BACKGROUND

Trauma to the head is commonly seen in many sports, especially those involving physical contact between players (Giza et al., 2013). The syndrome is generally referred to as concussion. Concussionis definedas *'A sudden and transient alteration in consciousness induced by traumatic biomechanical forces transmitted directly or indirectly to the brain'* (Ropper and Gorson, 2007).

The majority of concussions in sport occur without loss of consciousness (McCrory et al., 2013b). Only athletes who did not lose consciousness are included in this clinical review, since this type of concussion is more difficult to diagnose. In any case where the athlete has lost consciousness, he or she should immediately be removed from athletic activity.The athlete must be taken to the emergency room and examined by a physician.The physician will assist the patient and the sports physiotherapist in planning the next move.Acute concussion without loss of consciousness may, however, cause more uncertainty as both tests and risk factorshave beensparsely investigated.Thus, the focus of thisclinical reviewis on the acute management of concussion.

The terms mild traumatic brain injury (mTBI) and concussion are often used interchangeably. Concussions are low-velocity injuries that cause brain "shaking," resulting in clinical symptoms, and which are not necessarily related to a pathological injury. mTBI,on the other hand, is an injury characterized by pathological damage to the brain.

Mild traumatic brain injury is diagnosed six hours after the time ofinjury, as minor damage such as concussion may be excluded after that time. Mild traumatic brain injury is diagnosed using the Glasgow Coma Scale (GCS), where 15 is "normal" and indicates absence of neurological damage. Severe sports-related concussion may involve symptoms that rate on the GCS (13-15) (figure 1), butmTBIand concussion are not synonyms (McCrory et al., 2013b).

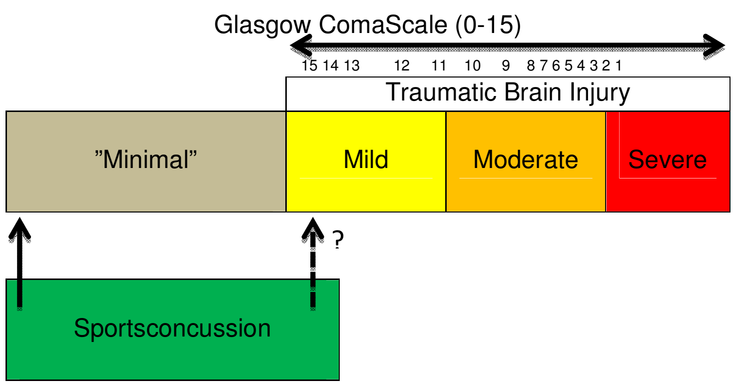

Figure 1.Conceptual understanding of sports concussion. Adjusted from McCrory et al. 2013 (McCrory et al., 2013b)

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Incidence and diagnostics

The incidence of concussions is highest among the 15-25 year olds and comes to a bit over 80 per 1000 inhabitants each year in Denmark (Møller, 2012). The injury is frequently reported in soccer and handball and contributes to 1% of all emergency room visits by handball and soccer players, 370 and 120,respectively, each year(Møller, 2012). Also, horseback riding sends about 400 people to the emergency room each year with a concussion. Giza et al. (2013) state that concussions are generally underreported due to an unclear symptom pattern.In their systematic review,they conclude that females have a higher risk than males(Giza et al., 2013).

A sports physiotherapist is often the first health-care professional to assess an athlete with a concussion. Concussions are considered to be among the most complex injuries in sports medicine to diagnose, assess, and manage (McCrory et al., 2013a). A sports physiotherapist must be very specific in his evaluation when athletessustain a concussion as the consequences of returning to activity may potentially be harmful. There is a huge pressure on the sports physiotherapist, especially in game situations where he must promptly assess whether the athlete is able to continue.In such situations it is crucial to have knowledge of the correct interpretation of symptoms in order to be able to assess the risk of prolonged symptoms.

