americans are permanently and severely disabled due to TBI[7]. Direct medical costs and indirect costs such as lost productivity after mild traumatic brain injury (mTBI) were 76.5 billion $ in the U.S. in 2000[8,9]. It is estimated that each year, emergency departments in the U.S treat 173,285 children and adolescents aged up to 19 years with mTBI acquired through sports or recreational activity. Most affected are children older than 10 years[10]. During a 10-year period, medical costs for treatment of mTBI in children and adolescents increased by 60% *per* year[10], from 153,375 mTBI in 2000 to 248,418 mTBI in 2009[10]. The increased number of mTBI is noted among participants in organized team sports. TBI almost doubled in children aged 8-13 years, and more than tripled among teenagers (aged 14-19 years) in the 1997-2007 period[11]. Among those with mTBI, there are 70.5% male and they were injured between age 10 and 19[10]. The greatest number of mTBI patients that requested medical attention suffered injury during cycling, American football, basketball, football, boxing or hockey[10-11]. TBI can occur by head-to-head, ball-to-head, head-on-the-post, head-on-surface, head-to-foot or head-to-hand collision.

Pathophysiology

Traumatic brain injury leads to changes in the metabolism of nerve cells and microscopic anatomy of the brain, which occurs in two different phases. Diffuse axonal injury is an initial sign of injury and occurs during the initial stages of traumatic force action and is a result of rotational force. It is important to distinguish it from other cortical contusions or hemorrhages from linear acceleration/deceleration[12]. The next phase model of brain injury involves a cascade of inflammatory changes, edema, ischemia, free radicals, ion release and programmed cell death[13]. Disruption of axonal organization causes disruption of axonal transport leading to axonal swelling, wallerian degeneration and transection[14]. The release of excitatory neurotransmitters (acetylcholine, glutamate and aspartate) along with free radical formation can lead to secondary brain injury[15].

Clinical Presentation of Traumatic Brain Injury in Athletes

The onset of symptoms may be immediately after the injury or a few minutes later[16]. Clinical signs of TBI can be amnesia, behavioral change, confabulation, delayed verbal and motor responses, balance disorder, disturbance of orientation, emotional instability, loss of consciousness, slurred or incoherent speech, or absence. TBI symptoms can be blurred vision, double vision, confusion, dizziness, excessive sleepiness, difficulty in sleeping, feelings of fogginess, turbidity or hangover, headache, lack of concentration, nausea, vomiting and photo- and phonophobia[17]. Mood swings, emotional outbursts and behavioral changes can also be symptoms of TBI. The athletes are exposed to above-average physical and mental efforts with the aim of achieving sports results. This includes participation in adverse conditions and competition through a multitude of injuries. Athlete's wish to do best to help himself and the team is achieved at the cost of his own bodily injury. Athletes are well known for dissimulation problems, which might lead to exclusion from sports competitions. So, TBI symptoms may be presented as the effects of stress, high demand and high effort of the game. There are also other incentives beyond the sports that manage athletes to run with TBI: the presence of sports managers, the possibility of an athletic scholarship, advancing towards higher level in the team, and more money. Coaches are not able at all times to fully disclose all information on the health condition of the competitors, especially in the case of the key players who they want to keep in the sports arena. Parents who want to see their children get ahead also neglect the state of health after TBI and do nothing to excuse them from athletic competition.

Each contestant where there is suspicion that the player has sustained TBI should be immediately removed from the arena and sent to proper assessment. If there is a player with a suspected brain injury and the doctor is not present at the scene, the player must leave the game and be sent to the doctor for proper assessment before returning to the game. It should be emphasized that the majority of concussions usually include loss of consciousness, which greatly facilitates the diagnosis and clinical evaluation. At the same time, we should not forget the possibility of later neurological symptoms as with any clinical suspicion of mTBI sets imperative for performing serial examinations. Multiple studies have shown that mTBI in high school athletes may show delayed symptoms and neuropsychological deficits after the injury[18-23]. If diagnosed with mTBI, the athlete must be out of the game or competition. During the next 24 hours, it is necessary to assess the clinical condition of the athletes that have suffered from mTBI and on this basis to make judgment about when and how to return to sports competition.

Complete data on the number of athletes, especially young ones, who go to primary care physicians and specialist clinics after mTBI are not available because some of these athletes never present for clinical assessment. The increasing incidence of mTBI is multifactorial and partly due to the increasing youth participation in sports activities[24]. To reduce mTBI consequences in athletes, it is necessary to increase the consciousness in public, including parents and coaches to report and refer athletes to doctor for clinical judgment.

Many studies have shown that in contact sports, there is almost an "epidemic" of chronic effects that manifest themselves in cognitive impairments and electroencephalography changes [25,26]. At the same

time, there are various studies indicating that genetic predisposition may be important for the fatal outcome of mTBI (subunit mutations in the calcium channel gene CACNA1A). There is also a known APOE gene variation, especially in boxers, which can significantly affect the outcome of multiple blows to the head[27].

