Concussion and traumatic brain injury

Conmoción cerebral y traumatismo cráneoencefálico

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A concussion is a mild form of traumatic brain injury which affects brain functions, generally temporarily, with symptomatology of slight loss of consciousness, concentration and memory, headache, confusion, affecting balance and coordination[1-5].

A traumatic brain injury (TBI) is known as a blow or impact, a jolt in the cranium or facial region producing an injury on the scalp or face, affecting the level of consciousness to a certain extent which might injure neurones and cause biochemical changes that must be assessed, diagnosed and treated. Its severity is conditioned by the cause (traffic accident, workplace accident, impact from a fall, sport, attack, others), its location and the appearance of subsequent complications (cognitive, behavioural, physical, balance, coordination and/or emotional)[4,5].

TBIs can be mild (brief alteration of mental state or consciousness, headache, dizziness, vomiting, blurred vision, behavioural changes) or evolve progressively to become severe (persistent loss of consciousness or reasoning/behavioural problems after suffering an injury)[5,6]. Long term effects depend on severity, location of the injury, the patient's age and prior state of health.

Although most medical consultations for TBI are mild, traumatic head injuries are the top cause of death and disability in the population aged under 45 years old in developed countries. In 2007, the WHO estimated that it would be the top cause of mortality in 2020[7]. In Spain, three out of four patients with TBI are men aged between 15 and 30 years old; the main cause is traffic accidents (decreasing), falls among people aged over 65 years old (increasing), childhood accidents during leisure activities and during sport[8,9]. Neurological after-effects involving disability stand at 15% (Spanish Neurology Society, 2018)[8].

Sports-Related Concussion (SRC)

Concussion is considered to be one of the most complex injuries in sport because it is difficult to assess, diagnose and provide care for it[3]. Sports doctors are uniquely skilled to give the required care throughout an SRC from acute assessment to return to playing and care for SRC complications and coexisting medical issues thanks to their knowledge, experience and daily proximity to the athlete[10]. Most SRC are resolved within 1 to 4 weeks, although there are cases with complicated and/or lengthy recovery stages that might require a multidisciplinary team with experience in checking on and caring for SRCs.

SRC characteristics include[2,3,10]:

- Aetiology, due to acute trauma from a blow, collision or repetitive exposure to impacts (opponent, ground or ball) and/or jolts to the head, face or neck (whiplash), and in any other part of the body with a driving force to the head (attack, defence, tackle).
- The urgent care, assessment and diagnosis that take place on the playing field.
- Immediately prohibiting sport (training, competition) for any affected athlete, irrespective of the type of activity and age, given that this is an acute injury where the diagnosis can change quickly, and which requires caution and fast action.
- Care and treatment must be swift and managed properly in the short and long term, including the return to sport, to guarantee the athlete's health and avoid consequences.

Sports with the greatest risk of suffering a concussion, at any age, include any which involve physical contact with drive, crashes, blows, falls, sporadic or repetitive impact and others with a risk of high speed

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collision, above all without the right protection or safety gear, such as American football, hockey, rugby, boxing and football[11-18]. Statistically, a greater proportion of women than men are assisted for SRC.[2] Two recent systematic reviews show a greater statistically-significant incidence rate for concussion among women than men, in football and basketball[19] and a greater prevalence of concussion and symptom-reporting among women. The role of biological gender should be investigated to evaluate its importance in SPC assessment, care and subsequent treatment[20].

Clinical diagnosis

Most SRCs present without loss of consciousness or clear neurological signs that might be transitory and appear in the first 24-48 hours. The inflammatory cell activation, axon degeneration and altered plasticity can occur in the sub-acute and chronic stages of concussion[10]. Even without clear symptomatology in the acute phase, it can thereby appear a posteriori, masked by behaviour that is considered normal in the athlete's surroundings (family, social, sporting).

Risk factors to develop a subsequent disorder include more symptoms early on (such as headaches: and fatigue), previous multiple concussions, psychiatric disorders (anxiety, depression), being unconscious for longer, or amnesia and an earlier age[5]. Consequently, patients should be monitored after the acute phase of the concussion[3].

