

REVIEW ARTICLE

WILEY

Recommendations for initial examination, differential diagnosis, and management of concussion and other head injuries in high-level football

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Funding information

Fédération Internationale de Football Association (FIFA) funded travel and accommodation for the participants of the group meetings in Zurich, Switzerland.

Head injuries can result in substantially different outcomes, ranging from no detectable effect to transient functional impairments to life-threatening structural lesions. In high-level international football (soccer) tournaments, on average, one head injury occurs in every third match. Making the diagnosis and determining the severity of a head injury immediately on-pitch or off-field is a major challenge for team physicians, especially because clinical signs of a brain injury can develop over several minutes, hours, or even days after the injury. A standardized approach is useful to support team physicians in their decision whether the player should be allowed to continue to play or should be removed from play after head injury. A systematic, football-specific procedure for examination and management during the first 72 hours after head injuries and a graduated Return-to-Football program for high-level players have been developed by an international group of experts based on current national and international guidelines for the management of acute head injuries. The procedure includes seven stages from the initial on-pitch examination to the graduated Return-to-Football program. Details of the assessments and the consequences of different outcomes are described for each stage. Criteria for emergency

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management (red flags), removal from play (orange flags), and referral to specialists for further diagnosis and treatment (persistent orange flags) are provided. The guidelines for return to sport after concussion-type head injury are specified for football. Thus, the present paper presents a comprehensive procedure for team physicians after a head injury in high-level football.

KEYWORDS

assessment, examination, head trauma, signs and symptoms, sports

1 | INTRODUCTION

Across all sports, special attention should be given to acute head injuries, since they may be potentially severe and may lead to a prolonged recovery or to long-term consequences.¹ The incidence of head injuries and concussions in football has been reported to be lower than in American football, ice hockey, or rugby² but higher than in non-contact sports.³ Published incidences are higher in female than male players,^{4,5} during matches than during training,⁵ and highest during international tournaments with about one injury in every third match, and one or two concussions per tournament.⁴ As in other sports, the total number of concussions and other head injuries in football appears to be underreported.⁶⁻⁸

Head injuries include all injuries caused by a direct or indirect blow against/transmitted to the head and can result in substantially different central and peripheral outcomes, ranging from no detectable functional effects to transient functional impairments, from absent to major structural lesions, and from clinically absent to life-threatening deficits.⁹⁻¹² A differentiation between injuries of the brain, the skull, the face, the cervical spine, or the inner ear (vestibular and cochlear labyrinth) is often not possible on-pitch or off-field,¹³ especially since combined injuries of different central and peripheral systems (eg, brain, cervical, vestibular, cochlear, and ophthalmological) are frequent.^{10,14,15} In addition, an athlete may not have or may not report any symptoms immediately after the injury, nor demonstrate any pathological signs; however, he/she might develop symptoms and/or abnormalities on physical examination minutes, hours, or even days later.^{12,16-18} Thus, the diagnosis and estimation of the severity of an injury on-pitch or off-field is a major challenge for the team physician.¹⁹ Nevertheless, an immediate, targeted assessment and diagnosis is of great importance for the return-to-play decision and the therapeutic approach.^{10,13} The present paper provides practical recommendations for team physicians on the management during the first 72 hours after a head injury in high-level football, and a football-specific Return-to-Sport program.

Our recommendations are based on a review of the literature with regard to the newest findings on concussion,

that is, mild traumatic brain injury (mTBI), as well as peripheral injuries (eg, vestibular organ or cervical spine), and are specifically designed for high-level football. We have defined high-level football as participation in international or national competitions. The review of the literature included national and international guidelines for the management of concussion in sports by expert groups (eg, Concussion in Sports Group),^{11,20-22} American Academy of Neurology,²³ American Medical Society for Sports Medicine (AMSSM),¹⁰ American Association of Neurological Surgeons,²⁴ and sport federations (eg, World Rugby,²⁵ National Football League,²⁶ National Hockey League,²⁷ English Ice Hockey Federation,²⁸ Parachute Canada,²⁹ Water Polo Canada³⁰) as well as national and international guidelines on the management of mTBI^{12,16} and (other) head injuries.¹⁸

All authors are experienced in the management of concussion/TBI and cover different medical areas: Emergency Medicine, Neurology, Neuro-Otology and Neuro-Ophthalmology, Internal Medicine, Football and Sports Medicine, Performance Medicine and Rehabilitation Medicine. Four authors (G.C., C.C., M.P., and T.M.) are team physicians and two (E.K. and G.C.) emergency physicians in high-level football. The authors are from three continents.

2 | PROCEDURE AFTER HEAD INJURY

A systematic approach for the initial examination, diagnosis, and management in the first 72 hours after head injury in high-level football has been developed (Figure 1). The procedure can be initiated by the team physician or his/her designee. It consists of seven post-injury phases and includes the emergency management (Figure 2), an initial (on-pitch) examination (phase 1), followed by off-field/quiet area (phase 2/3), post-match examinations (phases 4-6), and a detailed Return-to-Football program (phase 7).

The initial (on-pitch), off-field, and quiet area examinations are not designed to make a specific diagnosis, such as a concussion, but to identify clinical signs and symptoms, which require (temporary) removal from play for a more detailed