Repetitive mTBI over a long period of time (months, years) may result in cumulative neurological and cognitive deficits. Retired American professional football players with a history of three or more TBI are 5 times more likely to have mild cognitive impairment[28]. Professional boxers have a significant risk of cognitive decline and changes in brain functioning. However, greater problem are the cumulative effects that can occur in athletes experiencing "routine" injuries during competitions, such as football or ice hockey. Long-term effects of repetitive head injury include chronic motor and neurocognitive damage[29,30]. The nature and duration of clinical symptoms may be more important than the presence or duration of amnesia after the injury. Research conducted at the University of Michigan Institute for Social Research, organized by the National Football League on a sample of 1063 retired NFL players found a 19-fold increase in the rate of memory impairment as compared to the control group. Chronic traumatic encephalopathy is described in a former boxer; however, there are an increasing number of case reports in the literature of athletes in other sports that have a significant incidence of emergence TBI. In Croatia, there is one such study conducted on former amateur soccer players active during the competition that suffered repeated ball blows to the head. Results indicated a higher incidence of damage to attention and electroencephalographic changes in former soccer players compared to the control group[31].

Sports medicine is working on reducing the number of chronic consequences of mTBI using SCAT-2 (Sport Concussion Assessment Tool-2), with the help of consensus guidelines established in Zurich in 2008 during the 3rd International Conference on Head Injuries in Sports. Although there are no prospective studies on the effectiveness of these guidelines, it was believed to be the quality of the assessment because they contain key components of various scales, and were drawn up by the leading experts in the field of mTBI in sports. The guidelines include a review of subjective symptoms, Glasgow coma scale (GCS), standardized assessment of concussion (SAC), cognitive assessment, Maddocks evaluation and assessment of balance and coordination. The resulting scores are added together, however, physicians should be aware that there is no "normal score" or rating that completely passed evaluation of the degree of injury. SCAT-2 is most effective when comparing basic data with data obtained after serial examination of athletes with mTBI. On mTBI assessment, athletes must undergo thorough evaluation, including previous illnesses, medical history, neurological examination with emphasis on coordination and balance, and cognitive functioning. However, outside of typical recovery at a 1- to 3-month interval, at least 15% of people with mTBI visited doctors due to permanent problems[29,32-35]. The presence of clinical consequences is not undisputed, partly because there is no readily apparent physiological damage or deficiency, and they seek to explain the existence of other ailments. In doing so, they can use alternative explanations, such as participation in compensation request and previous medical history.

Consequences of Mild Traumatic Brain Injuries in Sports

Media attention, legislation and constant revision of guidelines on medical care for TBI have led to increased understanding of the short- and long-term consequences of TBI. Direct impact of TBI on athletes is the appearance of symptoms such as headache (one of the most common symptoms), insomnia, excessive sleepiness, poor concentration and impairment of cognitive ability. It is estimated that 1.8 million people develop acute posttraumatic headache every year and 400,000 people develop chronic post-traumatic headache[36]. As most athletes are students, these symptoms will have an obvious impact on their success in studying. The athletes having suffered three or more concussions had greater likelihood of headaches, were vulnerable to repeated head injuries compared to those who did not have a head injury, and were three times more likely to experience additional injury during their high school and college studies[37]. Also, replay with mTBI in a short period of time (hours, days or weeks) can have serious consequences. Today, there

is increasing evidence for the association of brain injury and long-term consequences.

Medical Training in the Assessment of Head Injuries in Sports

It is very important that after a head injury in an athlete, the physician performs appropriate assessment of the injury, which is highly relevant for further treatment and monitoring. To achieve this, medical personnel must be trained. Many studies have concluded that most doctors have little or no knowledge about setting up an accurate diagnosis and treatment of patients with TBI. Powel *et al.* report that more than 50% of patients admitted to emergency department with TBI are not recognized by physicians[38]. A survey of primary care physicians on their knowledge of guidelines for the management of TBI found that less than half of the physicians were familiar with current guidelines for TBI care[39]. In a survey of the American Society for Sports Medicine members, only 30% of the physicians treated their patients according to the current established guidelines. As the incidence of brain injury continues to grow, there must be a simultaneous increase and improvement of knowledge and training of physicians on the assessment and treatment of TBI in sports.

