

Addressing potential barriers to implementing an exercise program with concussion

KRISTIN MOORE, PT,DPT

RACHEL COHEN, PT, DPT

Course Objectives



Recognize limitations to BCTT with different patient populations



Identify alternative treatment options for a patient who cannot tolerate standard graduated aerobic exercise



Identify signs and symptoms of orthostatic intolerance



Identify assessment tools to assess for orthostatic intolerance

Aberrant response to BCTT



VESTIBULAR AND
OCULOMOTOR DEFICITS



CERVICOGENIC DIZZINESS



PHYSIOLOGIC/AUTONOMIC
DYSFUNCTION

Vestibular and Oculomotor

Presentation: dizziness, headache, nausea, diplopia, blurred vision, fogginess, unsteady

Objectives: VOMS, BPPV, DVA, head thrust, head shaking nystagmus, FGA, BESS, balance assessment

Treatment/Research:

Vestibular rehab is recommended when deficits are present. Including, static/dynamic balance, VOR, adaptation, habituation, canalith repositioning ^{1,2,3}

Alsalaheen 2010 Retrospective study: Vestibular rehab reduced dizziness improved gait, static/dynamic balance.

Vision therapy:
•Convergence training ^{4,5}
•Ziaks 2019 propose a timeline for vision and vestibular interventions ⁶

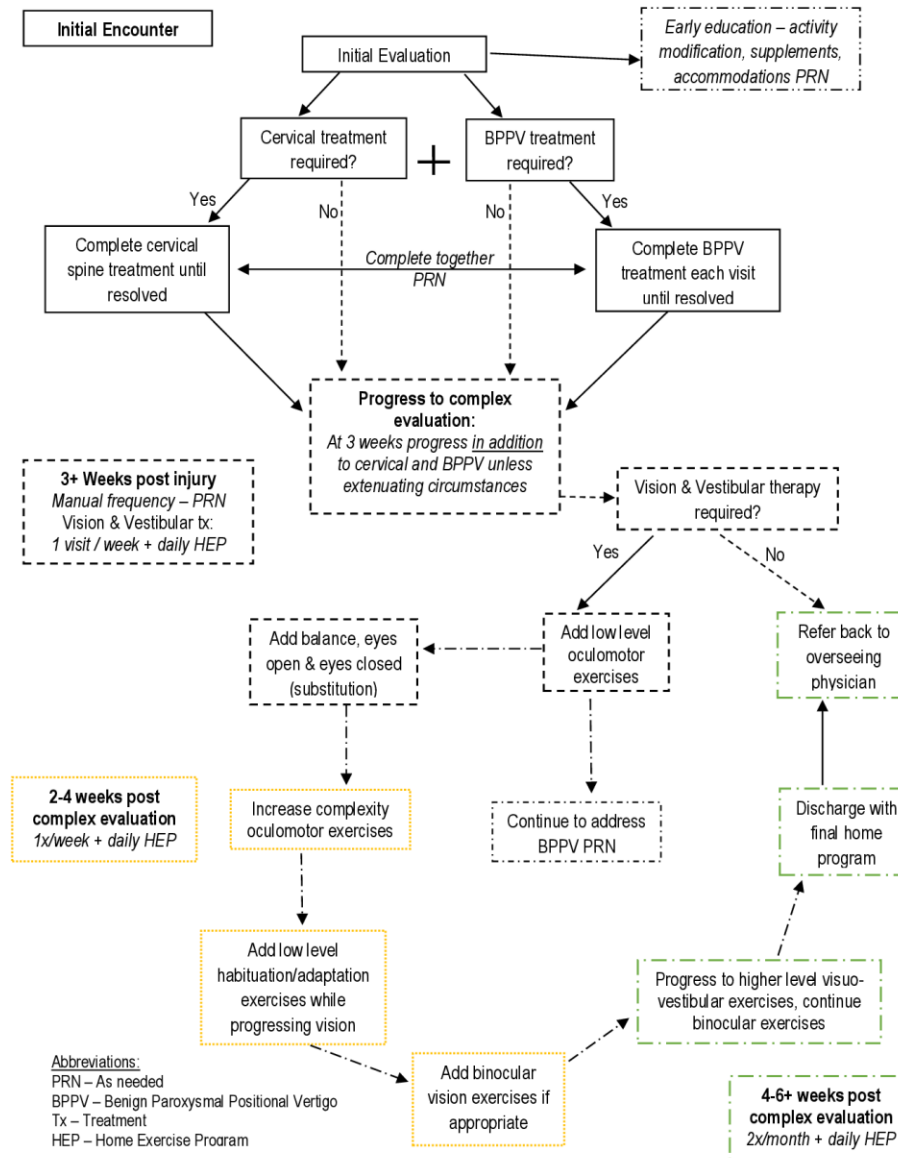


Figure 3. Proposed timeframe for appropriate interventions

Cervicogenic

Presentation: headache, dizziness, blurred vision, neck pain/stiffness, unsteady, fogginess, light headed

