

PEDIATRIC CONCUSSION TREADMILL TEST (PCTT) FOR AGES 5 – 12 INSTRUCTION MANUAL

Cathlyn B Corrado, PT, DPT; Mohammad N Haider, MD, PhD; Spozhmai Qadiri, MA; John J Leddy, MD; Barry S Willer, PhD

Purpose

- To assess the presence and severity of exercise intolerance in young children with concussion, age 5-12.
- To identify the heart rate (HR) at which concussion-like symptom exacerbation occurs (i.e. the Heart Rate Threshold [HRt]).
- To help establish a safe level of exercise for treatment of concussion.
- To help differentiate between concussion and other possible diagnoses for concussive symptoms (e.g. cervicogenic injury).
- To identify patient's level of recovery.

CAUTION: The PCTT alone should never be used to make a diagnosis of concussion or clearance to begin the return-to-play protocol. The PCTT is a supplementary test and should be interpreted alongside a complete history and physical examination.

Contraindications to Pediatric Concussion Treadmill Test

- The American Heart Association has stated that there are few contraindications to stress testing in this population when compared to adults.¹ Before beginning the PCTT, participants should be evaluated for any contraindications to exercise testing. The AHA Guidelines contraindications to exercise testing are as follows:

Low Risk:

- Symptoms during exercise in an otherwise healthy child who has a normal CVS exam and ECG
- Exercise-induced bronchospasm studies in the absence of severe resting airways obstruction
- Asymptomatic patients undergoing evaluation for possible long-QTc syndrome
- Asymptomatic ventricular ectopy in patients with structurally normal hearts
- Patients with unrepaired or residual congenital cardiac lesions who are asymptomatic at rest
- Routine follow-up of asymptomatic patients at risk for myocardial ischemia
- Patients with palliated cardiac lesions without uncompensated CHF, arrhythmia, or extreme cyanosis
- Patients with a history of hemodynamically stable SVT

High Risk:

- Patients with pulmonary hypertension
- Patients with documented long-QTc syndrome
- Patients with dilated/restrictive cardiomyopathy with CHF or arrhythmia
- Patients with a history of a hemodynamically unstable arrhythmia
- Patients with hypertrophic cardiomyopathy who are symptomatic
- Patients with greater than moderate airways obstruction on baseline pulmonary function tests
- Patients with Marfan syndrome and activity-related chest pain in whom a non-cardiac cause of chest pain is suspected
- Patients suspected to have myocardial ischemia with exertion
- Unexplained syncope with exercise

Apart from these, concussion-specific contraindications to treadmill testing include:

- Patient is experiencing such cervical dysfunction that motion while walking on a treadmill could cause considerable pain or harm.
- Patient is experiencing vestibular/balance issues that would impair the ability to safely walk on a treadmill.
- Patient has a lower extremity or spinal orthopedic injury that compromises safe walking.
- Patient feels too symptomatic and temporary exacerbation of symptoms is not beneficial
 - a. Examples of this situation include high scores on the VAS during the acute period within 48-72 hours of injury. Treadmill testing can be delayed by a few days if needed.

CAUTION: The PCTT is a guideline and should never supersede clinical judgement, especially when it comes to safety concerns.