PROCEDURE AFTER HEAD INJURY IN HIGH-LEVEL FOOTBALL

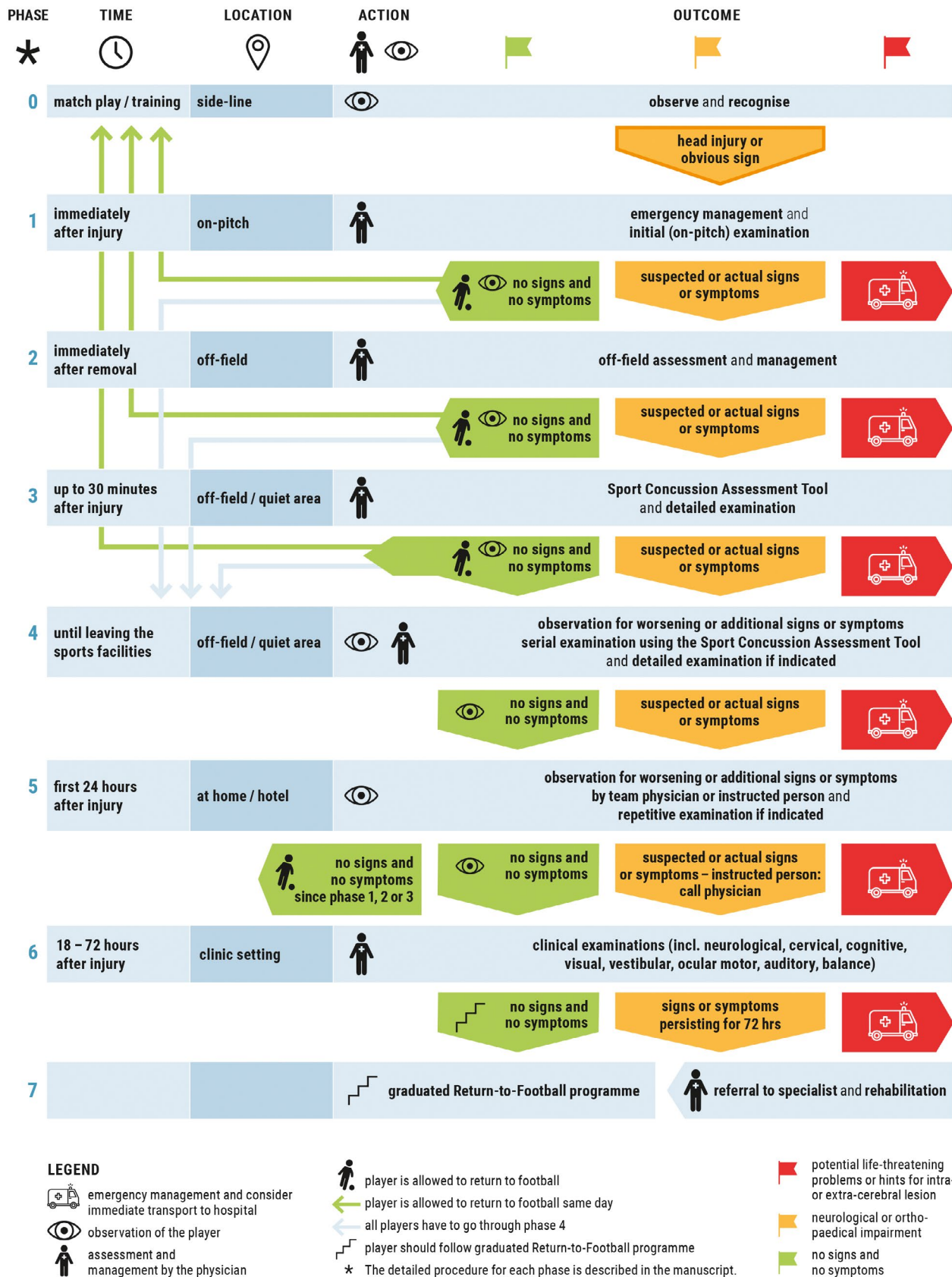


FIGURE 1 Procedure after head injury in high-level football

EMERGENCY MANAGEMENT ACCORDING TO ADVANCED TRAUMA LIFE SUPPORT™ PRINCIPLES




Domain	Concern (C), Examination (E)	Actions	Consequence
cardiopulmonary	C: Cardiopulmonary arrest E: Unresponsiveness, not breathing normally	<ul style="list-style-type: none"> → Start cardiopulmonary resuscitation (CPR) chain: emphasis on chest compression and rapid defibrillation → Place the Automated External Defibrillator (AED) but shock the player only if the AED device self charges and verbally recommends pressing the shock button → Place player onto spinal stabilizing device (e.g. spinal board) and strap appropriately 	<p>Remove the player from the pitch and continue emergency management if indicated</p> <p>Consider immediate emergency transport to hospital</p> 
brain	C: Intra-cranial lesion E: Glasgow Coma Scale < 13/15, loss of consciousness, severe headache, repetitive vomiting, seizure/convulsion, abnormal posturing, new difference in pupil size, nystagmus, fall due to imbalance	<ul style="list-style-type: none"> → Neutralise and stabilise cervical spine appropriately → Maintain and protect airway as safely as possible → Ventilate the unconscious patient if necessary → Place player onto spinal stabilizing device (e.g. spinal board) and strap appropriately 	
skull & face	C: Fracture E: Severe headache, blood or clear fluid exiting from the ear(s) or nose, deformity, periorbital or retroauricular haematoma	<ul style="list-style-type: none"> → Neutralise and stabilise cervical spine appropriately → Control any external bleeding → Place player onto spinal stabilizing device (e.g. spinal board) and strap appropriately 	
cervical spine & neck	C: Fracture or intraspinal lesion E: Deformity, severe pain, swelling over the neck, paresis, impaired sensation	<ul style="list-style-type: none"> → Neutralise and stabilise cervical spine appropriately → Place player onto spinal stabilizing device (e.g. spinal board) and strap appropriately 	

FIGURE 2 Emergency management according to Advanced Trauma Life Support™ principles

examination. Due to the potential severe neurological consequences of a head injury, any suspicion of abnormal findings should result in initiation of appropriate emergency management in case of red flags (Figure 2), further examination in case of orange flags (Figure 3), and *removal from match or training*. If the physician is in doubt, the player should be removed from the pitch. Only players without suspected signs or symptoms of a TBI (including concussion) or other significant injury *should be allowed to continue to play or train*.

The post-match examinations serve to establish a diagnosis to accurately initiate therapeutic strategies and a safe return to football. The physician should be aware that an emergency situation can arise at any time in the first hours and days after the head injury,¹⁸ and therefore, repetitive examinations are required. Ideally, the team physician knows each individual player, their characteristics, medical history, and baseline tests results, if performed, and should be able to communicate with all players appropriately.