Objectives: ROM, flexion-rotation test, joint mobility testing, ligament testing for instability, DNF endurance test, JPE, smooth pursuit neck-torsion test, head-neck differentiation

Treatment/Research:

Manual therapy, cervical stabilization and endurance training, cervicocephalic proprioception training, patient education^{3,11,13}

Kennedy 2019: Prospective case series. 90% of patients found to have neck problems contributing to their concussion symptoms¹¹

Schneider 2014: Combination of vestibular + cervical treatment in SRC were ~4x/more likely to be medically cleared than a control group³

Table I. Summary of pathophysiology, predominant symptoms, pertinent physical examination findings, graded treadmill test results and treatment options in patients with PCDs.

	Physiologic PCD	Vestibulo-ocular PCD	Cerviogenic PCD
Pathophysiology	<ul style="list-style-type: none"> • Persistent alterations in neuronal depolarization, cell membrane permeability, mitochondrial function, cellular metabolism, and cerebral blood flow 	<ul style="list-style-type: none"> • Dysfunction of the vestibular and oculomotor symptoms 	<ul style="list-style-type: none"> • Muscle trauma and inflammation • Dysfunction of cervical spine proprioception
Predominant symptoms	<ul style="list-style-type: none"> • Headache exacerbated by physical and cognitive activity • Nausea, intermittant vomiting, photophobia, phonophobia, dizziness, fatigue, difficulty concentrating, slowed speech 	<ul style="list-style-type: none"> • Dizziness, vertigo, nausea, light-headedness, gait instability and postural instability at rest. • Blurred or double vision, difficulty tracking objects, motion sensitivity, photophobia, eye strain or brow-ache, and headache exacerbated by activities that worsen vestibulo-ocular symptoms (i.e. reading) 	<ul style="list-style-type: none"> • Neck pain, stiffness, and decreased range of motion • Occipital headaches exacerbated by head movements and not physical or cognitive activity • Lightheadedness and postural imbalance
Physical exam findings	<ul style="list-style-type: none"> • No focal neurological findings • Elevated resting HR 	<ul style="list-style-type: none"> • Impairments on standardized balance and gait testing • Impaired VOR, fixation, convergence, horizontal and vertical saccades 	<ul style="list-style-type: none"> • Decreased cervical lordosis and range of motion • Paraspinal and sub-occipital muscle tenderness • Impaired head-neck position sense
Graded treadmill test	<ul style="list-style-type: none"> • Graded treadmill tests are often terminated early due to symptom onset or exacerbation 	<ul style="list-style-type: none"> • Patients typically reach maximal exertion without exacerbation of vestibulo-ocular symptoms on graded treadmill tests 	<ul style="list-style-type: none"> • Patients typically reach maximal exertion without exacerbation of cervicogenic symptoms on graded treadmill tests
Management options	<ul style="list-style-type: none"> • Physical and cognitive rest • School accommodations • Sub-symptom threshold aerobic exercise programs should be considered for adolescent and adult athletes 	<ul style="list-style-type: none"> • Vestibular rehabilitation program • Vision therapy program • School accommodations • Sub-symptom threshold aerobic exercise programs should be considered for adolescent athletes 	<ul style="list-style-type: none"> • Cervical spine manual therapy • Head-neck proprioception re-training • Balance and gaze stabilization exercises • Sub-symptom threshold aerobic exercise programs should be considered for adolescent and adult athletes

Physiological

- ➔ Orthostatic Intolerance
 - ➔ POTS: Postural Orthostatic Tachycardia Syndrome
 - ➔ Miranda 2018: 11.4% of 722 patients¹⁶
 - ➔ Subtypes: Neuropathic, Hypovolemic, Hyperadrenergic

