Sport-Related Concussion Management

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Helping athletes achieve their maximum performance naturally

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Disclosure

- FICS makes every effort to provide contemporary information.
- FICS desires to build the best of the best in International Sports Chiropractic.
- FICS and their instructors are vetted by the FICS Education Commission, composed of academic members and leaders from most regions of the planet.
- The information instructed today has been established and approved by the FICS Education Commission.
- FICS will not be held liable for any injuries as a result of today's instruction.

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Presentation Overview

- Part I – Re-evaluate
- Part II – Rest and Exercise
- Part III – Rehabilitation
- Part IV – Return-to-Learn and Return-to-Sport

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Part I
Re-evaluate

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13 'Rs' of Sport-Related Concussion

(Patricios et al, 2023)

- The Concussion in Sport Group's (CISG) **13 'R's of SRC management** to provide a logical flow of clinical concussion management and considerations:
  1. Recognise
  2. Reduce
  3. Remove
  4. **Re-evaluate**
  5. Rest and Exercise
  6. Refer
  7. Rehabilitation
  8. Recovery
  9. Return-to-sport / Return-to-learn
  10. Reconsider
  11. Retire
  12. Refine


Consensus statement

Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport–Amsterdam, October 2022

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"The purpose of developing a Sport Concussion Office Assessment Tool (SCOAT6/Child SCOAT6) was to give HCPs a standardised, expansive and age-appropriate clinical guide to a multidomain evaluation in the subacute phase (72 hours to weeks postinjury), **with a view to guide individualised management.**"

- Patricios et al, 2022

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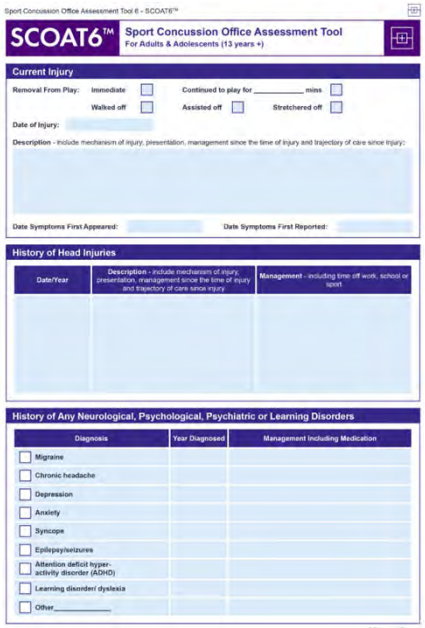
SCOAT6

(Patricios et al, 2023b)

- Step 1: History
- Step 2: Symptom Evaluation
- Step 3: Verbal Cognitive Tests
- Step 4: Examination
  - **Orthostatic Vital Signs**
  - **Cervical Spine Assessment**
  - Neurological Examination
  - **Balance (mBESS)**
  - Timed Tandem Gait
  - Complex Tandem Gait
  - Dual Task Gait
- **Step 5: mVOMS**
- Step 6: Anxiety, Depression, Sleep Screen
- Step 7: Delayed Word Recall
- Step 8: Computerised Cognitive Test Results (if used)
- **Step 9: Graded Aerobic Exercise Test**
- Step 10: Overall Assessment, Management & Follow-up Plan
- **Step 11: Return-to-Learn & Return-to-Sport**


Sport Concussion Office Assessment Tool 6 - SCOAT6™

SCOAT6™ Sport Concussion Office Assessment Tool
For Adults & Adolescents (13 years +)

Current Injury

Removal From Play: Immediate ☐ Continued to play for _____ mins ☐
Walked off ☐ Assisted off ☐ Stretchered off ☐

Date of Injury:

Description - include mechanism of injury, presentation, management since the time of injury and trajectory of care since injury:

Date Symptoms First Appeared: Date Symptoms First Reported:

History of Head Injuries

Date/Year	Description - include mechanism of injury, presentation, management since the time of injury and trajectory of care since injury	Management - including time off work, school or sport

History of Any Neurological, Psychological, Psychiatric or Learning Disorders

Diagnosis	Year Diagnosed	Management including Medication
☐ Migraine		
☐ Chronic headache		
☐ Depression		
☐ Anxiety		
☐ Syncope		
☐ Epilepsy/seizures		
☐ Attention deficit hyper-activity disorder (ADHD)		
☐ Learning disorder/ dyslexia		
☐ Other_____		

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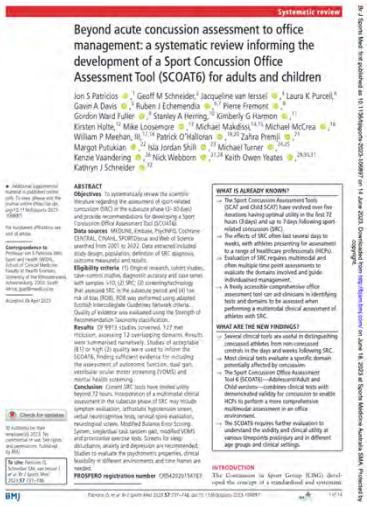
Orthostatic Vital Signs

(Patricios et al, 2023a; Patricios et al, 2023b)

- Emerging evidence has associated concussion with changes in the ANS.
  - Postulated mechanisms including trauma to the hypothalamus, limbic cortex and midbrain nuclei, regions of the brain responsible for autonomic function.
- **Orthostatic tachycardia has been described as being associated with a substantial subset of concussion clinic patients**.
- Significant orthostatic changes have been defined as:
  - symptomatic HR increase of at least 30 bpm in adults (40 bpm in adolescents)
  - in the absence of postural hypotension



Systematic review

Beyond acute concussion assessment to office management: a systematic review informing the development of a Sport Concussion Office Assessment Tool (SCOAT6) for adults and children

Jon S Patricios, Geoff M Schneider, Jacqueline van Iersel, Laura K Purcell, Gavin A Davis, Ruben J Echemendia, Pierre Fremont, Gordon Ward Fuller, Stanley A Herring, Kimberly G Harmon, Kirsten Holte, Mike Loosemore, Michael Makdissi, Michael McCrea, William P Meehan, III, Patrick O'Halloran, Zahra Premji, Margot Putukian, Isla Jordan Skill, Michael Turner, Kenzie Vaandering, Nick Webborn, Keith Owen Yeates, Kathryn J Schneider

ABSTRACT

WHAT IS ALREADY KNOWN?

WHAT ARE THE NEW FINDINGS?

INTRODUCTION

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Orthostatic Vital Signs

(Patricios et al, 2023b)

Orthostatic Vital Signs

The first blood pressure and heart rate measurements are taken after the patient lies supine on the examination table for at least 2 minutes. The patient is then asked to stand up without support and with both feet firmly on the ground and the second measurements are taken after standing for 1 minute. Ask the patient if they experience any dizziness or light-headedness upon standing (initial orthostatic intolerance) or by one minute (orthostatic intolerance).

Orthostatic Vital Signs	Supine	Standing (after 1 minute)
Blood Pressure (mmHg)		
Heart Rate (bpm)		
Symptoms[1] • Dizziness or light-headedness • Fainting • Blurred or fading vision • Nausea • Fatigue • Lack of concentration	No ☐ Yes ☐ If yes: Description	No ☐ Yes ☐ If yes: Description
Results	☐ Normal ☐ Abnormal	

Test results are deemed clinically significant if they include at least one of the following AND symptoms:
(1) systolic BP drop of ≥ 20mmHg or (2) diastolic BP drop of ≥ 10mmHg (3) HR decreases (4) HR increases by > 30bpm

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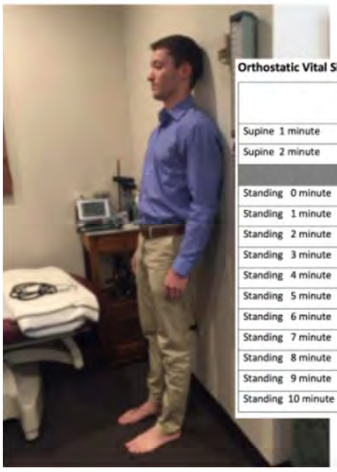
Orthostatic Vital Signs
NASA Lean Test
(Bungo et al, 1985)

General test preparation instructions, adjusted as appropriate for each patient.

- Limit water/fluid intake to 1000 mL for 24 hours before the test
- Limit sodium intake for 48 hours before the test
- Do not wear compression socks or clothing on the day of the test
- Withhold medications, supplements, or substances that might affect blood pressure or heart rate, with timing based on the drug half-life and patient safety.



Orthostatic Vital Signs/The NASA 10-minute Lean Test

	Blood Pressure (BP)		Pulse	Comments
	Systolic	Diastolic		
Supine 1 minute				
Supine 2 minute				
Standing 0 minute				
Standing 1 minute				
Standing 2 minute				
Standing 3 minute				
Standing 4 minute				
Standing 5 minute				
Standing 6 minute				
Standing 7 minute				
Standing 8 minute				
Standing 9 minute				
Standing 10 minute				

Image taken from: https://batemanhornecenter.org/wp-content/uploads/2016/09/NASA-Lean-Test-Instructions-1.pdf

BESS (Modified BESS)
(Echemendia et al, 2023; Patricios et al, 2023b)

Modified BESS	(20 seconds each)		On Foam (Optional)	
Double Leg Stance:		of 10	Double Leg Stance:	of 10
Tandem Stance:		of 10	Tandem Stance:	of 10
Single Leg Stance:		of 10	Single Leg Stance:	of 10
Total Errors:		of 30	Total Errors:	of 30

Note: If the **mBESS** yields normal findings then proceed to the **Tandem Gait/Dual Task Tandem Gait**.
If the **mBESS** reveals abnormal findings or clinically significant difficulties, **Tandem Gait** is not necessary at this time.
Both the **Tandem Gait** and optional **Dual Task** component may be administered later in the office setting as needed (see SCOAT6).