SELECTED SIGNS AND SYMPTOMS INDICATING RED AND ORANGE FLAGS AFTER HEAD INJURY

Domain	Red Flags	Orange Flags
alertness / attention	Glasgow Coma Scale < 13/15	signs: Glasgow Coma Scale 13/15, 14/15, blank look, confusion, disorientation, delayed, slow or inappropriate response, difficulty concentrating, remembering symptoms: feeling slowed down, "don't feel right", drowsiness, fatigue, "low energy"
neuromotor	seizure/convulsion or postictal signs, abnormal posturing	signs: impaired control of trunk or limb movements
headache	severe headache, repetitive vomiting	signs: nausea or vomiting (once), holding of head symptoms: pressure, headache
dizziness / balance	fall due to imbalance	signs: imbalance symptoms: vertigo, dizziness, fogginess, unsteadiness
vision / ocular motor function	crossed eyes, nystagmus, other acute disordered eye movements, new difference in pupil size	symptoms: blurred vision, "eyes cannot follow", sensitivity to light
emotion / behaviour		signs: emotional instability, irritability or aggression with little or no provocation
hearing	acute hearing loss	symptoms: hyperacusis, hypacusis, tinnitus
cervical spine/ spinal cord	pain, tenderness, swelling, deformity, paresis, impaired sensation in upper or lower extremities	signs: impaired hearing, tinnitus, sensitivity to noise symptoms: neck pain
skull / face	blood or clear fluid exiting from ear(s) or nose, deformity, periocular or retroauricular haematoma	signs: contusion, laceration
personal history	anticoagulation, clotting disorder	previous brain injury

Note: Some signs and symptoms can be attributed to different domains.

Orange flags can turn into red flags.



RED FLAGS

potential life-threatening problems or hints for intra- or extra-cerebral lesion
→ if any: emergency management and consider immediate transport to hospital



ORANGE FLAGS

neurological or orthopaedical impairment
→ if any or the physician is in doubt: removal from football and further examination, if required by a specialist

FIGURE 3 Selected signs and symptoms indicating red and orange flags after head injury

Observe and recognize (phase 0):

Team physicians should observe the match (or training) with a focus on potential head injury, which often happens during aerial duels,^{5,31,32} and specifically the immediate red and orange flags (Figure 3), such as (suspected) loss of consciousness, convulsion or abnormal posturing, slowness, or imbalance.^{10,33} The injury mechanism and player behavior are best recognized using direct observation, if possible supported by immediate video review.^{22,33}

With respect to concussion, observable signs demonstrated on video, such as lying motionless, motor incoordination, ataxia, staggering gait, no protective action (floppy, tonic), cervical hypotonia, seizure/convulsion, tonic posturing, and blank/vacant look, have been shown to be useful for clinical decision making.³³

Emergency management and red flags for referral to hospital:

It is important to consider the differential diagnoses when examining a deteriorating or collapsed player.¹⁷ Potentially life-threatening emergency concerns after acute head injury (Figure 2) include signs or symptoms of cardio-pulmonary arrest or of severe structural injuries to the brain, skull, face, cervical spine, or spinal cord, which have been denoted as *red flags* (Figure 3). The emergency assessment and management after any acute head injury should be performed according to clear principles and standardized practice, for example, embodied in the Advanced Trauma Life Support (ATLSTM) principles.^{17,18} The first priority is the treatment of the greatest threat to life and the avoidance of further harm.^{18,34}

Cardiac arrest is extremely rare and not considered to be a consequence of a head injury. It can be caused by a hit against the chest (commotio cordis) or occur spontaneously.³⁵ Full Advanced Cardiac (Life) Support procedures have to be undertaken.^{17,36,37}

Any head injury should be regarded as having a concomitant cervical spine injury until excluded by clinical examination or imaging if indicated (Figure 2).¹² Any suggestion of a cervical fracture or intraspinal lesion (GCS < 15 on initial assessment, neck pain or tenderness, focal neurological deficit, paresthesia, or weakness in the extremities, any other clinical suspicion of cervical spine injury) should result in immobilization and stabilization of the cervical spine, appropriate removal from pitch, and emergency transport to hospital.¹⁸ Similarly, all players with a suspected fracture of the skull should be removed from the pitch for further examination. This includes also players with a suspected skull fracture who are free of symptoms or have local pain only. In addition to local ocular tenderness to palpation, other significant signs and symptoms of an orbital floor fracture are periorbital hematoma, double vision (diplopia), and abnormalities in eye movements. Any deterioration of signs and symptoms can indicate intracranial bleeding and/or swelling,

which can only be diagnosed by tomographic imaging (eg, computerized tomography) of the brain. Therefore, it is also important to continuously observe players even if they are initially symptom-free.

Any red flag (Figure 3) mandates removal from play, treatment on site (on-pitch/sideline/medical room) as necessary and consideration of immediate emergency transport to a hospital, if the sign or symptom is confirmed, persists, or deteriorates.

Initial (on-pitch) examination (phase 1):

The outcome of the initial (on-pitch) examination is the basis for the team physician's decision on emergency management, referral to hospital, off-field/quiet area assessment, and removal from or return to match play or training. The physician's decision should be communicated to the referee during match play and to the manager/coach during training. If no physician is present, the principles of "recognize and remove" and "if in doubt, sit them out" should be applied.³⁸

During this initial examination, it is essential to focus on red and orange flags. The elements of the initial (on-pitch) inspection and examination (Figure 4) are based on the latest version of the Sport Concussion Assessment Tool (eg, SCAT5TM)³⁹ and the NICE criteria.¹⁸ The inspection concentrates on visible signs (eg, loss of consciousness, vomiting), while the examination assesses core signs and symptoms of neurological impairment of different brain areas (cortical, subcortical, cerebellar, brain stem)^{11,40,41} and of a cervical spine or intraspinal injury. Any period of loss of consciousness or GCS < 15 indicates a concussion/mTBI or a more severe TBI.

The injured player should be *removed from the pitch* to the off-field location for further assessments (Figure 1, phase 2) if (a) the outcome in one or more criteria of the initial assessment (Figure 4) is considered or suspected to be abnormal, (b) additional time for examination is required, or (c) all tests yield normal results, but the team physician suspects that the player is suffering from functional neurological impairment.

Note: Any period of *loss of consciousness* or GCS < 15 indicates a concussion/mTBI or a more severe TBI, and thus, the player has to be removed from match play or training, albeit he/she might not have other acute or suspected findings.

The player should *only be allowed to continue to play* or train if all on-pitch examinations reveal no (suspected) signs or symptoms and on explicit confirmation of the player's capability to play by the team physician to the referee during match play and to the manager/coach during training. If the team physician is uncertain, the principle "if in doubt, take him/her out" applies.

The team physician should continue observing the player throughout the match play or training (phase 4) and re-evaluate him/her serially to watch for the delayed onset of signs or symptoms (phase 5). All players after head injury should be observed for the first 24 hours (phase 6).