Orthostatic intolerance

How to recognize this

- Subjective reports: dizziness (lightheaded), headache, nausea, reduced mental clarity/brain fog, poor sleep, generalized fatigue- sound familiar?
 - General body pain, heaviness, GI symptoms, poor temperature regulation
- Objective testing:
 - Gold Standard: Head-Up Tilt table test ^{16, 23}
 - Supine for 30 minutes, BP and HR taken
 - Transition to 70deg upright, vitals taken incrementally for 10 minutes
 - POTS: >30bpm increase from supine HR OR >120bpm
 - Clinic assessment: Can perform 10 minute standing test: > 30 bpm HR increase or 40bpm in adolescents
 - Want to differentiate orthostatic hypotension (20mmHg drop systolic or 10 mmHg in diastolic)
 - Resting HR after 10 minutes of supine then standing HR/BP at 3,5,7, and 10 minutes ¹⁶

Patient recommendations

Salt: Please aim for 10 grams of salt per day. In general it is better to consume your salt added to water compared to food. Use any of the following methods: Add liberal sea salt to meals (not ideal) Nuun brand electrolyte replacement (each tablet contains 360mg sodium, 100mg potassium) 2-6 tablets per day. Salt sticks brand electrolyte capsules (215mg sodium, 63mg potassium) 4-8 capsules per day.

Hydration: Finding the 'goldilocks dose' of water can be challenging. Please consume at least 2 liters of water per day, although some POTS patients often feel better at up to 4 liters of water per day. Drinking water quickly rather than sipping can be helpful for some patients

Exercise: Exercise can be one of the most important, but one of the most difficult treatments for POTS. Exercising in water can be helpful because the weight of the water 'pushes' circulation to your muscles and organs. Recumbent exercise is often better tolerated. Take frequent rest breaks putting your legs up a wall if you get dizzy or out of breath. This will help get blood circulation out of your legs and into your chest and head. Starting a program with a physical therapist familiar with POTS specific exercise programs to improve outcomes.

Compression: recommend getting 2 strengths of compression socks: 15-20mmHg and 30-40mmHg. Wear compression socks during all times of activity, especially standing for longer periods of time. Some patients benefit from wearing compression full time. Some patients benefit from wearing compression leggings, abdominal binder.

Digestive support: If you have significant digestive symptoms the following things can be helpful: Eat meals slowly in a low stress environment. Avoid drinking liquids during your meal, a small amount is ok. Use of digestive enzymes (Ginger, Iberogast).

Treatment

- CHOP Protocol
 - HR training zone calculation¹⁶
 - Heart Rate Reserve (HRR)= Max HR (220-age)-RHR
 - Maximal Steady State (MSS)=75% HRR +RHR
 - Base Pace: 75-85% MSS
 - Recovery Zone: <Base Pace
 - ~8 Month Protocol²⁷
 - Month 1-3: Horizontal or seated training
 - Month 4: Upright bike
 - Month 5: Upright exercise (Elliptical, Treadmill)
 - Month 6-8: Upright high intensity training

Month 1

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Training Mode 1 5-10 min Warm Up 3 min Base Pace 2 min recovery 3 min Base Pace 5-10 min Cool down	Strength Training	Training Mode 1 5-10 min Warm Up 3 min Base Pace 2 min recovery 3 min Base Pace 5-10 min Cool down	Strength Training	Training Mode 1 5-10 min Warm Up 3 min Base Pace 2 min recovery 3 min Base Pace 5-10 min Cool down	
	Training Mode 1 5-10 min Warm Up 4 min Base Pace 3 min recovery 4 min Base Pace 5-10 min Cool Down	Strength Training	Training Mode 1 5-10 min Warm Up 4 min Base Pace 3 min recovery 4 min Base Pace 5-10 min Cool Down	Strength Training	Training Mode 1 5-10 min Warm Up 4 min Base Pace 3 min recovery 4 min Base Pace 5-10 min Cool Down	
	Training Mode 1 5-10 min Warm Up 5 min Base Pace 3 min recovery 5 min Base Pace 5-10 min Cool Down	Strength Training	Training Mode 1 5-10 min Warm Up 5 min Base Pace 3 min recovery 5 min Base Pace 5-10 min Cool Down	Strength Training	Training Mode 1 5-10 min Warm Up 5 min Base Pace 3 min recovery 5 min Base Pace 5-10 min Cool Down	
	Training Mode 1 5-10 min warm Up 6 min Base Pace 3 min recovery 5 min Base Pace 5-10 min Cool Down	Strength Training	Training Mode 1 5-10 min Warm Up 7 min Base Pace 3 min recovery 5 min Base Pace 5-10 min Cool Down	Strength Training	Training Mode 1 5-10 min Warm Up 7 min Base Pace 3 min recovery 5 min Base Pace 5-10 min Cool Down	

Training Mode 1 = any of supine cycling, recumbent bike, swimming laps with a kick board, rowing, seated stepper

Recovery = slow down, reduce resistance, get a drink, but don't stop moving.