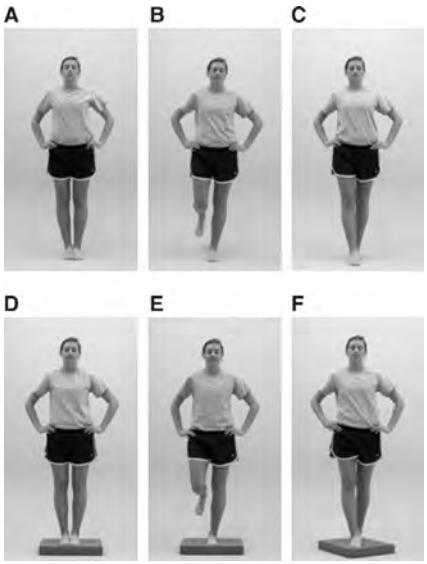
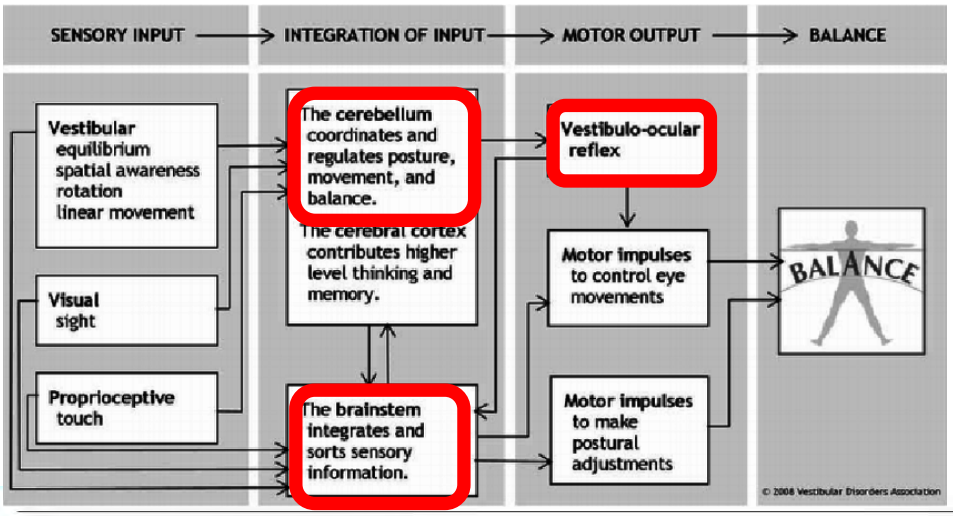


Image taken from:
https://www.researchgate.net/figure/Balance-Error-Scoring-System-BESS-performed-on-the-firm-surface-A-C-and-the-foam_fig1_26775223

Postural Stability
Sensorimotor Integration
(Marzano et al, 2015; Campbell, 2013; Biller, 2012)



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Postural Stability
Sensorimotor Integration
(Herdman, 2007; Peterka, 2002)

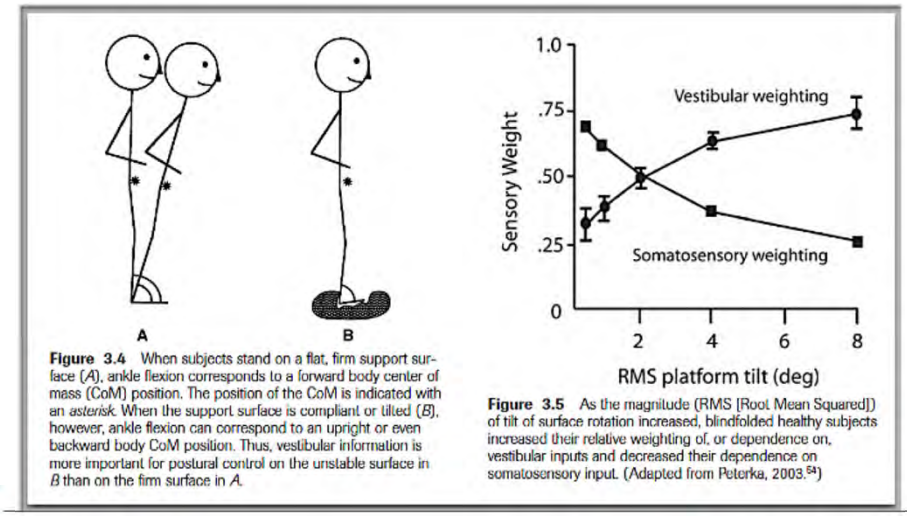

Figure 3.4 When subjects stand on a flat, firm support surface (*A*), ankle flexion corresponds to a forward body center of mass (CoM) position. The position of the CoM is indicated with an *asterisk*. When the support surface is compliant or tilted (*B*), however, ankle flexion can correspond to an upright or even backward body CoM position. Thus, vestibular information is more important for postural control on the unstable surface in *B* than on the firm surface in *A*.

Figure 3.5 As the magnitude (RMS [Root Mean Squared]) of tilt of surface rotation increased, blindfolded healthy subjects increased their relative weighting of, or dependence on, vestibular inputs and decreased their dependence on somatosensory input. (Adapted from Peterka, 2003.[54])

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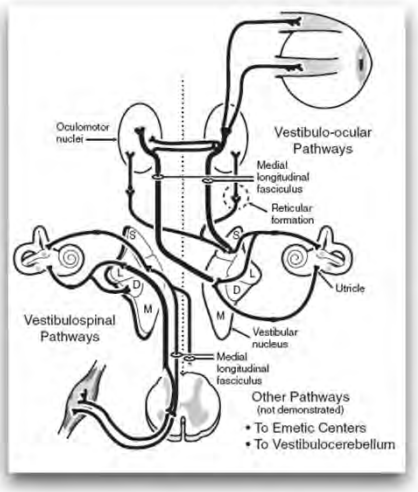
Modified Vestibular Ocular Motor Screening
mVOMS for Concussion

(Patricios et al, 2023a; Patricios et al, 2023b)

- **Symptom provocation with VOR and VMS tests appear to be associated with concussion**.
- The modified VOMS (mVOMS) has the same diagnostic accuracy and applicability as the original VOMS.
- It is important to recognise that **if symptoms are reproduced during the VOMS this does not 'rule in' the presence of a vestibular or oculomotor problem.**



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mVOMS for Concussion

(Patricios et al, 2023b; Mucha et al, 2014)

Modified Vestibular/Ocular-Motor Screening (mVOMS) for Concussion

For detailed instructions please see the Supplement.

mVOMS	Not Tested	Headache	Dizziness	Nausea	Fogginess	Comments
Baseline symptoms	N/A					
Smooth pursuits (2 horizontal and 2 vertical, 2 seconds to go full distance right-left and back; up-down and back)						
Saccades – Horizontal (10 times each direction)						
VOR – Horizontal (10 repetitions) (metronome set at 180 beats per minute – change direction at each beep, wait 10 secs to ask symptoms)						
VMS (x 5, 80° rotation side to side) (at 50 bpm, change direction each beep, wait 10 secs to ask symptoms)						

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mVOMS – Smooth Pursuits

(Mucha et al, 2014)

- Patient is instructed to maintain focus on a target (3 ft. from patient) as the examiner moves the target smoothly in the horizontal direction 1.5 ft. to the right and left of midline.
  - Target moved at a rate of ~2 seconds from one-side-to-the-other
- Perform 2 repetitions
- Repeat the test in a vertical direction
  - **Record:**
    - Headache, Dizziness, Nausea & Fogginess ratings after the test
  - **Observe for:**
    - Saccadic eye movements; Evidence of a cranial nerve deficit. (Ellis et al, 2015)

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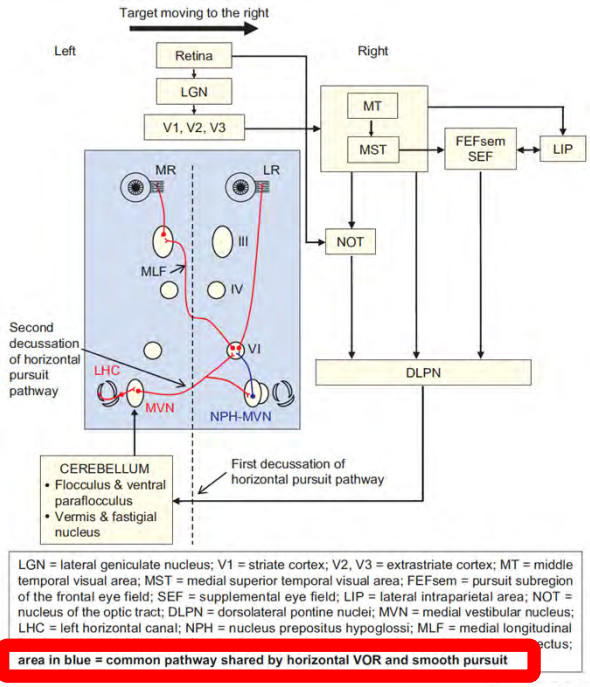
Pursuits (Horizontal) Parietotemporal Cortex

Image taken from: Wong. 2007. p. 77



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Pursuits (Vertical)
Temporal Cortex