Clinical diagnosis can be made with the following symptoms which are reasonably unspecific to be able to make a diagnosis themselves[2,3,10]:

- Physical: headache, dizziness, affected vision, balance and sensitivity to light and noise.
- Cognitive: confusion, difficulty to concentrate with expression and memory problems.
- Emotional: irritability, exacerbation of feelings (sadness, lack of energy, effusiveness, rage, fear), the jitters.
- Sleep disorders: changes to sleep patterns with an increase or decrease in the usual number of hours, drowsiness affecting the period of wakefulness or activity.

At the time of a possible injury, the medical professional on the ground assesses the behaviour of the injured person in terms of orientation, memory, concentration, movement and balance, speech and reasoning, plus a cervical exploration to evaluate other injuries[3,10]. If an SRC is suspected, the examination should be exhaustive and specific. The injured person should not be left alone, and their condition should be supervised for the first few hours. Sports organisations must allow enough time to perform this assessment. OPne aspect that could be improved is determining a given time in sports rules that still do not include it.

Any athlete that suffers increased symptomatology after the suspicion of a concussion must withdraw from the activity until an additional assessment can confirm or rule out SRC.

The justification for immediate withdrawal from the sports field and consequent evaluation would be the presence of warning signs or visible indicators such as loss of consciousness, convulsions due to the impact, difficulty remaining upright, empty gaze, lack of motor coordination or balance[3,10]. Any of these observed or reported symptoms must imply stopping any sporting activity for at least the rest of the day.

Presenting more severe head injuries with lengthy loss of consciousness, intense or worsening headaches, vomiting that does not stop, declining mental state, focal neurological shortfall or suspicion of a significant head injury (skull fracture, intracranial haemorrhage) must trigger the emergency plan.

Diagnosis

A medical examination is the first step to diagnose a possible head injury.[2,3,5,10] If there are signs or symptoms from one or more of the examination areas (neurological, motor, sensory, cognitive), an SRC must be suspected, a differential diagnosis determined, and the appropriate care strategy followed. The medical professional who knows the athlete is the most appropriate person to detect subtle changes in their personality and performance. The concussion assessment must be performed in a distraction-free environment with plenty of time for the examination and to complete the concussion tests.

In terms of differential diagnosis, it must be distinguished from symptoms due to drugs, alcohol, use of medicine or other injuries (vertebra, peripheral vestibular dysfunction) or other co-morbidities (psychological or medical afflictions)[3,5,10].

An SRC can cause neuropathological changes, but the acute clinical signs and symptoms largely reflect a functional alteration instead of a structural injury and, as such, no abnormality is seen in the standard structural neuroimaging studies[3].

Underlying factors prior to an SRC have been demonstrated[21,22], such as the type of sport, a prior history of concussion, age, suffering migraines, fatigue and sleep alterations, that can be predicted from subsequent symptomatology with a longer recovery and the appearance of symptoms related to the cognitive-somatic-sensory axis.

Consequently, the concussion diagnosis is a clinical diagnosis[2,3,10,21-23] working from the clinical history and the secondary assessment in the first instance and then according to how the injury evolves:

The clinical history included in the medical check-up prior to taking part in the sport, plus the usual examinations regarding balance, reflexes, hearing and sight, an assessment of previous concussions or other traumatic brain injuries (number, recovery evolution and time between injuries), presence of other premorbid/comorbid conditions, or other factors, that can make diagnosis and/or care for the concussion difficult, including a background of learning disorders, mood swings, attention deficit, motion sickness or sensitivity to movement, personal or family history of migraines and information on current medicine consumption. These data will be used, in the event of an SRC, to provide assistance, improve care and draw up an emergency plan.

The secondary assessment with a physical and neurocognitive examination, using a fast, reliable and standardised assessment system. This should be performed immediately and/or in a distraction-free

environment with the concussed person at rest, depending on how badly hurt they are.

Currently, the best developed tool with the widest field of implementation available for secondary assessment is the SCAT Sport Concussion Assessment - which is updated periodically, according to scientific evidence, by the Concussion in Sport Group (CISG) from the second International Consensus Conference on Concussion in Sport held in Prague in 2004[2,3,10,24,25]. The 5th version, SCAT5, is currently in use, as the latest version agreed on by the panel of experts from the 5th International Consensus Conference on Concussion in Sport held in Berlin in 2016[3,26]. Its official supports are SCAT5 for athletes aged 13 or over[27,28] and paediatric SCAT5 for children from 5 to 12 years old, due to their differences from adults[29-32].

