* Define concussion and WAD and identify the possible overlap in physical complaints related to these conditions.
* Describe the pathophysiologic process post-concussion relating it to the importance of post-injury rest.
* Learn updated research on Evaluation of PCS – What are the key points that you’re emphasizing here?
* Improve clinical reasoning for implementing EBP into Interventions – not sure what this means
* Describe recommended progressions for patient return to sport or recreational activities
* Slide 4
	+ **Concussion/mild Traumatic brain injury**-- a traumatic injury that affects the brain, induced by biomechanical forces transmitted to the head by a direct blow to, or forces exerted on, the body, but that does not result in an extended period of unconsciousness, amnesia, or other significant neurological signs indicative of a more severe brain injury. Concussions can occur in many different contexts, including but not limited to falls, motor vehicle accident, blast exposures, sport/recreational injuries, or assault. Concussion can cause brain injury in conjunction with injury to other structures to the musculoskeletal (esp neck) or vestibular systems.[1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)Additionally, loss of consciousness can be a part a mTBI, but most situations do not result in loss of consciousness rather an altered mental state.
	+ A criteria for concussion/mTBI consists of: post-traumatic amnesia < 24 hours, a Glasgow score between 13 and 15 as well as the appearance of any transient neurological sign [2](https://sciwheel.com/work/citation?ids=11784489&pre=&suf=&sa=0&dbf=0)
	+ **PCS**--persistent post-concussion syndrome is defined as the persistence of 3 or more symptoms at 4 weeks. [2](https://sciwheel.com/work/citation?ids=11784489&pre=&suf=&sa=0&dbf=0)
	+ Another definition via the fourth edition of the *Diagnostic and Statistics Manual* as (1) cognitive deficits in attention or memory and (2) at least 3 or more of the following symptoms: fatigue, sleep disturbance, headache, dizziness, irritability, affective disturbance, apathy, or personality change.[3](https://sciwheel.com/work/citation?ids=4209568&pre=&suf=&sa=0&dbf=0)
	+ **Whiplash**--Whiplash occurs during minor indirect cervical trauma, secondary to a rear impact that most often results from a road accident, with fast acceleration/deceleration of the head and neck, causing injury to bone and soft tissue. Furthermore, whiplash can occur in a situation where the head hits an object like a wall or the ground. This pathology creates a sprain or cervical musculoligamentous strain with no bone lesion, or loss of consciousness. Persistent symptoms, known as “Whiplash associated disorder” (WAD) is a consequence of whiplash. A classification was provided by the Quebec Task Force in 1995 with four grades. Grade 1 describes neck pain, stiffness or tenderness without any other signs, while in grade 2, a stiffness is objectified with a decreased range of motion. Neurological signs are present in grade 3, and grade 4 is described in the event of fracture or dislocation of the cervical spine. However, let’s focus on grade 2 because ~93% of the whiplash cases will be in this stage. [2](https://sciwheel.com/work/citation?ids=11784489&pre=&suf=&sa=0&dbf=0)
* Slide 5[2](https://sciwheel.com/work/citation?ids=11784489&pre=&suf=&sa=0&dbf=0)
	+ **Initial injury**
		- TBI results from blunt force, nonpenetrating head trauma, trauma, concussion, assault, or sports-related injuries. These acceleration, deceleration, rotational, and shear forces can cause neuron injury at the on the dendrites or attachments such as the synaptic terminals. At the cellular level, cells can change their ability to depolarize by increasing too much which will cause increased potassium outside the cell and increase calcium inside the cell. This process of mitochondrial Ca2+ uptake in combination with nitrogen oxide production triggers the collapse of mitochondrial membrane potential, culminating in cell death. Important to use the metabolic cascade and energy crisis as descriptors, I think, b/c it links to the importance of rest after an injury to allow homeostasis to return.
		- While, whiplash can occurs during minor indirect cervical trauma, for example in rear impact car accident that cause a fast acceleration/deceleration of the head and neck, causing injury to bone and soft tissue. This pathology does not cause a bone lesion nor loss of consciousness unlike potential issues associated with a mTBI, but creates a sprain or cervical musculoligamentous strain which is similar to a mTBI.
	+ **Vestibulocochlear disorders** could appear as a result of a mono synaptic input between the C2 dorsal root ganglion and its afferences: lateral and central cervical nucleus, caudal projections to C5 level, cuneate nucleus and lateral cuneate nucleus, nucleus tractus solitarius, and nucleus X of the vestibular system. An injury to these central pathways, in both pathologies (whiplash and concussion), would lead to an impairment of the cervico-collic, and cervico-ocular reflexes which act with the vestibulo-ocular reflex. This will lead to difficulty in stabilizing the head and trunk during head/neck movements and in stabilizing the gaze during head rotations. This shows the close neurological and anatomical connection between the cervical region and the vestibular system and describes how the additional proprioceptive input in balance disorders, vertigo and oculomotor disorders can be impacting a patient. Frequently the vestibular system presents in a central integration issue but sometimes it can be due to peripheral damage of the vestibular system and/or peripheral dysfunction such as BPPV.
	+ **Regarding the secondary onset of mTBI symptoms.** They argue that this secondary appearance could be the consequence of diffuse axonal lesions of secondary appearance, not by mechanical trauma at the time of whiplash, but by a sequential process of axonal swelling and axoplasmic transport malfunction that would create an axonal disconnect. Brain injuries, with changes in blood flow and brain perfusion in functional imaging show a decrease in grey matter density in voxel-based morphometry studies and hypoperfusion in single photon emission computed tomography and positron emission tomography. Bilateral parieto-occipital hypoperfusion can occur in whiplash subjects with chronic symptoms.
		- **Encouraging withdrawal from competitive activities**
			* Conservative strategy of restrictive physical and cognitive rest (i.e., removing athletes from participation and placing him/her on rest until normal brain functioning returns), was long considered to be the preferred therapeutic option for athletes post-concussion and has been endorsed as the standard of practice by experts. However, this strategy is often frustrating for athletes, given they tend to be physically-focused, task orientated individuals. Recent evidence suggests that strict, total rest may prolong functional recovery following concussion. Therefore, we must find balance and modify their activities rather than completely restrict them because they may become hypersensitive to stimulus if they are on complete rest.[4](https://sciwheel.com/work/citation?ids=8165763&pre=&suf=&sa=0&dbf=0) I will preface that there are a few studies looking at early rehabilitation once symptoms are “stable” (i.e. not getting worse) as a starting point rather than waiting till asymptomatic.
		- This leads me into my text topic, signs and symptoms that patients with concussions can experience.
* Slide 6
	+ I would like to preface this with the fact that a lot of these symptoms can overlap in mechanism or symptom presentation. However, we can attempt to categorize common symptoms into these domains.
* Slide 7
	+ **Headaches:** Post-traumatic cephalalgia and headaches can be used interchangeably but cephalagia is another medial term to describe headaches. Headaches tends to be conceptualized as a single entity as currently classified using the ICHD-3, but it’s important to understand that headaches can be from numerous generators.[5](https://sciwheel.com/work/citation?ids=10918766&pre=&suf=&sa=0&dbf=0) Cervicogenic headache is commonly from cervical joint dysfunction, muscle tension/guarding and stiffness, cervical flexor deconditioning[2](https://sciwheel.com/work/citation?ids=11784489&pre=&suf=&sa=0&dbf=0) or migrainous’ features, being nausea, vomiting, photophobia or phonophobia quite commonly reported.[6](https://sciwheel.com/work/citation?ids=11127715&pre=&suf=&sa=0&dbf=0) Post-traumatic headache (PTH) is, in fact, classified according to the sole temporal and, partly, neuroimaging data regarding head trauma, without any description of pain characteristics. Most of the issues regarding PTH remain controversial and need more epidemiological, clinical and pathophysiological studies.[7](https://sciwheel.com/work/citation?ids=2349712&pre=&suf=&sa=0&dbf=0) According to the latest International Classification of Headache Disorders (ICHD-3), post-traumatic headaches are defined as a secondary headache with onset within seven days following trauma or injury, or within seven days after recovering consciousness, or within seven days after recovering the ability to sense and report pain.[8](https://sciwheel.com/work/citation?ids=9979370&pre=&suf=&sa=0&dbf=0)
	+ If we suspect this patient has a headache stemming from a migraine, then we should refer out to their PCP. This isn’t perfect picture of the differentiating, but I think it helps give you an idea of how to attempt to tease out differences.
* Slide 8
	+ **Dizziness:** Dizziness associated with mTBI is generally of a vestibular or central nervous system origin. Another form of dizziness that can occur with mTBI is cervicogenic due to cervical trauma. Factors that can contribute to dizziness: Benign paroxysmal positional vertigo (BPPV), poor gaze stabilization, motion sensitivity, migraine headache, exertional activity, and cervical injury in conjunction with the mTBI. Dizziness is the most common complaint in both acute and chronic symptoms.[9](https://sciwheel.com/work/citation?ids=6246389&pre=&suf=&sa=0&dbf=0)
* Slide 9
	+ **Vestibulo-oculomotor impairments:** Can cause dizziness or balance deficits due to vertigo, blurred vision, headaches, nausea, sensitivity to light, sensitivity to sound, mental fogginess, difficulty reading, difficulty concentrating, anxiety, and fatigue.[1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)
* Slide 10
	+ **Exertional intolerance**: Autonomic nervous system can be injured and cause cerebral blood flow (CBF) and heart rate dysfunction during exercise. [9](https://sciwheel.com/work/citation?ids=6246389&pre=&suf=&sa=0&dbf=0) Autonomic dysfunction resulting from the brain injury itself may be a contributing factor. The central autonomic nervous system dysfunction and its interaction with the heart can lead to a reduced ability to maintain and adjust cerebral blood flow, blood pressure, and/or heart rate in response to increases and decreases in physical exertion. Autonomic dysregulation has been linked to higher perceived rates of exertion after concussion even though they are not working out harder in comparison to individuals who have not recently sustained a concussion and may be captured by assessments for orthostatic hypotension. Poor tolerance of physical exertion may also be associated with higher reports of fatigue, as the effects of physical exertion may not occur during actual exercise but may emerge post workout 30mins to a few hours later. Another potential source of poor tolerance of physical exertion is general deconditioning or secondary physical inactivity/lifestyle changes that may be recommended or occur as a result of the concussive injury.[1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)
* Slide 11
	+ **Motor Function impairments**: This can include static and dynamic/postural control impairments, changes in dual/multitasking abilities, delayed motor reaction time, and increased difficulty with motor coordination (especially with more complex environments or tasks)[1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)
