

Evaluation in the medical practice

Which tests are most relevant?



Swisski+



What?

Exclude neurologic and cervical Red Flags

- Refer for further investigations if necessary

Confirm or rule out the diagnosis of concussion?

Refer for appropriate rehabilitation

Educate the athlete

Identify factors that may influence injury risk & persistent symptoms

Why?

There is a risk of subsequent injuries

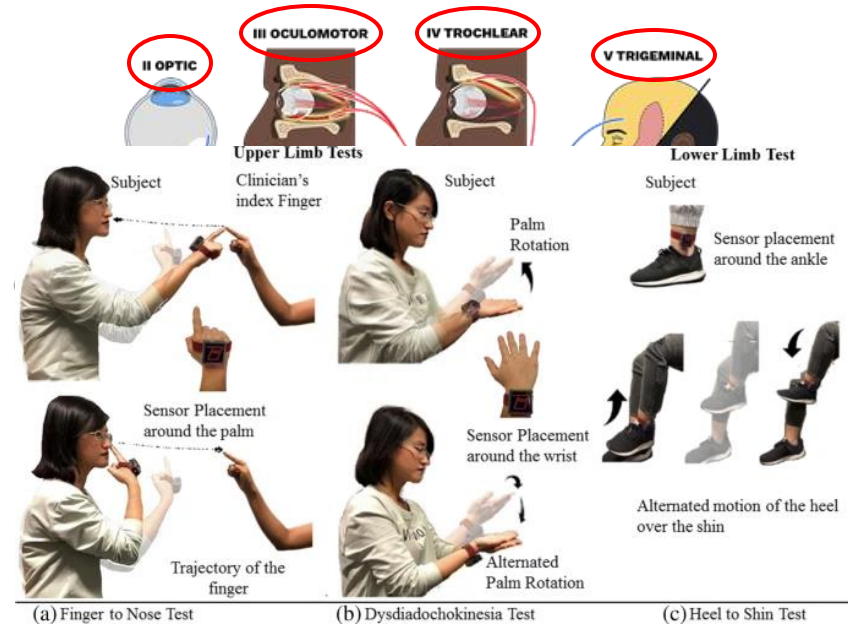
There is a risk of Persistent Postconcussive Symptoms (PPCS)

Rehabilitation is beneficial in treating concussed athletes

How? – Exclude neurologic and cervical Red Flags

Neurological examination

- Alertness (GCS)
- Cranial nerves
- Tone
- Strength
- Sensitivity
- Deep tendon reflexes
- Cerebellar function :
Balance, muscle tone, and
coordination of voluntary movement
- Cervical pain & mobility



Krishana R, et al. *Journal of NeuroEngineering and Rehabilitation* 2019



How? – Confirm or rule out the diagnosis?

Post-Concussion Symptom Scale (PCSS)

Standardized Assessment of Concussion (SAC)

Orientation – Memory – Concentration

Balance Error Scoring System (BESS)

Cervical and neurological examination

Vestibular Ocular Motor Screening (VOMS)

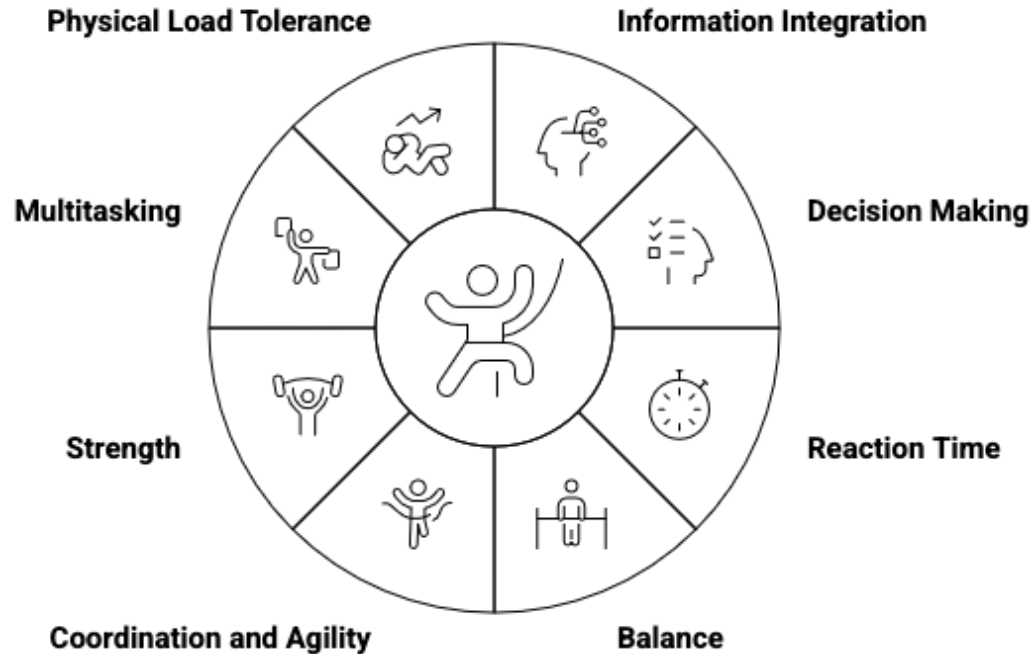
King-Devick, Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT), ...