Neurocognitive function, self-reported symptomsand balance should all be considered in the assessment of concussion (Broglio and Puetz, 2008). The Sport Concussion Assessment Tool 3 (SCAT3) is endorsed by a number of international organizations, including FIFA, as it includes the above elements (McCrory et al., 2013a, Echemendia et al., 2013, SCAT3, 2013). SCAT3 has not been validated as one combined tool, but several of the included tests have been validated separately (see below). A concussion may be diagnosed immediately, and may, over time, develop into intracerebral hemorrhages. However, one must bear in mind the fact that tests do not diagnose a concussion.The mentioned tests are not diagnostic tests *per se*, but are important components in the overall assessment of the condition. Tests may reveal physical, psychological, cognitive and behavioral changes and may thus be used toassist in the diagnosis of concussion (McCrory et al., 2013b). In case of uncertainty about the diagnosis and grading, biomarkers may be used and CT scans may be performed (McCrea et al., 2013, McCrory et al., 2013b).

SUMMARY OF FINDINGS

The literature on which this clinical review is based is generally of a moderate methodological quality equivalent to evidence level 3 (table 1).In addition, two statements from *The American Medical Society for Sports Medicine* (Harmon et al., 2013) and *The 4th International Conference on Concussion in Sport* (McCrory et al., 2013a) are included. Both are based on the latest literature within this field, but are characterized by low methodological quality due to lack of transparency in literature search and/or inclusion and exclusion criteria. Consequently, they are considered expert opinions at evidence level 5.

Table 1: Levels of evidence for diagnosis, prevention and treatment of concussion.						
		Levels of evidence				
		1	**2**	**3**	**4**	**5**
Diagnosis	Low diagnostic ability of Maddocks Score: low positive likelihood ratio (2.3-5.4) and low negative likelihood ratio (0.79-0.29). Very low to low sensitivity (0.32-0.75) and moderate specificity (0.86).				**x**	
	Low to moderate diagnostic ability of The Standardized Assessment of Concussion (SAC): low to high positive likelihood ratio (3.3-10.4) and low to high negative likelihood ratio (0.26-0.07). Low to highsensitivity (0.80-0.94) and low to highspecificity (0.76-0.91).			**x**		
	Low diagnostic ability of Balance Error Scoring System (BESS): low to moderate positive likelihood ratio (3.78-7.11) and low negative likelihood ratio (0.73-0.40). Very low sensitivity (0.34-0.64) and high specificity (0.91).			**x**		
Prevention	There is limited evidence to suggest that protective headgear may reduce the risk of sustaining a concussion.			**x**		
	Rule changes in soccer, ice hockey and rugby have a preventive effect on the number of concussions.			**x**		
	The use of baseline screening tests has no effect.			**x**		
Treatment	There is little evidence supporting rest alone as a treatment for concussion.				**x**	
	There is a small indication that light physical activity which does not provoke symptoms has a positive effect on concussion symptoms.			**x**		
	There is no evidence supporting the most appropriate protocol for return to activity. However, guidelines have been proposed.					**x**

	In young athletes with persistent dizziness and symptoms from the cervical spine, manual treatment of the cervical spine combined with vestibular rehabilitation as a supplement to conventional rehabilitation following a concussion has shown to have an effect on return time to activity.		**x**			

Diagnosis: Diagnostic ability of positive and negative likelihood ratio (very low=LH+ of 1 - 2 and LH- of 0.5 to 1, low=LH+ of 2 - 5 and LH- of 0.2 to 0.5, moderate=LH+ of 5 - 10 and LH- of 0.1 to 0.2, high= LH+ >10 and LH- < 0.1), sensitivityand specificity (very low= <0.65, low= 0.65 - 0.85, moderate= 0.85 - 0.9, high= >0.9).
Prevention and treatment: Effect size (small=0.2, moderate=0.5, large=0.8).

Level 1 refers to well-conducted systematic reviews of randomized trials (treatment and prevention) or cross sectional studies with consistently applied reference standard and blinding (diagnosis)

Level 2 refers to well-conducted individual randomized trials or observational studies with dramatic effect (treatment and prevention) or cross sectional studies with consistently applied reference standard and blinding (diagnosis)

Level 3 refers to well-conducted non-randomized controlled studies / cohort or follow-upstudies (treatment and prevention) or non-consecutive studies or studies withoutconsistently applied reference standards (diagnosis)

Level 4 refers to case-series, case-control studies or historically controlled studies (treatment and prevention) or case-control studies or studies withpoor or non-independentreference standard (diagnosis)

Level 5 refers to mechanism-based reasoning (treatment and prevention) and (diagnosis)