Safety Considerations

- While testing, participant must be dressed for exercise (comfortable clothing, running shoes), wearing any vision or hearing aids (glasses, etc.) and should be hydrated.
 - Check to make sure shoes are laced and tied appropriately.
 - Remove outerwear such as sweatshirts or jackets prior to child getting on treadmill.
- It is suggested that 2-3 persons assist in conducting the PCTT in order to assure safety of the participant. The first examiner should be positioned diagonally in front/next to the patient controlling the treadmill settings. The second examiner is positioned behind the patient (at the back of the treadmill) at all times while test is in progress. The third examiner's primary responsibility is to record the HR, RPE, VAS, and any other observations. If a 3rd examiner is not available, the 1st examiner assumes their recording responsibilities.
 - The second examiner positioned behind the child should position themselves in one of two ways (in order of recommendation):
 1. Standing behind the child on the foot rails of the treadmill, spotting the child at the pelvis.
 2. Sitting on a bench that straddles the treadmill to be able to sit the child onto their lap or the bench if need be, spotting the child at the pelvis. If the bench cannot straddle over the entire width of the treadmill, it should not be used. This technique is more beneficial when shorter children are matched with taller examiners.
- It is important for the first examiner to engage in a casual conversation with the patient during the exercise test to assess his/her confidence level as well as any changes in cognitive and communicative functioning. As exercise intensifies, note if patient seems to have difficulty communicating, looks suddenly pale or withdrawn, or otherwise appears to be masking serious discomfort. – *Examples of age-appropriate dual tasking cognitive activities are listed in Table 1.*
- The use of gait belt around the child's waist, a treadmill safety key to be managed by the 1st examiner that is in front of the child, and proper guarding techniques are critical for maintaining safety.
- If the chest strap for monitoring HR requires a watch to be used, the 1st examiner should wear the watch so the child does not get distracted.
- Be aware of postural changes (slouching, rounding the back, leaning head) since noting the patient's thoracic and cervical posture can offer clues on the etiology of the injury.
- The child should not eat immediately before the test to prevent nausea.

Equipment Requirements and Testing Environment

- A pediatric treadmill is recommended because of its ability to accommodate shorter children, however, any treadmill that has the ability to increase incrementally to a 10-degree incline and adjust speed by 0.1 mph will suffice.
- If a bodyweight support system is available, the test can still be safely administered with fewer examiners.
- A chest HR monitor should be used to measure HR with a strap size of “pediatric” or “small” due to the smaller chest diameter of children compared to adults. It is suggested that a clip to be used to shorten an adult size strap, if need be.
- Adequate lighting, humidity, and temperature in the testing room.
- Chair with a back on it, water, and towel for patient recovery after exercise.

Setup

- Attach HR monitoring device according to manufacturer’s instructions, cinch and clip chest strap to accommodate smaller children as needed.
- Place RPE and VAS scales within comfortable viewing distance of participant while on treadmill (it is suggested that participants should not have to turn head to view scales). It is suggested that placing them over the dashboard on the treadmill will help decrease distraction for the child.

CAUTION: To ensure safety and decrease risk of accidentally powering on treadmill, the examiner should keep safety switch with them at all times, and only attach to treadmill once set up is complete.

Symptom and Exertion Scales

- **Visual Analogue Scale (VAS) combined with Wong Baker FACES Scale:** Research has shown that combining a 0-10 VAS with a WONG Baker FACES scale can improve reliability of pain reporting in young children. It can be explained to patients as a measure of “how bad” their concussion-specific symptoms are. It should be clarified that getting tired from walking on a treadmill is not a concussion-specific symptom and should be reported in the next scale – See *form attached*
- **Rating of Perceived Exertion (RPE):** Can be explained to patients as a measure of “how hard you feel like you’re working out”. The scale ranges from 1 – 10, 1 being no exertion and 10 being the maximum they could ever do. Descriptors of each exercise intensity level should be pointed out and patient should be allowed to read through it and have it read to them before the test begins.
- It is important to take the time to read it out loud to them, explain both scales, and give examples as needed since reading proficiency and comprehension vary greatly at these ages.

Treadmill Protocol

- 1) Inform child and parent/guardian about test procedures and what to expect during the PCTT.
- 2) Prior to testing, the child should have the option to try out the treadmill at a self-selected walking pace due to the novelty of the task. Proper guarding should be in place by the examiners, as described within this manual.
- 3) Explain and demonstrate the VAS and RPE scales and obtain resting scores. Remind participant that he/she will be asked to rate symptom severity and exertion every 2 minutes during exercise.
- 4) Obtain resting HR by using the chest HR monitor after 2-minute seated position before getting the patient on the treadmill. The first examiner should have the safety key at all time to prevent any accidental turn on of the treadmill.

