Traumatic Head Injuries in Sports

Head injuries are relatively common in football, accounting for up to 22% of all injuries in the sport(1). A significant fraction of these injuries are concussions, which are states of neural dysfunction resulting from head trauma in which there is the possibility of dizziness, headache, confusion, visual disturbance, amnesia, loss of consciousness, drowsiness, nausea, and/or vomiting. Slurred speech, disorientation, lack of coordination, inappropriate emotions, and auditory abnormalities may also be observed as part of the concussive state. Concussions in football players have been linked with drop-offs in their cognitive functioning. For example, in a study carried out at Erasmus University in Rotterdam, the Netherlands, in which 84 active professional players from several premier-league football clubs were evaluated, the frequency of football-related concussions was linked with poorer results on tests measuring sustained attention and visuoperceptual processing(2). In addition, a classic study carried out with 69 active football players and 37 former members of the Norwegian national football team determined that 30% of the former players complained of permanent problems such as headache, dizziness, irritability, neck pain, and impaired memory(1). In addition, 35% of the active players and 32% of the former players displayed abnormal EEGs, compared with about 12% of matched control individuals. When the former players were subjected to cerebral computed tomography (CT) and a neuropsychological examination, a full one-third of the athletes were found to have central cerebral

atrophy (wasting of the central region of the brain), and 81% displayed at least some signs of neuropsychological impairment. Many of these problems were believed to be linked to concussions suffered by the players during their football careers.

How footballers compare with swimmers

In a very interesting recent study, cognitive functioning in football players was compared with mental functioning in athletes involved in a sport with a low risk of head injury – swimming(3). 32 football players (26 college and six professional) and 29 swimmers (22 college and seven masters-level), all of whom had been training and competing in their sports at collegiate or national levels for at least four years, participated in the investigation. The athletes underwent four neuropsychological tests which had 11 outcome measures associated with muscular speed, attention, concentration, reaction time, and conceptual thinking. **As it turned out, football players performed significantly worse than swimmers on measures of conceptual thinking, reaction time, and concentration.** In fact, among football players who were not goalkeepers, length of career predicted significantly poorer test performance on six of 11 outcome measures, even when statistical controls were applied to age; this level of association between participation time and impairment in neuropsychological functioning was not present in swimmers.

Worse than American football

In an effort to determine the actual frequency of concussions in popular sports, researchers at McGill University in Canada completed a pilot, retrospective study with 44 American-style university football and 52 university football players in 1998(4). Somewhat surprisingly, more football players had experienced symptoms of concussion during the prior season, compared with American footballers; 46% of football participants had reported such symptoms, versus just 34% of American football competitors. Amazingly, only 29% of the footballers and 17% of the American footballers realised that they had experienced a concussion, and all of the concussed American footballers and three-quarters of the footballers suffered from more than one concussion during the season! **Having a past history of recognised concussion significantly increased the risk of contracting another one during the season.** As you can see, the frequency of concussion is quite high in popular sports like American football and football.

Is the 'three-strike rule' valid?

Overall, the beliefs that concussions may be connected to long-term brain damage and that sustaining several concussions over a sporting career will necessarily result in permanent damage to the nervous system has helped set the stage for the formulation of the widely used 'three-strike rule', which simply says that once an athlete has sustained three concussions, he or she is ruled out of competition for a significant period of time. In some cases, use of the three-strike rule

has caused athletes to retire from their sports at a relatively early age. The three-strike rule was first formulated in 1945 (5) and has been ‘in play’ since then, but in fact there is no scientific support for the principle (6). As mentioned, the unexpressed fear behind the three-strike approach has been that athletes suffering from repetitive concussions will necessarily undergo gradual cognitive declines and will in many cases end up displaying the punch-drunk behaviour of chronic traumatic encephalopathy, similar to what is observed all too often in retired professional boxers. However, recent scientific research indicates that long-term brain damage in athletes may actually be more related to genetic and other factors, rather than repeated concussive traumas (7). It is certainly true that boxing carries a high risk of neurological injury. However, bear in mind that boxing is quite unique among sports in terms of the frequency with which head trauma occurs and in terms of the forces which are actually applied to the head and which create damaging internal forces within the cranium. Thus, although boxers experience high rates of concussions, we should not conclude from the boxing experience that concussions per se cause neurological damage. Tissue destruction which occurs as a result of significant and repetitive but non-concussive blows to the head may be the real culprit underlying brain damage in the boxing profession.