Levels may be graded down on the basis of low study quality, imprecision, indirectness (due to not patient-relevant outcome, indirect comparisons or where the study involves another group of patients) and inconsistency betweenstudies, or because the absolute effect size is very small. Levels may be graded up if there is a very large effect size (OCEBM Levels of Evidence Working Group*. "The Oxford 2011 Levels of Evidence".Oxford Centre for Evidence-Based Medicine.
http://www.cebm.net/index.aspx?o=5653)

DIAGNOSTICS

Clinical tests

Initial examination at first contact

At first contact with an athlete, it is essential to exclude any severe cervical spine injury.If damage to the cervical spine is suspected, the athlete must notbe moved until the cervical spine has been stabilized (evidence level 3) (Putukian et al., 2013). If no damage to the spine is suspected, the sports physiotherapist must carefully examine the athlete to rule out severe brain damage prior to any further examination(table 2). If severe brain damage cannot be ruled out, the athlete should immediately be evaluated by a physician (at the emergency room, if required)(evidence level 3) (Putukian et al., 2013). Where the sports physiotherapist does not suspect any damage to the spine or severe brain damage, the athlete should be evaluated for mTBI or concussion.

Table 2 When to refer to an emergency facility
Worsening headache
Very drowsy or cannot be easily awakened
Cannot recognize people or places
Develops significant nausea or vomiting
Behaves unusually, more confused or irritable
Develops seizures
Weakness or numbness in the arms or legs
Slurred speech or unsteadiness of gait

Adjusted from Putukian et al. 2013.Evidence level 3 (Putukian et al., 2013).

Orientation to time and place

The Maddocks Score may be used as a sideline screening tool (table 3) (evidence level 4) (Maddocks et al., 1995). The test may be applied to rapidly screen orientation to time and place. In an older study, the Maddocks Score was tested to have low to very low sensitivity (0.32-0.75) and moderate specificity (0.86)(Maddocks et al., 1995). This results in a low diagnostic ability at both a positiveand negative test (LH+ 2.3-5.4, LH- 0.79-0.29) (evidence level 4) (Maddocks et al., 1995).There is no indication of how many incorrect answers are required to constitute a positive test. Consequently, the result of the Maddocks Score should always be assessed in combination with other clinical signs.

Table 3 **Maddocks Score**
"I am going to ask you a few questions, please listen carefullyand give your best effort."
Modified Maddocks questions (1 point for each correct answer)

At what venue are we at today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week / game?	0	1
Did your team win the last game?	0	1
Maddocks Score	of 5	

Adjusted from Maddocks et al. 1995 (Maddocks et al., 1995).

Suspected concussion

Where concussion is suspected on the basis of the Maddocks Score and/or the most common signs of concussion,(table 4), the athlete should be examined further either on the sideline or in the more tranquil surroundings of a locker room (evidence level 3) (Putukian et al., 2013).

Under no circumstances should an athlete with suspected concussion return to athletic activities the same day of injury. Not least because concussion symptoms may evolve over time (evidence level 3) (Putukian et al., 2013, McCrory et al., 2013b). A study examining the risks involved in returning to athletic activities after sustaining a concussion found that 33% of athletes with suspected concussion who returned to play on the same day of injury experienced delayed onset of symptoms compared with only 12.6% of those who did not return to play on the same day of injury. (evidence level 4) (Guskiewicz et al., 2003).

The athlete should not be left alone after the injury, and monitoring for deterioration is essential over the initial few hours after injury (evidence level 5) (McCrory et al., 2013a).

Table 4 Acute and delayed signs of concussion

Cognitive	Somatic	Affective	Sleepdisturbances
Confusion	Headache	Emotionally lability	Trouble falling asleep
Anterogradeamnesia	Dizziness	Irritability	Sleeping more than usual
Retrograde amnesia	Balance disruption	Fatigue	Sleeping less than usual
Loss of consciousness	Nausea/vomiting	Anxiety	
Desorientation	Visual disturbances	Sadness	
Feeling 'in a fog'			
Vacant stare, inability to focus			
Delayed verbal or motor responses, slurred/incoherent speech			
Excessive drowsiness			

Adjusted from Putukian et al. 2013. Evidence level 3 (McCrory et al., 2013b, Putukian et al., 2013).