Sport Concussion Assessment Tool (SCAT)

Head Injury Assessment (HIA)

How? – Identify signs & symptoms that influence injury risk

Disruption in the Perception – Action Loop



How? – Identify signs & symptoms that influence evolution



Persistent postconcussive symptoms

- Favouring/predicting factors?

**5P
Score**

- Age
- Sex
- History of concussions (and duration)
- History of migraines or mental/psychic condition
- Severity of post-concussion symptoms in the first few days *Iverson GL, et al. Br J Sports Med 2017*
- Dizziness at the time of injury *Lau BC, et al. Am J Sports Med 2011*
- Post-concussion development of migraines, dizziness, oculomotor difficulties, symptoms of depression
- Balance (mBESS), tandem walking + cognitive task

Van Deventer KA, et al. J Sport Health Sci 2021

Iverson GL, et al. Br J Sports Med 2017
McCrory P, et al. Br J Sports Med 2018
Harmon KG, et al. Br J Sports Med 2019

Table 5. Selected Predictor Variables for Multivariable Model of Persistent Postconcussive Symptoms (PPCS) at 28 Days in the Derivation Cohort^a

5p Clinical Score	No. of Risk Points for PPCS	Odds Ratio (95%CI)	P Value
Age group, y			
5-7	0	1 [Reference]	<.001
8-12	1	1.54 (1.09-2.19)	
13-<18	2	2.31 (1.62-3.32)	
Sex			
Male	0	1 [Reference]	<.001
Female	2	2.24 (1.78-2.82)	
Prior concussion and symptom duration			
No prior concussion; symptom duration <1 wk	0	1 [Reference]	.01
Prior concussion; symptom duration ≥1 wk	1	1.53 (1.10-2.13)	
Physician-diagnosed migraine history			
No	0	1 [Reference]	.001
Yes	1	1.73 (1.24-2.43)	
Answering questions slowly			
No	0	1 [Reference]	.008
Yes	1	1.37 (1.08-1.74)	
Balance Error Scoring System tandem stance No. of errors			
0-3	0	1 [Reference]	.02
≥4 or Physically unable to undergo testing	1	1.31 (1.04-1.66)	
Headache			
No	0	1 [Reference]	.01
Yes	1	1.66 (1.11-2.48)	
Sensitivity to noise			
No	0	1 [Reference]	.002
Yes	1	1.47 (1.15-1.87)	
Fatigue			
No	0	1 [Reference]	<.001
Yes	2	1.84 (1.37-2.46)	

Table 6. Risk Categories for Persistent Postconcussive Symptoms (PPCS) in the Derivation Cohort^a

PPCS Risk Category	Total No. of Risk Points	Estimated Risk of PPCS, % (95% CI)	No. With PPCS/ Total No. of Patients (%)
Low risk	0	4.1 (2.4-6.7)	0/6 (0)
	1	5.8 (3.9-9.5)	6/37 (16.2)
	2	8.3 (6.0-13.2)	11/98 (11.2)
	3	11.8 (8.5-17.8)	15/165 (9.1)
Medium risk	4	16.4 (11.9-22.4)	41/239 (17.2)
	5	22.3 (16.7-29.7)	71/289 (24.6)
	6	29.7 (22.7-37.9)	90/299 (30.1)
	7	38.2 (30.1-46.9)	96/243 (39.5)
	8	47.6 (38.9-57.1)	80/172 (46.5)
High risk	9	57.1 (48.2-65.6)	58/103 (56.3)
	10	66.1 (57.2-74.4)	30/43 (69.8)
	11	74.1 (65.8-81.5)	9/13 (69.2)
	12	80.8 (74.6-88.3)	3/3 (100)

Score of 9-12 = 82% persistent postconcussive symptoms !

