

Research versus Clinical Grading of the Buffalo Concussion Treadmill Test in Service Members with Mild Traumatic Brain Injury

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INTRODUCTION

Exercise intolerance is a common consequence of mild traumatic brain injury (mTBI) and is assessed using graded exertion testing. The most common graded exertion test in patients with mTBI is the Buffalo Concussion Treadmill Test (BCTT) which provides a binary grading of exercise tolerant (ET) or intolerant (EI). It also grades the severity of EI into early (more severe) or late (less severe), and the heart rate (HR) at symptom exacerbation (Heart Rate threshold, HRt) can be used to provide a sub-symptomatic exercise prescription. However, the published criteria for grading the BCTT is limited since it was developed on high school and collegiate athletes, and experienced clinicians grade this test using additional criteria.

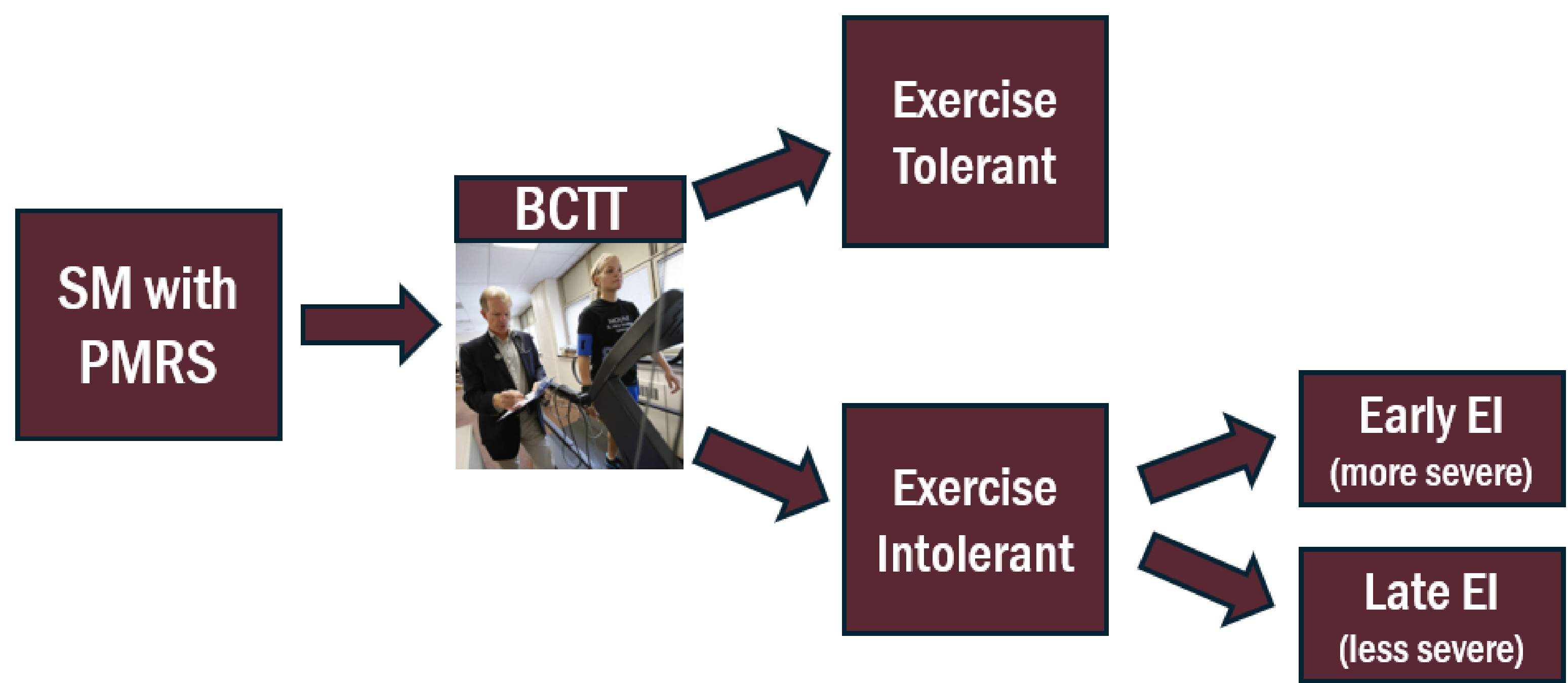
The purpose of this study is to compare results of the BCTT using the published research criteria versus a clinician’s interpretation.