* Slide 12
	+ **Social/Emotional distress:**
		- Image[10](https://sciwheel.com/work/citation?ids=7719348&pre=&suf=&sa=0&dbf=0)
		- An article specific for students found that symptoms can interfere with their academic performance (absents, grades dropping, unable to retain information—memory loss, unable to keep up with workload due to concentration and fatigue), relationships, and overall sense of well-being. Emotional symptoms can present as anxiety/stress, depression/sadness, interpersonal difficulties/isolation, and irritability/moodiness. Social withdrawal can occur as well. The article explored barriers and facilitators of recovery, which factors at school, factors at home, medical care, and level of involvement with sports and athletic personnel were common themes.[11](https://sciwheel.com/work/citation?ids=8409859&pre=&suf=&sa=0&dbf=0)
		- For adults, PTSD and depression are common-especially in the military population. Concussion lowers the threshold for developing emotional problems. Speed and accuracy (and their combined measure of mental efficiency) have been shown to decline across a range of cognitive functions, including simple reaction timeas well as delayed memory and executive functioning. Therefore, the impact of delayed memory and executive problems can frustrate them during their normal activities because they can’t remember something they feel like they should or look over previous work and ask themselves why they did that.[12](https://sciwheel.com/work/citation?ids=6651204&pre=&suf=&sa=0&dbf=0)
* Slide 13
	+ **Sleep/Fatigue**[13](https://sciwheel.com/work/citation?ids=12058318&pre=&suf=&sa=0&dbf=0)**:**
		- Sleep disturbance may result from damage to sleep-wake regulating centers or from secondary factors, including pain, depression, and anxiety. Sleep disturbances can be an immediate symptom, impacting their sleep within the first few days following the concussion, or impacting them later in their recovery due to these secondary factors. Sleep complaints can present with snoring, nightmares, poor sleep efficiency, delayed sleep onset, early awakenings, excessive daytime sleep, and generally poor sleep quality.
		- Fatigue may result from impaired attention and speed of information processing, necessitating greater cognitive effort in performing tasks, and secondary factors, including pain, medication, anxiety, and depression. Although fatigue may also cause depression and anxiety so it’s difficult to extrapolate which came first, therefore it’s important to understand what is going on but help them manage the symptoms. Physiological fatigue arises from depletion of energy, hormones, neurotransmitters, or neural connections, in this context due to brain injury. There can be psychological fatigue as well, which is defined as a state of weariness related to reduced motivation, prolonged mental activity, or boredom that occurs in situations such as chronic stress, anxiety or depression. This is more commonly considered given that anxiety and depression are more likely to develop after TBIs.
		- Why is it important to consider this domain? In the longer term, persisting fatigue and sleep problems may constrain day-to-day living and continue despite apparent physical recovery. These can effect an injured person’s ability to engage in domestic activities or complete a full day at work, so that activity levels and productivity are reduced, increased time is spent resting, and there is little energy for social or leisure activities.
		- Depending on the patient presentation and issues that are arising, we can utilize specific outcome measures as a screen. If score poorly or it’s highly impacting their function, then we can intervene appropriately and follow their progress.
			* PSQI[13](https://sciwheel.com/work/citation?ids=12058318&pre=&suf=&sa=0&dbf=0): is a measure of self-reported sleep quality shown to be sensitive to sleep disturbance in the TBI population. A cutoff score greater than 8 has demonstrated high sensitivity (93%) and specificity (100%) to insomnia in outpatients with TBI
			* ESS[13](https://sciwheel.com/work/citation?ids=12058318&pre=&suf=&sa=0&dbf=0): Requires individuals to rate their likelihood of dozing or falling asleep in specified sedentary situations. A total score greater than or equal to 10 (range 0–24) is considered an indicator of excessive daytime sleepiness (EDS).
			* FSS[13](https://sciwheel.com/work/citation?ids=12058318&pre=&suf=&sa=0&dbf=0): Assesses the behavioral consequences of fatigue and the impact of fatigue on daily functioning, rating 9 items on a 7-point scale. The FSS has acceptable internal consistency, stability over time, and sensitivity to clinical changes; distinguishing between brain-injured patients from controls; and correlates with other fatigue measures
* Slide 14 transition
* Slide 15
	+ **Concussion:** Due to direct access, sometimes we can evaluate a patient who sustained a MVA, fall, or another blunt trauma event to the head that may have caused a concussion, but didn’t seek any medical treatment prior to seeing us or that diagnosis wasn’t explored/was missed. Therefore, we need to be prepared to asking screening questions to determine if they are appropriate for PT. Thus, we must ask: did they have a decrease or loss of consciousness of <30 mins? Any post-traumatic amnesia—i.e. memory loss around the event? Perform Glasgow Coma Scale assessment –best if it’s performed in first 24 hours, which is extremely unlikely for a PT to have such early access.[1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0) Most frequently we will receive a referral from a physician for a patient that has a concussion diagnosis, but it’s important to be prepared for when or if we are the first medical professionals evaluating a patient.
	+ **Screening for Red flags:** These indicators (sidebar 1) will inform the clinician that the patient needs immediate emergency medical services: declining level or LOC, cognition, or orientation; GCS <13; new onset of pupillary asymmetry, seizures, repeated vomiting, or focal neurological signs; severe or rapidly worsening headache or neurological deficits; signs/symptoms indicating undiagnosed skull fracture; serious cervical spine fracture, dysfunction; or pathology (e.g. Vertebrobasilar artery insufficiency, cervical ligamentous instability, signs of central cord compression.[1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)
		- As a reminder, Central cord compression/syndrome will commonly present w/ motor weakness greater in UE than LE, bladder dysfunction, varying sensory loss below level of lesion, and the mechanism is the hyperextension.[14](https://sciwheel.com/work/citation?ids=10450724&pre=&suf=&sa=0&dbf=0)
	+ **Are they appropriate for PT**?: Yes, as long as they’re not showing signs requiring ER referrals and they are negative in the Canadian C-spine rules for a neck injury imaging . Assess for signs and symptoms that we just touched on which include: headaches, dizziness, vestibulo-oculomotor impairments, exertional Intolerance, motor Function impairments, social/emotional distress, sleep, and fatigue
* Slide 16 [1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)
	+ **Does the patient report neck pain with movement or at rest?**
		- Yes– then go to examination of cervical MSK impairments and provide interventions for pain management and to support symptom management to allow for further special testing esp vestibular that requires head movement
		- No— then go to next evaluation aspect
	+ **Do they report headache or dizziness with movement or at rest?**
		- Yes—Evaluate cervical MSK, vestibulo-oculomotor, orthostatic hypotension/autonomic impairments associated with dizziness and headaches. Go from least to most irritable testing. Depending on irritability and symptom provocation during initial assessment, it may be necessary to delay testing for further sessions. Depending on patient symptoms you can proceed with motor function impairments.
		- No– Still perform the same evaluation as yes, continue to consider irritability components during evaluation (e.g. frequency of symptom, vigor of movement required to elicit symptoms, severity of symptoms, how quickly the symptoms rise and fall, as well as any easing factors.
* Slide 17 transition
	+ Image[10](https://sciwheel.com/work/citation?ids=7719348&pre=&suf=&sa=0&dbf=0)
* Slide 18
	+ When evaluating the cervical ROM, pay attention to which movements elicit pain and how irritable this pain is. Joint mobility in the cervical spine can be PA, UPA, bias rotation w/ UPA, lateral glides, and AP with grades ranging from 1-4 depending on pain referral patterns, severity, and again irritability.
	+ During palpation, look for any trigger points or local tender points in the cervical and upper thoracic/scapular regions.
* Slide 19
	+ The cranial cervical flexion test when the patient is supine and has a blood pressure cuff between their neck and the table which is inflated to 20mmHg. Ask the patient to do a small “yes” nod to until it reads 22mmHg, hold of 10 secs. Then perform it again but ask them to reach 24mmHg and hold for 10 secs. This test emphasizes the deep neck flexors (DNF) and ideally minimizes the use of superficial neck flexors such as SCM to contract. Therefore, we can look for these compensatory techniques to limit the use of the DNF.
		- The intra- and inter-reliability for the CCFT ranged from fair to (ICC: 0.63 to 0.86) and construct validity has been demonstrated to be satisfactory. The discriminative validity of the CCFT is not as strong though.[15](https://sciwheel.com/work/citation?ids=12881641&pre=&suf=&sa=0&dbf=0)
	+ Cervical flexion rotation test will assess how well the upper cervical (C1 on C2 are moving which contribute 50% of cervical rotation) because rotation limitations could be inhibited by the upper cervical and/or the lower cervical vertebrae. This test allows you to differentiate rotation limitations.
		- Diagnostic accuracy, sensitivity, and specificity of the CFRT were very high (90% and 88% with 92% agreement for experienced examiners (P<.001)). Even for inexperienced examiners, they reported greater range for the CFRT than experienced examiners but psychometric prosperities such as sensitivity, specificity and agreement were still within clinically acceptable levels. [16](https://sciwheel.com/work/citation?ids=12881639&pre=&suf=&sa=0&dbf=0)
* Slide 20
	+ Smooth Pursuit Neck Torsion which is thought to test the proprioceptive reflexes of the neck, the cervico-collic reflex (CCR) and the cervico-ocular reflex (COR). In the test, eye movement is measured with the head in a neutral forward facing position and then with the trunk rotated beneath the head (a torsion maneuver of the neck). Thus, the patient will need to sit on a stool as they rotate the trunk while they keep the head facing forward. The latter position (trunk rotation) would stimulate the cervical receptors but not the vestibular receptors.[17,18](https://sciwheel.com/work/citation?ids=5143016,12694408&pre=&pre=&suf=&suf=&sa=0,0&dbf=0&dbf=0) Subjects with neck pain caused by trauma, however, displayed greater deficits than those with idiopathic neck pain.[17](https://sciwheel.com/work/citation?ids=5143016&pre=&suf=&sa=0&dbf=0) However, the smooth pursuit neck torsion test requires equipment to assess eye movement so it will be difficult to implement into a clinic. The sensitivity of the SPNT test in the WAD group with dizziness was 90% and the specificity was 91%.[14](https://sciwheel.com/work/citation?ids=12694408&pre=&suf=&sa=0&dbf=0)
	+ The Head-neck differentiation test will have a patient sit on a swivel chair. For cervical torsion, the clinician firmly stabilized the participant’s head in a centered position while the participant used the legs to rotate the body approximately 45 degrees to the left and right sides at a metronome pace of 60 beats per minute. For head rotation, the participant kept the trunk still while actively rotating the head approximately 45 degrees to the left and right for 30 seconds at a metronome pace of 90 beats per minute. Then, the participant rotated the head and trunk together 45 degrees to the left and right at a metronome pace of 60 beats per minute. After each test, the participant was asked to report any symptoms and the duration of these using the symptoms chart.[19](https://sciwheel.com/work/citation?ids=12694442&pre=&suf=&sa=0&dbf=0)