Image taken from: Marti et al, 2008)

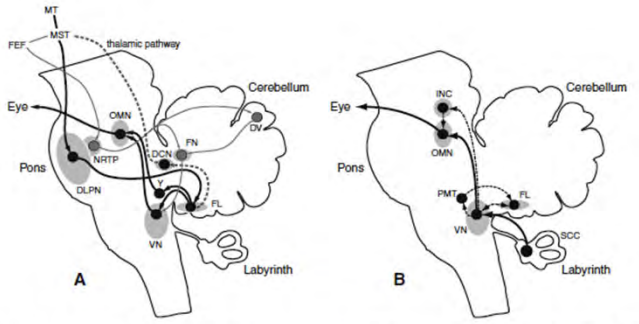

Fig. 2 a Vertical smooth pursuit (*SP*) pathways. *Solid bold arrow lines* cortico-ponto-cerebellar pathway from middle temporal (*MT*) and middle superior temporal area (*MST*) to the dorsolateral pontine nuclei (*DLPN*) and the floccular lobe (*FL*). Motor commands for pursuit eye movements reach the ocular motor neurons via projections of the FL to the VN and Y-group. *Gray thin arrow lines* parallel cortico-ponto-cerebellar pathway from the frontal eye field (*FEF*) via the nucleus reticularis tegmentum pontis (*NRTP*) to the cerebellar dorsal vermis (*DV*), which projects to the fastigial nucleus (*FN*) and from there to the VN. A feedback pathway via deep cerebellar nuclei (*DCN*) and the thalamus (thalamic pathway) connects the FL with area MST (*gray dashed lines*). The VN-PMT-FL loop and the brainstem integrator are shown in b for clarity. b Vertical vestibulo-neuron arc runs from the vertical semicircular canals (*SCC*) to the vestibular nuclei (*VN*) and from there to the vertical ocular motor *dotted lines*) connects the SCC, the VN and the brainstem integrator for vertical gaze holding (Nucleus interstitialis Cajal, INC) with the OMN. Parallel circuitries (*dashed lines*), which are important for VOR adaptation and gaze holding, link the VN, the paramedian tract neurons (*PMT*) and the floccular lobe (*FL*)

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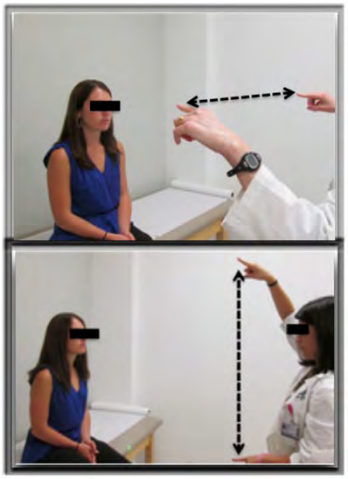
mVOMS – Saccades

(Mucha et al, 2014)



- The examiner holds two single targets (fingertips) *horizontally* at a distance of 3 ft. from the patient, and 1.5 ft. to the right and 1.5 ft. to the left of midline
- Instruct the patient to move their eyes as quickly as possible from target to target
- Perform 10 repetitions each direction
- ***Repeat for Vertical Saccades***
  - **Record:**
    - Headache, Dizziness, Nausea & Fogginess ratings after each test
  - **Observe for:**
    - Overshooting; > 2 saccadic corrections; Gross dysconjugate eye movements (Ellis et al, 2015)

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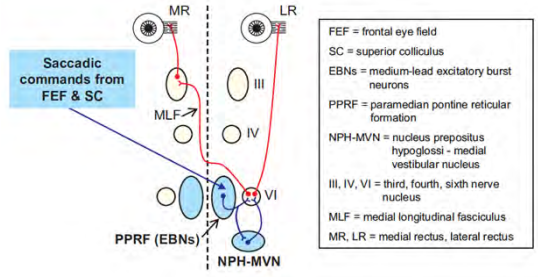
Saccades (Horizontal)
Frontal Lobe



- Activation of the **frontal eye field (FEF) and superior colliculus (SC)** on one side **generates contralateral horizonal saccades**

Image taken from: Wong. 2007. p. 65

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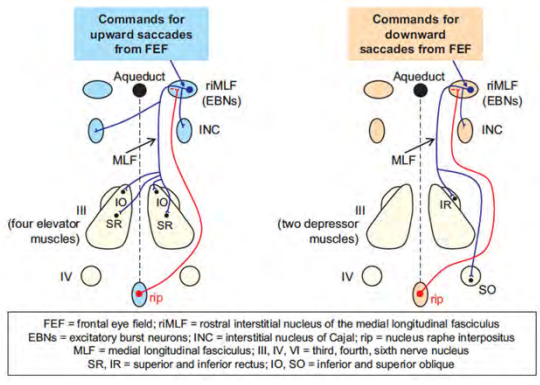
Saccades (Vertical)
Frontal Lobe



- Simultaneous activation of the **frontal eye fields (FEF) on both sides or superior colliculus (SC) on both sides generates vertical saccades.**

Image taken from: Wong. 2007. p. 67

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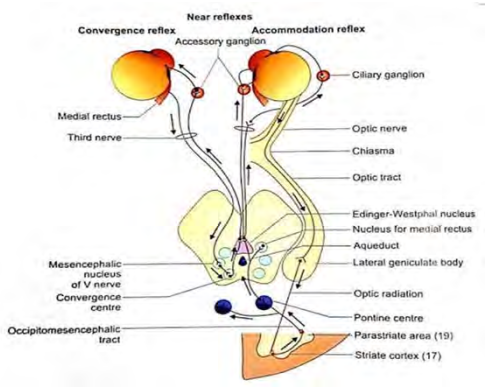
VOMS – Near Point Convergence

(Mucha et al, 2014)

- The patient focuses on a small target at arm's length and slowly brings it toward the tip of their nose.
- The patient is instructed to stop moving the target when they see two distinct images or when the examiner observes an outward deviation of one eye.
  - Blurring of the image is ignored.
- Measure distance in cm. between target and the tip of nose
  - **Repeat and record 3 times**
- Record:
  - Headache, Dizziness, Nausea & Fogginess ratings after the test
- **Observe for:**
  - **Inability of the eyes to converge; convergence >6cm**. (Ellis et al, 2015)

Near Point Convergence
Midbrain (Mesencephalon)



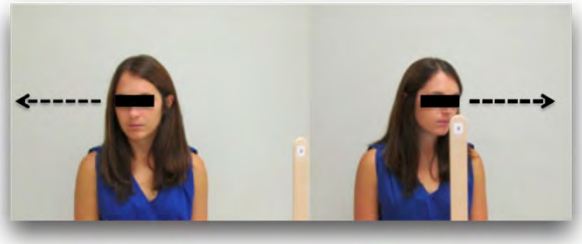
- Neurons in the supra-oculomotor area within the **mesencephalic reticular formation** send premotor commands to **ocular motor neurons**.
- The oculomotor nuclei play an important role in vergence
  - Oculomotor nucleus innervate the medial rectus

Image taken from: https://optography.org/pupillary-reflexes-and-their-abnormalities/

mVOMS – VOR

(Mucha et al, 2014)

- Examiner holds a target in front of the patient in midline at a distance of 3 ft.
- The patient is asked to rotate their head *horizontally* while maintaining focus on the target.
  - The head is moved at an amplitude of 20º to each side and a metronome 180 bpm to ensure the speed of rotation (one beat in each direction).
- Perform 10 repetitions
- ***Repeat for Vertical VOR***
  - **Record:**
    - Wait 10 secs then record Headache, Dizziness, Nausea & Fogginess after the test
  - **Observe for:**
    - Ability to maintain gaze stability (Casa Della et al, 2014)



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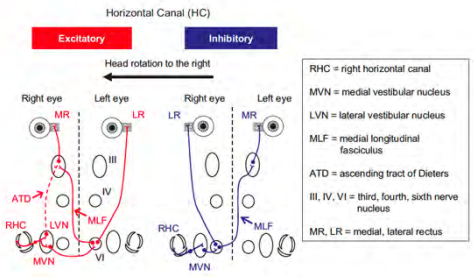
VOR (Horizontal)
Horizontal Canals

- **Head rotation to the right stimulates the right horizontal canal**, which leads to activation of the left lateral rectus & right medial rectus, so that **both eyes rotate to the left (slow phase to the left).**
- A lesion to left horizontal canal leads to unopposed action of the right horizontal canal, causing a tonic bias for the eyes to turn to the left.
  - This results in a vestibular nystagmus with slow phases toward the left and corrective quick phases toward the right



Redrawn from Ito M, Nisimaru N, Yamamoto M. Pathways for the vestibulo-ocular reflex excitation arising from semicircular canals of rabbits. Exp Brain Res. 1976; 24:257–71. With permission of Springer Science and Business Media and the authors.

Image taken from: Wong. 2007. p. 33

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VOR (Vertical)
Anterior & Posterior Canals

- Downward head acceleration (chin down) stimulates both anterior canals (ACs) so that both eyes rotate upward.
- Upward head acceleration (chin up) stimulates both posterior canals (PCs) so that both eyes rotate downward.