Sideline evaluation and the first 48 hours

For acute assessment of the damage and within the first 48 hours, the Standardized Assessment of Concussion (SAC) (table 5) has proven effective in identifying the presence of concussion.The SAC has been found to have a sensitivity of 0.80-0.94 and a specificity of 0.76-91 (evidence level 3) (Giza et al., 2013). This results in a positive and a negative likelihoodratio of LH+ 3.3-10.4 andLH-0.26-0.07, respectively, which corresponds to a moderate to low diagnostic ability. A meta-analysis from 2008 concluded that the SAC is particularly sensitive to neurocognitive impairment immediately following injury (Broglio and Puetz, 2008).

A SAC test is assessed to be positive if the test score following a concussion drops by 1-3 pointscompared with the baseline score. A change from the baseline score of only 1 point is associated with the risk of false positive testresults. I.e. an athlete that is suspected of having sustained a concussion is tested positive, but turns out not to have a concussion. On the other hand, a change of 3 points from the baseline score to the post-injury test may be associated with uncertainty in the form of false negative testresults, which means that an athlete suspected of concussion is tested negative, but turns out to have sustained a concussion. To be on the safe side, the authors suggest that a change of 1 point should constitute a positive test (Barr and McCrea, 2001).

A meta-analysis from 2008 (evidence level 3) (Broglio and Puetz, 2008)showed that a concussion had a large negative effect on neurocognitivefunctioning in the initial assessment following injury assessed by neurocognitive tests such as the SAC, ”pencil & paper” (P&P) and computer-based tests with an effect size of -0.81 (-1.01, -0.60), $p<0.001$. These tests – particularly the SAC – were sensitive to acute neurocognitive changes resulting from a concussion.

Balance test

The Balance Error Scoring System (BESS) consists of a number of balancetests for assessing the athlete’s postural stability. BESS has been found to have a low to moderate diagnostic precision (sensitivity 0.34-0.64, specificity 0.91) (evidence level 3) (Giza et al., 2013). This results in a positive and a negative likelihoodratio of LH+ 3.78-7.11 and LH- 0.73-0.40, respectively. LH+ corresponds to a low to moderate diagnostic ability, whereas LH- corresponds to a low diagnostic ability. Also, BESS has been found to have low interand intra-rater reliability (evidence level 5) (Harmon 2013). A modified version of the BESS is included in the SCAT3 test battery.

<u>Baseline testing</u>

Pre-season baseline tests should, in theory, enhance the diagnostic precision when compared with post-injury data. It will minimize the variation associated with pre-injury confounding variables. If baseline tests are not performed, it is essential to have normative data for comparison (evidence level 3-5) (Echemendia et al., 2013, McCrory et al., 2013a, Harmon et al., 2013). The fact that sideline tests may also be affected by physical stress, fatigue or overtraining should be included in the assessment (evidence level 3) (McCrory et al., 2013b, McCrea et al., 2013).

Table 5 **Standardized Assessment of Concussion (SAC)**						
Orientation (1 point for each correct answer)						
What month is it?	0	1				
What's the date today?	0	1				
What's the day of the week?	0	1				
What year is it?	0	1				
What time is it right now? (within 1 hour)	0	1				
Orientation Score	of 5					
Immediate Memory*						
List	Trial 1	Trial 2	Trail 3	Alternative lists		
Elbow	0 - 1	0 – 1	0 – 1	Candle	Baby	Finger
Apple	0 – 1	0 – 1	0 – 1	Paper	Monkey	Penny
Carpet	0 – 1	0 – 1	0 – 1	Sugar	Perfume	Blanket
Saddel	0 – 1	0 – 1	0 – 1	Sandwich	Sunset	Lemon
Bubble	0 – 1	0 – 1	0 – 1	Wagon	Iron	Insect
Total						
Immediate Memory Score	of 15					
Concentration: DigitsBackward**						
List	Trial 1	Alternative digit lists				
4-9-3	0 – 1	6-2-9	5-2-6	4-1-5		
3-8-1-4	0 – 1	3-2-7-9	1-7-9-5	4-9-6-8		
6-2-9-7-1	0 – 1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3		
7-1-8-4-6-2	0 – 1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6		
Total of 4						
Concentration: Months in Reverse Order*** (1 point for entire sequence correct)						
Dec-Nov-Oct-Sep-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan	0	1				
Concentration Score	of 5					
Delayed Recall**** NB: to be performed after the BESS test						
Delayed Recall Score	of 5					

**"I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order."*

"I am going to repeat that list again. Repeat back as many words as you can remember in any order, even if you said the word before."
***"I am going to read you a string of numbers and when I am done, you repeat them back to me backwards, in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7."*
****"Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November...Go ahead."*
*****"Do you remember the list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order."*
Adjusted from SCAT3 (SCAT3, 2013).