Zemez R, et al. JAMA 2016
Howell DR, et al. Am J Sports Med 2018

How? – Identify signs & symptoms that influence evolution



Persistent postconcussive symptoms

- Favouring/predicting factors?
 - Delayed withdrawal from the game and delayed consultation
 - Vestibular and cognitive disorders on first examination
 - VOMS impairment is associated with:
 - more symptoms, reduced academic performance
 - delayed recovery (except NPC)
 - delayed RTP if present at 14 days post-SRC

Barnhart M, et al. Sports Med 2021

Chareck DB, et al. J Head Trauma Rehabil 2020

Martinez C, et al. Archives of Physiotherapy 2020

Kontos AP, et al. JAMA Neurol 2020

Anzaone AJ, et al. Am J Sports Med 2017

Glendon K, et al. Brain Injury 2021

How? – Identify signs & symptoms that influence evolution

Vestibular Ocular Motor Screening (VOMS)

Baseline symptoms 0-10: Headache – Dizziness – Nausea – Fogginess

Smooth Pursuits



Saccades
Horizontal & Vertical



Convergence
Near Point



Vestibulo-Ocular Reflex
Horizontal & Vertical



Visual Motion
Sensitivity Test



Any item ≥ 2 pts

Near point convergence (NPC) ≥ 5 cm

3 items (VOR, VMS, NPC)

= +46% probability of concussion

= +34% probability of concussion

= 89% accuracy for identifying concussion from ctrl

Mucha A, et al. Am J Sports Med 2014

How? – Identify signs & symptoms that influence evolution



Persistent postconcussive symptoms

- Favouring/predicting factors?
 - Delayed withdrawal from the game and delayed consultation
 - Vestibular and cognitive disorders on first examination
 - VOMS impairment is associated with:
 - more symptoms, reduced academic performance
 - delayed recovery (except NPC)
 - delayed RTP if present at 14 days post-SRC
 - Low symptom threshold during physical activity (BCTT)
 - Symptom HRt $\leq$ 135bpm at BCTT increases chances of prolonged symptoms by 45x
 - Δ Rest HR - Symptom HRt $\leq$ 50bpm predictive of prolonged symptoms
(sensi 73%, specifi 78%)

Barnhart M, et al. Sports Med 2021

Chareck DB, et al. J Head Trauma Rehabil 2020

Martinez C, et al. Archives of Physiotherapy 2020

Kontos AP, et al. JAMA Neurol 2020

Anzaone AJ, et al. Am J Sports Med 2017

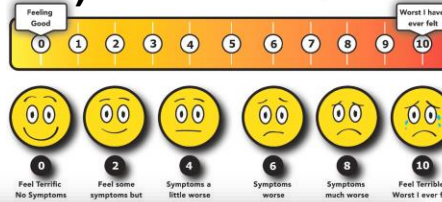
Glendon K, et al. Brain Injury 2021

Leddy JJ, et al. Clin J Sport Med 2017

Haider MN, et al. Front. Neurol. 2019

How? – Identify signs & symptoms that influence evolution

Buffalo Concussion Treadmill Test (BCTT)



Stop test if:

- Symptom AVS increased by >3 points.
- Maximum test in terms of HR/RPE.
- Stoppage requested by the athlete.

