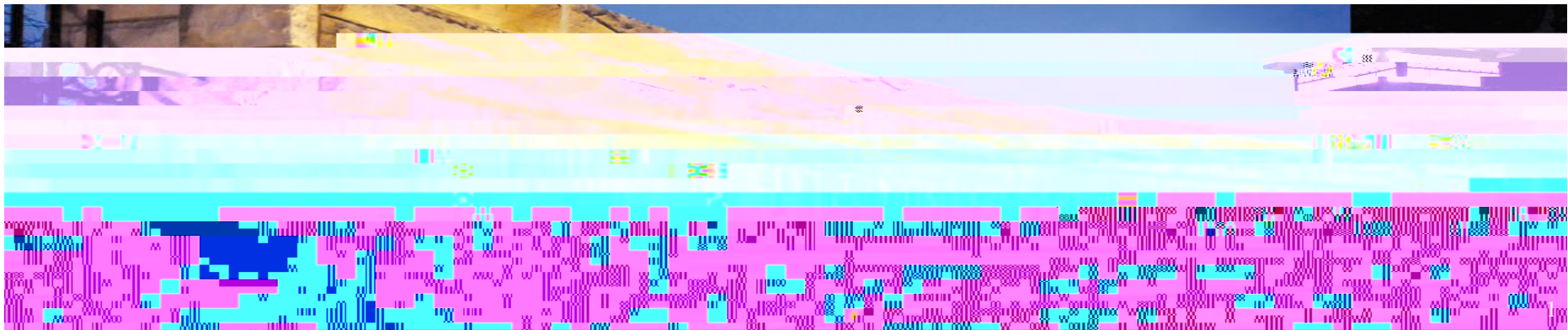


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Concussion Overview

Impact to the head or body

Diffuse axonal injury caused by acceleration/deceleration of gray and white matter

Shearing effect of axons creating a mechanical stretch of cell echa/MCIecha/MCIecha/M





Symptoms

Headache
Nausea/Vomiting
Balance and/or gait disturbance
Dizziness
Tinnitus
Photophobia
Difficulties focusing
Slowed speech
Lightheadedness
Extreme fatigue
Memory/cognitive dysfunction

Signs

Retrograde amnesia
Anterograde amnesia
Disorientation
Confusion
Gait imbalance
Memory deficits





Post-Concussion Subtypes

Physiologic

- Cerebral blood flow

- Cellular metabolism

- Ion transport regulation

Vestibulo-ocular

- Disruption of vestibulo-ocular reflex

- Disruption of vestibulo-spinal reflex

- Visual dysfunction

Cervicogenic

- Dysfunction of the cervical spine somatosensory system

- Disruption of proprioception





Buffalo Concussion Treadmill Test (BCTT)/Modified Balke Protocol

Equipment: Treadmill or cycle ergometer

Objective measures: heart rate (HR), post-concussion symptom scale (PCSS), rate of perceived exertion (RPE)

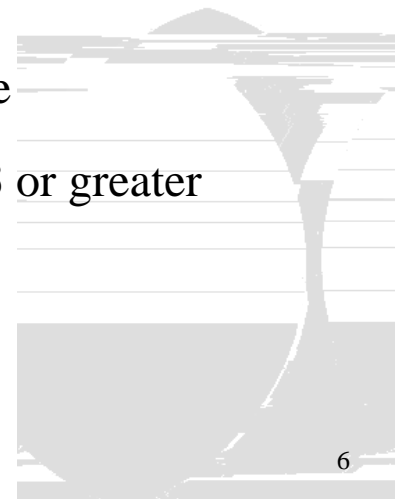
Start at 0% incline and 3.2-3.6 mph increasing 1% incline each minute

Test is terminated after total exhaustion or symptom exacerbation of 3 or greater

Each minute objective measures were assessed

Inter rater reliability (95%), Retest reliability (79%)⁵

Sensitivity (99%) and Specificity (89%)⁵





McMaster All-out Progressive Continuous Cycling Test

Equipment: cycle ergometer

Objective measures: HR, PCSS, and RPE

Begin at 25-85W pedaling at 60 rpm with progressive increase in work rate every 2 minutes

Test terminated if pedaling rate dropped below 50 rpm for 3 s, exhaustion, increase in concussion like symptoms

Objective measures were assessed every 2 minutes





The purpose of this study was to determine how graded exercise testing (GET) is being utilized in the clinical management of individuals following a concussion.