INITIAL (ON-PITCH) EXAMINATION AFTER HEAD INJURY (PHASE 1)

Inspection	1	Acute signs		
		Short-term loss of consciousness	no	yes
		Deformity or swelling of the head or neck or holding of head due to pain / for stabilisation	no	yes
		Blood or clear fluid exiting from ear(s) or nose	no	yes
		Blank look	no	yes
		Slow in getting up	no	yes
		Vomiting	no	yes
		Uncharacteristic behaviour	no	yes
Examination	2	Glasgow Coma Scale 15 / 15 points		
		Eye opening: spontaneous (4/4 points)	yes	no
		Verbal: oriented (name, place, date) (5/5 points)	yes	no
		Motor: obeys commands (6/6 points)	yes	no
	3	Selected new acute symptoms		
		Headache or pressure in the head	no	yes
		Neck pain	no	yes
		Nausea	no	yes
		Vertigo, dizziness, drowsiness, unsteadiness	no	yes
		Blurred or double vision, sensitivity to light	no	yes
		Tinnitus, hypacusis, hyperacusis	no	yes
		Impaired sensation for upper or lower extremities	no	yes
	4	Orientation and memory (Maddocks questions)		
		What venue are we at today?	correct	wrong
		Which half of the match is it now?	correct	wrong
		Who (which team) scored last in this match?	correct	wrong
		What team did your team play last week/match?	correct	wrong
		Did your team win the last match?	correct	wrong
	5	Delayed, slow or inappropriate responses	no	yes
	6	New difference in pupil size, crossed eyes, spontaneous nystagmus	no	yes
	7	Range of motion of cervical spine, only if no acute neck pain		
		Active rotation to the left and right from neutral position	normal and painless	impaired or painful
		Active flexion and extension from neutral position	normal and painless	impaired or painful
	8	Strength of upper and lower extremities	normal	impaired
	9	Touch sensation of upper and lower extremities	normal	impaired
	10	Balance, control and coordination of posture and limbs		
		Stand on both legs with heel-toe together (eyes closed, 10 sec.; if failed: maximal 1 repetition)	stable / no sway	failed
		Finger-to-nose task (right and left) (eyes closed, 2 repetitions both sides)	all trials correct	failed

 If no signs and no symptoms → player is allowed to return to match play or training; further observation until leaving the sports facilities


 Orange flags can turn into red flags
If any orange flag or if the physician is in doubt → removal from football and further examination
If any red flag → emergency management

FIGURE 4 Initial (on-pitch) examination after head injury (phase 1)

Off-field assessment (phase 2):

The off-field assessment should focus on red and orange flags (Figure 3). Testing of ocular motor function should be included, since many of the pathways in the brain potentially affected by head injuries are involved in ocular motor control.⁴²⁻⁴⁴ Obvious minor injuries, such as lacerations or bruises, might be treated.

Examination and treatment in a quiet area (phase 3):

Players attributed with any (suspected) orange flag on-pitch or off-field should be examined in a quiet area (eg, medical or locker/change room, pop-up tent) using the latest version of a sport concussion assessment tool (eg, SCAT5TM)^{39,45} and a detailed neurological examination.

The neurological examination should include an examination of cranial nerves, vestibular, balance, and coordinative functions (spontaneous nystagmus, head impulse test,⁴⁶ vertical eye deviation, dynamic visual acuity,⁴⁰ balance (Romberg), positioning maneuvers),^{43,47} cervical spine (range of motion, stability, proprioception, strength, muscle tone), motor function of upper/lower extremities, and standardized neurocognitive tests. Based on the outcome of the neurological examination, the team physician decides on further examinations, as recommended by the National Institute of Health and Care Excellence (NICE) for head injuries¹⁸ and by the European Federation of Neurological Societies (EFNS) guidelines for mTBI¹⁶ as well as other guidelines.¹²

Players who *continued playing or returned* to the match or training session where they incurred the head injury, and who have no further signs or symptoms after phase 2 (or 3) can be allowed to participate as usual in the next training and match. Players who are *removed* from the match or training session and *have signs or symptoms* of a TBI (including concussion) or of other significant head injury at any time should complete the graduated Return-to-Football program (Stage 7) once their symptoms have resolved.

Observation and serial re-examination until leaving the sports facilities (phase 4):

The team physician should observe the player until the end of the match or training for worsening or additional signs or symptoms regardless of whether the player had returned to or was removed from match play or training. Medications that may mask or worsen symptoms should be avoided unless a more severe head injury has been ruled out. Any worsening or newly developed signs or symptoms should result in emergency management in the case of red flags or further examinations in the case of orange flags (Figure 3).

Prior to leaving the sports facilities, all injured players should be re-examined for worsening of or new signs and symptoms using the latest version of a sport concussion assessment tool. Before travel without access to emergency care (eg, flight), any worsening of symptoms or concern for any form of brain, skull, or cervical spine injury should be

cleared with appropriate diagnostic imaging. Driving a car should not be allowed until medically cleared,³⁹ which was reported to take about 24 to 48 hours.⁴⁸

An initial computerized tomography (CT) scan is recommended on the day of injury, if risk factors for a brain injury (eg, Glasgow Coma Scale < 13 or < 15 after 2 hours, suspected skull fracture, more than 1 episode of vomiting, post-injury seizure, loss of consciousness, persistent anterograde amnesia, or focal neurological deficit) are present.^{12,16,18}

Observation for 24 hours after head injury (phase 5):

In general, all players after a head injury should be observed for 24 hours either by the team physician or by a reliable adult person instructed to immediately contact the team physician or the emergency department of the closest hospital in case of worsening of or new symptoms (red or orange flags, Figure 3).¹⁸ Until re-evaluation (phase 6), physical and cognitive rest is recommended, which includes avoidance of using electronic devices.

If a player was allowed to return to play on the day of injury, is free of symptoms, and has a normal neurological examination, the team physician may decide that the observation is not necessary.^{11,16} In any case, the injured player should be informed and instructed to report worsening or new symptoms, and the team physician should contact him/her the following morning with respect to symptom development and further steps.