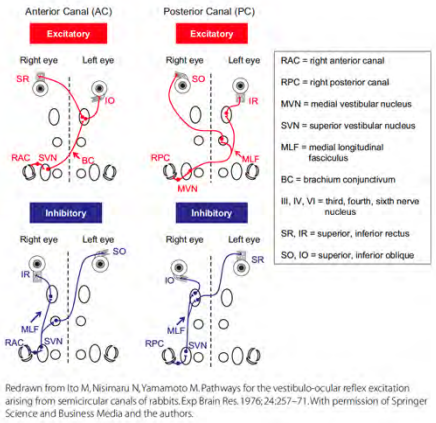

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Image taken from: Wong. 2007. p. 35

mVOMS – Visual Motion Sensitivity

(Mucha et al, 2014)

- The patient stands with feet shoulder width apart (facing a busy area of the clinic) with their arm outstretched and focusing on their thumb.
- Maintaining focus on their thumb, the patient rotates - together as a unit - their head, eyes and trunk at an amplitude of 80º to the right and left.
- A metronome 50 bpm to ensure the speed of rotation (one beat in each direction).
- Perform 5 repetitions
  - **Record:**
    - Wait 10 sec and record Headache, Dizziness, Nausea & Fogginess after the test

Visual Motion Sensitivity
VOR Cancellation

- Normally, the eyes should be able to maintain steady fixation.
- With inadequate VOR cancellation, the eyes are taken off target by VOR slow phases, which results in corrective saccades
  - **deficient VOR cancellation on rotation to the left corresponds to low pursuit gain to the left.**

(Wong, 2007)

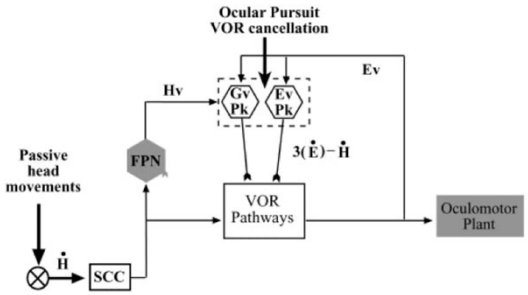

Image taken from: Belton & McCrea. 2000.

"…it is important to emphasize that the VOMS was not designed as a comprehensive tool for vestibular and oculomotor function and may not encompass all of the screening strategies necessary to examine all aspects of vestibular and oculomotor dysfunction. Therefore, it may be useful as a screening tool, but is not appropriate as a replacement for a comprehensive vestibular and oculomotor assessment."

- Quartman-Yartes et al, 2020

Cervical Spine Assessment

(Patricios et al, 2023b)

Cervical Spine Assessment

Cervical Spine Palpation	Signs and Symptoms	
Muscle Spasm	☐ Normal	☐ Abnormal
Midline Tenderness	☐ Normal	☐ Abnormal
Paravertebral Tenderness	☐ Normal	☐ Abnormal

Cervical Active Range of Motion	Result	
Flexion (50-70°)	☐ Normal	☐ Abnormal
Extension (60-85°)	☐ Normal	☐ Abnormal
Right Lateral Flexion (40-50°)	☐ Normal	☐ Abnormal
Left Lateral Flexion (40-50°)	☐ Normal	☐ Abnormal
Right Rotation (60-75°)	☐ Normal	☐ Abnormal
Left Rotation (60-75°)	☐ Normal	☐ Abnormal

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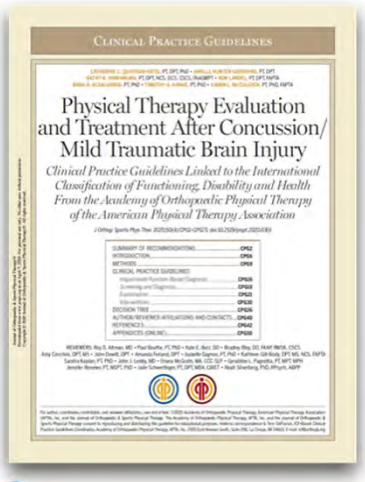
Cervical Musculoskeletal / Sensorimotor Impairments

(Quatman-Yates et al, 2020)



- There is clear evidence to suggest that **the cervical spine should be examined after a concussive event, but there is limited evidence on examination procedures for cervical musculoskeletal dysfunction** specific to patients who have experienced a concussive event.
- Low-level evidence suggests that a concussive event can cause cervical injury, and that cervical musculoskeletal impairments can cause symptoms that are often reported after a concussive event.

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Cervical Musculoskeletal / Sensorimotor Impairments
Manual Spine Exam

(Schneider et al, 2018; Schneider, 2019)

- **Extension Rotation Test:**
  - Patient is seated and asked to extend and rotate their head as far as possible.
- **Manual Spine Exam (MSE):**
  - Patient is prone and P-A force is applied over the articular pillars from C2-3 to C6-7
  - Any limitation to motion is rated as normal, slight, moderate or marked.
- **Palpation for Segmental Tenderness:**
  - The practitioner palpates the segmental muscles that overly the facet joints from C2-3 to C6-7.
- **Abnormal:**
  - **When familiar pain of ≥ 3/10 is reproduced**
  - **For MSE, resistance to motion is rated as moderate or marked.**
    - **A positive test on all three is highly predictive of facet joint mediated pain**


Musculoskeletal Science and Practice

Original article

Concussion - Part I: The need for a multifaceted assessment

Kathryn J. Schneider

ABSTRACT

1. Introduction

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Cervical Musculoskeletal / Sensorimotor Impairments
Cervical Flexion Rotation Test

(Schneider et al, 2018; Schneider, 2019)

Image taken from: http://jointefforttherapeutics.com/2013/06/04/cervical-flexion-rotation-test/

- The cervical flexion rotation test has been reported to have good diagnostic accuracy for C1/2 related cervicogenic headache.
- The practitioner positions the patient's neck into maximal flexion (to minimize movement at levels of the cervical spine other than the Cl-2)
- Maintaining the patient's neck in maximal flexion, the practitioner then assesses atlantoaxial rotation right and left
- **Abnormal:**
  - **A reduction of 10° (or greater) in ROM with a firm end feel and presence of pain**

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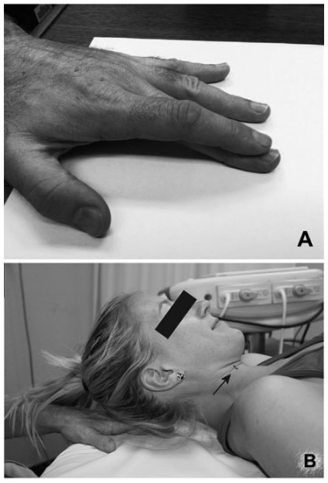
Cervical Musculoskeletal / Sensorimotor Impairments

Deep Neck Flexor Endurance Test

(Domenech et al, 2011; Schneider et al, 2018; Schneider, 2019)

- The patient is in a crook lying position with their head resting on the table
- Instruct the patient to perform cranio-cervical flexion ("chin tuck"), lift their head 2 finger widths off the table and hold this position for as long as possible
  - To fatigue or pain
- Stop the test if the patient's occiput touches your hand for more than 1-sec, or they have a loss of chin skin folds (from losing the chin tuck)



Cervical Musculoskeletal / Sensorimotor Impairments

Cervical Proprioception

(Jull et al, 2013; Hides et al, 2017; Treleaven, 2017)

Cervical Joint Position Error (JPE) Testing

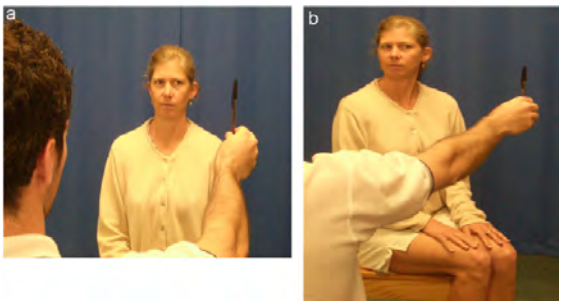
- The patient is seated in a chair with a back support, with a headband with laser centred on the forehead. The patient is seated 90 cm from a wall and is instructed to sit with their head in their natural resting position
- Ask the patient to close their eyes – or use a blindfold – and memorize the position.
- Instruct the patient to perform full cervical rotation, then return their head to the start position.
  - The patient is to verbally indicate when they perceive they have returned to their start position - Record position
  - Give no feedback on accuracy
  - The practitioner manually adjusts the persons head to match original starting position.
- Repeat 6 times alternately to each side
- Calculate the average for the left and right trials

Cervical Musculoskeletal / Sensorimotor Impairments

Smooth Pursuit Neck Torsion Test

(Treleaven, 2017; Treleaven, 2008)

- Ask patient to follow a slow moving target with their eyes while keeping their head still
  - The target is moved ~20º/sec through a visual angle of 40º
- Perform with head and trunk in neutral
- Perform with 'neck torsion'
  - head neutral, trunk rotated 45° left
  - head neutral, trunk rotated 45º right
- **Note differences in neck torsion positions compared to neutral position:**
  - Catch up saccades
    - Particularly when target crosses midline
  - Symptom reproduction in 'neck torsion'



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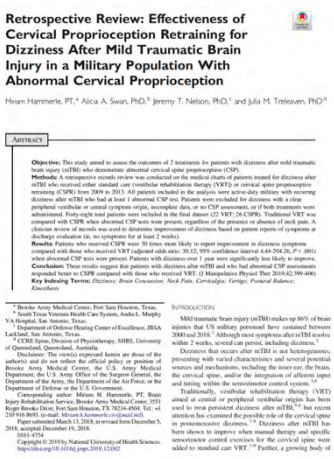
CSPR for Dizziness post mTBI

(Hammerle et al, 2019)

- ***"Results suggest that patients with dizziness after mTBI and who had abnormal CSP assessments (JPE and/or SPNT) responded better to CSPR compared with those who received VRT"***

- Exclusion criteria included any patients who had:
  - **clear peripheral vestibular or consistent central signs on clinical vestibulo-ocular testing** with or without visual suppression.