Self-reporting of symptoms to diagnose concussion

Self-reported symptoms alone as a test for concussion have acutely been found to have a sensitivity of 0.94, and after seven days of 0.04. The specificity was 1.00 (evidence level 4) (McCrea et al., 2005).

The athlete's own judgment of the severity of the symptoms, the extent of the injury and his or her motivation to continue the game or practice may have profound influence on the initial examination. Thus, effective communication between the athlete and the physiotherapist is crucial for agile decision making. The communication between the physiotherapist and the athlete may, however, be challenged if the athlete is in a dilemma and does not know which symptoms to report because it may "cost" him or her the game or practice (evidence level 3) (McCrory et al., 2013b).

Screening tools such as the SCAT3 should be applied on the suspicion of concussion, but a negative test should not overrule clinical signs (evidence level 3) (Putukian et al., 2013). Also, one must bear in mind that such screeningtestscannot replace a thorough neurological examination performed by a neurologist (evidence level 3) (Echemendia et al., 2013). The need for a thorough neurological examination arises where symptoms worsen within the first 24-48 hours or the symptoms do not resolve after 7-10 days (evidence level 3) (McCrory et al., 2013b, Cancelliere et al., 2014).

The purpose of the initial examination of the injured athlete is to exclude cervical spine injury andsevere brain damage (evidence level 3).

In case of doubt as to whether an athlete has sustained a concussion while still on the field, the Maddocks Score combined with clinical signs may be used as the first concussion tests (evidence level 4).

If the clinical picture and the Maddocks Score cannot rule out a concussion, the athlete must undergo further examination. The SAC is suitable for sideline assessment (evidence level 3).
Both tests are included in the SCAT3 and there is general consensus to utilize SCAT3 (evidence level 5).

PREVENTION

Relatively few studies have investigated the effect of different types of concussion prevention. Moreover, the studies are characterized by low methodological quality, which makes the results less reliable.

Protective headgear

A study on American high school football players using a Customized Mandibular Orthotic (CMO) saw fewer self-reported incidences of concussion amongthose who used CMO (OR: 38.3, 95% KI 8.2 – 178.6, p<0.05) (evidence level 4) (Singh et al., 2009). Also, Australian nonprofessional male rugby players who reported always wearing protective headgear during gameswere at a reduced risk of sustaining a concussion compared with players who never wore protective headgear (IRR: 0.57, 95% KI 0.40-0.82) (evidence level 4) (Hollis et al., 2009). However, both studies are of a very low methodological quality due to lack of randomization, controlgroup, calculation of sample size and risk of self-selection bias.
A clusterRCT of a questionable quality found no difference in the number of concussions between a group of young male rugby players with no protective headgear and two groups wearing different types of headgear (evidence level 3) (McIntosh et al., 2009).

A recent systematic review about risk-reduction strategies in sport concussion found that no conclusive evidence was provided to suggest that use of headgear in American football, ice hockey, soccer and rugby significantly reduced players' risk of concussion (evidence level 4) (Benson et al., 2013). However, there are indications that protective headgear will reduce the risk of concussion in skiing, cycling and motoring (evidence level 5)(Harmon et al., 2013, McCrory et al., 2013a).

The systematic review by Benson et al. 2013 concluded that training of the muscles of the neck strengthens the neck, but no evidence was provided to suggest an association between neck strength increases and concussion risk reduction (evidence level 4) (Benson et al., 2013).

Harmon et al. 2013 discussed the possibility that protective headgear may encourage the athlete to take greater risks in the performing situation as he or she feels protected. They suggest that this, in fact, may increase the risk of injury, including concussion (evidence level 5).

Rule changes

A Norwegian study that investigated the effect of stricter rule enforcement in case of late or two foot tackles and high elbowsin Norwegian male professional soccer found a reduction in theincidence of total head injuries from the 2010 season to the 2011 season. The number of head and neck incidents fell from 226 to

184 (rate[1] 28.5 (24.8-32.3) vs. rate 23.2 (19.9-26.6)), rate ratio 0.81 (0.67-0.99). This effect was not found for any other types of injury (evidence level 3) (Bjorneboe et al., 2013).