Re-evaluation within 18 to 72 hours after head injury (phase 6):

A player who was removed from football and those who continued to play and developed specific signs or symptoms at any time after the head injury should be re-evaluated within 72 hours by a physician, or his/her designee, experienced in head injury assessment according to current international guidelines.^{49,50} The time frame of up to 72 hours has been chosen, since symptoms can develop with latency, and a brief initial period of cognitive and physical rest after brain injury is currently recommended.^{51,52} Ideally, the team physician, or his/her designee, should assess the injured player daily during this period, if the number or the intensity of signs and symptoms do not improve or even worsen.

In addition to the examination of cranial nerves, cervical spine, motor function of upper/lower extremities, balance, vestibular, ocular motor, vision, coordination, emotions, and neuropsychological tests, a detailed medical history (eg, previous head injuries, pre-existing headache, or sleep problems), and, if indicated, neurocognitive tests should be included.⁴⁹ These examinations provide valuable hints to different head injury diagnoses.⁴⁹ Figure 5 indicates which signs and symptoms might be caused by injuries of the brain, the cervical spine, and the vestibular, cochlear, visual and ocular motor systems and thus helps to choose a medical specialist for further examination and treatment in case of persistence. Results from baseline testing may be helpful for comparison

of signs and symptoms in the decision-making process with respect to the most appropriate diagnostic and therapeutic approach.

The aim of the examination in phase 6 is to decide whether

1. The player is medically cleared to *start the graduated Return-to-Football program (phase 7)* in case of no, minimal, or improving symptoms and a normal outcome of all examinations in phase 6; or
2. The player should be *referred to a medical specialist* for further examination and treatment in case of persistent or orange flags (see Figures 3 and 5).

Graduated Return-to-Football (phase 7):

The graduated Return-to-Football program (Figure 6) is based on the Return-to-Sports protocol by McCrory et al¹¹ and intended to ensure a controlled stepwise return to sport activities for high-level adult football players after concussion/mTBI. It adds football-specific detail to the more general recommendations from the Concussion in Sports Group. For players with a structural damage (such as intracranial hemorrhage or skull fracture), the return-to-football procedure should be determined on an individual basis by the physician in charge.

The player should be re-examined by the physician in charge before starting symptom-limited activity (Stage 1), ideally within 18–72 hours after head injury (Figure 1, phase 6) and before returning to “routine/contact training” (Figure 6, Stage 5). The medical re-evaluations should focus on (a) the abnormal diagnostic findings on the day of injury, (b) persisting or additional signs or symptoms or changes in their character, intensity or frequency, and (c) symptom development under increasing physical and cognitive training load.^{10,53,54}

Current guidelines and position statements agree that a player with a (suspected) concussion should not return to sport on the same day.^{10,11} Although there is insufficient scientific evidence on appropriate duration of rest after concussion, an initial phase of cognitive and physical rest (24 to 48 hours) before the graduated return to training and match play is recommended. After this initial period of rest, low-level exercise that does not lead to worsening of pre-exercise intensity of symptoms or new symptoms has been identified as meaningful.^{55–57} Allowing a player to participate in low-level exertion without exaggeration of symptoms and without the risk for contact or fall may also minimize the players' likelihood for emotional affection as psychological response to the injury.^{58,59} Allowing a player, with symptoms to participate in low-level exercise (as part of the treatment plan) should be differentiated from the graduated or accelerated Return-to-Football program. The duration until return to match play varies and might be influenced by player's age or his/her history.^{10,11} A multidisciplinary team approach is

recommended especially with respect to return to routine/contact training.

The standard Return-to-Football program (Figure 6) comprises six stages with a graduated increase in physical demands (“aerobic” to “anaerobic,” “no resistance” to “resistance”), football-specific exercises (“simple” to “complex”), and the risk of contact (“individualized” to “team training,” “non-contact” to “full contact”) and head impact (“no heading” to “heading”). Each stage should include at least one training session and should last according to current guidelines for a minimum of 24 hours.^{10,11} In case of worsening or recurrence of symptoms during or after a training session of any stage, the player should rest until these symptoms have resolved (for a minimum of 24 hours) and then continue the program at the previous symptom-free stage.¹¹ The player should only be medically cleared to return to football, when each stage has been completed without symptoms. Currently, there are no scientific data on the appropriate duration of absence from match play after a head injury. In the adult players with minimal symptoms, no prior brain or other significant head injury, and no other risk factors, an accelerated Return-to-Football program can be considered, while in younger players and players with certain risk factors, such as a history of repetitive concussive injuries, a more conservative approach is recommended.^{60,61} In some leagues, there are more specific, mandated concussion guidelines and the team physician should refer to these where relevant.

The accelerated Return-to-Football program should only be initiated, if (a) any acute post-injury symptoms and signs were classified as not specific for concussion, (b) the duration of these unspecific symptoms was shorter than 24 hours, and (c) the results of the re-evaluation were normal (or similar to pre-injury baseline, if performed). Persisting orange flags or one or more red flags at any time after the head injury disqualify from an accelerated return to football. The accelerated return-to-football approach concentrates on stages 2 and 5 and requires a close cooperation of the player, the coach, and a physician experienced in concussion management. Individual variations between the accelerated and the standard approach are possible; however, no scientific evidence on the effectiveness is currently available. Any individual return-to-football procedure should include a multidisciplinary approach.

Detailed recommendations on Return-to-School/Work were published, for example, by the Concussion Awareness Training Tool (CATT),⁶² and are not specific for football.

Medical clearance for *return to football, school, work, or other physical activity* should always be made by the treating physician/s and based on medical considerations only, regardless of the player's desire to play, dissimulation of symptoms,^{62,63} and/or pressure from others including the coaching staff, parents, or media.

Signs and symptoms after a head injury and their differential diagnosis

Domain	Signs and symptoms	brain	cervical	vestibular	cochlear	ophthal- mologic
alertness / attention	difficulty concentrating	✓	(✓)	(✓)	(✓)	(✓)
	difficulty remembering	✓				
	feeling slowed down	✓				
	delayed, slow or inappropriate response	✓				
consciousness / awareness	confusion	✓				
	disorientation	✓				
	“don't feel right”	✓	(✓)	✓	(✓)	(✓)
	drowsiness	✓	(✓)	✓		(✓)
sleep	fatigue or low energy	✓	(✓)	(✓)		(✓)
	changes in sleep	✓	(✓)	(✓)	(✓)	
dizziness / balance	spontaneous nystagmus, positional nystagmus, gaze nystagmus	✓		✓		
	balance problems, imbalance, unsteadiness	✓	✓	✓		
	dizziness, vertigo	✓	(✓)	✓		(✓)
	feeling “like in a fog”	✓	✓	✓		(✓)
emotion	anxiety, irritability, nervousness	✓	(✓)	(✓)	(✓)	(✓)
	sadness	✓	(✓)	(✓)	(✓)	(✓)
headache	positional	✓	✓			
	craniocervical	✓	✓			
	retroorbital	✓	✓			✓
	exercise induced	✓	✓			
vision	blurred vision	✓	(✓)	(✓)		✓
	double vision	✓		✓		✓
	unilateral vision problems	✓				✓
	sensitivity to light	✓				✓
hearing	hyperacusis, hypacusis, tinnitus	✓	(✓)		✓	

Note: Many symptoms are non-specific and can be caused by other reasons such as dehydration, heat or other illness.

