

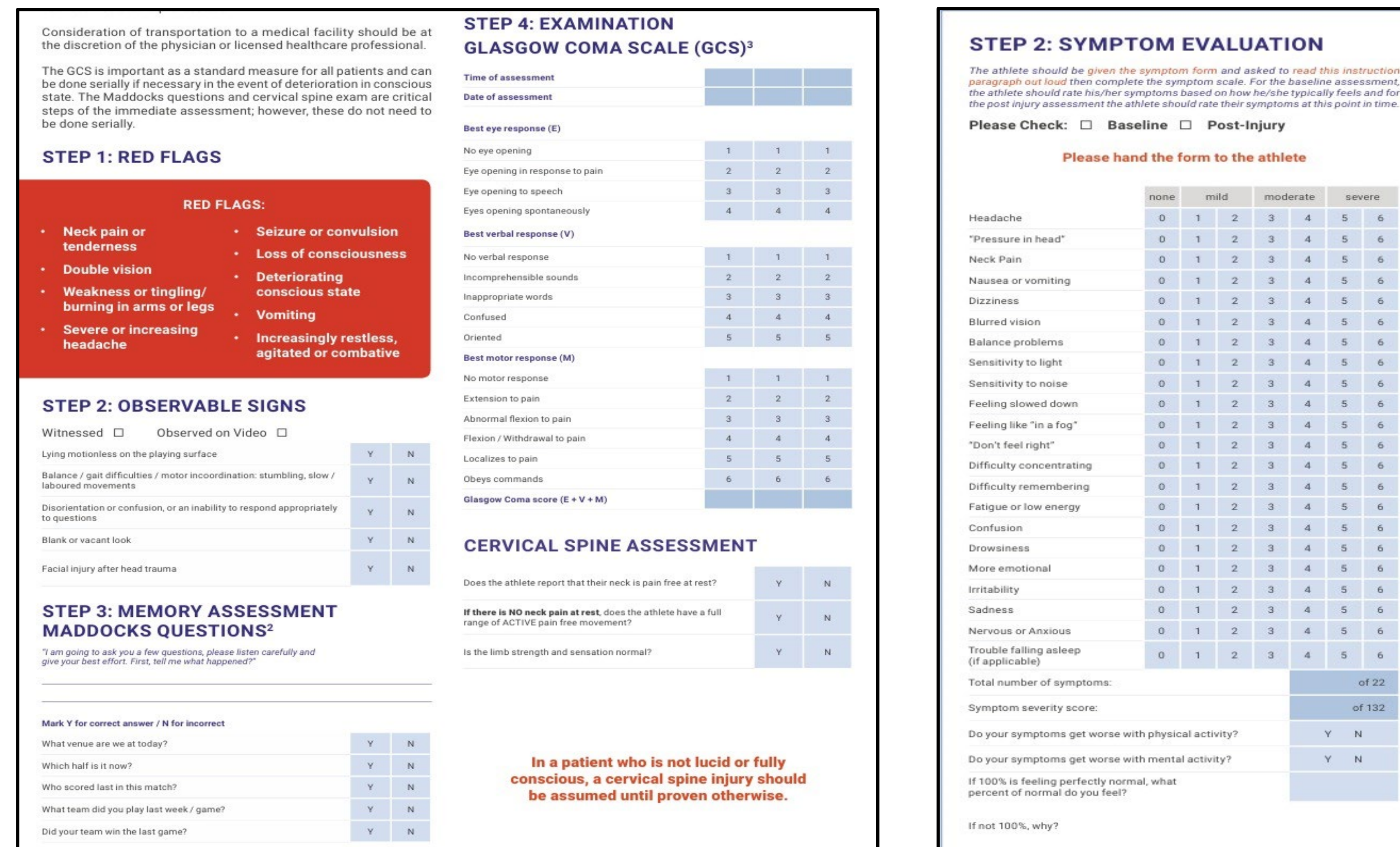
### Background

- Concussions represent a major health concern as they result in a temporary disruption of brain function, often described as form of traumatic brain injury (TBI).<sup>1</sup>
- Concussions occur due to the biomechanical forces introduced into the body or head, resulting in acceleration, deceleration, and rotational forces of the head.<sup>1</sup>
- Approximately 3.8 million concussions occur in the United States each year due to sport and recreation, with up to 50% not being reported.<sup>1</sup>
- Sports related concussions are typically self-limiting, with patients presenting with alterations in neurocognitive and neurological functioning that resolve within 7-10 days with appropriate return-to-play management.<sup>2</sup>
- Post-concussion syndrome (PCS) includes various physical, cognitive, behavioral, and emotional symptoms occurring after a TBI. These symptoms include headaches, fatigue, changes in vision, problems with balance, confusion, dizziness, insomnia, neuropsychiatric symptoms, and trouble with concentration.<sup>3</sup>
- Persistent post-concussion syndrome (PPCS) occurs when symptoms persist greater than 3 months.<sup>3</sup>
- Inadequate management of PPCS can lead to adverse outcomes, emphasizing the need for early and effective interventions implemented through a multidisciplinary approach.
- The goal of this case report is to familiarize providers with the evaluation, resources, and follow-up necessary to ensure patients can return-to-play in a safe and effective manner after a concussion with prolonged symptomatology.

### Case History

- The patient in this case is a 14-year-old male who presented for evaluation for concussion without loss of consciousness.
- He was hit in the back of the head while playing basketball in late July 2023.
- Two weeks after the incident, he developed headache, dizziness, and trouble falling asleep. He also endorsed multiple falls.
- He was seen for initial evaluation in clinic on 9/7/2023 following head injury. Physical exam at that time remarkable for discomfort with horizontal saccades. Referral placed for physical therapy for vestibular therapy and speech cognition evaluation for assessment of patient's memory.
- At follow-up on 9/19/2023, patient reported feeling 70% better. He continued to have irritability. On physical exam at that time, patient noted to have discomfort with horizontal and vertical saccades.