Warm ups and cool downs are done starting very slowly with little or no resistance and leading up to and out of your Base Pace HR zone

Physical therapist can begin with supine cycling only if a patient is beginning program as wheel-chair bound/bedridden.

Weight training can be done on the same days as cardio workouts if necessary.

Month 4

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Training Mode 1 10 min Warm Up 30 min Base Pace 10 min Cool Down	Strength Training	Training Mode 2 10 min Warm Up 20 min Base Pace 10 min Cool Down	Strength Training	Training Mode 2 10 min Warm Up 20 min Base Pace 10 min Cool Down	
Training Mode 1 or 2 10 min Warm Up 30 min Base Pace 10 min Cool Down	Strength Training	Training Mode 2 10 min Warm Up 30 min Base Pace 10 min Cool Down	Strength Training	Training Mode 1 or 2 10 min Warm Up 25 min MSS 10 min Cool Down	Training Mode 1 40 min recovery	
Training Mode 1 or 2 10 min Warm Up 40 min Base Pace 10 min Cool Down	Strength Training		Training Mode 1 or 2 10 min Warm Up 30 min MSS 10 min Cool Down	Training Mode 1 40 min recovery	Strength Training	Training Mode 1 or 2 10 min Warm Up 35 min Base Pace 10 min Cool Down
	Strength Training	Training Mode 1 or 2 10 min Warm Up 35 min MSS 10 min Cool Down	Training Mode 1 40 min recovery	Training Mode 2 or 3 10 min Warm Up 30 min Base Pace 10 min Cool Down	Strength Training	Training Mode 1-2 10 min Warm Up 40 min Base Pace 10 min Cool Down

Training Mode 1 = any of Recumbent Biking, Swimming, Rowing

Training Mode 2 = upright bike

Training Mode 3 = Treadmill walking (flat grade), Elliptical (stationary arms)

Training mode 4 = Treadmill walking (incline), Elliptical (with use of arms). Can progress to jogging if able.

Weight Training can be done on same days as Cardio workouts if necessary.

Month 5

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Training Mode 2 or 3 10 min Warm Up 35 min Base Pace 10 min Cool Down	Strength Training	Training Mode 2 or 3 10 min Warm Up 35 min Base Pace 10 min Cool Down	Strength Training	Training Mode 2 or 3 10 min Warm Up 35 min Base Pace 10 min Cool Down	
	Training Mode 2 or 3 10 min Warm Up 40 min Base Pace 10 min Cool Down	Strength Training	Training Mode 3 10 min Warm Up 3 min MSS 10 min Cool Down	Training Mode 2 or 3 40 min recovery Strength Training	Training Mode 2 or 3 10 min Warm Up 35 min Base Pace 10 min Cool Down	
	Training Mode 2-3 10 min Warm Up 60 min Base Pace 10 min Cool Down	Strength Training	Training Mode 2 or 3 10 min Warm Up 3 min Base Pace 10 min Cool Down	Training Mode 3 10 min Warm Up 35 min MSS 10 min Cool Down	Training Mode 2 or 3 25 min recovery Strength Training	Training Mode 2 or 3 10 min Warm Up 50 min Base Pace 10 min Cool Down
	Training Mode 3 10 min Warm Up 35 min Base Pace 10 min Cool Down	Strength Training	Training Mode 2 or 3 10 min Warm Up 45 min Base Pace 10 min Cool Down	Training Mode 3 10 min Warm Up 40 min MSS 10 min Cool Down	Training Mode 2 or 3 25 min recovery Strength Training	

Training Mode 2 = upright bike

Training Mode 3 = Treadmill walking (flat grade), Elliptical (stationary arms)

Training mode 4 = Treadmill walking (incline), Elliptical (with use of arms).

Weight Training can be done on same days as Cardio workouts if necessary.