SCAT is useful immediately post-injury to differentiate between concussed and not concussed athletes. It takes 10 minutes, but it seems to be significantly less useful 3 to 5 days after injury[4,10,25]. The symptom verification list, however, is clinically useful when monitoring recovery. It is recommended to use SCAT post-injury in situ with part of the questionnaire and finish it subsequently, in a quiet place, away from where the injury took place to make the data more objective (changing rooms, consulting room).

SCAT5 contains indications, instructions, questions to verify the symptoms and clinical assessments that are performed immediately and a few hours after the sports trauma with a concussion or suspicion of concussion. It includes an evaluation of the motor function (movement), the sensory function, coordination of reasoning and reflexes. It encompasses the system to assess memory with the Maddocks questions, the Glasgow Coma Scale (GCS), the Standardised Assessment of Concussion (SAC), the Modified Balance Error Scoring System (mBESS), the ruling based on the questionnaire scoring and advice for whoever is going to monitor the convalescent athlete. It is recommended to question the athlete on symptom assessment for an acute/post-acute phase, when taking the test. In the stable or baseline situation, it will be filled in by the affected person, and will be a self-assessment[26-28].

The paediatric SCAT5 includes tests and assessments scored according to paediatric age[29,31].

Other tools and tests that can be used in the secondary assessment, along with the SCAT5 or alone, according to presented symptomatology, are the CogSport (cognitive function tests), Automated Neuropsychological Assessment Metrics (ANAM), system of Central or Immediate Nervous System Vital Signs[3,10,25].

Vestibular/Ocular Motor Screening (VOMS) is useful to assess the vestibulo-ocular reflex in people aged over 8 years old[33,34] . The sensitivity (probability of correctly identifying the concussion) and the specificity (probability of correctly identifying the absence of concussion) of the sport concussion diagnosis can increase when combining multiple assessment tools.

Regarding the test-retest reliability (sensitivity and specificity), as a novel concept, the SCAT5 includes optional lists of 10 words and longer sequenced lists of digits counting backwards[27], to minimise the ceiling effect (obtaining the maximum score or close to it in most people), which was a bias in the SCAT3 memory and concentration assessment score. There are currently no applied sensitivity and specificity studies for SCAT5 and children's SCAT5 and it remains to be demonstrated whether these changes have made them more reliable than previous versions.

All the tests most widely used in the secondary evaluation, including any from SCAT5, can be applied as pre-season assessment (verification of symptoms, assessment of balance and cognitive function), above all in the case of post-concussion[10,21-24]. However, the whole battery of assessment tool tests is not essential or required to care for SRC properly.

It should be highlighted that, to optimise diagnosis from the result or score obtained from secondary evaluation tools, it is necessary to know about the limitations both in the case of the assessor and the subject[10]. The assessor can make a methodological mistake in the scoring if they are not familiar with the psychometric properties of the tools that they are using in relation to the symptoms presented by the concussed person to be assessed. Likewise, the subject can change the result of the self-assessment tests by performing them repetitively and thereby memorising them.

To reach an accurate diagnosis, all tests must be interpreted in combination with a decisive presentation of concussion.

The diagnostic imaging tests, including CT and MRI scans do not diagnose SRC[3,10]. However, in the case of suspecting an intracranial haemorrhage, they can help to rule out a potentially deadly brain injury, that might require immediate surgical attention.

Fluid biomarkers and genetic tests are important research tools, but they require additional validation to determine their whether they are clinically useful in SRC assessment[35]. More research is required on current limitations as a diagnostic resource for concussion.

Treatment and return to sporting practice

After a concussion, the symptomatology is generally resolved sequentially until the previously normal situation is restored, taking 1 to 4 weeks (10-14 days for adults, over 1 month for children) with cognitive and physical rest that reduces the post-concussion symptomatology as it demands less brain energy[3,6,10,30-32,36]. 80%-90% of teenagers and adults improve in 2 weeks, recovering their previous balance and cognitive function. Each person's recovery time is different and treatment must be individualised with gradual progression, limited by the symptoms[3]. It is currently not possible to quantitatively standardise the recovery period as the physiological aspect might take longer than the clinical symptomatology and there are no diagnostic tools to measure physiological changes (magnetic resonance, blood flow to the brain, electro-physiology, heart rate, fluid biomarkers, among others) which have been validated by the clinical interpretation[3]. More research is required in this field.