- At second follow-up on 9/28/2023, patient stated that he felt that he was 100% back to normal. Sport concussion assessment tool-5 (SCAT-5) was back to baseline. **Return to play protocol initiated.**
- On 10/31/2023, the athletic trainer at his school noted that patient continued to have symptoms, including dizziness, trouble with balance, sensitivity to light/noise, feeling slowed down, difficulty concentrating/remembering things, fatigue, confusion, and increased emotions.
- At third follow-up on 11/6/2023, the patient reported not being able to focus during athletic trainer evaluation as he had not taken his attention deficit hyperactivity syndrome (ADHD) medication. He denied symptoms. Emphasized that last day of tryouts for junior varsity basketball were on the day of follow-up, requesting clearance.
- Of note, patient had two major life events around November 2023, including suicide of friend and cancer diagnosis in family.
- Re-referral placed for patient to be evaluated by physical therapist.

### Concussion Evaluation and Management



**STEP 1: RED FLAGS**

RED FLAGS:

- Neck pain or tenderness
- Double vision
- Weakness or tingling/burning in arms or legs
- Severe or increasing headache
- Seizure or convulsion
- Loss of consciousness
- Deteriorating conscious state
- Vomiting
- Increasingly restless, agitated or combative

**STEP 2: SYMPTOM EVALUATION**

Please hand the form to the athlete

	none	mild	moderate	severe
Headache	0	1	2	3
"Pressure in head"	0	1	2	3
Neck Pain	0	1	2	3
Nausea or vomiting	0	1	2	3
Dizziness	0	1	2	3
Blurred vision	0	1	2	3
Balance problems	0	1	2	3
Sensitivity to light	0	1	2	3
Sensitivity to noise	0	1	2	3
Feeling slowed down	0	1	2	3
Feeling like "in a fog"	0	1	2	3
"Don't feel right"	0	1	2	3
Difficulty concentrating	0	1	2	3
Difficulty remembering	0	1	2	3
Fatigue or low energy	0	1	2	3
Confusion	0	1	2	3
Drowsiness	0	1	2	3
More emotional	0	1	2	3
Irritability	0	1	2	3
Sadness	0	1	2	3
Nervous or Anxious	0	1	2	3
Trouble falling asleep (if applicable)	0	1	2	3

Total number of symptoms: **0/22**  
 Symptom severity score: **0** of 132

Do your symptoms get worse with physical activity? **Y N**  
 Do your symptoms get worse with mental activity? **Y N**  
 If 100% is feeling perfectly normal, what percent of normal do you feel? **Y N**  
 If not 100%, why?