	+ For general motor control assessment, we would access their neuromuscular coordination and strength in movements or proprioception with joint awareness. To be efficient, the motor control would be observed as we perform these other assessments, but making note of compensations or lack of control is pertinent information. For example, cranial cervical flexion test, we can see a patient’s ability to coordinate the DNF vs gross neck flexors.
* Slide 21[1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)
	+ VOMS, vestibulo-ocular motor screen consists of smooth pursuit, saccades (horizontal and vertical), convergence, and VOR (cancellation, x1, and/or x2). It’s also worth considering doing horizontal and vertical VOR as well. Head thrust can be another component to the VOMS. Also consider speed at which they perform each task. Look for nystagmus, the eye slipping up/down, or increase in symptoms (dizziness, headaches) when performing these assessments.
	+ Dix-Hallpike test or BBQ roll for horiz canal is indicated if you suspected a BPPV and this test is the gold standard for accessing it. A good functional question to ask can be: Are they having issues with positional changes, especially moving from seated to lying down in one direction?
* Slide 22
	+ Mildly blunted heart rate response, altered heart rate variability, and higher ratings of perceived exertion have been observed among individuals who have experienced a concussive event during graded exercise testing, suggesting potential autonomic dysfunction. It has been documented that these are safe, tolerable, and symptoms associated with exertional intolerance/autonomic dysfunction can result in slight, short-term exacerbation of symptoms. [1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0) Thus, use your clinical judgement to be considerate of HR changes, utilization of RPE, and frequently check in about exacerbation of symptoms when performing these tests. Primarily, use symptom thresholds as intervention plans based on how they respond during these tests.
	+ Potential considerations in regards to risks or potential harms related to exertional intolerance examinations include: exacerbation of concussion-related symptoms, varying comfort levels and preferences of patients for exercise in general or with certain exercise modalities, a general lack of fitness that may limit the utility of an exertional assessment for identifying specific injury-related impairment, for some patients with cardiovascular, orthopedic, or vestibular conditions or impairments, and inability to tolerate certain types of exertional modalities or protocols. [1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)
	+ Other considerations can be aerobic based exercise intolerance tests and dynamic based exercise intolerance tests. The HRs and symptom scores are commonly recorded at 2-minute intervals during exercise. A recently published article in 2021 assessed athletes’ response to dynamic activities and they used a criteria of symptom[s] considered provoked by either of 2 metrics: (1) if a symptom that was not present before exercise developed during the workout or (2) if the severity of a preexisting symptom increased by 3 or more points on the Likert scale.[20](https://sciwheel.com/work/citation?ids=11918845&pre=&suf=&sa=0&dbf=0) This article evaluating the difference between passing the Buffalo Concussion treadmill test and Gapski-Goodman Test (GGT) or modified GGT (mGGT). The GGT has been used as a final RTP test at the professional sport level for more than 5 years. The GGT is stopped and deemed a fail at the first sign or report of any symptoms. Test completion without symptom onset is deemed a pass. I will discuss the details of this protocol later in the presentation.
* Slide 23
	+ High-quality cohort study demonstrated that concussion may affect postural control during gait as far as 2 months post injury and that a dual-task assessment may help capture these deficits. Evidence shows response times and postural control deficits are greater and gait strategies are less efficient under divided-attention tasks among individuals who have experienced a concussion. After a concussive event motor function/dysfunction may be present including impairments in static and dynamic balance, dual-task, multitasking gait activities, and motor coordination with complex movement tasks. When performing these activities they may or may not correlate with symptom reports. Several studies indicate that examination techniques most sensitive for detecting concussion-related motor function impairments may necessitate special equipment (eg, force plates or accelerometers) and/or advanced analyses (eg, entropy analyses or complexity metric analyses), thus limiting clinical relevance and practicality. It Is worth noting that the CPGs stated there is poor to no quality evidence to support evaluation of these components.[1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)
	+ **Postural control:** Static and dynamic balance in patients with concussion is commonly assessed via Clinical Test of Sensory Organization and Balance (CTSIB), the Sensory Organization Test (SOT), the Balance Error Scoring System (BESS), and the Romberg test. The BESS is well documented in its ability to evaluate balance problems immediately after a concussion. However, it lacks the ability to detect balance problems after the third day of recovery. Further investigation is needed to establish the use of the CTSIB, SOT, Romberg test.[21](https://sciwheel.com/work/citation?ids=4484710&pre=&suf=&sa=0&dbf=0) When reviewing research there is low quality to randomized control trails for this domain and BESS is commonly used. However, BESS has a low sensitivity which indicates we cannot confidently rule it out. The SOT will benefit clinicians most because we can use its norms to compare patients to and see if they’re handling the conditions appropriately.[22,23](https://sciwheel.com/work/citation?ids=7105550,6003320&pre=&pre=&suf=&suf=&sa=0,0&dbf=0&dbf=0)
	+ **Reaction Time (RT**)[24](https://sciwheel.com/work/citation?ids=11918576&pre=&suf=&sa=0&dbf=0): Athletes must respond quickly to a ball or another athlete’s movement to successfully compete while avoiding injury. Another applicable situation for reaction time is if automobile drivers who must step on a brake pedal in reaction to collision avoidance. Thus, RT is fundamental to numerous activities across populations and is considered a critical post-concussion outcome. A 2020 systematic review found that significant medium-magnitude RT deficits were observed acutely for between- and within-subject effect models. RT deficits were present at the sub-acute and intermediate-term timeframes for between-subject effects. No significant RT mean effect was observed for the between-subject model at the long-term timeframe, indicating RT recovery among concussed participants relative to controls. RT deficits persisted up till the intermediate-term 21–59 days post-injury.
	+ \*\*\*Not added to PowerPoint, but kept for my own notes\*\*\* Hoefheinz et al[25](https://sciwheel.com/work/citation?ids=4671263&pre=&suf=&sa=0&dbf=0) determined, in the stroke population, that RT can be simplistically assessed via grasping a falling measuring stick instead of using expensive, laboratory equipment. They assessed athletes at baseline and within 48 h of injury. There was a statistically significant difference between concussed athletes and their control counterparts (p<0.001): there was also significant prolongation from baseline to postinjury in the concussed group (p=0.003). Sensitivity and specificity were maximized when a critical change value of 0 ms was applied (ie, any increase in RT clinical from baseline was interpreted as abnormal), which corresponded to a sensitivity of 75%, specificity of 68% and a 65% reliable change confidence level.
		- The set-up utilizes an 80 cm rigid measuring stick coated in friction tape with a weighted rubber disk affixed to one end. Athletes sat with their dominant forearm resting on a table and their hand positioned over the table edge. The hand was open surrounding, but without touching, the weighted disk portion of the RT clinical apparatus. The examiner suspended the device vertically such that the top face of the disk was aligned in a plane defined by the top of the athlete’s open hand. After pre-determined randomly assigned delays ranging from 2 to 5 seconds to prevent the athlete from anticipating a drop, the examiner released the apparatus and the athlete caught it as quickly as possible by hand closure. For each trial, a RTclinical value (in ms) was calculated from the distance (in cm) that the device fell using the formula for a body falling under the influence of gravity (d = ½ gt2). After 2 practice trials, each athlete completed 8 data acquisition trials and a mean RT clinical value was calculated for the test session.
		- I think we can take the application of this test and make it more clinically useful, but still having the weighted dowel drop and measuring the distance at which it’s caught. Are there more functional reaction time tasks that can be integrated into what you do in therapy that don’t require this sort of set up? Consider BITS systems that are also in many clinics to work on reaction time during therapy.
	+ **Dual Tasking** can either be a dual task training with a cognitive dual task or dual task training with a manual dual task[25](https://sciwheel.com/work/citation?ids=4671263&pre=&suf=&sa=0&dbf=0)
	+ In performance among children and adolescents with concussion and healthy controls with a demographics of n = 23; age = 14.1 ± 2.5 years; 52% female. Slower dual-task TUG and tandem gait times were detected across both time points (~6 days post injury and ~25 days post injury) for the concussion group relative to the control group.[26](https://sciwheel.com/work/citation?ids=6650495&pre=&suf=&sa=0&dbf=0) Understanding this was a small sample size, it’s important to take this article more for clinical utility rather than strong evidence based practice technique. However, this is an objective strategy to access a patient’s multi-tasking abilities.
* Slide 24
	+ **Cervical Spine instability:** address symptoms of heaviness and difficulty to sustain neck posture. Additionally, it’s important to screen for instability since this is a red flag and would require a referral before continuing with PT. However, sometimes we will get referrals for cervical spine instability and we should treat these patients with strength training in isometric conditions initially.
	+ **Assessment of DNF muscle performance** is important given the association between DNF muscle torque, endurance deficits, and patient complaints of head/neck pain. Harris et al[27](https://sciwheel.com/work/citation?ids=6054359&pre=&suf=&sa=0&dbf=0) accessed that psychometric properties for a group without neck pain which found the intrarater reliability to be good to excellent ( [ICC(3,1)]=.82-.91), and interrater reliability to be moderate to good (ICC[2,1]=.67-.78). The associated standard error of measurement (SEM) ranged from 8.0 to 11.0 seconds and from 12.6 to 15.3 seconds for intrarater and interrater, respectively. For the group with neck pain, interrater reliability was moderate (ICC[2,1]=.67, SEM=11.5).[27](https://sciwheel.com/work/citation?ids=6054359&pre=&suf=&sa=0&dbf=0) Based on the SEM, it doesn’t give me full confidence in this test but it can provide vital formation about DNF compensations, general endurance abilities, and another objective way to track progress.
* Slide 25
	+ The Dizziness Handicap Inventory (DHI)[28](https://sciwheel.com/work/citation?ids=11841390&pre=&suf=&sa=0&dbf=0) assesses the impact of dizziness on functional, emotional, and physical quality of life with excellent reliability and internal consistency.