Weight training can be done on same days as Cardio workouts if necessary

Month 8

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Strength Training	10 min Warm Up 45 min Base Pace 10 min Cool Down	10 min Warm Up 45 min Base Pace 10 min Cool Down	10 min Warm Up 45 min Base Pace 10 min Cool Down	Strength Training	10 min Warm Up 40 min MSS 10 min cool Down	
10 min Warm Up 60 min Base Pace 10 min Cool Down	Strength Training	10 min Warm Up 45 min Base Pace 10 min Cool Down	10 min Warm Up 45 min MSS 10 min Cool Down	10 min Warm Up 45 min Base Pace 10 min Cool Down	Strength Training	10 min Warm Up 7x2 min Intervals 10 min Cool Down 20 min Recovery
Strength Training	10 min Warm Up 5x3 min Intervals 10 min Cool Down 20 min Recovery	10 min Warm Up 45 min Base Pace 10 min Cool Down	10 min Warm Up 45 min MSS 10 min Cool Down	10 min Warm Up 45 min Base Pace 10 min Cool Down	10 min Warm Up 5x3 min Intervals 10 min Cool Down 20 min Recovery	Strength Training
10 min Warm Up 60 min Base Pace 10 min Cool Down	Weight Training	10 min Warm Up 10x2 min Intervals 10 min Cool Down 20 min recovery	10 min Warm Up 45 min Base Pace 10 min Cool Down	10 min warm Up 45 min MSS 10 min Cool Down	Strength Training	10 min Warm Up 60 min Base Pace 10 min Cool Down
Strength Training	10 min warm Up 45 min MSS 10 min Cool Down	10 min Warm Up 45 min Base Pace 10 min Cool Down	Strength Training	10 min Warm Up 45 min Base Pace 10 min Cool Down	10 min Warm Up 45 min Base Pace 10 min Cool Down	

Training modes are not listed because individuals should continue to progress to upright modes as they can tolerate
 We recommend beginning Interval training on the rower, upright bike or elliptical. Can progress to jogging if able.
 Weight Training can be done on same day as Cardio if necessary

If not responding to aerobics...



Seated bike



Address
cervical spine



Address
Vestibular
deficits



Consider
Occupational
Therapy - vision
therapy



Modify aerobic
program to
CHOP protocol

DISCUSSION: Case Example

Subjective history:

27 year old female. Presents 60 days post SRC- hit with a soccer ball to the side of the head. Unable to return to the game

Initial symptoms: dizziness, blurred vision, headache.

Primary current complaints: difficulty focusing at work as a Real estate agent. Low grade headache all the time worsens with busy environments, loud noises, working on computer. Feels overly tired (naps 1x/day), dizziness/lightheaded when she moves her head and being on her feet for prolonged periods.

Where to start???

