



Buffalo Concussion Treadmill Test (BCTT) – Instruction Manual

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Purpose

- To assess the degree of exercise tolerance in patients with concussion.
- To identify the heart rate (HR) at which concussion-specific 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 post-traumatic disorder).
- To identify physiological variables associated with exacerbation of symptoms, and the patient's level of recover.

Caution

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

Eligibility

- Do not perform the BCTT if the patient is experiencing such cervical dysfunction that motion while walking on a treadmill could cause considerable pain or harm, is experiencing vestibular/balance issues that would impair the ability to safely walk on a treadmill, or has a lower extremity or spinal orthopedic injury that compromises safe walking.
- Before beginning the BCTT, participants should be evaluated for any contraindications to exercise testing. The AHA Guidelines contraindications to exercise testing are as follows:

Absolute Contraindications

- Acute myocardial infarction (within 2 days)
- High-risk unstable angina
- Uncontrolled cardiac arrhythmias causing symptoms or hemodynamic compromise
- Symptomatic severe aortic stenosis
- Uncontrolled symptomatic heart failure
- Acute pulmonary embolus or infarction
- Acute myocarditis or pericarditis
- Acute aortic dissection

Relative Contraindications

- Left main coronary stenosis
- Moderate stenotic valvular heart disease
- Electrolyte imbalance





- Severe arterial hypertension (>200 mmHg systolic or >110 mmHg diastolic)
 - Tachyarrhythmia or bradyarrhythmia
 - Hypertrophic cardiomyopathy and other forms of outflow tract obstruction
 - Mental or physical impairment leading to inability to exercise adequately
 - High-degree atrioventricular block
- The BCTT is not recommended within 24 hours of concussive brain injury or if the patient is too symptomatic (symptom severity 7/10 or more).

Safety Considerations

- While testing, participants must be dressed for exercise (comfortable clothing, running shoes), wearing any vision or hearing aids (glasses, etc.), and should be hydrated.
- It is suggested that 2 persons assist in conducting the BCTT in order to assure safety of the participant, with 1 examiner positioned behind the patient (at back of the treadmill) at all times while test is in progress.
- It is important to engage in 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.
- Be aware of postural and structural 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.

Equipment Requirements

- Treadmill with capacity to reach 15 degrees of incline
- HR monitor (Polar OH arm band or chest band is recommended)
- BCTT Assessment Form for monitoring HR, symptom severity, RPE and relevant observations – *See form attached*
- Visual Analogue Scale (VAS): 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*
- Borg 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 6 – 10, 6 being no exertion and 20 being the maximum they can ever do. Descriptors of each exercise intensity level should be pointed out and patient should be allowed to read through it before the test begins. – *See form attached*
- Chair, water and towel for patient recovery after exercise.

Setup

- Attach HR monitoring device according to manufacturer's instructions.
- 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).





Test Protocol

- 1) Inform patient about test procedures and what to expect during the BCTT.
- 2) 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 each minute during exercise.
- 3) Obtain resting HR after 2-minute seated position before getting the patient on the treadmill.
- 4) Patient should begin by standing on the sides of the treadmill while the treadmill is turned on. The experimenter should set treadmill at a speed of 3.2mph for patients up to 5'10," and 3.6mph for those 5'10" and above. Starting incline is 0 degrees. Speed can be adjusted depending on athletic status 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 BCTT and not during the 2-minute seated rest.
- 5) After 1 minute at this pace, treadmill incline is increased by 1 degree and patient is asked to rate their symptom severity and RPE at the beginning of each stage. HR in bpm are also recorded at the beginning or each stage. Examiner should also record general observations as the test progresses if needed. This procedure is repeated each minute while treadmill incline is raised at a rate of 1 degree/minute. Changes to VAS rating should be specifically clarified/noted, for example, if the rating moves from 2 to 3, it should be clarified if this reflects the addition of a new symptom and 1-point for the addition of a new symptom, for example, if the patient reports symptom severity change from 2/10 to 3/10 and reports slight increase of headache and onset of light sensitivity, then this should be considered a 2-point increase to 4/10. Once treadmill reaches maximum incline (15 degrees), speed is increased by .4 mph each minute in lieu of increased incline.
- 6) Once test is terminated (see Stopping Criteria below), speed is reduced to 2.0 mph and incline reduced back to a 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.
- 7) Patient is allowed to rest on a chair in a quiet environment until symptom severity returns to pre-BCTT value or patient feels like they are able to continue with remainder of the clinical visit.

Stopping Criteria

The BCTT is terminated based on the following criteria:

- 1) Symptom exacerbation – defined as an increase of 3 or more points on the VAS scale from resting VAS score.
- 2) Voluntary exhaustion – defined as an RPE of > 17 without significant symptom exacerbation. If the patient has not reached at least 80% of age predicted maximum (calculated as 220-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 as significant health risk for the patient.





- 4) Patient has reached 90% 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 BCTT Assessment Form.

Interpretation

- The maximum HR achieved on the BCTT at symptom exacerbation is called the Heart Rate threshold (HRt) and a safe level of exercise is considered to be below 90% 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 physical examination impairments, then the patient can perform aerobic exercise at any HR up to the maximum achieved or at 85% of age appropriate 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 ubortho.com/services/concussion-management-center



Buffalo Concussion Treadmill Test Assessment Form

Patient: _____ Date: _____ Starting Speed: _____ mph

Min	HR	RPE	VAS scale	Symptom reports	Observations
REST		NA			
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
Post (2 min)					

Maximum Heart Rate at Symptom Exacerbation: _____ / NA Tester: _____

Additional comments: _____

Borg Rating of Perceived Exertion

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

VISUAL ANALOGUE SCALE (VAS)

Rate Your Overall Condition

Choose a number from 0 to 10 and describe your condition.



0

Feel Terrific
No Symptoms



2

Feel some
symptoms but
quite tolerable



4

Symptoms a
little worse



6

Symptoms
worse



8

Symptoms
much worse



10

Feel Terrible
Worst I ever felt

BE SURE TO TELL YOUR DOCTOR THE CONDITION YOU ARE IN