	+ The Activities-specific Balance Confidence (ABC)[28](https://sciwheel.com/work/citation?ids=11841390&pre=&suf=&sa=0&dbf=0) scale assesses individual sense of balance and correlates with cognitive measures after concussion
	+ Post-Concussion Symptom Scale (PCSS)[28](https://sciwheel.com/work/citation?ids=11841390&pre=&suf=&sa=0&dbf=0) assesses general post-concussion symptoms with specific symptom indices for associated sequelae including headache, with variable reliability for the different indices.
	+ Patient Specific Functional Scale (PSFS)[29,30](https://sciwheel.com/work/citation?ids=12730461,12730463&pre=&pre=&suf=&suf=&sa=0,0&dbf=0&dbf=0) is a patient-specific outcome measure, which asks the patients to identify problems in functioning due to a health condition. Therefore, we can focus on a unique set of problems for each patient. It focuses on issues most relevant to the patient and provides information explicitly from the patients’ perspective rather than practitioners dictating the most pertinent issues. It’s also been noted that the PSFS being increasingly used in patients with neurological conditions.
* Slide 26
	+ **Prognosis**
	+ Previous history of concussion 3 or more is statistically significant with increased PCS symptoms for emotional distress and reduced neurocognition functioning.[12](https://sciwheel.com/work/citation?ids=6651204&pre=&suf=&sa=0&dbf=0)
	+ An article published in 2017 performed a longitudinal study that had a sample size of 110 PCS (biased because around 140 were excluded due to exclusion criteria and one of them being <3months of symptoms). However, they found that only 27% of the population eventually recovered with 67% of those 27% who recovered did so within the first year. Notably, no eligible participants recovered from PCS lasting 3 years or longer. Those who did not recover (*n* = 80) were more likely to be non-compliant with a recommendation of do not RTP (*p* = 0.006). Also, they found that the more symptoms reported, the longer the time to recovery (*p* = 7.4 × 10−6), with each additional symptom decreased the recovery rate by approximately 20%.[31](https://sciwheel.com/work/citation?ids=6613221&pre=&suf=&sa=0&dbf=0)
	+ 294 pediatric patients in a case-control study in a published journal of Neurosurgery, the authors found that a previous history of concussion adjusted odds ration (aOR) 3.67, presenting SCAT2 score < 80 aOR 5.58, and female sex aOR 3.48, were all associated with a higher risk for post-concussion symptoms lasting >28 days. For those participants who did not take the SCAT-2, female sex and a history of ADHD significantly increased the odds of prolonged recovery which was an aOR 4.41 and aOR 3.87, respectively. In articles that had patients take the SCAT2 and articles that did not have patients take the SCAT2; they determined that concussions resulting from playing a nonhelmet sport were also associated with a higher risk for extended symptoms in patients which the OR was 2.59 and 2.17, respectively. Other considerations for prognosis to consider is that amnesia, balance abnormalities, and a history of migraines were not associated with symptoms lasting > 28 days.[32](https://sciwheel.com/work/citation?ids=4415073&pre=&suf=&sa=0&dbf=0)
	+ **Exertional Testing:** Evaluation of exercise tolerance testing for adolescents within 1 week of sports-related concussion did not affect recovery, and that the extent of early exercise intolerance may be strongly associated with prolonged recovery time.[1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)
	+ **Multi-modal approach:** Individuals receiving a cervical and vestibular intervention approach were nearly 4x more likely to be medically cleared for RTP by 8 weeks than those in the control group (only cervical interventions). We want to work on habituation exercise for vestibular interventions to improve their tolerance to stimulus.[1](https://sciwheel.com/work/citation?ids=8754195&pre=&suf=&sa=0&dbf=0)
* Slide 27
* Slide 28
	+ Understanding which tissues are irritable and causing symptoms are important for rehab. If we can address these complaints of pain and discomfort via manual techniques, then here are a few different strategies. Reducing musculoskeletal limitation was an important early goal via manual therapy and other strategies.[10,28](https://sciwheel.com/work/citation?ids=11841390,7719348&pre=&pre=&suf=&suf=&sa=0,0&dbf=0&dbf=0) Also, reducing pain via manual different strategies. Those presenting with signs and symptoms with chronic neck pain or cervicogenic headaches can benefit from manual strategies.[33](https://sciwheel.com/work/citation?ids=4813007&pre=&suf=&sa=0&dbf=0) However, manual therapy needs to be an adjunct with other exercises and vision interventions. Massage/Soft tissue mobilization to relax musculature, bring blood flow, and warm tissues. Trigger point release can help reduce radiating pain. PAIVMs can help with accessory movements of the vertebrae to help with facet dysfunction and improve ROM. FDN is becoming more prominent in our field and if you have this certification, then it can be another strategy. Stretching can be used for temporary relief and relaxation purposes. Proprioceptive Neuromuscular Facilitation such as contract-relax or muscle energy techniques can help retrain the nervous system and musculature to relax, gain length if it’s short, or other various mechanisms. Lastly, since patients may have a high level of movement response irritability[10](https://sciwheel.com/work/citation?ids=7719348&pre=&suf=&sa=0&dbf=0), introducing manual resisted contractions either isometrically or through motion to grade the proper resistance to increase muscle activation without increasing symptoms too can be a strategy to initiate resistance training and reduce the burden of guarding.
	+ Lastly, Argyriou et al [6](https://sciwheel.com/work/citation?ids=11127715&pre=&suf=&sa=0&dbf=0) systematic review focused non-pharmacological interventions for post-traumatic headache (PTH) and their primary outcome measure was changes in headache frequency and severity. These authors noted that neck manipulation should be avoided in patients with neck pain and therapeutic exercise is a viable, effective intervention to PTH.
	+ If you’re providing treatment and it presents migraine in nature or they’re not responding how you would anticipate to manual interventions, then it would be appropriate to refer this patient to their PCP for follow-up.
* Slide 29
	+ **Saccades** should be performed in different planes consisting of horizontal and vertical planes. For treatment ideas, we can change the speed at which they shift their focus from targets--for example we can set a metronome to increase speed. You will want to look for compensations such as the eye moving up or down, as well as increased PCS symptoms. We want to try to get saccades up to a speed ~120bpm.[34](https://sciwheel.com/work/citation?ids=12764171&pre=&suf=&sa=0&dbf=0) Further interventions ideas can be to have a simple background while performing task to checker boards or moving objects. Lastly, we can start them in a seated position, transition to standing, walking, or even lateral walking which we can see in the picture above. It’s important to acknowledge this vision intervention, but the CPG recommends not functioning on saccades alone, rather try to progress towards VOR oriented interventions.
	+ **Convergence**: Convergence is the inability to focus on objects that are close your face. For instance, if someone is having trouble reading or looking at their phone or watching a utensil move towards their mouth, then integrate convergence interventions to help with habituation of this stimulus. For instance, we can teach our patients “pencil push-ups” (PPP) which is the process of holding a pencil midline around 50cms away and focusing on the tip of it; then slowly bringing it slowly until double vision occurred. Then, slowly moving it back until patient is able to focus on tip of pencil and it’s in focus. Then repeating this for a certain amount of time. A study in 2015, Momeni-Moghaddam et al, introduced a pencil-push up for individuals with convergence insufficiency (not PCS), their intervention had a statistical improvement in dysfunction which consisted of perform PPP 3x/day for ~5mins, at 4 and 8 weeks.[35](https://sciwheel.com/work/citation?ids=12767987&pre=&suf=&sa=0&dbf=0) As well as “block string” which is having 3 or more beads on a string and having them focus on different beads to work on convergence insufficiency and other binocular vision abnormalities.[34](https://sciwheel.com/work/citation?ids=12764171&pre=&suf=&sa=0&dbf=0)
* Slide 30
	+ Vestibulo-ocular reflex is a common intervention when working with PCS patients because this complex system can cause dizziness and headache symptoms. Working into symptoms to create habituation is critical[9](https://sciwheel.com/work/citation?ids=6246389&pre=&suf=&sa=0&dbf=0). If their baseline is 1-2/10 headache or dizziness (which ever symptom is more problematic) we want to provoke symptoms a maximum of 3 numbers higher and ideally staying ≤ 5/10. There are many ways to increase the difficult of this intervention consisting of increase VOR requirements from cancelation, to x1, then x2 incorporating more head movement. Adding both x and y axis is also pertinent to functionality because we look across the horizon as well as up and down. Another way to add complexity will be changing from sitting>standing>balance environments to increase input to the brain and vestibular system. Lastly, we can incorporate VOR into dynamic movements such as walking, jogging, or variations in agility movements to make this more “sport-specific/recreationally specific”. Lastly, adding speed with a metronome asking them to change move through the full motion each beat and trying to get to 100-120bpm can drastically increase the difficulty.
	+ As well as increasing complexity of background and/or increase speed of head motion during VOR exercises is supported by Kane et al[9](https://sciwheel.com/work/citation?ids=6246389&pre=&suf=&sa=0&dbf=0) to improve VOR functionality.
* Slide 31
	+ Balance is pertinent to implement into the plan of care because it is commonly impaired and can be a great way to increase difficult of other tasks. Balance overlaps a great deal with other intervention types. Also, it’s a strategic way to make a simple task become a higher-level intervention forcing the patient to tolerate more processing information. However, at it’s most simple, implementation of balance activities can work by improving input to the brain utilizing the 3 most important systems facilitating balance: Vision, Vestibular, and proprioception.
	+ Depending on the severity and irritability, one can consider the static position (sitting) to more dynamic positions (i.e. balance– NBOS, semi-tandem, tandem, SL, etc) to appropriately challenge them and progress the load on the system.[9](https://sciwheel.com/work/citation?ids=6246389&pre=&suf=&sa=0&dbf=0)
	+ We want to make every treatment specific to the patient eg(or ie), what are they having difficult with? What activities do they want to get back to? For example: an elderly patient is having troubles with balance walking from their bed to the bathroom at night. In this scenario we can add a component of eyes closed to simulate darker/reduced vision input to rely more on proprioception and vestibular balance. If it’s an athlete constantly getting contact through shoulders, hips, etc, we can incorporate components of perturbations requiring reactionary balance to make the intervention specific to them. Lastly, if a person likes to hike and is constantly walking over uneven ground, sand, roots, and/or not simply a sidewalk, then adding foam pads as an unstable surface would be specific for them. Be creative and think outside the box to best treat the patient.
* Slide 32
	+ **Multi-tasking** should be utilized as a way to increase brain stimulus, requiring more processing by asking a patient to perform a certain balance, strength, vestibulo-ocular, or exertional exercise while trying to be successful in a cognitive or physical task. As one would expect, this will most likely change the quality, speed, or ability to perform the primary task while they focus more on the secondary task.