- 5) The patient stands on the treadmill belt with speed set to 0 mph, with gait belt donned. The examiner's position, in relation to the patient, are as follows:
 - a. The 1st examiner is standing diagonally in front of the child and is responsible for controlling the TM speed and incline, engaging the child, wearing the HR monitor watch (if applicable), and is responsible for the safety shut off switch.
 - b. The 2nd examiner is behind the patient as safety precaution. This examiner is over the back of the treadmill either on a bench, or standing on foot rails straddling treadmill belt, guarding the child at their hips/gait belt.
 - c. The 3rd examiner records the HR, RPE, VAS, and any other observations, if a 3rd examiner is available. If not, then the 1st examiner will assume these responsibilities.
- 6) Starting incline is 1 degree. Speed can be adjusted depending on athletic status, height, or overall comfort of treadmill speed – patients should be moving at a brisk walking pace. The HR at Stage 0 is the HR when the patient is standing on the treadmill before starting the PCTT and not during the 2-minute seated rest. – *For recommended starting speeds for each age, please see Table 2.*
- 7) Each stage of the PCTT lasts 2 minutes and the patient is asked to rate their symptom severity and RPE at the end of each stage. Examiner should also record general observations as the test progresses. This procedure is repeated every two minutes. Within each stage, there will be adjustments made to the incline and speed of the treadmill 2 times, increasing 1% incline and 0.2 mph speed (once each minute), at which time the HR will be recorded.
 - a. The child is only asked to report their symptoms and RPE at the end of each 2-minute stage to allow for increased time for processing compared to adults. However, patients should still be encouraged to speak up at any time within each stage if their symptoms or RPE changes or if they would like to stop.
- 8) Changes to VAS rating should be specifically clarified/noted to ensure that they are concussion-related symptoms. Often times young children need follow up questions to describe how they are feeling. Any change in symptoms related to concussion-like symptoms should prompt cessation of the test.
- 9) Once test is terminated (see Stopping Criteria below), speed is reduced to 1.8 mph and incline reduced back to 0 for a 2-minute cool down (if patient is able). HR, RPE, VAS plus any additional comments (if needed) are recorded after the 2-minute cool down.
- 10) Patient is allowed to rest seated in a chair in a quiet environment until symptom severity returns to pre-PCTT value or patient feels like they are able to continue with the remainder of the clinical visit.

Stopping Criteria

The PCTT is terminated based on the following criteria:

- 1) Symptom exacerbation – defined as any change in points on the VAS pain scale from baseline VAS pain score.
- 2) Voluntary exhaustion – defined as an RPE of > 8 without significant symptom exacerbation. If the patient has not reached at least 70% of age-predicted maximum (calculated as $220 - \text{age}$), the examiner should encourage the patient to try and keep going but should not push the patient if they are too exhausted.
- 3) Examiner notes a rapid progression of complaints (pressure in head to searing focal headache), or patient appears faint, or has stopped communicating, or continuing the test constitutes a significant health risk for the patient.
- 4) Patient has reached 70% or more of age predicted maximum without any increase in symptoms and still reporting low RPE. The RPE scale should be discussed with the patient at this time to make sure they accurately understand it before we begin the cool down period.
- 5) Patient requests to stop for any reason. The reason for stopping, other than the above mentioned, should be recorded in the PCTT Assessment Form.

CAUTION: The PCTT is a guideline and should never supersede clinical judgement, especially when it comes to safety concerns.

Interpretation

- The maximum HR achieved on the PCTT at symptom exacerbation is called the Heart Rate threshold (HRt) and a safe level of exercise is considered to be below 80% of HRt.
- If the patient is able to exercise to voluntary exhaustion without any increase in symptoms (i.e. does not have symptom-limited exercise intolerance) but is not cleared to return-to-play because of symptoms at rest or other physical examination impairments, then the patient can perform aerobic exercise at any HR up to the maximum achieved or at 70% of age-predicted maximum.
- Patients who have symptoms at rest, but do not have a physiologic threshold (can exercise to max without increase in concussion-specific symptoms) should be evaluated for dysfunction of the cervical spine, vestibular system or temporomandibular region.