Only the number of head injuries caused by arm-to-head collisions differed between 2010 and 2011. The number fell from 109 to 79 (rate 13.8 (11.2-16.3) vs. rate 10.0 (7.8-12.2)), rate ratio 0.72 (0.54-0.97).

As regards head injuries caused by heading duels, there was only a difference in head injuries caused by arm-to-head collisions, 84 incidents compared to 47 (rate 10.6 (8.3-12.9) vs. rate 5.9 (4.2-7.6)), rate ratio 0.56 (0.39-0.80) (evidence level 3) (Bjorneboe et al., 2013).

In their systematic review about effective risk-reduction strategies in sport concussion, Benson et al. 2013 concluded that rule changes seem to have a preventive effect in ice hockey and rugby (evidence level 4).

There is conflicting evidence regarding the preventive effect of protective headgear on the basis of concussion incidences in American football, ice hockey, soccer and rugby (evidence level 4).

Protective headgear seems to have a protective effect in concussion prevention when it comes to skiing, cycling and motoring (evidence level 5).

Rule changes seem to have a preventive effect on the incidence of concussions in soccer (evidence level 3), ice hockey and rugby (evidence level 4).

[1]The rate is the number of injuries per 1000 player hours

TREATMENT

There is a near absence of quality literature on the treatment of sports-related concussions. In particular, there is no literature on the long-term effect of different types of treatment. The physiotherapeutic treatment of concussion primarily consists of counselling and monitoring of physical activity and related symptoms the injured athlete may be experiencing.

Rest

A systematic review by Schneider et al. 2013 (evidence level 4) evaluated the effect of rest and the effect of treatment following a sports-related concussion. The literature on the effect of rest includes only poorly designed retrospective studies and cross-sectional studies with no control group. In general, the literature is largely characterized by inconsistency in results (evidence level 5) (McCrory et al., 2013a).

A study concluded that athletes who were prescribed cognitive rest had prolonged symptoms compared with athletes who were not (evidence level 4) (Gibson S, 2010). On the other hand, another study showed that one week of cognitive and physical rest significantly improved the symptoms experienced by injured athletes (evidence level 4) (Moser et al., 2012). Finally, Schneider et al. 2013 included a study which indicated that self-reported moderate level of physical and cognitive activity resulted in better symptom relief than a low or high level of physical and cognitive activity (evidence level 4) (Majerske et al., 2008).

Training and physiotherapy

The quality of the literature describing the effect of training is higher than the literature describing the effect of rest, but the amount of literature is still scarce. Leddyet al. investigated the effect ofsubsymptom threshold exercise training on a treadmill 5-6 times a week on athletes with a concussion until they were free from symptoms. The provoking trauma had occurred more than six weeks earlier and less than 12 months earlier.There was a significant reduction in overall mean symptom score between the baseline and treatment periods. All participants returned to their former level of activity (evidence level 4) (Leddy et al., 2010).

In spite of limited literature, Schneider et al. 2013 concluded in a systematic review (evidence level 4) that proper management of concussion involves a symptom-free, graduated return to school and social activities prior to return to athletic activities. They suggest physical activity that does not provoke symptoms as intervention instead of rest (evidence level 4) (Schneider et al., 2013).

In a more recent RCT, Schneider et al. found that a combination of cervical spine physiotherapy (joint mobilization of the cervical and thoracic spine, neuromotor exercise training and sensorimotor training) and vestibular rehabilitation (visual stabilization, standing and dynamic balance exercises and repositioning exercises)in addition to conventional rehabilitation for eight weeks decreased time to medical clearance of athletes with prolonged post-concussion symptoms compared with conventional rehabilitation alone(evidence level 2)(Schneider et al., 2014). A total of 11 out of 15 in the treatment group were medically cleared to return to athletic activities within eight weeks compared with one out of 14 in the control group.Thus, the chance of returning to athletic activities within eight weeksof initiation of treatment was 10.27 (KI 1.51-69.56; p<0.001) times larger within the treatment group (evidence level 2)(Schneider et al., 2014). In a more conservative calculation (Intention To Treat), where it is assumed that the two dropouts from the control group returned to athletic activities within eight weeks, the figure is adjusted downwards to a3.91 (KI 1.34 – 11.34)times larger chance of returning to athletic activities within eight weeks within the treatment group, which is still statistically significant (evidence level 2) (Schneider et al., 2014).