Discussion

Traumatic brain injury is still a popular topic in medical community and social media, especially in young athletes. In the last 10-15 years, the number of children and adolescents presenting to emergency medical services for evaluation of sports generated TBI has doubled and tripled. It is important to understand that athletes are a unique part of the population with its own culture and risk factors for injury. Achieving results is often the primary goal, even at the cost of injuries. Earlier, mTBI was considered to occur in contact sports (boxing, hockey), while today it is known that it is not true, as exemplified by the incidence of brain injury in soccer players. Cognitive impairment as well as long-term consequences are associated with mTBI. Protecting athletes using our current knowledge about brain injuries and other injuries is the primary goal of medical services. The main objective of health service is to set up an accurate diagnosis after injuries in athletes, implement appropriate treatment in the acute phase of injury and extensive workup to assess the status and time for the athlete to return to competition. It is imperative to train doctors to be familiar with all the knowledge necessary for the care of athletes after TBI, especially with modern guidelines on the management of TBI. Athletes are not allowed to return to the game until there is no more physiological stress. Education of the public is essential for correct understanding of the importance of head injuries in athletes and the need of referral to appropriate medical care. It is also necessary to understand better why there are differences in brain injury in adults compared to children and adolescents. At present, a more prominent motive of "higher interests" of the sports, where Coubertin 's slogan "It's important to participate" has been long forgotten, leads to asking the following question: "Do sports bring health or disability?", which is primarily expressed in professional sports, although in amateur athletics there are more injuries that carry different degree of disability and cause increased financial allocations for their treatment. Without respect for the fundamental laws of the sports with intense participation of sports science, it will become the source of all injuries and a growing percentage of disability to the possible fatal outcome. It is time to make a change.

References

1. SAIDOFF D, APFEL S. The healthy body handbook: a total guide to the prevention and treatment of sports injuries. New York: Demos Medical Publishing, 2004.
2. MIŠKOVIĆ D. Ozljede u sportu. Zagreb: Clinical Department of Surgery, Merkur University Hospital, School of Medicine, University of Zagreb, 2011. (in Croatian)
3. PEĆINA M. Športska medicina. Zagreb: Medicinska naklada, 2004. (in Croatian)
4. BAIMA J. Sports injuries. Westport, Connecticut: Greenwood Press, 2009.
5. RANALLI DN. Prevention of sports-related traumatic dental injuries. Dent Clin North Am 2000;44:35-51,v-vi.
6. ANDERSSON E, BJORKLUND R, EMANUELSON I, STALHAMMAR D. Epidemiology of traumatic brain injury: a population based study in Western Sweden. Acta Neurol Scand 2003;107:256-9.
7. http://www.cdc.gov/traumaticbraininjury/pdf/blue_book.pdf, 09.05.2010.)