For more information, please visit concussion.ubmd.com

Tables and Figures

Table 1: Dual Tasking Cognitive Activities for Ages 5-12

Math: Addition, subtraction, and/or multiplication

Spelling: Patient's name spelled forwards and backwards, their favorite sport, and/or their siblings

ABC Picnic Game: Going through the alphabet, naming a food or drink with each letter, and repeating the previous letters/food throughout (for the younger kids, prompt them with letters)

Favorite Teams: Name as many teams as patient can from patient's favorite sports

3 Item Recall: Have patient repeat out loud 3 items: recall at 1 minute and then 5 minutes

Table 2. Recommended Starting Speed for Children Aged 5 – 12

(Derived from 6-Minute Walk Test Normative Data, and subtracting 0.5 mph for the novelty of the task)

AGE IN YEARS	RECOMMENDED PCTT STARTING SPEED
5	2.1 mph
6	2.3 mph
7	2.5 mph
8	2.5 mph
9	2.6 mph
10	2.6 mph
11	2.8 mph
12	2.8 mph

Figure 1. Combined WONG-Baker and Visual Analogue Scales (Pain Scale)

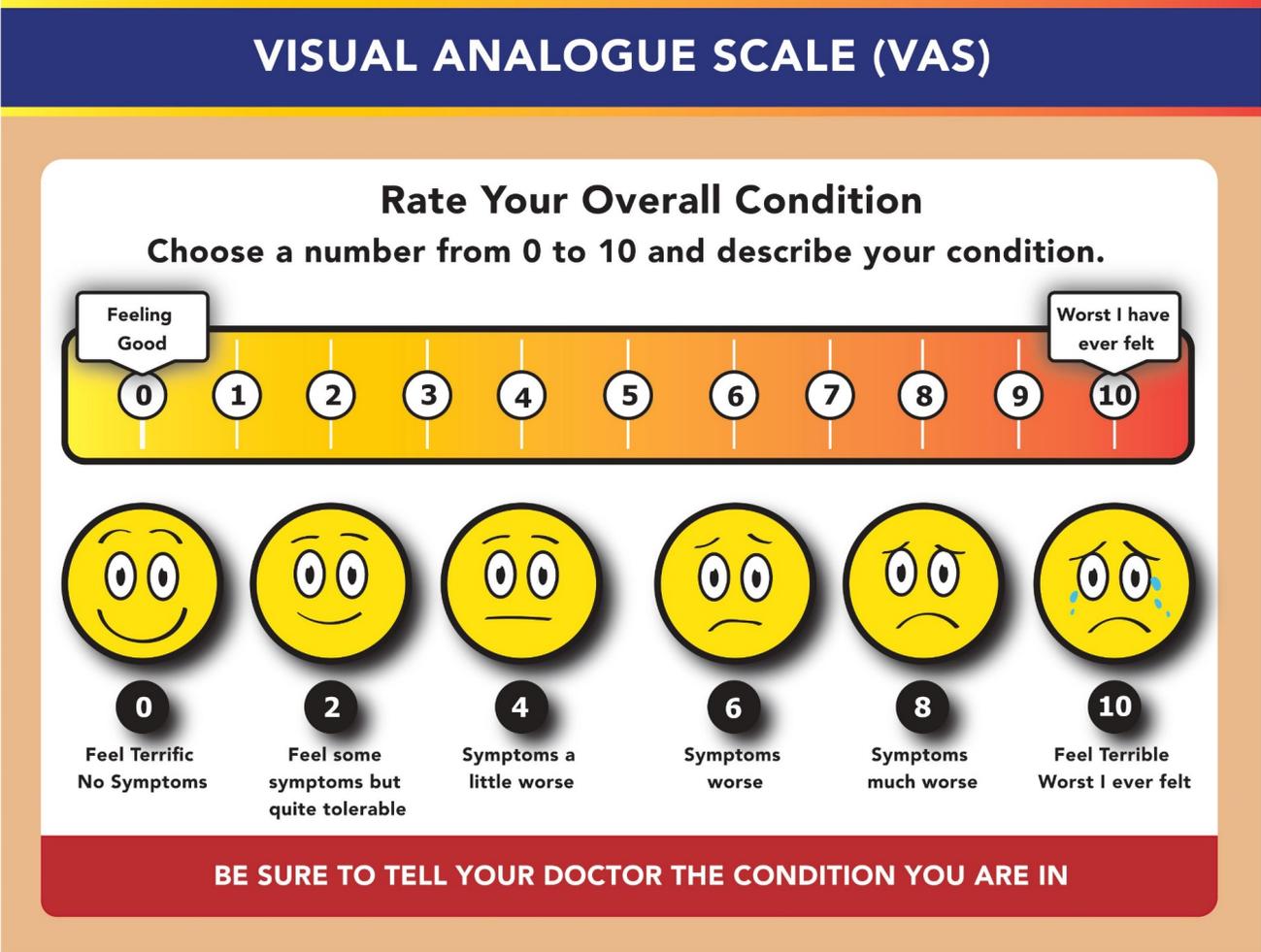
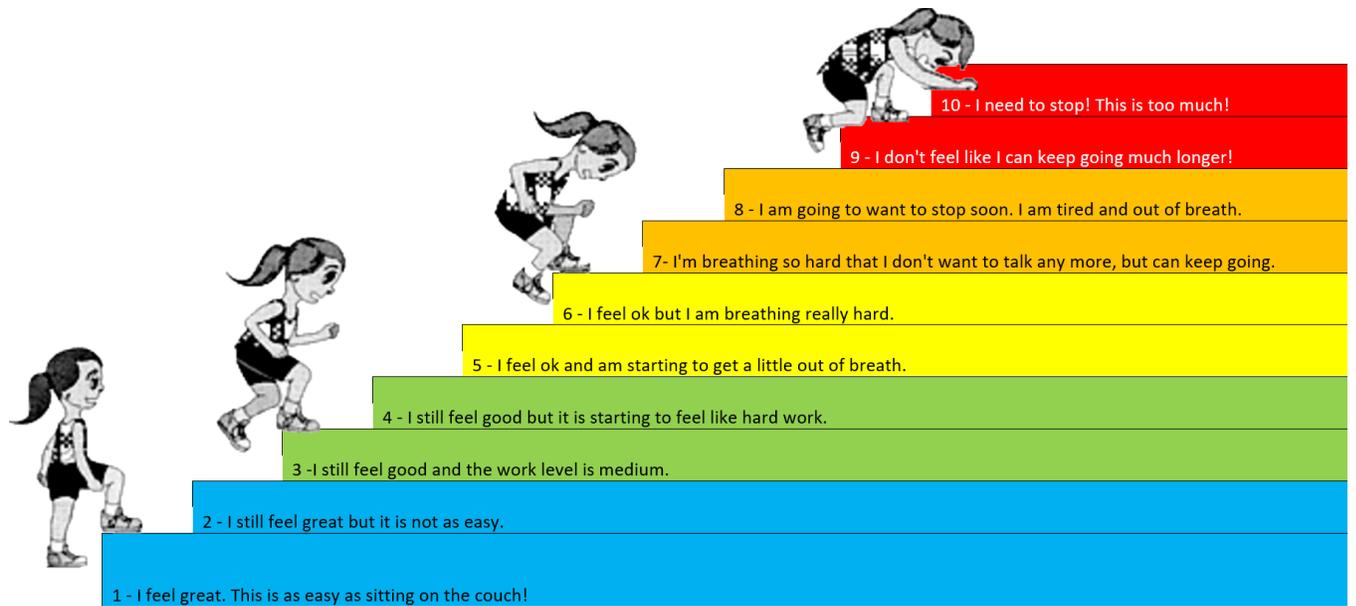


Figure 2. A Modified Children's OMNI Rate of Perceived Exertion Scale



Helpful Tip: To ensure best understanding for the child, the examiner's tone of voice and affect should match the text within this RPE figure.

Pediatric Concussion Treadmill Test Assessment Form

Patient Name: _____ Patient Age: _____ Date: _____ Assessor: _____

Pre-Test: Seated Resting HR: _____ BP: _____ Post Test: Seated Resting HR: _____ BP: _____ Max HR: _____

STAGE	Minutes	Speed	Incline	HR	RPE	VAS	Symptom reports	Observations
1	0		1					
	1		2					
	2		3					
2	3		4					
	4		5					
3	5		6					
	6		7					
4	7		8					
	8		9					
5	9		10					
	10	-----	-----					
Cool down	2 min	1.8	0					

Recommended PCTT starting speed for Children Aged 5 – 12, based on 6-Minute Walk Test Normative Data

Age in years	Recommended PCTT Starting Speed	Age in years	Recommended PCTT Starting Speed
5	2.1 mph	9	2.6 mph
6	2.3 mph	10	2.6 mph
7	2.5 mph	11	2.8 mph
8	2.5 mph	12	2.8 mph