METHODS

This study reports on preliminary findings from an ongoing prospective randomized controlled trial “Treatment Optimization of Brain-injured Warfighters: A Prescribed Sub-symptomatic Exercise Treatment (TOBI-SET), Principal Investigator (PI): Jason M. Bailie, PhD, ClinicalTrials.gov ID - NCT06561100.

Participants: Active-duty male and female service members with persisting mTBI-related symptoms (PMRS) were included. 101 service members (92.1% male) with a mean age of 34.6 (SD: 7.8) years and approximately 6.2 (SD: 6.0) years since last mTBI participated in the study and performed the BCTT. Mean concussion symptom severity on the Neurobehavioral Symptom Inventory was 37.4 (SD: 15.0) before performing the test.

The BCTT was graded using the published criteria.



MAIN OUTCOME MEASURE

- Published BCTT Guidelines (Leddy 2013 and Leddy 2018):**
- Begin at a speed of 3.2 – 3.6 mph at 0% incline. Increase the grade by 1% every minute for up to 15 minutes and increase speed by 0.4 mph from Minute 16 – 20.
 - Participants are EI if they report an increase of concussion symptom severity of 3 or greater on the Visual Analogue Scale (VAS, Fig. 1) before reaching voluntary exhaustion (Borg Rating of Perceived Exertion > 17) or reaching 90% of age-appropriate maximum HR using the Karvonen method (220- age).
 - Participants have Early EI if they experience symptom exacerbation at an HR of < 135 bpm

Clinical Grading:
Three experienced exercise clinicians reviewed the BCTT assessment form (Fig. 2) and graded if they thought the test was valid and if the SM was exercise tolerant up to a “moderate” intensity (defined by the ACSM as able to perform at least 30 minutes of aerobic exercise at 65-75% of HR max).

RESULTS

Using research criteria, 58 participants were ET and 43 participants were EI. Using clinical criteria, 37 participants were ET, 58 were EI, and 6 tests were considered invalid (4 were intolerant due to orthopedic issues and 2 tests were too short to rule out EI). The Cohen’s Kappa of agreement was 0.672 (p<0.001). Most common reason for discrepancy between published and clinical grading were SM reporting a symptom increase of only 2 points on the VAS.

Table 1. Agreement of research vs clinical grading		Clinical Grading			
		EI	ET	Invalid	Total
Research Grading	EI	42	0	1	43
	ET	16	37	5	58
	Total	58	37	6	101

Out of the 58 participants who were EI, 39 were considered Early EI but only 29 of them had symptom exacerbation below 135 bpm. Only 1 participant who was considered Late EI had a maximum heart rate below 135 bpm (Kappa = 0.616, p<0.001). Most common cause for discrepancy were SM reaching a HR of > 135bpm within the first 5 minutes of exercise and that 31 SM (30.7%) had a resting HR of >100 bpm.

Table 2. Agreement of Early vs Late EI		Clinical Grading		
		Early	Late	Total
Research Grading	<135 bpm	29	1	30
	≥135 bpm	10	18	28
	Total	39	19	58

ABBREVIATIONS

EI: Exercise intolerant; **ET:** Exercise tolerant; **PMRS:** persisting mTBI-related symptoms; **BCTT:** Buffalo Concussion Treadmill Test; **HR:** heart rate; **HRt:** heart rate threshold; **VAS:** visual analogue scale.