BORG 6-20 original	Perception	Activité
6	repos	repos
7		
8	très très facile	marche
9		
10	facile	léger jogging
11		
12	modéré	jogging
13		
14	un peu dur	
15	dur	seuil
16		
17	très dur	intervalles
18		
19	très très dur	
20	maximal	

If symptom HRt : $\leq 135\text{bpm}$

= $\uparrow$ chances of prolonged symptoms by 45x

If Δ Rest HR - Symptom HRt : $<50\text{bpm}$

= predictive of prolonged symptoms

Physical activity considered as safe

= 80-90% of symptom HRt

10				
11				
12				
13				
14				

Leary JJ, et al. Clin Sport Med 2017
Haider MN, et al. Front. Neurol. 2019

How? – Refer for appropriate rehabilitation

Subsymptom threshold aerobic exercise treatment is recommended to start **within 2 days**

Cervical & Vestibular rehabilitation programme is recommended for adolescents and adults with headache, neck pain, dizziness and/or balance problems **at 10 days**

Collaborative care and **active rehabilitation** is recommended for adolescents and adults **when symptoms persist > 30 days**

Leddy JJ, et al. Br J Sports Med 2023
Schneider KJ, et al. Br J Sports Med 2023

How? – Refer for appropriate rehabilitation

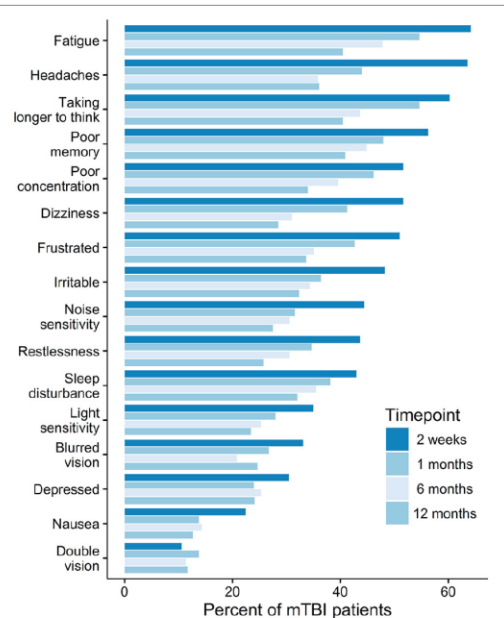
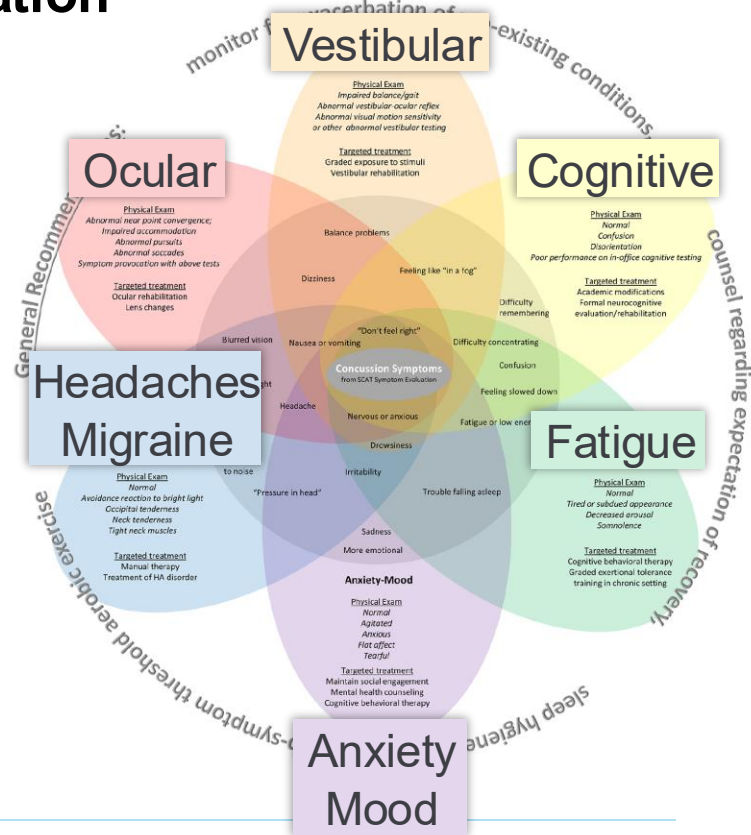
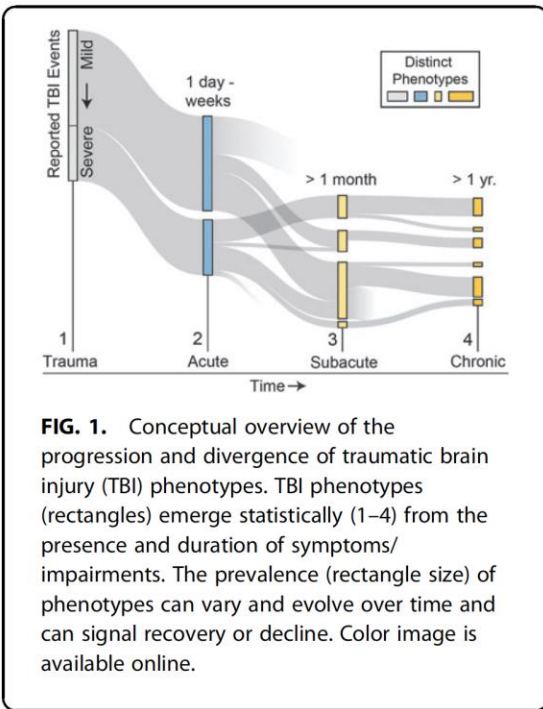
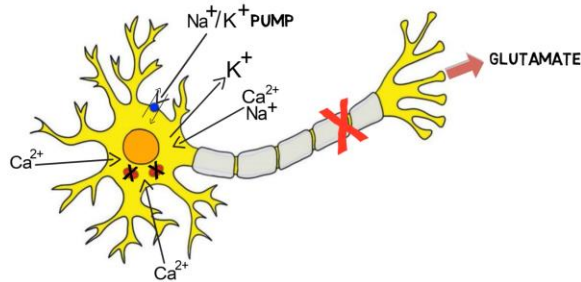