Retrospective Review: Effectiveness of Cervical Proprioception Retraining for Dizziness After Mild Traumatic Brain Injury in a Military Population With Abnormal Cervical Proprioception

Miriam Hammerle, PT,[a] Alicia A. Swan, PhD,[b] Jeremy T. Nelson, PhD,[c] and Julia M. Treleaven, PhD[d]

ABSTRACT

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"Properly determining whether concussion or cervical injury is the source of symptoms is vital **because the management of each condition differs considerably**."

- Cheever et al, 2016

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Graded Aerobic Exercise Test

(Leddy et al, 2023; Patricios et al, 2023a)

- Exercise testing should be performed only when the athlete reports the general resting concussion symptom burden is not >7/10 on a 0–10 visual analogue scale (VAS).
- Clinicians can **prescribe targeted HR aerobic exercise treatment based on 90% of the individual's HRt** at the more-than-mild symptom exacerbation point
- Subsymptom threshold aerobic exercise treatment can be progressed systematically based on the determination of the new HRt on repeat exercise testing (every few days to every week).

Systematic review

Beyond acute concussion assessment to office management: a systematic review informing the development of a Sport Concussion Office Assessment Tool (SCOAT6) for adults and children

Jon S Patricios, Geoff M Schneider, Jacqueline van Iersel, Laura K Purcell, Gavin A Davis, Ruben J Echemendia, Pierre Fremont, Gordon Ward Fuller, Stanley A Herring, Kimberly G Harmon, Kirsten Holte, Mike Loosemore, Michael Makdissi, Michael McCrea, William P Meehan, Patrick O'Halloran, Zahra Premji, Margot Putukian, Isla Jordan Shill, Michael Turner, Kenzie Vaandering, Nick Webborn, Keith Owen Yeates, Kathryn J Schneider

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Graded Aerobic Exercise Test

(Leddy et al, 2023; Patricios et al, 2023a)

- Prescribed **subsymptom threshold aerobic exercise within 2–10 days of SRC is effective for reducing the incidence of persisting symptoms** after concussion (symptoms >1 month) and is **also effective for facilitating recovery in athletes suffering from symptoms lasting longer than 1 month.**

Systematic review

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ABSTRACT

WHAT IS ALREADY KNOWN?

WHAT ARE THE NEW FINDINGS?

INTRODUCTION

BMJ

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Graded Aerobic Exercise Test

(Patricios et al, 2023b)

Graded Aerobic Exercise Test

Not Done ☐

Exclude contra-indications: cardiac condition, respiratory disease, significant vestibular symptoms, motor dysfunction, lower limb injuries, cervical spine injury.

Protocol Used:

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Graded Aerobic Exercise Test
Buffalo Concussion Treadmill Test

(Clausen et al, 2016; Kozlowski et al, 2013; Leddy et al, 2013)

- Patient to walk on a treadmill initially set at **3.4 mph (5.5 km/h) at a 0.0º incline**
  - Speed can be altered if needed (increase speed a little to comfort for taller or athletic persons, and reduce the speed for shorter or sedentary persons)
- **Each minute, increase the incline grade by 1º**
- **Each minute record HR, Rating of Perceived Exhaustion** (RPE, Borg Scale) and **assess the presence of symptoms**. (Borg, 1982; Leddy et al, 2013)
- Once treadmill reaches maximum incline (e.g. 12º or 15º) speed is increased by 0.4 mph (0.6 km/h) each minute
- **Continue until patients reach maximum exertion (RPE 19.5)**, OR have **onset of new symptoms**, OR **exacerbation of symptoms (3/10)**, OR **patient reports an inability to continue the test safely**
- Upon test termination, immediately record final measurements

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"Understanding the pathophysiology of concussion proves especially critical for the 20–30% of concussed patients who develop persistent postconcussion symptoms (PPCS)."

- Callaway & Kosofsky, 2019

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Part II
Rest and Exercise

13 'Rs' of Sport-Related Concussion

(Patricios et al, 2023)

- The Concussion in Sport Group's (CISG) **13 'R's of SRC management** to provide a logical flow of clinical concussion management and considerations:
  1. Recognise
  2. Reduce
  3. Remove
  4. Re-evaluate
  5. **Rest and Exercise**
  6. Refer
  7. Rehabilitation
  8. Recovery
  9. Return-to-sport / Return-to-learn
  10. Reconsider
  11. Retire
  12. Refine


Consensus statement

Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport–Amsterdam, October 2022

Aerobic Exercise

(Worts et al, 2019)

- Individuals with acute concussion display:
  - **impaired CBF** (present within 24 hours and continues >30 days), **cerebral oxygenation**, and/or cerebrovascular reactivity
  - abnormal BP responses
  - **dysautonomia**.
- It is suggested that **cerebral hypoperfusion might be responsible for the provocation or worsening of concussion symptoms** or reported exercise intolerance
- Increases in CBF, cerebral glucose, BDNF, and HRV are considered favorable biomarkers
- **Increases in systolic BP (SBP), mean arterial pressure (MAP), cortisol, and oxidative stress and reductions in diastolic BP (DBP) are considered detrimental**.
  - E.g. a significant increase in SBP during exercise may elicit a myogenic response in the cerebral arteries, thus stimulating reflexive cerebral vasoconstriction, resulting in reduced CBF in an already impaired state.

Sports Medicine
https://doi.org/10.1007/s40279-019-01065-1

REVIEW ARTICLE

A Physiologically Based Approach to Prescribing Exercise Following a Sport-Related Concussion

Phillip R. Worts[1,2,3] · Scott O. Burkhart[4,5] · Jeong-Su Kim[2,3,6]

© Springer Nature Switzerland AG 2019

Abstract

Clinical management of concussion has evolved over the last 20 years, and complete cognitive and physical rest remains a common clinical recommendation. The duration of rest may vary widely, from 24–48 h to several weeks or until the patient's symptoms have resolved or returned to near baseline levels. Following a period of rest, a stepwise progression of exercise is used for gradual return to play or to work. Previous research in healthy people suggested that prolonged periods of physical inactivity consistently induced deleterious physiological and psychological effects. A growing body of evidence indicates that initiating exercise earlier in the recovery process following a concussion may reduce symptom burden and lower the incidence of post-concussion syndrome. Preliminary findings appear promising, but data on the appropriate exercise prescription for patients who recently sustained a concussion are limited. We reviewed the literature in healthy individuals and patients with concussion and post-concussion syndrome to develop a physiologically based exercise prescription for the days following a concussion. Using this, practitioners may shorten the rest period and initiate controlled exercise earlier during the recovery process following a concussion.

Key Points

Prolonged periods of strict rest are likely detrimental to concussion recovery.

Therapeutic aerobic exercise can elicit positive physiological responses across multiple organ systems that may enhance recovery following a concussion.

Low-intensity, controlled aerobic exercise is likely well-tolerated in acutely concussed patients when appropriately prescribed.

1 Introduction

It is estimated that upwards of 3.8 million concussions occur annually in the USA from sports participation or recreational activities, and nearly 30% of all concussions treated in emergency departments are due to a sport or recreational activity [1, 2]. A concussion can cause neuropathologic and neurometabolic changes in the brain that may reflect a functional impairment rather than a structural injury [3]. These changes may result in the immediate or delayed onset of symptoms, clinical signs, balance impairment, behavioral alterations, cognitive dysfunction, sleep irregularities, cardiac autonomic dysfunction, or visual disturbances [4–6]. After a concussion occurs, and following a brief period of rest, patients can initiate a stepwise progression of exercise that is used for gradual return to play (RTP) or return to activity and guided by symptom provocation and clinical judgement.

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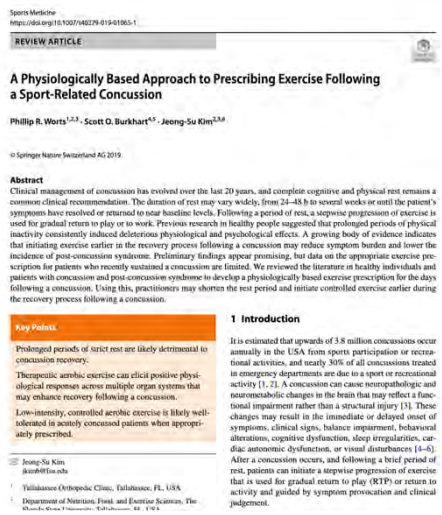
[2] Department of Nutrition, Food, and Exercise Sciences, The

Aerobic Exercise

(Worts et al, 2019)

- **Low intensity aerobic exercise** (57–63% MHR) has shown:
  - Increased CBF and cerebral oxygen
  - no adverse effects on exercising BP, CBF, cortisol, or BDNF levels
- **Moderate intensity aerobic exercise** (64-76% MHR) has shown:
  - Generally has positive effects on CBF, cortisol, oxidative stress and BDNF levels
- **High intensity aerobic exercise** (77-95% MHR) has shown:
  - increased BP, variable findings for CBF, increased free radical production and cortisol synthesis, dangerous increases in MAP, and reductions in cerebral glucose
  - "high-intensity aerobic exercise would likely be detrimental for physiologically compromised concussed patients."