	+ **Cognition**
	+ Memory multi-tasking can be for sample asking the patient to name two objects for each letter in your name[4](https://sciwheel.com/work/citation?ids=8165763&pre=&suf=&sa=0&dbf=0); say 3-7 words prior to a task then ask them to recall after task; or say a few numbers (e.g. 1-5-3-6), then ask them to repeat them backwards after performing task( 6-3-5-1).
	+ Categories[4](https://sciwheel.com/work/citation?ids=8165763&pre=&suf=&sa=0&dbf=0) can be incorporated by saying: Cars, and they have to name as many cars as possible while perform 30sec SLS. Fruit, Vegetables, Animals, anything that requires brain processing power while performing another task.
	+ Simple Math tasks such as start from 100, subtract 3 or 7; or easy addition such as 1+3, 3+2, 1+5.[4](https://sciwheel.com/work/citation?ids=8165763&pre=&suf=&sa=0&dbf=0)
	+ **Physical tasks** can be incorporated by having patient catch and throw balls, kicking, or moving an object between hands, and/or around their body. Anything that modifies a task to an appropriate level, but still challenges their system.
	+ Another example of secondary manual tasks can be as simple as carrying a cup of water and asking them not to spill it.[25](https://sciwheel.com/work/citation?ids=4671263&pre=&suf=&sa=0&dbf=0) Make each task relevant to the patient to help them achieve their goals and functional abilities.
* Slide 33
	+ Active rehabilitation with graded progression of sub-symptom aerobic exercise appears to be supported by the literature.[9](https://sciwheel.com/work/citation?ids=6246389&pre=&suf=&sa=0&dbf=0) Initially we want to incorporate what is called “relative rest” which consists of physical and cognitive activities that do not provoke symptoms such as light physical activities, quiet environment with limited stimulation, healthy sleep, and nutrition. Light physical activities consist of walking, stationary cycling at slow to medium pace, but does not include resistance training.[9](https://sciwheel.com/work/citation?ids=6246389&pre=&suf=&sa=0&dbf=0) Again, cerebral blood flow (CBF) is impacted following a concussion, so during physical activities CBF increases possibly causing dizziness and headache symptoms. Also, cardiovascular response is impacted because the sympathetic/parasympathetic nervous system controlling HR has variability.
	+ Schneider et al[36](https://sciwheel.com/work/citation?ids=4504021&pre=&suf=&sa=0&dbf=0) in a systematic Review from 2017 found one eligible RCT that evaluated the effects of strict rest following sport related concussion (SRC) in adolescents and found that they had a 20% reduction in total energy expenditure following injury. Individuals who were randomized to recommendation of strict rest reported higher total symptoms over 10 days and had reduction speed of symptom resolution. Other articles in this systematic review had controversial findings, however, more recent research is leaning towards early integration of exercise rather than strict rest. Thus, we should be reiterating the need for encouraging our PCS patients to keep performing light activities initially. When we are beginning to progress physical activity, we must consider the different metabolic systems such anaerobic and aerobic; and how these impact other systems. Therefore, incorporating general running for aerobic purposes and sprinting/HITT for anaerobic purposes to address the diverse energy processes an athlete or recreational participant may perform makes our rehab more robust.
		- Exercise:  concussed male and female athletes with persistent symptoms lasting between 1 and 12 months were typically introduced to sub-symptom submaximal (light) aerobic exercise multiple times per week. Overall, the systematic review supports the notion that controlled exercise performed at an intensity and duration that does not exacerbate symptoms is likely safe and beneficial for adult athletes with persistent symptoms following concussion. Athletes in the submaximal exercise groups typically reported fewer symptoms, recovered to baseline on cognitive and balance scores more quickly.
	+ A good rule of thumb can be utilized follows the BCTT guidelines for safety which states that the protocol to halt a exertional test should be based on signs of excessive participant stress, including HR >85% of predicted heart rate max, RPE >16, a reported increase >2 on the symptom scale over baseline values or the examiner identifies that testing to be unsafe. It’s also clear to the participants that they could discontinue testing at any time if they deemed it necessary. [Predicted max HR via 220-age].[37](https://sciwheel.com/work/citation?ids=11424790&pre=&suf=&sa=0&dbf=0)
	+ Also, it’s been stated in articles that a new symptom presenting during exercise can count as 1 point towards the >2 symptom scale. When training exertional activity habituation, then increased symptoms is expected which will commonly present as dizziness, headaches, vision changes but others not as common may include fogginess sensation or difficulty concentrating. At max stay around 5-6/10 of symptom severity level.[38](https://sciwheel.com/work/citation?ids=12768936&pre=&suf=&sa=0&dbf=0) When prescribing exercise for HEP (not supervised), then it’s recommended to prescribe around 60-80% subthreshold symptom exacerbation.
* Slide 34[39](https://sciwheel.com/work/citation?ids=6417291&pre=&suf=&sa=0&dbf=0)
	+ A recent RCT from 2019 accessed sub-threshold exercise for SRC. Sports medicine physicians diagnosed concussions at the initial clinic visit. A total of 103 participants (average 15.35 years old) were included with no statistical difference between intervention and control groups. Diagnosis was based on a detailed history (i.e. a cognitive evaluation and concussion symptom questionnaire) a standardized physical examination, and an exercise tolerance assessment with the Buffalo Concussion Treadmill Test (BCTT). The sub-symptom threshold aerobic exercise prescription target HR was initially determined by their first BCTT trail at which symptom exacerbation occurred; then they calculated as 80% of this HR. Participants were instructed to stop their home exercise session if their symptoms increased by ≥2 from their pre-exercise symptom level (on a 10-point visual analog scale) or at 20 minutes of exercise, whichever came first. Each week, they performed the BCTT in the clinic and a new target HR was established as long as the patient remained symptomatic. The control group participants (stretching) were directed to follow a prescribed stretching program and given the same instructions about resting as the aerobic group. They were provided a booklet containing a gentle, whole-body, progressive stretching program (with pictures and instructions) that would not considerably increase the heart rate and to perform stretching for 20minutes per day.
	+ The incidence of participants with delayed recovery (>30 days) was higher in the stretching group n = 7; which took 36-62 day to pass BCTT. The aerobic exercise group n = 2; which took 46-54 days.
	+ There was not a statistical difference (p=0.08), but a tendency for aerobic exercise to also prevent some adolescents from a delayed recovery. Given the burden of social and academic problems during extended periods of recovery in this age group, it’s critical to understand its benefits. The results can give clinicians confidence that moderate levels of physical activity, including prescribed subsymptom threshold aerobic exercise, after the first 48 hours following sport related concussion can safely and considerably increase recovery.
* Slide 35 Transition
* Slide 36
	+ When we are beginning to consider allowing them to go to practice their sport or recreational activities. It’s critical we make sure to provide interventions that are sport-specific and give them confidence to be successful. Always performing activities in the clinic can be considered sterile, it’s well controlled. Having a few treatments or portions of treatments outside to mimic their sport-specific environments can gradually adapt them to the “real world” environments. E.g. having a patient that wears clients come to the clinic with them and go outside to perform plyometrics and agility outside. Or having a basketball player bring their shoes to do activities outside on a “court” with unexpected stimulus. Not only does their get closer to the environments they will be put in, but it helps build confidence towards optimal performance in their sport.
* Slide 37[40](https://sciwheel.com/work/citation?ids=6133967&pre=&suf=&sa=0&dbf=0)
	+ Marshall et al found that the Buffalo Concussion Treadmill/Bicycling test does not challenge athletes enough for a proper clearance for RTP. Therefore, we must increase our requirements for medical clearance. The BCTT is “performed in a single linear direction with increasing difficulty provided through a gradual increase in incline which challenges an athletes’ aerobic system in a mostly steady state.” The Therefore, we’re not challenging the vestibular, oculomotor, and physiological systems enough the mimic athletes real world scenarios because they perform not only aerobic exercise, but anaerobic exercise. Furthermore, they perform in multi-planar directions and typical have some type of contact or high-risk component to it. The Gapski-Goodman Test (GGT), is a standardized physical exertion test that seems to challenge an athlete enough to determine if they have achieved full recovery from autonomic and cerebrovascular dysfunction following their concussion. It combines alternating aerobic and anaerobic states in addition to sport-based vestibular and visual challenges designed to mimic a dynamic sporting atmosphere. All 759 participants of this study were medically cleared by a physician and must have been asymptomatic through cognitive activity, return to school, the BCTT, and at least two sport- specific non-contact practices of increasing intensity. Also, all athletes in the study had maintained a symptom-free status for at least 7 days prior to attempting the GGT. 14.6% of all participants failed the test on the first attempt and 88.3% of all participants performed the GGT over the mGGT. Based on the Chi-square test analysis, no participants characteristics specifically were associated with pass/fail besides anxiety (p=0.029). Independent samples on a T-test, revealed a significant difference in mean initial symptom severity scores between those who passed **(27.12**, SD = 20.44) and those who failed (**32.16**, SD = 23.43) on their first GGT/ mGGT attempt (**p =0.021**).
	+ The first component of the GGT incorporates stationary cycling including gradual hill- climbs and high-intensity intervals. The second component involves plyometric activities including lateral hurdle jumps, burpees, lateral box jumps, and jumping 180-degree rotations.
	+ With all that being said, it’s critical to know your patient and their goals and the demands required on their bodies based on these goals. If a patient simply just wants to get back to walking without symptoms, then a BCTT may be appropriate. If you’re working with an athlete, then we need to challenge them more to reduce the likelihood of getting symptoms at higher play and increase their confidence while playing smart, then the GGT/mGGT is more vigorous to test their function.
* Slide 38
	+ There are 2 phases of this test:
	+ First phase consists of both performing the stationary bicycle going from low RPM pedaling to high-tension, high RPM sprint.
	+ Second phase consists of the plyometric components:
		- 1) Plyometric hops. GGT performs POGO (two foot jumping) over an 8in hurdle as you can see noted as Image C. While mGGT will perform as a single hop over 8in hurdles as noted in image D&E.
		- 2) Burpees. GGT performs burpees with full push-ups as seen in image F and G. While mGGT isn’t required to perform push-up.
		- 3) Lateral Hop/Step overs. GGT performs two foot hop overs a seen in image I. mGGT performs lateral step overs as seen in image H & J
		- 4) 180˚ Jumps. Both groups perform these plyometric skills. As seen in image K&L.