FIGURE 2 | The prevalence of post-concussion symptoms over time. Permission has been obtained to base our figure on data presented in Theadom (27).



How? – Educate the athlete



Brain Concussion

Maintain symptom increase below 2/10 with hourly recovery

Split working/course/revision time to stay below the symptom threshold

Promote aerobic activities below the symptom threshold (50-70% HRmax or 80-90% HRt)

Optimize diet & sleep

Limit medications & harmful substances

Avoid NSAIDs, opiates, sleeping pills, alcohol, tobacco, drugs, ...

Wear your glasses as much as possible

My practical approach – First medical visit

History with confounding factors and prior head injuries

Symptoms (PCSS) – Identification of a phenotype if possible

Neurological examination and SCOAT 6 (Orientation, Memory, Concentration, Balance)

VOMS – if sufficient time (otherwise at 2 weeks)

5P score – if applicable

→ BCTT for prognostic and therapeutic planning purposes in the 1st week

→ Additional investigations according to symptoms, duration, and phenotype

Phone follow-up at 1 week

In-person follow-up at 2 & 4 weeks

Physician - Physio contact in between



History

(recent, past, neuro, psych, developmental, family history, medications)

Symptoms (PCSS)

Cognitive (SAC) :

Immediate memory

Concentration

Orthostatism

Cervical examination

Complete neurological examination

Coordination & Balance (BESS)

Vestibular & Oculomotor Screening (VOMS)

Screening :

Anxiety

Depression

Sleep disorders

Cognitive (SAC) :

Delayed memory

Exercise tolerance test (BCTT)

Take Home Message

Clinical Diagnosis, **Keep a low suspicion threshold !** – visible clues, symptoms, tools

▶ Look for Red Flags ▶

Be attentive :

- To factors that increase **risk of injury** – disruption of the perception-action loop
 - The risk of a second concussion in the same season = **3x higher**
 - The risk of subsequent injury = **↑ 40-60%**
- To **predictors of persistent postconcussive symptoms**
- To the expressed **symptom profile/phenotype**

Educate and Rehabilitate the athlete

- Sub symptom threshold aerobic exercise treatment is recommended to start within 2 days

Refer in case of Red flag or Symptom duration of > 4 weeks

Guskiewicz KM, et al. Am J Sports Med 2000

Rafferty J, et al. Br J Sports Med 2019

McPherson AL, et al. Am J Sports Med 2018

Ramirez V, et al. USPT 2022

Leddy JJ, et al. Br J Sports Med 2023

Schneider KJ, et al. Br J Sports Med 2023

Reneker JC, et al. Musculoskeletal Science and Practice 2019

Thank you for your attention