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[1] Tallahassee Orthopedic Clinic, Tallahassee, FL, USA
[2] Department of Nutrition, Food, and Exercise Sciences, The

Rest and Exercise

(Patricious et al, 2023)

- Recommending strict rest until the complete resolution of concussion-related symptoms is not beneficial following SRC.
- **Relative (not strict) rest**, which includes activities of daily living and reduced screen time, **is indicated immediately and for up to the first 2 days after injury.**
- HCPs are encouraged to **recommend early (after 24–48 hours) return to PA as tolerated**
  - Individuals can systematically advance their exercise intensity based on the degree of symptom exacerbation experienced during the prior bout of aerobic exercise.
- HCPs can **prescribe subsymptom threshold aerobic exercise treatment within 2–10 days after SRC**, based on the individual's heart rate threshold (HRt) that does not elicit more than mild symptom exacerbation during the exercise test
  - Subsymptom threshold aerobic exercise treatment can be progressed systematically based on the determination of the new HRt on repeat exercise testing (every few days to every week).
  - Athletes may **continue/advance the duration and intensity of PA or prescribed aerobic exercise provided there is no more than mild and brief exacerbation of their concussion-related symptoms**

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Sub-Symptom-Threshold Submaximal Exercise

(Leddy et al, 2013; Leddy et al, 2023; Patricios et al, 2023a)

- During the Treadmill Test, if a submaximal symptom exacerbation threshold is identified, patients are to **perform aerobic exercise (on a stationary bike, treadmill or elliptical) at a subthreshold intensity (90% of the threshold HR achieved on the Treadmill Test)**
  - **Exercise for 20 min/day for 5 to 6 days/week using an HR monitor.**
    - They should **terminate exercise at the first sign of symptom exacerbation (>2/10) or after 20 min**, **whichever comes first.**
- The Treadmill Test can be repeated every 2 to 3 weeks to establish a new symptom-limited threshold HR until symptoms are no longer exacerbated on the treadmill
- A more reasonable / cost-effective approach is to establish the threshold HR on the initial test and **increase the exercise HR target by 5-10 bpm every 2 weeks, provided the patient is responding favorably**
  - Fit patients and athletes generally respond faster and can increase by 10 bpm every 2 weeks
  - Nonathletes typically respond better to 5 bpm increments every 2 to 3 wk.
    - Rate of exercise intensity progression varies, and some patients may have to stay at a particular HR for more than 2 weeks

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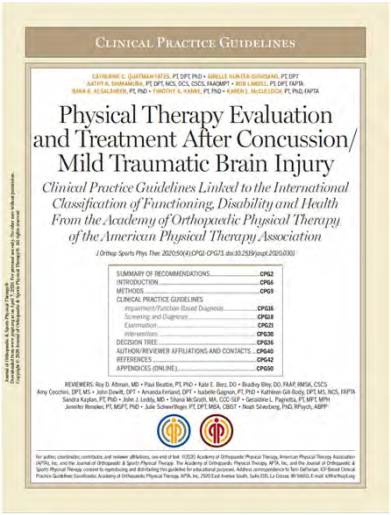
Aerobic Exercise

(Quatman-Yates et al, 2020)

- Both alone and coupled with other impairment-specific active rehabilitation interventions, **aerobic exercise training has been linked to faster symptom resolution and rate of return to sport and enhanced neurologic recovery.**
- Aerobic training interventions should be guided by symptoms
  - exacerbation of symptoms beyond a mild degree (>2/10) = termination for the session
  - absence of symptom exacerbation provides support for progressing exercise intensity and duration



Part III

Rehabilitation

13 'Rs' of Sport-Related Concussion

(Patricios et al, 2023)

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  1. Recognise
  2. Reduce
  3. Remove
  4. Re-evaluate
  5. Rest and Exercise
  6. Refer
  7. **Rehabilitation**
  8. Recovery
  9. Return-to-sport / Return-to-learn
  10. Reconsider
  11. Retire
  12. Refine


Consensus statement

Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport–Amsterdam, October 2022

Jon S Patricios, Kathryn J Schneider, Jiri Dvorak, Osman Hassan Ahmed, Cheri Blauwet, Robert C Cantu, Gavin A Davis, Ruben J Echemendia, Michael Makdissi, Michael McNamee, Steven Broglio, Carolyn A Emery, Nina Feddermann-Demont, Gordon Ward Fuller, Christopher C Giza, Kevin M Guskiewicz, Brian Hainline, Grant L Iverson, Jeffrey S Kutcher, John J Leddy, David Maddocks, Geoff Manley, Michael McCrea, Laura K Purcell, Margot Putukian, Haruhiko Sato, Markku P Tuominen, Michael Turner, Keith Owen Yeates, Stanley A Herring, Willem Meeuwisse

ABSTRACT

For over two decades, the Concussion in Sport Group has held meetings and developed five international statements on concussion in sport. This 6th statement summarises the processes and outcomes of the 6th International Conference on Concussion in Sport held in Amsterdam on 27–30 October 2022 and should be read in conjunction with the (1) methodology paper that outlines the consensus process in detail and (2) 10 systematic reviews that informed the conference outcomes. Over 3½ years, author groups conducted systematic reviews of predetermined priority topics relevant to concussion in sport. The format of the conference, expert panel meetings and workshops to revise or develop new clinical assessment tools, as described in the methodology paper, evolved from previous consensus meetings with several new components. Apart from this consensus statement, the conference process yielded revised tools including the Concussion Recognition Tool-6 (CRT6) and Sport Concussion Assessment Tool-6 (SCAT6, Child SCAT6). This consensus process also integrated new features including a focus on the para athlete, the athlete's perspective, concussion-specific medical ethics and matters related to both athlete retirement and the potential long-term effects of SRC, including neurodegenerative disease. This statement summarises evidence-informed principles of concussion prevention, assessment and management, and emphasises those areas requiring more research.

INTRODUCTION

This Amsterdam 2022 International Consensus Statement on Concussion in Sport (Statement) builds on previous Concussion in Sport Group (CISG) statements with the goal of updating current recommendations for sport-related concussion (SRC) through an evidence-informed consensus methodology. The purpose of this Statement is to provide a summary of the evidence and practice recommendations based on science and expert panel consensus recommendations at the time of the conference. Additional outputs of the consensus process include freely available evidence-informed tools to assist in the detection and assessment of SRC, including the Concussion Recognition Tool-6 (CRT6), Sport Concussion Assessment Tool-6 (SCAT6), Child SCAT6, Sport Concussion Office Assessment Tool-6 (SCOAT6) and Child SCOAT6. Apart from this Statement, in the interest of knowledge translation, the tools are free to distribute in their original formats.

This Statement is developed for the healthcare professional (HCP) involved in the care of athletes at risk of SRC or who have sustained a suspected SRC at any level of sport (ie, recreational to professional). The authors recognise that differences in geography, healthcare structure and culture are important considerations when implementing the principles presented. Thus, this Statement provides recommendations that can be adapted for different sport, clinical and cultural environments and is not meant to be used as a prescriptive guideline. We also recognise that the science of concussion continues to evolve, and the Amsterdam Statement reflects the state of the evidence at the time of the Consensus Conference and will need to be updated as new scientific information emerges. Also included are recommendations for future research where notable gaps in the literature have been identified. Although this Statement provides recommendations and is a summary of the consensus process, it should be read in combination with the 10 systematic reviews and methodology papers that informed the consensus process and outcomes.

MEDICOLEGAL CONSIDERATIONS

This Statement is not intended as a clinical practice directive or legal standard of care and should not

BMJ

Rehabilitation

(Patricios et al, 2023)

- If dizziness, neck pain and/or headaches persist for more than 10 days, **cervicovestibular rehabilitation is recommended.**
- Those with dizziness/balance problems, **either vestibular rehabilitation or cervicovestibular rehabilitation may be of benefit.**
- The inclusion of **subsymptom threshold aerobic exercise** in combination with other treatments should be considered.
- **In the case of a recurrence of symptoms** when progressing through the return-to- learn (RTL) or return-to-sport (RTS) strategies, **re-evaluation and referral for rehabilitation may be of benefit to facilitate recovery.**

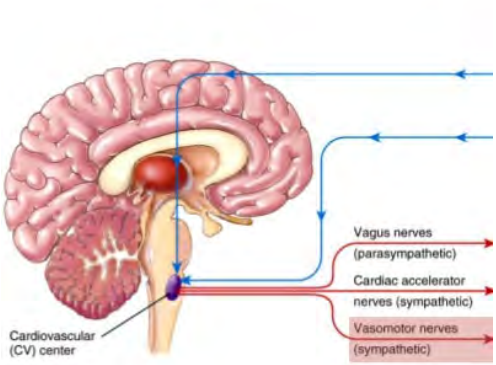

Consensus statement

Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport–Amsterdam, October 2022

Dysautonomnia

(Leddy & Willer, 2013)

- Concussed athletes have altered ANS balance, which is reflected by higher HR during steady-state exercise versus controls.
- **The primary ANS control center, located in the brainstem, may be damaged in concussion, particularly if there is a rotational force applied to the upper cervical spine.**
- **Altered autonomic regulation after TBI is believed to be due to changes in the autonomic centers in the brain and/or an uncoupling of the connections between the central ANS, the arterial baroreceptors, and the heart.**
  - It is proportional to TBI severity and improves during TBI recovery



"Recent evidence suggests that **ANS dysfunction because of diffuse axonal injury including brainstem structures and pathways mediating normal cerebrovascular autoregulation** could account for many of the symptoms commonly seen postconcussion."