References

1. Broglio SP, Collins MW, Williams RM, Mucha A, Kontos AP. Current and emerging rehabilitation for concussion: a review of the evidence. *Clin Sports Med.* 2015; 34:213-231. <https://doi.org/10.1016/j.csm.2014.12.005>
2. Alsalaheen BA, Mucha A, Morris LO, et al. Vestibular rehabilitation for dizziness and balance disorders after concussion. *J Neurol Phys Ther.* 2010;34:87-93. <https://doi.org/10.1097/NPT.0b013e3181dde56>
3. Schneider KJ, Meeuwisse WH, Nettel-Aguirre A, et al. Cervicovestibular rehabilitation in sport-related concussion: a randomised controlled trial. *Br J Sports Med.* 2014;48:1294-1298. <https://doi.org/10.1136/bjsports-2013-093267>
4. Storey EP, Master SR, Lockyer JE, Podolak OE, Grady MF, Master CL. Near point of convergence after concussion in children. *Optom Vis Sci.* 2017;94:96-100. <https://doi.org/10.1097/OPX.0000000000000910>
5. Gallaway M, Scheiman M, Mitchell LG. Vision Therapy for Post-Concussion Vision Disorders. *Optom Vis Sci.* 2017;94(1): 68-73
6. Ziaks L, Giardina R, Kloos A. Integration of Vision and Vestibular Therapy for Vestibulo-Ocular Post-Concussion Disorder – A Case Study. *The Internet Journal of Allied Health Sciences and Practice.* 2019 Jun 28;17(3), Article 11.
7. DuPrey KM, Webner D, Lyons A, Kucuk CH, Ellis JT, Cronholm PF. Convergence insufficiency identifies athletes at risk of prolonged recovery from sport-related concussion. *Am J Sports Med.* 2017; 45: 2388–2393
8. Mucha A, Collins MW, Elbin RJ, et al. A brief Vestibular/Ocular Motor Screening (VOMS) assessment to evaluate concussions: preliminary findings. *Am J Sports Med.* 2014; 42: 2479– 2486.
9. Pearce KL, Sufrinko A, Lau BC, Henry L, Collins MW, Kontos AP. Near point of convergence after a sport-related concussion: measurement reliability and relationship to neurocognitive impairment and symptoms. *Am J Sports Med.* 2015; 43: 3055– 3061.
10. Rebbeck, T, Evans, K, Elliott, J. Concussion in Combination with Whiplash-Associated Disorder may be missed in primary care: Key recommendations for assessment and Management. *JOSPT.* Volume 49;11. November 2019
11. Kennedy E, Quinn D, Chapple C, Tuimity S. Can the neck contribute to persistent symptoms post concussion? A prospective descriptive case series. *J Orthop Sports Phys Ther* 2019;49(11):845-854. Epub 1 June 2019. doi:10.2519/jospt.2019.8547
12. Marshall CM, Vernon H, Leddy JJ, et al. The role of the cervical spine in post-concussion syndrome. *Phys Sportsmed.* 2015; 43: 274-84; Broglio SP, Surma T, and Ashton-Miller JA High school and collegiate football athlete concussions: a biomechanical review. *Ann Biomed Eng.* 2012. 40(1): p. 37–46
13. Jull G, Trott P, Potter H, et al. A randomized controlled trial of exercise and manipulative therapy for cervicogenic headache. *Spine (Phila Pa 1976).* 2002;27:1835-1843; discussion 1843. <https://doi.org/10.1097/00007632-200209010-00004>
14. Ellis M, Leddy J, Willer B. Physiological, Vestibulo-ocular, and cervicogenic post concussion disorders: An evidence based classifications system with directions for treatment. *Brain Inj.* 2015; 29(2): 238–248
15. Thieben MJ, Sandroni P, Sletten DM, Benrud-Larson LM, Fealey RD, Vernino S, Lennon VA, Shen WK, Low PA. Postural orthostatic tachycardia syndrome: the Mayo Clinic experience. *Mayo Clin Proc.* 2007;82:308–313
16. Miranda N, Boris J, Kouvel K et al. Activity and Exercise Intolerance after Concussion: Identification and Management of Postural Orthostatic Tachycardia Syndrome. *J Neurol Phys Ther.* 2018 Jul; 42(3): 163–171
17. Stewart JM. Chronic orthostatic intolerance and the postural tachycardia syndrome (POTS). *J Pediatr.* 2004;145(6):725–730.
18. Raj SR, Biaggioni I, Yamhure PC, et al. Renin-aldosterone paradox and perturbed blood volume regulation underlying postural tachycardia syndrome. *Circulation.* 2005;111(13):1574–1582.
19. Goodman BP. Evaluation of postural tachycardia syndrome (POTS). *Auton Neurosci.* 2018;215:12–19
20. Boris JR, Bernadzikowski T. Demographics of a large pediatric postural orthostatic tachycardia syndrome program. *Cardiology in the Young.* 2018;28(5):668–674.
21. Goodman B, Dhawan P, Bogle J, Barrs D, Hoffman-Snyder C. Vestibular symptoms are common in postural tachycardia syndrome (PoTS) (P1. 281). *Neurology.* 2015;84(14 suppl):P1–281.
22. Kanjwal K, Saeed B, Karabin B, Kanjwal Y, Grubb BP. Clinical presentation and management of patients with hyperadrenergic postural orthostatic tachycardia syndrome. A single center experience. *Cardiol J.* 2011;18(5):527–531
23. Heyer GL, Fischer A, Wilson J, et al. Orthostatic intolerance and autonomic dysfunction in youth with persistent postconcussion symptoms: a head-upright tilt table study. *Clin J Sport Med.* 2016;26(1):40-45
24. Low PA, Sandroni P, Joyner M, et al. Postural tachycardia syndrome (POTS). *J Cardiovasc Electrophysiol.* 2009;20:352–358.
25. Raj SR. Postural tachycardia syndrome (POTS). *Circulation.* 2013; 127(23):2336-2342.
26. Plash WB, Diedrich A, Biaggioni I, et al. Diagnosing postural tachycardia syndrome: comparison of tilt testing compared with standing haemodynamics. *Clin Sci (Lond).* 2013;124(2):109-114.
27. Exercises for dysautonomia patients: CHOP modified Dallas protocol. Dysautonomia International Web site. <http://www.dysautonomiainternational.org/exercise>. Published June 2017. Accessed December 8, 2019.