Figure 1. Portions of SCAT-5 form; with the left portion being completed immediately/on-field after injury and the right portion being filled out in office/off-field.<sup>4</sup>

Table 1. SCAT-5 Scores in Clinical Setting

Office Visit Date	SCAT-5 Score (Number of symptoms, Symptom Severity)
9/07/2023	20/22, 50/132
9/19/2023	20/22, 46/132
9/28/2023	14/22, 29/132
11/6/2023	2/22, 2/132
11/16/2023	0/22, 0/22

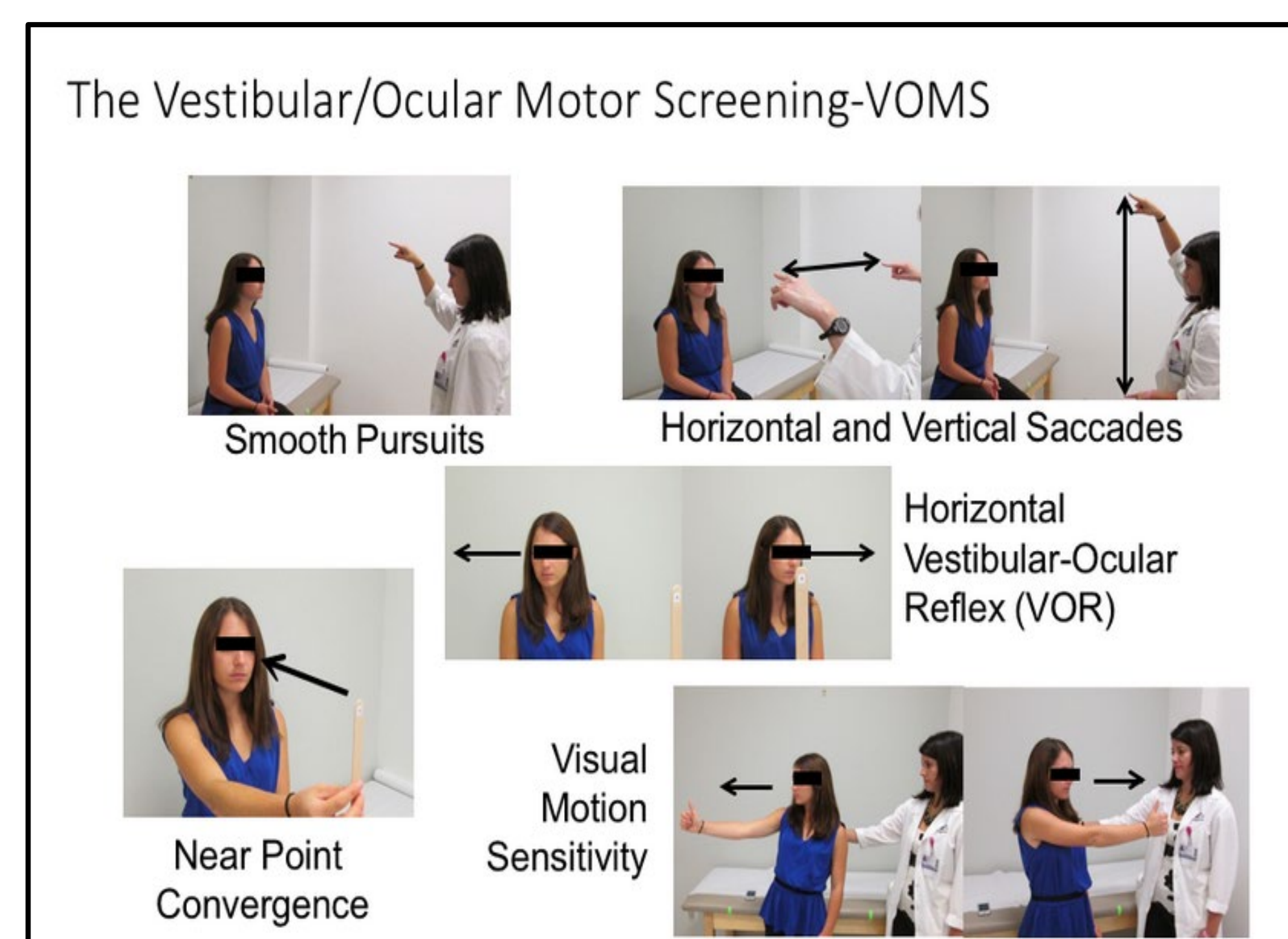


Figure 2. Vestibular/Ocular Motor Screening (VOMS) occurs at each patient encounter and during vestibular therapy. It has been noted that the vestibular-ocular system is the best indicator of outcomes followed sport related concussions. The patient in this case initially had discomfort with horizontal and vertical saccades, which improved over several months.<sup>5</sup>

Rating of Perceived Exertion / The Borg Scale		
Green	6	Zero exertion
	7	Extremely light
Yellow	8	Minimal recognition of effort
	9	Very light exertion (Comfortable walking pace)
	10	Can just start to hear your breathing
Orange	11	Conversation is easy and you can run like this for a while
	12	Light exertion
	13	Somewhat hard
	14	You can hear your breathing but you're not struggling
Red	15	You can talk but not in full sentences
	16	Hard work
	17	Very hard - Starting to get uncomfortable
	18	You can no longer talk because of your breathing
	19	Extremely hard - Your body is screaming at you
	20	Maximal exertion

Figure 3. The Buffalo concussion treadmill test helps establish the heart rate at which exercise induced symptoms occur after a concussion. It is effective in diagnosing and managing concussions, along with guiding in the decision of when it is appropriate to initiate return-to-play.<sup>6,7</sup>

### Rehabilitation

- The patient was evaluated by physical therapy on 11/7/2023; VOMS was positive with vertical smooth pursuit and horizontal/vertical vestibular-ocular reflex.
- During the Buffalo concussion treadmill test, a significant amount of diaphoresis noted at four minutes. He was unable to look ahead while walking and maintain gaze with gait. Mild syncopal-like episode noted after aerobic testing.
- Patient's symptoms were consistent with persistent post-concussion syndrome with underlying dysautonomia.
- It was recommended at that time that patient participate in a home exercise program, with weekly physical therapy for 6 weeks.