- Callaway & Kosofsky, 2019

Tilt Table Training

(Kinay et al, 2004)

- **In-hospital tilt training program:**
  - Rest 5 min supine
    - Measure HR and BP at start and end of rest period
  - Tilt to 70º for a period of 30 min
    - Measure HR and BP every 5min
    - If syncope develops, return to supine position and immediately measure HR and BP as soon as supine
  - If patient can complete in-hospital tilt training (once daily) without syncope for 3 consecutive days, referred to home tilt training program

Tilt Table Training

(Kinay et al, 2004; Ector et al, 1998)

- **Tilt training program at home:**
  - Stand with feet 15 cm away from the wall
  - Lean with the upper back against the wall
    - **Maintain for 15-30 min**
    - **2 sessions daily**
  - Perform in a safe place (without risk of injury)
  - **Stop the session at the occurrence of first symptom**

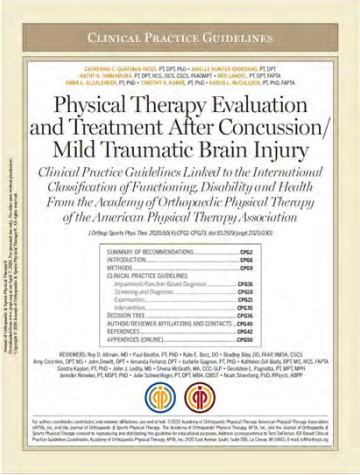
Tilt Table Training

(Baltz et al, 2013)

- **Alternative tilt training program:**
  - Patient secured to tilt table and elevated to 45º for 5 min
    - Assess clinical and subjective indices for tolerance
    - If ssx of intolerance, participants returned to resting supine position, and vitals are again assessed
  - Successful completion of 45º elevation, progress to 60º, 70º, 80º and 90º for a max. of 20 min at or above 60º, for patients who demonstrate tolerance.
  - If signs of intolerance are observed at any angle, return patients to a horizontal position at the rate of ~3º/sec, and vitals are re-assessed.

Vestibulo-Oculomotor Rehabilitation

(Quatman-Yates et al, 2020)


CLINICAL PRACTICE GUIDELINES

Physical Therapy Evaluation and Treatment After Concussion/ Mild Traumatic Brain Injury

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Academy of Orthopaedic Physical Therapy of the American Physical Therapy Association

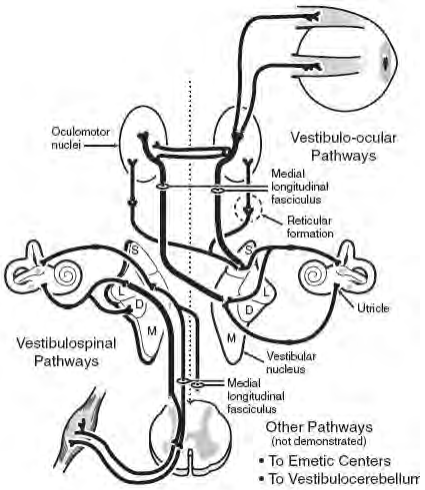
- Vestibulo-oculomotor rehabilitation, when prescribed in isolation or in conjunction with other rehabilitation interventions, **is associated with reduced dizziness, improved balance, and faster return to sport.**
  - It is expected that vestibulo-oculomotor rehabilitation exercises cause a mild transient increase in symptoms.
- Patients with posterior and lateral canal **BPPV should be treated with canalith repositioning procedures.**
  - Although repositioning maneuvers can be effective in treating BPPV, a patient may require additional interventions in the presence of concomitant vestibular hypofunction.

Vestibulo-Oculomotor Rehabilitation

(Kontos et al, 2017)

- If a vestibular or oculomotor clinical profile is identified, targeted rehabilitation strategies should be implemented
- Rehabilitation strategies should be **based on a targeted approach that matches therapies to the specific clinical profile**

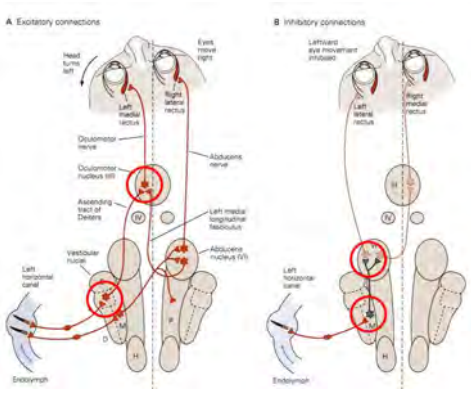
(Kontos et al, 2017; Reynolds et al, 2014; Broglio et al, 2015)



Vestibulo-Ocular Reflex (VOR)

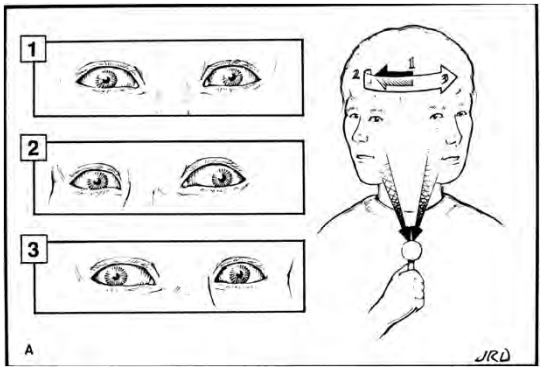
(Herdman, 2007)

- Impairment of the VOR can be improved by targeted gaze-stability training.
- Gaze stability refers to the ability to hold the eyes on a fixed location while the head is in motion.
- Gaze-stability training requires a patient to maintain visual focus while moving their head to facilitate recovery from VOR impairment.



Gaze Stabilisation
VOR x1
(Herdman, 2007)

- **VOR x1 viewing paradigm**
  - Designed to *increase the gain* of the vestibular system
  - **Visual target is stationary and patient moves the head back and forth** whilst maintain visual fixation on the target



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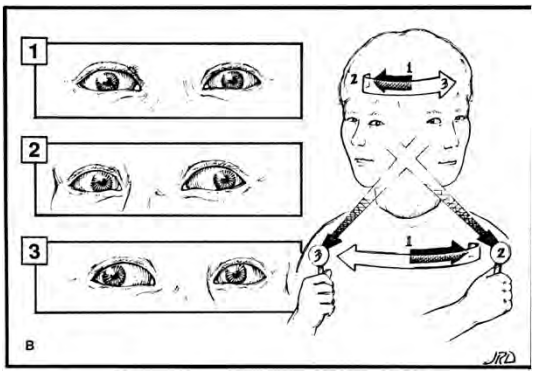
Gaze Stabilisation
VOR x2
(Herdman, 2007)

- **VOR x2 viewing paradigm**
  - Designed to *increase the gain* of the vestibular system
  - **Visual target and head move in opposite directions** while the patient maintain visual fixation on the target



64

Gaze Stabilisation
VOR x0 (VOR Cancellation)

- **VOR x0 (VOR Cancellation)**
  - Designed to *decrease the gain* of the vestibular system
  - **Head/Body and Visual target move in the same direction** while the patient maintains visual fixation on the target

65

Gaze Stabilisation
(Treleaven, 2008; Treleaven, 2010; Treleaven, 2017)

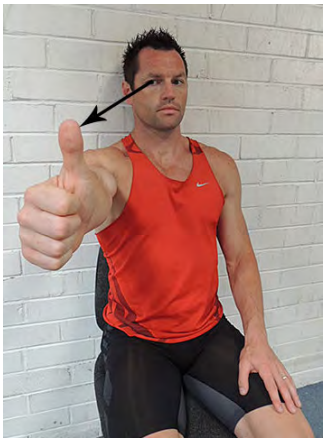
- Fixate on a single dot
  - Passive to Active neck movements
  - Non-WB to Seated to Standing
  - Walking with head movements

66

Visual Tracking (Pursuits)

(Treleaven, 2008; Treleaven, 2010; Treleaven, 2017)

- Practice following thumb with eyes (head stays still) in the previously determined abnormal direction(s)
  - Progress to eye-head coordination movements
  - Non-WB to Seated to Standing

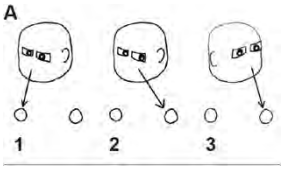


67

Saccadic Eye Movement

(Kontos et al, 2017; Bae, 2016; Han et al, 2011)

- Eyes are directed to a target(s) - while the head stays still - in the previously determined abnormal direction(s)
  - Progress to eye-head coordination movements



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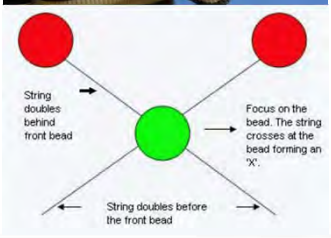
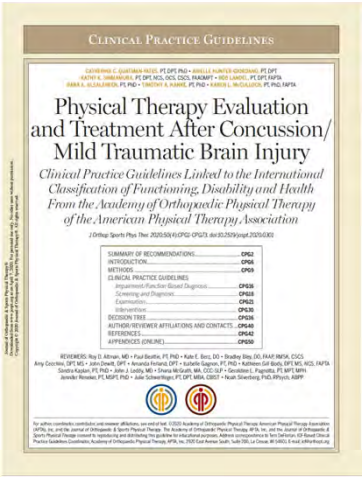
Vergence Eye Movements
Brock String
(Kontos et al, 2017)