Return to play guidelines

An athlete must not return to athletic activities if they provoke symptoms that may prolong the athlete's recovery time (evidence level 5) (Harmon et al., 2013). An athlete should not return to athletic activities before returning to social, school or work activities (evidence level 5) (Harmon et al., 2013). At the International Conference on Concussion in Sport held in 2012 in Zurich, a graduated return to play protocol (table 6) was introduced. The protocol may be applied where the acute symptoms have resolved within the first 24-48 hours following injury. Generally, each step of the protocol should take 24 hours.The athlete should continue to proceed to the next level if asymptomatic after 24 hours at the current level. Thus, an athlete will take approximately one week to proceed through the full rehabilitation protocol. If any post-concussion symptoms occur while in the stepwise program then the athlete should drop back to the previous asymptomatic level and try to progress again after a further 24-hour period of rest has passed(evidence level 5) (McCrory et al., 2013a).

Table 6 Graduated return to play protocol

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
1. No activity	Symptomlimited physical and cognitive rest.	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity <70 % of maximum permitted heart rate. No resistance training.	IncreaseHR
3. Sport-specificexercise	Skating drills in ice hockey, running drills in soccer. No headimpact activities.	Addmovement
4. Non-contacttrainingdrills	Progression to more complex training drills e.g. passing drills in football and ice hockey. May start progressive resistance training.	Exercise, coordination and cognitive load
5. Full contactpractice	Following medical clearance participate in normal training activities.	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play.	

Adjusted fromMcCrory et al. 2013.Evidence level 5 (McCrory et al., 2013a).

Athletes who have suffered head trauma and who appear to be symptom-free, but who are on medications, should not participate in athletic activities.Medications may mask or modify relevant symptoms.Moreover, an athlete should not take any kind of medications that may modify the symptoms of concussion within the first ten hours following the injury.Also, the athlete should not take any medications in connection with an assessment of return to athletic activities (evidence level 5) (McCrory et al., 2013a).However, the athlete is allowed to take non-prescription drugs such as Panodil.

> There is considerable uncertainty in the evidence when it comes to rest in the treatment of sports-related concussion. Existing literature suggests that both too much rest and too little rest may have a negative effect on symptoms (evidence level 4).
>
> Training exercises that do not provoke symptoms seem to be better than no training (evidence level 4).
>
> A combination of manual treatment of the cervical spine and vestibular rehabilitation as a supplement to conventional rehabilitation decreased time to medical clearance of young athletes with prolonged post-concussion symptoms (evidence level 2).

OUTCOME

The treatment of concussion is based on symptom reduction through rest. Therefore, it makes sense to employ the diagnostic tests as outcome measures. There is consensus in the literature that it will take days to weeks to recover from a sports-related concussion (evidence level 3) (Cancelliere et al., 2014, McCrory et al., 2013b).

Risk stratification of acute concussion

Prognostic effect of symptoms at the initial on-field assessment

Lovell et al. 2003 studied the effect of mental status changes (retrograde and anterograde amnesia or confusion) for more than 5 minutes as opposed to less than 5 minutes in 64 high school athletes who had suffered concussion.Athletes who exhibited on-field mental status changes for more than 5 minutes had strong post-concussion symptoms after 36 hours (ES 1.37, $p<0.003$). Athletes who exhibited mental status changes for less than 5 minutes had moderate post-concussion symptoms after 36 hours (ES 0.73, $p<0.00007$). There was no difference between the groupsat 4 and 7 days post-injury (evidence level 4) (Lovell et al., 2003).

Clinically, this means that physiotherapists must be more aware of the symptoms of athletes who exhibit mental status changes for more than 5 minutes than of athletes who exhibit mental status changes for less than 5 minutes within the first 36 hours following injury. Moreover, athletes who exhibit mental status changes may be expected to have symptoms for at least 36 hours after having sustained a concussion.

Prognostic effect of symptoms at sideline assessment

Lovell et al. 2003 also studied the effect of the ”sideline assessment” symptoms immediate memory and drowsiness.After 36 hours, ES was 0.74 (moderate), after 4 days 0.69 (moderate) andafter 7 days 0.34 (small) compared with baseline(evidence level 4)(Lovell et al., 2003).