FIGURE 5 Signs and symptoms after a head injury and their differential diagnosis

GRADUATED RETURN-TO-FOOTBALL PROGRAMME FOR HIGH-LEVEL PLAYERS

STAGE	FOCUS	ACTIVITY
1	Symptom-limited activity	Daily activities without exaggeration of symptom-threshold (worsening of pre-activity symptoms or additional symptoms), e.g. 10 min of slow walking
2	Light aerobic exercises (unspecific)	a) Cardiovascular exercise on stationary bike; 25 – 40 min. including warm up and cool down; controlled activities, low to moderate intensity b) Mobility / stretching, stabilization and balance (double and single stance) exercises
3	Football-specific exercises	a) Cardiovascular training on the field - Warm up for 10 min. at moderate intensity with variable running tasks - Interval runs at higher intensities with sufficient breaks - Cool down for 5 – 10 min. at low intensity b) Technical training with the ball (1:1) - Basics: balance and passing; short / long passing; easy shooting on targets c) Body training (no resistance / add elastic resistance) - Mobility and stretching exercises - Trunk strength / stabilization exercises (no resistance; no explosive movements) - Basic lower / upper extremities strength exercises (elastic resistance) - Balance exercises (double and single stance) on unstable surfaces No heavy resistance training, no contact activities For goalkeepers: controlled diving movements (not explosive) on foam surface in the gym (without catching the ball)
4.1	Non-contact football training drills	a) Cardiovascular training on the field - Warm up for 10 min. at moderate intensity with straight running, changes of direction, lateral shuffles, forward-backwards running, zig-zag running - Interval runs at high intensity up to 90% HR max - Cool down for 5 – 10 min. at low intensity b) Technical training (with small group of players) - Small size-game - Short / long passing - Shooting on goal / targets - Plant / cut, dribbling with the ball - Basics: easy heading with only a soft ball (increase in complexity: while balancing) controlled setting and limited quantity c) Body training (incl. elastic resistance) - Mobility and stretching exercises - Trunk strength / stabilization exercises (incl. free weights) - Basic lower / upper extremities strength exercises (elastic resistance, free weights) - Balance exercises (double- and single stance) on unstable surfaces d) Strength training - Keep resistance below about 80 % 1-RM, no Olympic weight lifting or exercises with head below the level of the hips - Progressively increase external resistance for multi-joint exercises No contact activities For goalkeepers: diving drills on foam surface without and with catching the ball (shots from short / medium range; 1:1 with the goalie coach)
4.2	Football training drills with controlled contact	Controlled contact activities: simulate controlled contact situations (e.g. headers, checks, tackles) - Stepwise increase of intensity - From player with 1 partner (e.g. Rehab-coach) to training in small groups of players - Increase from small playing field (1/3, 1/4) to whole playing field - Heading with regular ball in controlled settings (e.g. after throwing the ball; heading without opponent); gradual increase in the number of headers For goalkeepers: controlled diving drills on grass without and with catching the ball (shots from short/medium/long range; 1:1 with the goalie coach)
5	Full contact practice (team training)	Following medical clearance, ideally by a multi-disciplinary team, participate in normal team training a) Cardiovascular training: continue to progress b) Body and strength training: regain usual routine training (unrestricted) c) Assess and assure psychological readiness
6	Return-To-Football	Normal match play

Note: Move to the next stage only, when activities are tolerated without worsening of pre-activity symptoms or additional symptoms. Student-players shall return to full-time school activities before progressing to phase (stage) 5 and 6.

Abbreviations: e.g. = for example / min. = minutes / HR max = maximum heart rate / incl. = including / 1-RM = one repetition maximum.

FIGURE 6 Graduated Return-to-Football program for high-level players

3 | CONCLUSION

The present paper presents a standardized practical procedure for the initial examination, differential diagnosis, and first 72-hour management after head injury in high-level football and a graduated Return-to-Football program developed by an international group of experts based on review of the literature and current national and international guidelines for the management of head injuries. It should serve as recommendation for team physicians with respect to a consistent procedure after a head injury in football.

4 | PERSPECTIVE

Head injuries can result in different outcomes, and signs and symptoms can develop or change rapidly within minutes, hours, and days after head injury. Therefore, a systematic procedure for examination and management of football players after head injuries should be implemented

to support team physicians in their decision whether the player should be allowed to continue to play or should be removed from play. The presented procedure can be adapted to other sports. Awareness to the potential severity of a head injury should be raised across sports and responsible medical persons.

Future research should focus on biomechanical aspects, such as severity of impact (threshold), and on the time course of pathophysiological/metabolic changes, that may eventually lead to an energy crises and delayed signs or symptoms. Further development and validation of on-pitch tests and measures to quantify signs and symptoms are needed.

ACKNOWLEDGEMENTS

The authors thank the Fédération Internationale de Football Association (FIFA) for funding the group meetings in Zurich, Switzerland. The authors gratefully acknowledge Dr Mario Bizzini for valuable input on the practical procedure in the graduated Return-to-Football program (Figure 6).