8. FINKELSTEIN E, CORSO P, MILLER T. The incidence and economic burden of injuries in the United States. New York, NY: Oxford University Press, 2006.
9. CORONADO VG, McGUIRE LC, FAUL M, SUGERMAN D, PEARSON W. Traumatic brain injury and public health issues. Brain injury medicine: principles and practice. 2nd edn. New York: Demos Medical Publishing, 2012;84-100.
10. GILCHRIST J, THOMAS KE, XU L, McGUIRE LC, CORONADO VG. Nonfatal sports and recreation related traumatic brain injuries among children and adolescents treated in emergency departments in the United States, 2001-2009. Morbid Mortal Wkly Rep 2011;60:1337-42.
11. MITKA M. Reports of concussions from youth sports rise along with awareness of the problem. JAMA 2010;304:1775-6.
12. GOODMAN JC. Pathologic changes in mild head injury. Semin Neurol 1994;14:19-24.
13. CHESTNUT RM, MARSHALL LF. Management of severe head injury. In: ROPPER AH, editor. Neurological and neurosurgical intensive care. 3rd edn. New York, NY: Raven Press, 1993;203-46.
14. POVLISHOCK JT, KATZ DI. Update of neuropathology and neurological recovery after traumatic brain injury. J Head Trauma Rehabil 2005;20:76-94.
15. HAYES RL, DIXON CE. Neurochemical changes in mild head injury. Semin Neurol 1994;14:25-31.
16. KELLY JP, ROSENBERG JH. Diagnosis and management of concussion in sports. Neurology 1997;48:575-80.
17. American Academy of Neurology. Practice parameter: the management of concussion in sports (summary statement): report of the Quality Standards Subcommittee. Neurology 1997;48:581-5.
18. GUSKIEWICZ KM, McCREA M, MARSHALL SW. Cumulative effects associated with recurrent concussion in collegiate football players: the NCAA concussion study. JAMA 2003;290:2549-55.
19. LOVELL M, COLLINS M, BRADLEY J. Return to play following sports-related concussion. Clin Sports Med 2004;23:421-41.
20. COLLINS MW, FIELD M, LOVELL MR. Relationship between postconcussion headache and neuropsychological test performance in high school athletes. Am J Sports Med 2003;31:168-73.
21. COLLINS MW, GRINDEL SH, LOVELL MR. Relationship between concussion and neuropsychological performance in college football players. JAMA 1999;282:964-70.
22. McCREA M, GUSKIEWICZ KM, MARSHALL SW. Acute effects and recovery time following concussion in collegiate football players: the NCAA concussion study. JAMA 2003;290:2556-63.
23. McCREA M, HAMMEKE T, OLSEN G, LEO P, GUSKIEWICZ K. Unreported concussion in high school football players: implications for prevention. Clin J Sport Med 2004;14:13-7.
24. SEEFELDT VD, EWING ME. Youth sports in America: an overview 1997;2: No.11. President's Council on Physical Fitness and Sports Research Digest.
25. LOWELL MR, COLLINS MV, IVERSON GI, FIELD M, MAROCINI JC. Recovery from mild concussion in high school athletes. J Neurosurg 2003;98:296-301.
26. MATSER T, KESSELS G, JORDAN B, LEZAK D, TROOST J. Chronic traumatic brain injury in professional soccer players. Neurology 1998;51:791-6.
27. CHAMELIAN L, RETS M, FEINSTEIN A. Six-month recovery from mild to moderate traumatic brain injury: the role of APOE-epsilon 4 allele. Brain 2004;127:2621-8.
28. GUSKIEWICZ KM, MARSHALL SW, BAILES J. Association between recurrent concussion and late-life cognitive impairment in retired professional football players. Neurosurgery 2005;57:719-26.
29. de BEAUMONT L, LASSONDE M, LECLERC S, THORET H. Long-term and cumulative effects of sports concussion on motor cortex inhibition. Neurosurgery 2007;61:329-36.
30. de BEAUMONT L, THORET H, MONGEON D. Brain function decline in healthy retired athletes who sustained their last sports concussion in early adulthood. Brain 2009;132 (Part 3):695-708.
31. RADIĆ B. Osobitosti usmjerene i suzdržane pažnje i elektroencefalograma u nogometaša s ponavljajućim blagim traumama glave. Doctoral dissertation. Zagreb: University of Zagreb, 2012;97-9. (in Croatian)
32. McCRORY PR, BERKOVIC SF. Second impact syndrome. Neurology 1998;50:677-83.
33. JORDAN BD, RELKIN NR, RAVDIN LD, JACOBS AR, BENNETT A, GANDY S. Apolipoprotein E ε4 associated with chronic traumatic brain injury in boxing. JAMA 1997;278:136-40.
34. COLLINS MW, GRINDEL SH, LOVELL MR. Relationship between concussion and neuropsychological performance in college football players. JAMA 1999;282:964-70.
35. MATSER T, KESSELS AG, LEZAK MD, JORDAN BD, TROOST J. Neuropsychological impairment in amateur soccer players. JAMA 1999;282:971-3.
36. LENAERTS ME, COUCH JR. Posttraumatic headache. Curr Treat Options Neurol 2004;6:507-17.
37. IVERSON GL, GAETZ M, LOVELL MR, COLLINS MW. Cumulative effects of concussion in amateur athletes. Brain Injury 2004;18:433-43.
38. POWEL MJ, FERRARO JV, DIKMEN SS, TEMKIN NR, BELL KR. Accurancy of Mild Traumatic Brain Injury Diagnosis. Arch Phys Med Rehabil 2008; Vol.89:1550-55.
39. GESSEL LM, FIELDS SK, COLLINS CL, DICK RW, COMSTOCK RD. Concussions among United States high school and collegiate athletes. J Athl Train 2007;42:495-503.

Sažetak

SPORT I ZDRAVLJE: ISTOZNAČNOST ILI SUPROTNOST

B. Radić, P. Radić i *D. Duraković*

Bavljenje sportom je široko poznat način promicanja zdravlja. Za zdravlje je potrebno uravnoteženo vježbanje i zdrava i uravnotežena prehrana. Međutim, većina sportova uzrokuju različite ozljede, od ozljeda zglobova do ozljeda glave. Ozljede glave su često, iz različitih razloga, nedovoljno liječene, iako uzrokuju akutne i kronične smetnje. Godišnje se u Europi u hitnoj službi pregleda oko 1.600.000 ozljeđenika. U različitim sportovima ozljede glave se javljaju po učestalosti od 4% do 22% i nastaju poglavito u sportovima kao što su boks, američki nogomet, nogomet, hokej, rukomet, košarka, biciklizam. Osobito su značajne kronične poteškoće ponavljajućih ozljeda glave: kognitivni deficit i promjene u elektroencefalogramu. Osposobljenost stručnog osoblja nedovoljna je za stručnu procjenu i liječenje ozljeda glave. Povratak na temeljne postavke sporta uz korištenje svih znanstvenih spoznaja su najbolja prevencija da sport postane bitna karika zdravlja.

Ključne riječi: *Sportske ozljede – prevencija i kontrola; Sportske ozljede – komplikacije; Kraniocerebralna ozljeda – prevencija i kontrola; Sportska medicina*