- Look at the near bead.
  - Move the bead closer/further until you see a single bead
  - The near bead should be moved closer and closer as the task becomes easier. Eventually the near bead should be only 2.5cm from the bridge of your nose.
- **You should see two strings, each of which appears to come from your eyes - if fixation is accurate - the two strings should appear to meet exactly at the bead forming an "X"**
  - As the bead is moved into 2.5cm from your nose, the two strings should appear to meet exactly at the bead forming a "V".
- **Shift fixation to the middle fixation bead and then to the far fixation bead and repeat**
  - **If fixation of the far bead is accurate, the two strings should appear to meet exactly at the bead forming a "V".**



Cervical Musculoskeletal Rehabilitation
(Quatman-Yates et al, 2020)


CLINICAL PRACTICE GUIDELINES

Physical Therapy Evaluation and Treatment After Concussion/ Mild Traumatic Brain Injury

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Academy of Orthopaedic Physical Therapy of the American Physical Therapy Association

- Patients with concussion who exhibit signs of cervical musculoskeletal impairment **may respond well to interventions for cervical spine dysfunction alone and in combination with other active rehabilitation strategies.**
  - E.g. aerobic exercise training and/or oculomotor-vestibular interventions
- Additionally, **neck strength and muscle strength imbalances have been shown to be associated with concussion risk.**
- Therefore, even when cervical spine impairments are not present as a result of concussion, it **may be valuable for practitioners to provide cervical musculoskeletal interventions, with the goal of decreasing risk for subsequent concussive injuries.**

Supine Deep Neck Flexors Isometric Biofeedback

(Treleaven, 2017

- Practice performing cranio-cervical flexion
  - **Begin at 22mmHg**
  - **10 x 10sec holds**
  - Progress to 24, 26, 28, 30 mmHg
- *Note the patient does not retract the neck*

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Banded Deep Neck Flexors Isometric

- Band is held at eye level
- Create a long neck with a chin tuck initiated via cranio-cervical flexion (C0-C1 joint)
- Shoulders neutral and eyes fixated
- Supine to Seated to Standing

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Cervical JPS Rehabilitation

(Treleaven, 2008; Treleaven, 2010; Treleaven, 2017)

- Practice relocating head from the previously determined abnormal direction(s)
  - Eyes closed
  - Progress to eyes open
  - Progress to tracing patterns (e.g. Figure 8)

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Part IV

Return-to-Learn and Return-to-Sport

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13 'Rs' of Sport-Related Concussion

(Patricios et al, 2023)

- The Concussion in Sport Group's (CISG) **13 'R's of SRC management** to provide a logical flow of clinical concussion management and considerations:
  1. Recognise
  2. Reduce
  3. Remove
  4. Re-evaluate
  5. Rest and Exercise
  6. Refer
  7. Rehabilitation
  8. Recovery
  9. **Return-to-sport / Return-to-learn**
  10. Reconsider
  11. Retire
  12. Refine

Consensus statement

Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport–Amsterdam, October 2022

Jon S Patricios, Kathryn J Schneider, Jiri Dvorak, Osman Hassan Ahmed, Cheri Blauwet, Robert C Cantu, Gavin A Davis, Ruben J Echemendia, Michael Makdissi, Michael McNamee, Steven Broglio, Carolyn A Emery, Nina Feddermann-Demont, Gordon Ward Fuller, Christopher C Giza, Kevin M Guskiewicz, Brian Hainline, Grant L Iverson, Jeffrey S Kutcher, John J Leddy, David Maddocks, Geoff Manley, Michael McCrea, Laura K Purcell, Margot Putukian, Haruhiko Sato, Markku P Tuominen, Michael Turner, Keith Owen Yeates, Stanley A Herring, Willem Meeuwisse

ABSTRACT

For over two decades, the Concussion in Sport Group has held meetings and developed five international statements on concussion in sport. This 6th statement summarises the processes and outcomes of the 6th International Conference on Concussion in Sport held in Amsterdam on 27–30 October 2022 and should be read in conjunction with the (1) methodology paper that outlines the consensus process in detail and (2) 10 systematic reviews that informed the conference outcome. Over 3½ years, author groups conducted systematic reviews of predetermined priority topics relevant to concussion in sport. The format of the conference, expert panel meetings and workshops to revise or develop new clinical assessment tools, as described in the methodology paper, evolved from previous consensus meetings with several new components. Apart from this consensus statement, the conference process yielded revised tools including the Concussion Recognition Tool-6 (CRT6) and Sport Concussion Assessment Tool-6 (SCAT6), Child SCAT6, as well as a new tool, the Sport Concussion Office Assessment Tool-6 (SCOAT6), Child SCOAT6. The consensus process also integrated new features including a focus on the para athlete, the athlete's perspective, concussion-specific medical ethics and matters related to both athlete retirement and the potential long-term effects of SRC, including neurodegenerative disease. This statement summarises evidence-informed principles of concussion prevention, assessment and management, and emphasises those areas requiring more research.

INTRODUCTION

This Amsterdam 2022 International Consensus Statement on Concussion in Sport (Statement) builds on previous Concussion in Sport Group (CISG) statements with the goal of updating current recommendations for sport-related concussion (SRC) through an evidence-informed consensus methodology. The purpose of this Statement is to provide a summary of the evidence and practice recommendations based on science and expert panel consensus recommendations at the time of the conference. Additional outputs of the consensus process include freely available evidence-informed tools to assist in the detection and assessment of SRC, including the Concussion Recognition Tool-6 (CRT6), Sport Concussion Assessment Tool-6 (SCAT6), Child SCAT6, Sport Concussion Office Assessment Tool-6 (SCOAT6) and Child SCOAT6. Apart from this Statement, in the interest of knowledge translation, the tools are free to distribute in their original formats.

This Statement is developed for the healthcare professional (HCP) involved in the care of athletes at risk of SRC or who have sustained a suspected SRC, at any level of sport (ie, recreational to professional). The authors recognise that differences in geography, healthcare structure and culture are important considerations when implementing the principles presented. Thus, this Statement provides recommendations that can be adapted for different sport, clinical and cultural environments and is not meant to be used as a prescriptive guideline. We also recognise that the science of concussion continues to evolve, and the Amsterdam Statement reflects the state of the evidence at the time of the Consensus Conference and will need to be updated as new scientific information emerges. Also included are recommendations for future research where notable gaps in the literature have been identified. Although this Statement provides recommendations and is a summary of the consensus process, it should be read in combination with the 10 systematic reviews and methodology papers that informed the consensus process and outcomes.

MEDICOLEGAL CONSIDERATIONS

This Statement is not intended as a clinical practice directive or legal standard of care and should not

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Return-to-Learn (RTL) Strategy

(Patricios et al, 2023)

Step	Mental Activity	Activity at Each Step	Goal
1	Daily activities that do not result in more than a mild exacerbation* of symptoms related to the current concussion.	Typical activities during the day (e.g., reading) while minimizing screen time. Start with 5–15 min at a time and increase gradually.	Gradual return to typical activities.
2	School activities.	Homework, reading, or other cognitive activities outside of the classroom.	Increase tolerance to cognitive work.
3	Return to school part time.	Gradual introduction of schoolwork. May need to start with a partial school day or with greater access to rest breaks during the day.	Increase academic activities.
4	Return to school full time.	Gradually progress school activities until a full day can be tolerated without more than mild* symptom exacerbation.	Return to full academic activities and catch up on missed work.

- Progression through the RTL strategy is symptom limited (no more than mild exacerbation of **current concussion symptoms**)
- Student-athletes **should complete full RTL before unrestricted RTS**.

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Return-to-Sport (RTS) Strategy

(Patricios et al, 2023)

- Expect a **minimum of 1 week** to complete the full RTS strategy (24 hours for each step), but **typically unrestricted RTS can take up to 1 month**
- Athletes with difficulty progressing through RTS or with SSx that are not progressively recovering beyond the first 2-4 weeks may benefit from rehab / involvement of a team of HCPs experienced in managing SRC

Step	Exercise Strategy	Activity at Each Step	Goal
1	Symptom-limited activity.	Daily activities that do not exacerbate symptoms (e.g., walking).	Gradual reintroduction of work/school.
2	Aerobic exercise **2A – Light** (up to approx. 55% max HR) **then** **2B – Moderate** (up to approximately 70% max HR)	Stationary cycling or walking at slow to medium pace. May start light resistance training that does not result in more than mild and brief exacerbation* of concussion symptoms.	Increase heart rate.
3	Individual sport-specific exercise **NOTE:** if sport-specific exercise involves any risk of head impact, medical determination of readiness should occur prior to step 3.	Sport-specific training away from the team environment (e.g., running, change of direction and/or individual training drills away from the team environment). No activities at risk of head impact.	Add movement, change of direction.
Steps 4-6 should begin after resolution of any symptoms, abnormalities in cognitive function, and any other clinical findings related to the current concussion, including with and after physical exertion.			
4	Non-contact training drills.	Exercise to high intensity including more challenging training drills (e.g., passing drills, multiplayer training). Can integrate into team environment.	Resume usual intensity of exercise, coordination, and increased thinking.
5	Full contact practice.	Participate in normal training activities.	Restore confidence and assess functional skills by coaching staff.
6	Return to sport.	Normal game play.	

maxHR = predicted maximal Heart Rate according to age (i.e., 220-age)

Age Predicted Maximal HR= 220-age	Mild Aerobic Exercise	Moderate Aerobic Exercise
55%	220-age x 0.55 = training target HR	
70%		220-age x 0.70 = training target HR

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Doctors working at international events need to update their head injury module every 2 years to remain current.

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