Clinically, this means that athletes who demonstrate impairments on immediate memory and who are drowsy may be expected to demonstrate moderately impaired memory for up to 4 days after having sustained a concussion and slightly impaired memory for up to 7 days.

Prognostic effect of symptoms in the days following a concussion

Risk factors for persistent neurocognitive problems or prolonged return to athletic activities include early posttraumatic headache, fatigue/fogginess, early amnesia, alteration in mental status, disorientation, young age, a history of headache and dizziness (evidence level 3) (Giza et al., 2013).

In a meta-analysis, Broglio et al. 2008 concluded that, compared with the SAC and computer-based tests, the pencil & paper test was the most suitable to assess neurocognitive deficits 14 days following injury(Broglio and Puetz, 2008).

There is considerable uncertainty in the literature as to whether a history of previous concussion results in delayed recovery in case of recurrent concussion(evidence level 3) (Cancelliere et al., 2014). However,there is an increased risk for repeat concussion in the first 10 days after an initial concussion (evidence level 3) (Giza et al., 2013).

LITERATURE SEARCH

Medline, Cochrane Library, Cinahl, Embase and PEDro were searched. Moreover, relevant literature identified by the hand search of references was also included.
First, the search was conducted with a view to including meta-analyses, systematic reviews and RCTs. In case of insufficient information from these sources, other types of studies were included.
Titleand abstract were reviewed for relevance and inclusion and exclusion criteria (table 7). Studies that met all criteria were retrieved in full text.

Table 7

Inclusioncriteria	Exclusioncriteria
Language: Danish, English, Norwegian and Swedish	If the concussion was not sustained during athletic activities
Acute assessment and treatment of concussion + predictive values	If the athletelost consciousness
Prognosis andpredictivevalues	Not published within the past 10 years
Screening includingpre-season	Advanceddiagnostic equipment and tests, e.g. MRIscans and blood tests

The following search was conducted in the Cochrane Library on 25th March 2014 at 12.00 noon.

Diagnosis:

Cochrane Library, PICO(S)

P1	P2	I	S
“Brain Concussion” [MeSH] ”Brain Concussion” [tiab] “Head Injuries” [MeSH] “Head Injuries” [tiab] “Brain Injuries” [MeSH] “Brain Injuries” [tiab]	“Athletes” [MeSH] ”Athletes” [tiab] ”Sports” [MeSH] ”Sports” [tiab] “Athletic Injuries” [MeSH] ”Athletic Injuries” [tiab]	“Diagnosis” [MeSH] ”Diagnosis” [tiab] “Health Screening” [MeSH] ”Health Screening” [tiab]	Meta-analysis Systematic review RCTstudy

Prevention:

Cochrane Library, PICO(S)

P1	P2	I	S
"Brain Concussion" [MeSH] "Brain Concussion" [tiab] "Head Injuries" [MeSH] "Head Injuries" [tiab] "Brain Injuries" [MeSH] "Brain Injuries" [tiab]	"Athletes" [MeSH] "Athletes" [tiab] "Sports" [MeSH] "Sports" [tiab] "Athletic Injuries" [MeSH] "Athletic Injuries" [tiab]	"Risk factors" [MeSH] "Risk factors [tiab]" "Prevention" [tiab]	Meta-analysis Systematic review RCT study

Treatment:

Cochrane Library, PICO(S)			
P1	P2	O	S
"Brain Concussion" [MeSH] "Brain Concussion" [tiab] "Head Injuries" [MeSH] "Head Injuries" [tiab] "Brain Injuries" [MeSH] "Brain Injuries" [tiab]	"Athletes" [MeSH] "Athletes" [tiab] "Sports" [MeSH] "Sports" [tiab] "Athletic Injuries" [MeSH] "Athletic Injuries" [tiab]	"Return to sport" [tiab]	Meta-analysis Systematic review RCT study

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RECOMMENDED LITERATURE LIST

Clinical diagnosis

McCrory, P., Meeuwisse, W. H., Echemendia, R. J., Iverson, G. L., Dvorak, J. & Kutcher, J. S. 2013b. What is the lowest threshold to make a diagnosis of concussion? *Br J Sports Med,* 47**,** 268-71.

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