- Therapeutic exercise/interventions performed during that encounter included pencil pushups, vestibular ocular reflex testing, high intensity interval training, and target following with basketball.
- He was seen for follow-up with physical therapy on 11/16/2023; exam at that time demonstrated mild loss of target with recovery with smooth pursuits and positive horizontal vestibular-ocular reflex testing with quick recovery.
- At this follow-up, the patient was evaluated by the NASA 10-minute lean test, which involves measuring the blood pressure and heart rate while resting supine and then every minute for a total of 10 minutes while standing. This test evaluates orthostatic intolerance, with reported symptoms being recorded during the test.<sup>8</sup>
- During NASA 10-minute lean test, the patient remained asymptomatic.
- Patient did well with his second session of physical therapy; improvement was noted in all VOMS testing. Neuro-muscular re-education and therapeutic exercises were utilized to stimulate athletic play with patient not presenting with any symptoms of provocation. Patient was deemed to be stable to continue home exercise plan to include VOR with walking and progressions. He no longer required physical therapy.
- On follow-up in clinic on 11/16/2023, patient was given permission to resume his return-to-play protocol with noncontact practice, with gradual return to contact practice before being fully cleared. Athletic trainer was notified of plan.

### Discussion

- Concussions are a common medical concern encountered in daily clinical practice.
- Studies have demonstrated that effectively addressing persistent post-concussive symptoms necessitates a collaborative approach involving primary care physicians, physical therapists, speech-language pathologists, psychologists, and athletic trainers.<sup>2</sup> By working together, they can ensure a timely diagnosis and personalized treatment plans, while providing support to patients and families.
- This case shows how while the patient initially showed improvement, his athletic trainer noted increased symptoms during the return-to-play protocol assessment. Through re-evaluation and physical therapy, the patient's symptoms improved and facilitated his safe return to sports.
- Interdisciplinary collaboration is key in enhancing patient outcomes and mitigating the long-term impact of concussions.<sup>2</sup>

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