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REFERENCES

- Chiang Colvin A, Mullen J, Lovell MR, et al. The role of concussion history and gender in recovery from soccer-related concussion. *Am J Sports Med.* 2009;37(9):1699-1704.
- Prien A, Grafe A, Rössler R, et al. Epidemiology of head injuries focusing on concussions in team contact sports: a systematic review. *Sports Med.* 2018;48(4):953-969.
- Zuckerman SL, Kerr ZY, Yengo-Kahn A, et al. Epidemiology of sports-related concussion in NCAA athletes from 2009–2010 to 2013–2014: incidence, recurrence, and mechanisms. *Am J Sports Med.* 2015;43(11):2654-2662.
- Junge A, Dvorak J. Injury surveillance in the World Football Tournaments 1998–2012. *Br J Sports Med.* 2013;47(12):782-788.
- Maher ME, Hutchison M, Cusimano M, et al. Concussions and heading in soccer: a review of the evidence of incidence, mechanisms, biomarkers and neurocognitive outcomes. *Brain Inj.* 2014;28(3):271-285.
- McDonald T, Burghart MA, Nazir N. Underreporting of concussions and concussion-like symptoms in female high school athletes. *J Trauma Nurs.* 2016;23(5):241-246.
- Kroshus E, Garnett B, Hawrilenko M, et al. Concussion under-reporting and pressure from coaches, teammates, fans, and parents. *Soc Sci Med.* 2015;134:66-75.
- Kerr ZY, Register-Mihalik JK, Kay MC, et al. Concussion non-disclosure during professional career among a cohort of former national football league athletes. *Am J Sports Med.* 2018;46(1):22-29.
- Putukian M, Schepart Z. Sideline assessment of concussion. *Handb Clin Neurol.* 2018;158:75-80.
- Harmon KG, Clugston JR, Dec K, et al. American Medical Society for Sports Medicine position statement on concussion in sport. *Br J Sports Med.* 2019;53(4):213-225.
- McCrory P, Meeuwisse W, Dvorak J, et al. Consensus statement on concussion in sport-the 5(th) international conference on concussion in sport held in Berlin, October 2016. *Br J Sports Med.* 2017;51(11):838-847.
- Levin HS, Diaz-Arrastia RR. Diagnosis, prognosis, and clinical management of mild traumatic brain injury. *Lancet Neurol.* 2015;14(5):506-517.
- Leddy JJ, Baker JG, Merchant A, et al. Brain or strain? Symptoms alone do not distinguish physiologic concussion from cervical/vestibular injury. *Clin J Sport Med.* 2015;25(3):237-242.
- Arshad Q, Roberts RE, Ahmad H, et al. Patients with chronic dizziness following traumatic head injury typically have multiple diagnoses involving combined peripheral and central vestibular dysfunction. *Clin Neurol Neurosurg.* 2017;155:17-19.
- Elzière M, Devèze A, Bartoli C, et al. Post-traumatic balance disorder. *Eur Ann Otorhinolaryngol Head Neck Dis.* 2017;134(3):171-175.
- Vos PE, Alekseenko Y, Battistin L, et al. Mild traumatic brain injury. *Eur J Neurol.* 2012;19(2):191-198.
- Galvagno SM Jr, Nahmias JT, Young DA. Advanced trauma life support((R)) update 2019: management and applications for adults and special populations. *Anesthesiol Clin.* 2019;37(1):13-32.
- Excellence NifHaC. Head Injury: Assessment and Early Management. 2014. <https://www.nice.org.uk/guidance/cg176/resources/head-injury-assessment-and-early-management-pdf-35109755595493>. Accessed May 8, 2020.
- Feddermann-Demont N, Straumann D, Dvorak J. Return to play management after concussion in football: recommendations for team physicians. *J Sports Sci.* 2014;32(13):1217-1228.
- Makdissi M, Davis G, McCrory P. Updated guidelines for the management of sports-related concussion in general practice. *Aust Fam Physician.* 2014;43(3):94-99.
- Patricios J, Fuller GW, Ellenbogen R, et al. What are the critical elements of sideline screening that can be used to establish the diagnosis of concussion? A systematic review. *Br J Sports Med.* 2017;51(11):888-894.
- Putukian M, Echemendia RJ, Chiampas G, et al. Head injury in soccer: from science to the field; summary of the head injury summit held in April 2017 in New York City, New York. *Br J Sports Med.* 2019;53(21):1332.
- American Academy of Neurology Quality Standards Subcommittee Minneapolis M. N. U. S. Summary of Evidence-based Guideline Update: Evaluation and Management of Concussion in Sports 2013. www.aan.com/Guidelines/home/GuidelineDetail/582. Accessed May 8, 2020.
- American Association of Neurological Surgeons. Sports-related Head Injury. www.aans.org/Patients/Neurosurgical-Conditions-and-Treatments/Sports-related-Head-Injury. Accessed May 8, 2020.
- World Rugby. World Rugby Concussion Management. <https://playerwelfare.worldrugby.org/concussion>. Accessed May 8, 2020.
- League NF, Head NFL. Neck and Spine Committee's Concussion Diagnosis and Management Protocol. 2017. <https://www.playsmartplaysafe.com/wp-content/uploads/2017/06/2017-nfl-concussion-protocol.pdf>. Accessed May 8, 2020.
- National Hockey League. Concussion Evaluation and Management Protocol 2016. http://cdn.agilitycms.com/nhlpacom/2016-17_ConcussionProtocol.pdf. Accessed May 8, 2020.
- English Ice Hockey Federation. Medical. <https://eiha.co.uk/eiha-education-program/medical/>. Accessed May 8, 2020.
- Parachute. Homepage. <http://www.parachutecanada.org/injury-topics/item/concussion>. Accessed May 8, 2020.
- Water Polo Canada. Concussion Education & Protocols. <http://www.waterpolo.ca/concussionprotocol.aspx>. Accessed May 8, 2020.
- Fuller CW, Junge A, Dvorak J. A six year prospective study of the incidence and causes of head and neck injuries in international football. *Br J Sports Med.* 2005;39(Suppl 1):i3-i9.
- Beaudouin F, der Fünten K, Tröb T, et al. Time trends of head injuries over multiple seasons in professional male football (soccer). *Sports Med Int Open.* 2019;3(1):E6-E11.
- Davis GA, Makdissi M, Bloomfield P, et al. International consensus definitions of video signs of concussion in professional sports. *Br J Sports Med.* 2019;53:1264-1267.
- Excellence NifHaC. Pre-hospital Management for Patients with Head Injury 2014. <https://pathways.nice.org.uk/pathways/head-injury#path=view%3A/pathways/head-injury/pre-hospital-manag>