[Bibliography](https://sciwheel.com/work/bibliography)

[1.    Quatman-Yates CC, Hunter-Giordano A, Shimamura KK, et al. Physical therapy evaluation and treatment after concussion/mild traumatic brain injury. *J Orthop Sports Phys Ther*. 2020;50(4):CPG1-CPG73. doi:10.2519/jospt.2020.0301](https://sciwheel.com/work/bibliography/8754195)

[2.    Gil C, Decq P. How similar are whiplash and mild traumatic brain injury? A systematic review. *Neurochirurgie*. 2021;67(3):238-243. doi:10.1016/j.neuchi.2021.01.016](https://sciwheel.com/work/bibliography/11784489)

[3.    Leddy JJ, Sandhu H, Sodhi V, Baker JG, Willer B. Rehabilitation of Concussion and Post-concussion Syndrome. *Sports Health*. 2012;4(2):147-154. doi:10.1177/1941738111433673](https://sciwheel.com/work/bibliography/4209568)

[4.    Register-Mihalik JK, Guskiewicz KM, Marshall SW, et al. Methodology and Implementation of a Randomized Controlled Trial (RCT) for Early Post-concussion Rehabilitation: The Active Rehab Study. *Front Neurol*. 2019;10:1176. doi:10.3389/fneur.2019.01176](https://sciwheel.com/work/bibliography/8165763)