Flaws in the methodology

Bear in mind, too, that although the football studies linking concussions with long-term brain damage are compelling, the

methodology of these investigations is actually somewhat flawed. For example, alcohol-related brain impairment was not controlled in the Norwegian football research, an omission which could cloud the results considerably. In addition, in studies carried out with American football players, ‘information-processing deficits’ were present within 24 hours after a concussion, but neuropsychological functioning returned to normal within five to 10 days after the injury (8). This exact situation was also observed in Australian-Rules footballers (9). It is also important to note that in studies of experimental concussion which have been carried out on animals, subjects were concussed up to 35 times, and yet no residual damage to the nervous system was found (10). Somewhat surprisingly, genetics may play a powerful role in determining whether athletes display long-term brain damage in response to forces applied to the head. In boxers, for example, the so-called apolipoprotein E epsilon-4 (ApoE4) gene, which is a susceptibility gene for late-onset familial and sporadic Alzheimer’s disease, may be linked with a higher risk of chronic traumatic encephalopathy (11). True, we shouldn’t be too trusting in the idea that what takes place with boxers will also happen to athletes in other sports, but the ApoE4 gene was recently linked with death and adverse outcomes following acute traumatic brain injury among patients followed in a neurosurgical hospital unit (12). In addition, in a recent prospective investigation, there was a strong connection between the presence of the ApoE4 gene and a poor clinical outcome among individuals who had suffered from serious head injuries (13). It may be that the presence of the ApoE4 gene – rather than the frequency of

concussions – may be the overriding factor determining whether an athlete will suffer from long-term mental damage.

If you carry ApoE4, don't smoke!

Incidentally, the ApoE4 allele is associated with another medical problem – atherogenesis. Individuals carrying the ApoE4 gene tend to have lower levels of HDL-cholesterol (aka 'good cholesterol') and higher levels of low-density lipoprotein cholesterol ('bad cholesterol'), compared with individuals who do not have ApoE4. In addition, the ApoE4 gene may be particularly hazardous in smokers, who ordinarily have about 1.7 times the risk of developing carotid-artery atherosclerosis, compared with non-smokers, but individuals who smoke and have ApoE4 in their genomes have almost a four-fold risk of developing carotid-artery atherosclerosis, compared with non-smokers who do not possess ApoE4 (14). Fortunately, increased levels of physical activity, especially if the activity is intense in nature, may modulate the effects of the ApoE4 genotype on lipid profiles. In one cross-sectional survey carried out in Switzerland with 1708 randomly selected men and women aged 35 to 74, an increased percentage of high-intensity activity had protective effects for ApoE4 individuals for both HDL-cholesterol and triglycerides, in men and women(15).

Action to take

Returning to our concussive problems, what should an athlete who has suffered from more than one concussion actually do about sports participation? Right now, there is no scientifically validated guideline

upon which an athlete can base a medical decision about the continuation of his/her career. As it stands now, the athlete should work closely with his/her medical advisor and seek individualized clinical and neuropsychological assessments to determine whether the concussions which have been experienced are associated with any changes in nervous-system function. Brand-new, web-based, computerized neuropsychological test batteries are available to screen athletes after concussions and other head injuries; these tests are cheap and can be used by team or other doctors involved in the care of athletes (16). Of course, athletes who are known to have the ApoE4 allele should weigh the potential risks of returning to sporting activity following a head injury very, very carefully. It is possible for all athletes to get themselves tested for the ApoE4gene, and the test is not prohibitively expensive. For those athletes who are involved in sports which are associated with a high risk of head injury (football, American football, rugby, boxing, etc), such genetic testing appears to be a very reasonable idea.

If the athlete feels OK?

How about the athlete who has suffered a concussion but feels OK shortly thereafter? Should he/she be allowed to resume the activity associated with sustaining the concussion? The general rule here is that an athlete who has sustained a concussion should never be allowed to return to play while he or she is still showing even the slightest sign of the concussion. In most cases, this means that the athlete will not return to play on the same day (17). If the athlete has

not been rendered unconscious, is completely free of symptoms, and shows no sign of negative changes in neurological or physical status for 15 minutes, then a doctor may ask the athlete to carry out some physical activities which increase intracranial pressure (sit-ups or wind sprints, for example). If symptoms recur as a result of these activities, the athlete should not return to play that day. If symptoms do not recur, it is generally considered to be safe for the athlete to return to activity – provided it is his/her first concussion. Note, though, that there is no real science underlying these guidelines: they are simply reasonable-sounding rules.

Owen Anderson

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