- ement-for-patients-with-head-injury.xml&content=view-node%3AAnodes-first-priority-treat-the-greatest-threat-to-life-and-avoid-further-harm. Accessed May 8, 2020.
35. Weinstock J, Maron BJ, Song C, et al. Failure of commercially available chest wall protectors to prevent sudden cardiac death induced by chest wall blows in an experimental model of commotio cordis. *Pediatrics*. 2006;117(4):e656-e662.
 36. Panchal AR, Berg KM, Kudenchuk PJ, et al. 2018 american heart association focused update on advanced cardiovascular life support use of antiarrhythmic drugs during and immediately after cardiac arrest: an update to the american heart association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*. 2018;138(23):e740-e749.
 37. Nikolaou NI, Arntz H-R, Bellou A, et al. Resuscitation Council Guidelines for Resuscitation 2015 Section 8. Initial management of acute coronary syndromes. *Resuscitation*. 2015;95:264-277.
 38. Echemendia RJ, Meeuwisse W, McCrory P, et al. The concussion recognition tool 5th edition (CRT5): background and rationale. *Br J Sports Med*. 2017;51(11):870-871.
 39. SCAT5. *Br J Sports Med*. 2017. <https://bjsm.bmj.com/content/bjsports/early/2017/04/26/bjsports-2017-097506SCAT5.full.pdf>. Accessed May 8, 2020.
 40. Petersen JA, Straumann D, Weber KP. Clinical diagnosis of bilateral vestibular loss: three simple bedside tests. *Ther Adv Neurol Disord*. 2013;6(1):41-45.
 41. Akhand O, Balcer LJ, Galetta SL. Assessment of vision in concussion. *Curr Opin Neurol*. 2019;32(1):68-74.
 42. Kontos AP, Deitrick JM, Collins MW, et al. Review of vestibular and oculomotor screening and concussion rehabilitation. *J Athl Train*. 2017;52(3):256-261.
 43. Mucha A, Collins MW, Elbin RJ, et al. A brief vestibular/ocular motor screening (VOMS) assessment to evaluate concussions: preliminary findings. *Am J Sports Med*. 2014;42(10):2479-2486.
 44. Yue JK, Phelps RRL, Chandra A, et al. Sideline concussion assessment: the current state of the art. *Neurosurgery*. 2020. <https://doi.org/10.1093/neuros/nyaa022>
 45. Echemendia RJ, Meeuwisse W, McCrory P, et al. The sport concussion assessment tool 5th edition (SCAT5): background and rationale. *Br J Sports Med*. 2017;51(11):848-850.
 46. Halmagyi GM, Chen L, MacDougall HG, et al. The video head impulse test. *Frontiers in neurology*. 2017;8:258.
 47. Tarnutzer AA. Benign Paroxysmal Positional Vertigo (BPPV) – Hands on 2018. https://www.ean.org/fileadmin/user_upload/ean/ean/learn/educational_events/Spring_School/Teaching_Material/Presentations_2018/Day_3_Tarnutzer_bppv_hands_on_ean_2018_v1.pdf. Accessed May 8, 2020.
 48. Schmidt JD, Lynall RC, Lempke LB, et al. Post-concussion driving behaviors and opinions: a survey of collegiate student-athletes. *J Neurotrauma*. 2018;35(20):2418-2424.
 49. Feddermann-Demont N, Echemendia RJ, Schneider KJ, et al. What domains of clinical function should be assessed after sport-related concussion? A systematic review. *Br J Sports Med*. 2017;51(11):903-918.
 50. Broglio SP, Harezlak J, Katz B, et al. Acute sport concussion assessment optimization: a prospective assessment from the CARE consortium. *Sports Med*. 2019;9(12):1977-1987.
 51. Schneider KJ. Concussion part II: rehabilitation - the need for a multifaceted approach. *Musculoskelet Sci Pract*. 2019;42:151-161.
 52. Schneider KJ, Leddy JJ, Guskiewicz KM, et al. Rest and treatment/rehabilitation following sport-related concussion: a systematic review. *Br J Sports Med*. 2017;51(12):930-934.
 53. Ellis MJ, Leddy JJ, Willer B. Physiological, vestibulo-ocular and cervicogenic post-concussion disorders: an evidence-based classification system with directions for treatment. *Brain Inj*. 2015;29(2):238-248.
 54. Sufrinko A, Charek D, Gillie B. *Multimodal Concussion Assessment. Return to Play in Football*. Heidelberg, Germany: Springer; 2018:683-698.
 55. Lawrence DW, Richards D, Comper P, et al. Earlier time to aerobic exercise is associated with faster recovery following acute sport concussion. *PLoS ONE*. 2018;13(4):e0196062.
 56. Leddy JJ, Haider MN, Hinds AL, et al. A preliminary study of the effect of early aerobic exercise treatment for sport-related concussion in males. *Clin J Sport Med*. 2019;29(5):353-360.
 57. Leddy JJ, Haider MN, Ellis MJ, et al. Early subthreshold aerobic exercise for sport-related concussion: a randomized clinical trial. *JAMA Pediatr*. 2019;173(4):319-325.
 58. Reardon CL, Hainline B, Aron CM, et al. Mental health in elite athletes: International Olympic Committee consensus statement (2019). *Br J Sports Med*. 2019;53(11):667-699.
 59. Chang C, Putukian M, Aerni G, et al. Mental health issues and psychological factors in athletes: detection, management, effect on performance and prevention: American Medical Society for Sports Medicine Position Statement-Executive Summary. *Br J Sports Med*. 2020;54(4):216-220.
 60. Davis GA, Anderson V, Babl FE, et al. What is the difference in concussion management in children as compared with adults? A systematic review. *Br J Sports Med*. 2017;51(12):949-957.
 61. Iverson GL, Gardner AJ, Terry DP, et al. Predictors of clinical recovery from concussion: a systematic review. *Br J Sports Med*. 2017;51(12):941-948.
 62. Concussion Awareness Training Tool. Return to School 2020. <https://catonline.com/wp-content/uploads/2017/10/CATT-Return-to-School-V11.pdf>. Accessed May 8, 2020.
 63. Kutcher JS, Eckner JT. At-risk populations in sports-related concussion. *Curr Sports Med Rep*. 2010;9(1):16-20.

How to cite this article: Feddermann-Demont N, Chiampas G, Cowie CM, et al. Recommendations for initial examination, differential diagnosis, and management of concussion and other head injuries in high-level football. *Scand J Med Sci Sports*. 2020;30:1846–1858. <https://doi.org/10.1111/sms.13750>