[5.    Dwyer B, Zasler N. Post-traumatic cephalalgia. *NeuroRehabilitation*. 2020;47(3):327-342. doi:10.3233/NRE-208006](https://sciwheel.com/work/bibliography/10918766)

[6.    Argyriou AA, Mitsikostas D-D, Mantovani E, Litsardopoulos P, Panagiotopoulos V, Tamburin S. An updated brief overview on post-traumatic headache and a systematic review of the non-pharmacological interventions for its management. *Expert Rev Neurother*. 2021;21(4):475-490. doi:10.1080/14737175.2021.1900734](https://sciwheel.com/work/bibliography/11127715)

[7.    Formisano R, Bivona U, Catani S, D’Ippolito M, Buzzi MG. Post-traumatic headache: facts and doubts. *J Headache Pain*. 2009;10(3):145-152. doi:10.1007/s10194-009-0108-4](https://sciwheel.com/work/bibliography/2349712)

[8.    Tessler J, Horn LJ. Post-Traumatic Headache. In: *StatPearls*. StatPearls Publishing; 2022.](https://sciwheel.com/work/bibliography/9979370)

[9.    Kane AW, Diaz DS, Moore C. Physical Therapy Management of Adults with Mild Traumatic Brain Injury. *Semin Speech Lang*. 2019;40(1):36-47. doi:10.1055/s-0038-1676652](https://sciwheel.com/work/bibliography/6246389)

[10.   Alsalaheen B, Landel R, Hunter-Giordano A, et al. A Treatment-Based Profiling Model for Physical Therapy Management of Patients Following a Concussive Event. *J Orthop Sports Phys Ther*. 2019;49(11):829-841. doi:10.2519/jospt.2019.8869](https://sciwheel.com/work/bibliography/7719348)

[11.   Davies SC, Bernstein ER, Daprano CM. A Qualitative Inquiry of Social and Emotional Support for Students with Persistent Concussion Symptoms. *Journal of Educational and Psychological Consultation*. Published online August 12, 2019:1-27. doi:10.1080/10474412.2019.1649598](https://sciwheel.com/work/bibliography/8409859)

[12.   Spira JL, Lathan CE, Bleiberg J, Tsao JW. The impact of multiple concussions on emotional distress, post-concussive symptoms, and neurocognitive functioning in active duty United States marines independent of combat exposure or emotional distress. *J Neurotrauma*. 2014;31(22):1823-1834. doi:10.1089/neu.2014.3363](https://sciwheel.com/work/bibliography/6651204)

[13.   Ponsford JL, Sinclair KL. Sleep and fatigue following traumatic brain injury. *Psychiatr Clin North Am*. 2014;37(1):77-89. doi:10.1016/j.psc.2013.10.001](https://sciwheel.com/work/bibliography/12058318)

[14.   Sisto SA, Druin E, Sliwinski MM. *Spinal Cord Injuries: Management and Rehabilitation*. Mosby Elsevier; 2009.](https://sciwheel.com/work/bibliography/10450724)

[15.   Cranio‐cervical Flexion Test - Physiopedia. Accessed April 25, 2022. https://www.physio-pedia.com/Cranio%E2%80%90cervical\_Flexion\_Test](https://sciwheel.com/work/bibliography/12881641)

[16.   Cervical Flexion-Rotation Test - Physiopedia. Accessed April 25, 2022. https://www.physio-pedia.com/Cervical\_Flexion-Rotation\_Test?utm\_source=physiopedia&utm\_medium=search&utm\_campaign=ongoing\_internal](https://sciwheel.com/work/bibliography/12881639)

