How Graded Exercise Testing is Being Utilized in the Clinical Management of Concussion: A Systematic Review

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Overview

- Introduction
- Purpose
- Database
- Search Terms
- Sackett Level
- PRISMA
- Results
- Discussion
- Clinical Relevance
Introduction

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 membrane
- Leads to a multitude of effects - metabolic cascade
  - Ionic influx
  - Diffuse depolarization
  - Calcium influx
  - Mitochondrial swelling
- Region mainly affected is subcortical areas of the brain
  - Confirmed by imaging studies using Diffuse Tensor Imaging observing the lack of water diffusion deep to the cerebral cortex
Introduction

Symptoms$^{1,2}$

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

Signs$^{1,2}$

- Retrograde amnesia
- Anterograde amnesia
- Disorientation
- Confusion
- Gait imbalance
- Memory deficits
Introduction

Post-Concussion Subtypes$^2,3$

- **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\textsuperscript{3,4}

- 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%)\textsuperscript{5}
- Sensitivity (99%) and Specificity (89%)\textsuperscript{5}
Graded Exercise Testing

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.
Methods

Databases

- PubMED
- CINHAL
- Google Scholar
- ProQuest Central
Methods

Search Terms

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

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

Search Limits

● English language
● Human subjects
● Peer-reviewed
Methods

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 after duplicates removed (n = 4,252)

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

Full text articles assessed for eligibility (n = 67)

Studies included in qualitative synthesis (n = 13)

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

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

- Systematic Review - 25
- Imaging - 3
- Computerized Testing - 2
- Critically Appraised Topic - 5
- Powerpoint - 2
- Expert Opinion - 1
- No GET - 10
- On Field Testing - 2
- No Concussion - 2
- No Clinical Management - 2
## Sackett Levels

<table>
<thead>
<tr>
<th>Article Citation</th>
<th>Study Design</th>
<th>Sackett Score</th>
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<tbody>
<tr>
<td>Cordingley et al.³</td>
<td>Retrospective chart review</td>
<td>4</td>
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<tr>
<td>Leddy JJ et al.⁴</td>
<td>Prospective randomized controlled trial</td>
<td>1b</td>
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<tr>
<td>Dematteo et al.⁶</td>
<td>Cross-sectional study</td>
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<tr>
<td>Leddy et al.⁹</td>
<td>Prospective case series</td>
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<tr>
<td>Baily NF¹⁰</td>
<td>Case Report</td>
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<tr>
<td>Moore BM et al.¹¹</td>
<td>Prospective Longitudinal Design</td>
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<td>Manikas et al.¹²</td>
<td>Pre-Post Prospective Design</td>
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<td>Chrisman et al.¹³</td>
<td>Retrospective Cohort Study</td>
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<td>Case-Controlled Study</td>
<td>3b</td>
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Results

- Total of 613 subjects with an age range of 10-72 years old were included
- Mechanism of injury varied
  - 10 articles Sports Related Concussion (SRC)\(^3,4,7-9,11-15\)
  - 5 articles MVA/falls\(^8-11,13\)
  - 2 not specified\(^6,16\)
- Time since injury was not clearly defined
  - 5 articles acute concussion\(^3,4,7,15,16\)
  - 10 articles chronic concussion\(^3,6-14\)
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
Results

- 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 planning[^11]
<table>
<thead>
<tr>
<th>Article Citation</th>
<th>Graded Exercise Test</th>
<th>Diagnosis</th>
<th>Prognosis</th>
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Results

- 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\(^3,4,7,9,13,14\)
Discussion

- 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
Limitations

- Limited number of strong evidence studies
- The developer of the BCTT, Dr. John Leddy, as the primary author and/or contributor of the majority of articles reviewed
- Lack of standardization in the use of graded exercise testing amongst researchers and clinicians
Future Research

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

● Future studies for standardization should include
  ○ Testing vs. stage of recovery
  ○ Physical therapy concussion evaluation
  ○ Utilization of treadmill compared to cycle ergometer
  ○ Psychometric values of special populations
Clinical Relevance

● Graded exercise testing can be utilized to
  ○ Diagnose concussion subtypes
  ○ Determine treatment at subsymptom threshold
  ○ Predict recovery time
  ○ Guide return to play decision making

● Graded exercise testing can be safely and feasibly implemented in PT clinical examination and management of concussion
References


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John Sanko, PT, EdD
Questions?
## Appendix

### Rate Your Overall Condition

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<th>Subject ID</th>
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#### Rating Scale

- **1** = Feel terrific, no symptoms
- **3** = Feel some symptoms but quite tolerable
- **5** = Symptoms a little worse
- **7** = Symptoms much worse
- **9** = Feeling quite symptomatic
- **10** = Feel terrible, worst I've ever felt

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<th>Min</th>
<th>HR</th>
<th>RPE</th>
<th>Likert Scale</th>
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