Databases

PubMed

CINHAL

Google Scholar

ProQuest Central



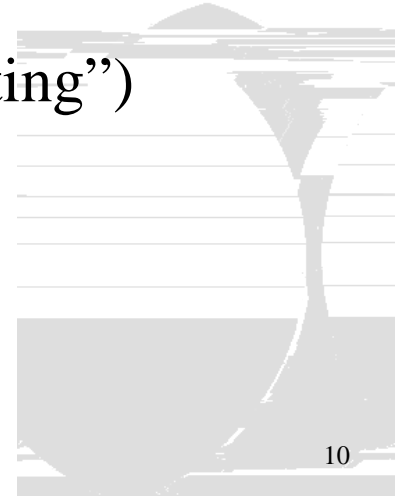


Search Terms

(“Concussion” **OR** “mTBI” **OR** “mild traumatic brain injury)

AND

(“Buffalo” **OR** “Balke” **OR** “graded exercise testing”)





Search Limits

English language

Human subjects

Peer-reviewed





Selection Criteria

Original research

Individuals with concussion or post concussion syndrome

Graded exercise testing

PT clinical management



PRISMA



Records Identified
through database
searching (n = 4,320)

Additional records
identified through other
sources (n = 5)

Records excluded (n = 978)
Excluded articles without keywords in title or
abstract

Records after duplicates removed (n = 4,252)

Records screened
(n = 1045)
Screened title and abstract for concussion, clinical
management, and exercise testing

Full-text articles excluded with reasons (n = 54)
Systematic Review - 25

Studies included in qualitative synthesis (n = 13)

Sackett Levels



Article Citation	Study Design	Sackett Score
Cordingly et al. ³	Retrospective chart review	4
Leddy JJ et al. ⁴	Prospective randomized controlled trial	1b
Dematteo et al. ⁶	Cross-sectional study	2b
Darling SR et al. ⁷	Retrospective chart review	4
Kozlowski et al. ⁸	Cross-sectional study	2b
Leddy et al. ⁹	Prospective case series	4
Baily NF ¹⁰	Case Report	4
Moore BM et al. ¹¹	Prospective Longitudinal Design	2c
Manikas et al. ¹²	Pre-Post Prospective Design	4
Chrisman et al. ¹³	Retrospective Cohort Study	4
Grabowski et al. ¹⁴	Retrospective Cohort study	4
Gunter et al. ¹⁵	Case Report	4
Anderson V et al. ¹⁶	Case-Controlled Study	3b



Clinical Management

Diagnosis

Determine subtype involvement

Prognosis

Length of recovery correlated with heart rate upon symptom exacerbation

Return to Play (RTP)

Decision making and timeline

Treatment Plan

Subsymptom threshold and subtype management





Buffalo Concussion Treadmill Test/Modified Balke Protocol was utilized in 10 articles^{3,4,7-10,11,13-15}

5 used the BCTT as a diagnostic tool^{3,8,10,14,15}

2 as a prognostic tool^{3,4}

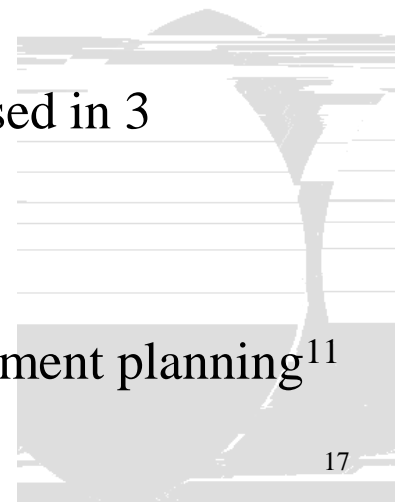
7 for treatment planning^{3,9,10,11,13,14,15}

2 for RTP decision making^{3,7}

McMaster All-out Progressive Continuous Cycling Test was used in 3 articles^{6,12,16}

All 3 articles the MAPCCT was used for RTP and prognosis

Modified cycle ergometer protocol used for diagnosis and treatment planning¹¹

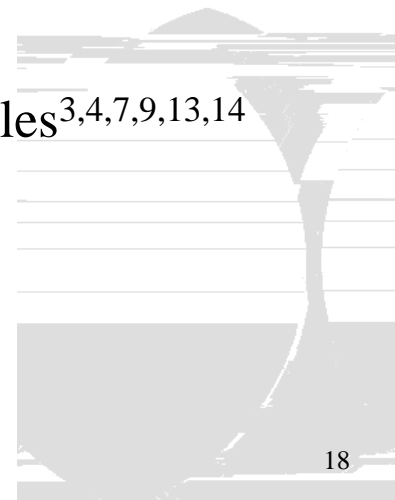




All 13 articles assessed HR and used a symptom exacerbation scale as objective measures^{3,4,6-16}

4 used blood pressure^{3,8,9,11} and 7 used RPE to monitor patients throughout testing^{3,6,8,9,11,13,16}

Safety in clinical management was assessed in 6 out of 13 articles^{3,4,7,9,13,14}





Articles reviewed suggest that graded exercise testing is utilized for multifactorial clinical management of concussion

Graded exercise testing may be safely implemented in the acute and chronic stages of concussion management







Further research is needed to assess how graded exercise testing can be utilized as a standardized approach

Future studies for standardization should include





Graded exercise testing can be utilized to

Diagnose concussion subtypes

Determine treatment at subsymptom threshold

Predict recovery time

Guide return to play decision making





1. Barkhoudarian G, Hovda DA, Giza CC. The molecular pathophysiology of concussive brain injury. *Clin Sports Med.* 2011;30:33





9. Leddy JJ, Kozlowski K, Donnelly JP, et al. A preliminary study of subsymptom threshold exercise training for refractory post-concussion syndrome. *Clin J Sport Med.* 2010;20(1):21-27. doi: 10.1097/JSM.0b013e3181c6c22c





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