[17.   Treleaven J, Jull G, LowChoy N. Smooth pursuit neck torsion test in whiplash-associated disorders: relationship to self-reports of neck pain and disability, dizziness and anxiety. *J Rehabil Med*. 2005;37(4):219-223. doi:10.1080/16501970410024299](https://sciwheel.com/work/bibliography/5143016)

[18.   Tjell C, Rosenhall U. Smooth Pursuit Neck Torsion Test: A Specific Test for Cervical Dizziness. *American Journal of Otology*. 1998;19(1):76-81.](https://sciwheel.com/work/bibliography/12694408)

[19.   Treleaven J, Joloud V, Nevo Y, Radcliffe C, Ryder M. Normative Responses to Clinical Tests for Cervicogenic Dizziness: Clinical Cervical Torsion Test and Head-Neck Differentiation Test. *Phys Ther*. 2020;100(1):192-200. doi:10.1093/ptj/pzz143](https://sciwheel.com/work/bibliography/12694442)

[20.   Popovich M, Sas A, Almeida AA, et al. Symptom Provocation During Aerobic and Dynamic Supervised Exercise Challenges in Adolescents With Sport-Related Concussion. *J Athl Train*. Published online January 11, 2021. doi:10.4085/1062-6050-0072.20](https://sciwheel.com/work/bibliography/11918845)

[21.   Murray N, Salvatore A, Powell D, Reed-Jones R. Reliability and validity evidence of multiple balance assessments in athletes with a concussion. *J Athl Train*. 2014;49(4):540-549. doi:10.4085/1062-6050-49.3.32](https://sciwheel.com/work/bibliography/4484710)

[22.   Christy JB, Cochrane GD, Almutairi A, Busettini C, Swanson MW, Weise KK. Peripheral vestibular and balance function in athletes with and without concussion. *J Neurol Phys Ther*. 2019;43(3):153-159. doi:10.1097/NPT.0000000000000280](https://sciwheel.com/work/bibliography/7105550)

[23.   Ruhe A, Fejer R, Gänsslen A, Klein W. Assessing postural stability in the concussed athlete: what to do, what to expect, and when. *Sports Health*. 2014;6(5):427-433. doi:10.1177/1941738114541238](https://sciwheel.com/work/bibliography/6003320)

[24.   Lempke LB, Howell DR, Eckner JT, Lynall RC. Examination of Reaction Time Deficits Following Concussion: A Systematic Review and Meta-analysis. *Sports Med*. 2020;50(7):1341-1359. doi:10.1007/s40279-020-01281-0](https://sciwheel.com/work/bibliography/11918576)

[25.   Hofheinz M, Mibs M, Elsner B. Dual task training for improving balance and gait in people with stroke. *Cochrane Database Syst Rev*. Published online October 18, 2016. doi:10.1002/14651858.CD012403](https://sciwheel.com/work/bibliography/4671263)

[26.   Howell DR, Wilson JC, Brilliant AN, Gardner AJ, Iverson GL, Meehan WP. Objective clinical tests of dual-task dynamic postural control in youth athletes with concussion. *J Sci Med Sport*. 2019;22(5):521-525. doi:10.1016/j.jsams.2018.11.014](https://sciwheel.com/work/bibliography/6650495)

[27.   Harris KD, Heer DM, Roy TC, Santos DM, Whitman JM, Wainner RS. Reliability of a measurement of neck flexor muscle endurance. *Phys Ther*. 2005;85(12):1349-1355. doi:10.1093/ptj/85.12.1349](https://sciwheel.com/work/bibliography/6054359)

[28.   Wong CK, Ziaks L, Vargas S, DeMattos T, Brown C. Sequencing and Integration of Cervical Manual Therapy and Vestibulo-oculomotor Therapy for Concussion Symptoms: Retrospective Analysis. *Int J Sports Phys Ther*. 2021;16(1):12-20. doi:10.26603/001c.18825](https://sciwheel.com/work/bibliography/11841390)

[29.   Weightman M, Radomski M, Mashima P, Roth C. Mild Traumatic Brain Injury Concussion Rehabilitation Toolkit (US Military) . *Borden Institute- US Army Medical Department Center and School*. Published online December 2014.](https://sciwheel.com/work/bibliography/12730461)

[30.   Storløs B, Roaldsen KS, Soberg HL, Kleffelgaard I. Patient-specific functioning related to dizziness and balance problems after traumatic brain injury – A cross sectional study using an ICF perspective. *Cogent Medicine*. 2021;8(1). doi:10.1080/2331205X.2021.1932247](https://sciwheel.com/work/bibliography/12730463)

[31.   Hiploylee C, Dufort PA, Davis HS, et al. Longitudinal study of postconcussion syndrome: not everyone recovers. *J Neurotrauma*. 2017;34(8):1511-1523. doi:10.1089/neu.2016.4677](https://sciwheel.com/work/bibliography/6613221)

[32.   Miller JH, Gill C, Kuhn EN, et al. Predictors of delayed recovery following pediatric sports-related concussion: a case-control study. *J Neurosurg Pediatr*. 2016;17(4):491-496. doi:10.3171/2015.8.PEDS14332](https://sciwheel.com/work/bibliography/4415073)

[33.   Varatharajan S, Ferguson B, Chrobak K, et al. Are non-invasive interventions effective for the management of headaches associated with neck pain? An update of the Bone and Joint Decade Task Force on Neck Pain and Its Associated Disorders by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. *Eur Spine J*. 2016;25(7):1971-1999. doi:10.1007/s00586-016-4376-9](https://sciwheel.com/work/bibliography/4813007)

[34.   Concussion/mTBI Lab  –    Vision Assessment and  Treatment . *Canadian Physiotherapy Association*. Published online 2018.](https://sciwheel.com/work/bibliography/12764171)

[35.   Momeni-Moghaddam H, Kundart J, Azimi A, Hassanyani F. The effectiveness of home-based pencil push-up therapy versus office-based therapy for the treatment of symptomatic convergence insufficiency in young adults. *Middle East Afr J Ophthalmol*. 2015;22(1):97-102. doi:10.4103/0974-9233.148357](https://sciwheel.com/work/bibliography/12767987)

[36.   Schneider KJ, Leddy JJ, Guskiewicz KM, et al. Rest and treatment/rehabilitation following sport-related concussion: a systematic review. *Br J Sports Med*. 2017;51(12):930-934. doi:10.1136/bjsports-2016-097475](https://sciwheel.com/work/bibliography/4504021)

[37.   Prim JH, Davila MI, McCulloch KL. A pilot study on exertional tasks with physiological measures designed for the assessment of military concussion. *Concussion*. 2021;6(1):CNC88. doi:10.2217/cnc-2020-0018](https://sciwheel.com/work/bibliography/11424790)

[38.   McCulloch K. Challenging at just the right level: Sports concussion. PowerPoint presented at the: UNC-CH DPT, PHYT 874; 2022.](https://sciwheel.com/work/bibliography/12768936)

[39.   Leddy JJ, Haider MN, Ellis MJ, et al. Early Subthreshold Aerobic Exercise for Sport-Related Concussion: A Randomized Clinical Trial. *JAMA Pediatr*. 2019;173(4):319-325. doi:10.1001/jamapediatrics.2018.4397](https://sciwheel.com/work/bibliography/6417291)

[40.   Marshall CM, Chan N, Tran P, DeMatteo C. The use of an intensive physical exertion test as a final return to play measure in concussed athletes: a prospective cohort. *Phys Sportsmed*. 2019;47(2):158-166. doi:10.1080/00913847.2018.1542258](https://sciwheel.com/work/bibliography/6133967)

[41.   Hutting N, Scholten-Peeters GGM, Vijverman V, Keesenberg MDM, Verhagen AP. Diagnostic accuracy of upper cervical spine instability tests: a systematic review. *Phys Ther*. 2013;93(12):1686-1695. doi:10.2522/ptj.20130186](https://sciwheel.com/work/bibliography/603915)

[42.   Domenech MA, Sizer PS, Dedrick GS, McGalliard MK, Brismee J-M. The deep neck flexor endurance test: normative data scores in healthy adults. *PM R*. 2011;3(2):105-110. doi:10.1016/j.pmrj.2010.10.023](https://sciwheel.com/work/bibliography/3391007)