Figure 1

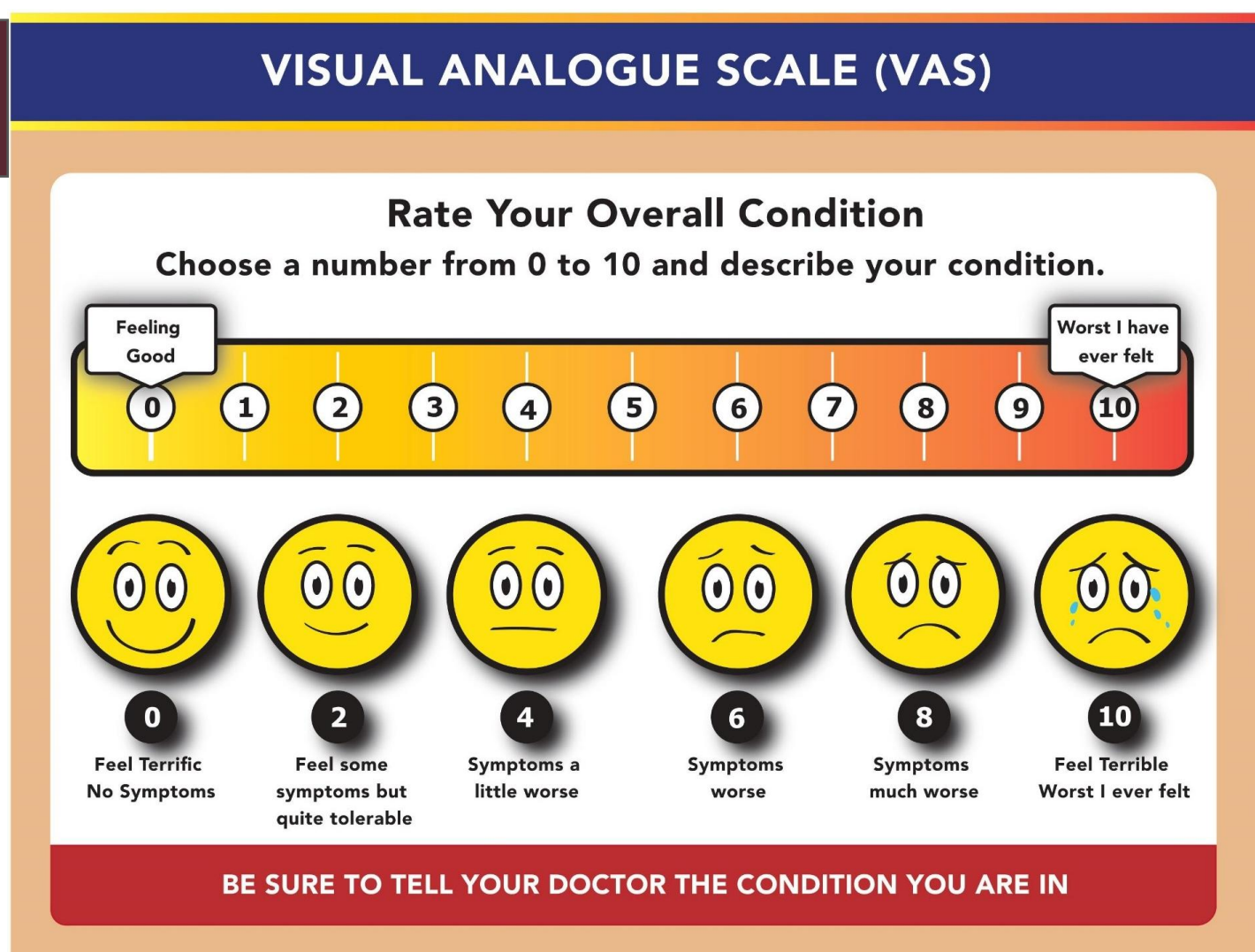


Figure 2

Participant ID: _____

Min	HR	RPE	Overall condition (Likert scale)	Symptoms / Observations
REST				
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
Post-Exercise				
1				
2				

CONCLUSIONS

There is satisfactory, but not excellent, agreement between published guidelines and an experienced clinician’s interpretation. In addition to symptom reports and maximum HR achieved, experienced clinicians should also consider duration of exercise, progression of self-reported exertion, and the difference between resting and maximum HR achieved when interpreting the results of the BCTT.

PROPOSED CRITERIA

- Begin at a speed of 2.0 – 3.6 mph at 0% incline. Select a speed where the SM can perform a brisk walk for at least 15 minutes. Increase the grade by 1% every minute for up to 15 minutes and increase speed by 0.4 mph from Minute 16 – 20.
- Participants are EI if they report an increase of concussion symptom severity of 2 or greater on the VAS before reaching voluntary exhaustion, or within 15 minutes of the BCTT, or reaching 90% of age-appropriate maximum HR.
- Participants have Early EI if they experience symptom exacerbation at an HR of < 135 bpm if resting HR is below 100, or within 5 minutes of the test.

REFERENCES

1. Leddy JJ, Willer B. Use of graded exercise testing in concussion and return-to-activity management. Current sports medicine reports. 2013 Nov 1;12(6):370-6.

2. Leddy JJ, Hinds AL, Miecznikowski J, Darling S, Matuszak J, Baker JG, Picano J, Willer B. Safety and prognostic utility of provocative exercise testing in acutely concussed adolescents: a randomized trial. Clinical journal of sport medicine. 2018 Jan 1;28(1):13-20.