Should the recovery time top one month, this is usually related to a history of prior concussions, suffering migraines, sleep and psychiatric variations (anxiety, depression)[5,21,22], more evident in children, teenagers

and young adults[32,36]. The recovery delay is also influenced by a greater degree of symptom presentation and the severity, loss of consciousness, retrograde amnesia or post-trauma amnesia[3], and the early appearance of headaches and depression[36]. More research studies are required to set clinical profiles with the duration of the recovery period, the age and the gender.

The athlete must rest physically and cognitively to a certain extent to ease remission of symptoms, starting with 24-48 hours and spanning several days. Their symptomatology should be monitored by a person nearby, who is aware of the possible variations (worsening headaches, drowsiness, vomiting, inability to recognise persons/places, variations in behaviour and speech).

If behaviour changes are observed, or vomiting, worsening headaches, double vision or excessive drowsiness, this would constitute an emergency and you would have to get in urgent contact with your doctor or with the emergency services[3,10,26].

In most cases, after getting through the first 24-48 hours and after a few days' rest, the athlete will be able to gradually increase their level of daily physical activity and non-contact aerobic exercise, as long as the symptoms do not get worse or become exacerbated[37]. Several studies refer to a short recovery with sub-symptomatic threshold aerobic exercise between 3 and 7 days after the injury, in adolescent males and young people[37,38]. There are currently insufficient consensus tests to prescribe complete rest for over 24-48 hours to improve recovery[3,10].

When the athlete is capable of performing all usual daily activities asymptomatically, they can begin the phase to progressively return to sports practice[3,10]. This should involve a gradual exercise programme following stages (type of exercise, intensity, duration, with/without contact), run by a doctor. The duration time for gradual incorporation into sport is multi-factor (age, history, type of sport and level, etc.) and must be managed individually. Different stages must be defined, conditioned by the clinical evolution, as a strategy for gradual return to sport[27], such as setting aside more than 24 hours for each one, not introducing endurance training until the 3rd or 4th week or the last stages and going back to the previous stage if the athlete's condition gets worse with a frequency of at least 24 hours. When to introduce early training, and in which cases, is still under investigation[10]. Early activity and exercise do not replace the gradual return to sport.

Among children and young people, it is important to consider that their learning ability can be affected by concussion. Coordination is therefore vitally important between the doctor, parents, carers, when appropriate, and teachers to manage the plan to return to school[6,26,27]. In children, non-sporting games should also be considered, particularly in unpredictable environments (school playground), to avoid a relapse or a further injury[6,29-32]. The return to playing sport is conditioned by an absence of symptomatology in daily physical-cognitive activities and academic learning activities.

If clinical symptoms persist during the sequential evolution of the recovery, this may be associated with recurring injuries of the cervical column and the peripheral vestibular system that might require a multidisciplinary professional group for well-managed therapy including psychological, cervical and vestibular rehabilitation[3,10].

Symptomatic pharmacological treatment has not been properly corroborated[3]. If it can be justified, the athlete should not play again until this treatment is complete as it might be masking or modifying the SRC symptomatology. The doctor should assess when this return is appropriate.

Regarding treating concussion with dietetic supplements such as group B vitamins, vitamins C, D, E, magnesium, branched-chain amino acids, N-acetyl cysteine, N-methyl-D-aspartate, Nicotinamide riboside, fatty acids ω-3, creatinine, curcumin, resveratrol, caffeine and melatonin, with evidence of improving symptomatology in animal models, protecting or accelerating recovery, it cannot be extrapolated and lacks sufficient research in humans, and would require more research to be used rigorously, reliably and safely[36,37].

In summary, it can be concluded that post-concussion treatment must be individualised by introducing physical activity and gradual cognitive activity, limited by symptoms, with sub-symptomatic aerobic exercise and therapy programmes according to variations in the vestibular and cognitive-behavioural function. Return to sporting practice can be determined with gradual programming of physical exercise monitored by a doctor, conditioned by lack of symptomatology in daily activities and school or academic learning, in students.

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