Return to work after work-related traumatic brain injury

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Presenters disclosure

- AC and TM have no financial or non-financial interests to disclose
- Speaker Bureau/Honoraria: none
- Consulting fees: none
- Other: none
Objectives

1) To understand the incidence and nature of occupational brain injury with a sex and gender lens

2) To understand perceived factors associated with return to work after occupational brain injury

3) To understand the nature and relevance of sleep disorders associated with occupational brain injury
Overview of TBI
Traumatic brain injury (TBI) is...

• An “alteration in brain function, or other evidence of brain pathology, caused by an external force”

• Major cause of death and disability globally

• Major causes: Falls, motor vehicle crashes, struck by object

• Can happen to anyone!
TBI is more common than we think

- Over 30% with TBI by age 25 (McKinlay et al., 2008)
- 20% of Ontario High School Students (Ilie et al., 2014)
- Common in vulnerable populations
  - Homeless: 53% (Hwang et al., 2008)
  - Incarcerated: up to 87% (Shiroma et al., 2010)
- Highest incidence in children/youth and older adults (Colantonio et al., 2010)
Healthcare burden of TBI in Canada

- Places substantial burden on the health care system
- By 2031 TBI will be the most prevalent neurological condition
- Indirect economic costs due to working-age disability will increase and will be greatest for hospitalized traumatic brain injury (rising from $7.3 billion in 2011 to $8.2 billion in 2031)

PHAC, 2014
Post-injury symptoms after work related traumatic brain injury in Canadian population

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Distribution of post-injury symptoms
Mild injury can have longer term consequences:

Dr. Anne Forrest, PhD in Economics, sustained a mild TBI after rear-end collision

- Did not lose consciousness
- Struggled with life/work, communication, memory, daily activities

- Most people with mild brain injuries recover
TBI at Work (wrTBI)

- Large percentage among seriously or fatally injured workers
- An injury with any loss of consciousness is considered “critical”
- Tremendous need to increase employment opportunities, workplace accommodations, technologies, and policies!
- Employment can make enormous difference in lives of people with a brain injury and their families
TBI Awareness

- Invisible disability
- Stigma
- Can be lifelong: considered a chronic condition
- Need for long term support for individuals/families
- Can be a risk factor for other conditions, for example Alzheimer’s Disease, epilepsy
Focus of CIHR Research Chair in Gender, Work and Health:

1. Epidemiology of work-related TBI: Cross-jurisdictional comparisons and implications for prevention
2. Return to work after work-related (wr)TBI
3. Impact of sleep disorders on vocational outcomes of men and women with wrTBI
4. Knowledge translation using research-informed dramatic productions, apps, online fact sheets
5. Capacity building
What is ‘sex’ and ‘gender’?

**Sex**
Typically refers to “...the biological and physiological characteristics that distinguish males from females”

**Gender**
Typically refers to the “...socially constructed roles, relationships, behaviours, relative power, and other traits that societies ascribe to women and men”

- Although sex (male/female) and gender (men/women) are both commonly discussed as discrete and binary concepts, CIHR acknowledges that both are fluid and dynamic.
- Sex and gender are interrelated; the relationships are complex.

(CIHR, 2010)
Epidemiology of work-related(TBI)
Searched electronic databases (e.g. Medline, Embase)

98 studies from worldwide literature were included, 23 specifically focused on wrTBI

Estimates of burden (incidence, proportion of occupational injuries or TBI), demographics, injury characteristics, outcomes
Based on worldwide estimates, approximately 2-24% of all TBI incidents are work-related.

In Ontario, 7.3% of TBI-related cases identified from the Ontario Trauma Registry are work-related (Kim et al., 2006).

In the US, the proportion of TBIs that are work-related ranged from 4-14%.
The numbers *cont’d*

TBI accounts for a large proportion of severe and/or fatal work-related injuries:

- **TBI contributed to approximately half of all workplace fatalities in Ontario, based on a review of coroners’ records** (Tricco et al., 2006)

- **20% of traumatic occupational injuries and 60% of work-related deaths in Washington State involved TBI** (Sears et al., 2013)
Brain injury in the workplace in Ontario: Lost-time claims

• Males account for the vast majority (>85%) of severe/fatal wrTBI cases

• Percent male decreases when milder injuries are included

• In Ontario, more than 40% of wrTBIs were sustained by females
  (Colantonio et al., 2010)
Rates of work related TBI by industry sector (N = 1,047)

Other primary for female group - † (small cell size) Colantonio et al., 2010
*Includes finance and insurance, business services, accommodation, food and beverage industries.
**Includes mining, forestry, fishing and trapping, agricultural and related industries.
Sex differences in work-related traumatic brain injury due to assault

Tatyana Mollayeva\textsuperscript{a,b,c,*}, Shirin Mollayeva\textsuperscript{d,e}, John Lewko\textsuperscript{f} and Angela Colantonio\textsuperscript{e,g}

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\textsuperscript{f}Centre for Research in Human Development, Humanities and Social Sciences, Laurentian University, Sudbury, ON, Canada
\textsuperscript{g}Department of Occupational Science and Occupational Therapy, University of Toronto, ON, Canada
Examining the epidemiology of work-related traumatic brain injury through a sex/gender lens: analysis of workers’ compensation claims in Victoria, Australia

Vicky C Chang,¹ Rasa Ruseckaite,²,³ Alex Collie,²,³ Angela Colantonio¹,⁴,⁵
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Male</th>
<th>Female</th>
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<tbody>
<tr>
<td>Age at injury (median)</td>
<td>37</td>
<td>40</td>
</tr>
<tr>
<td>Pre-injury income</td>
<td>![Up arrow]</td>
<td>![Down arrow]</td>
</tr>
<tr>
<td>Employer size</td>
<td>Small and medium-sized companies</td>
<td>Large companies, government</td>
</tr>
<tr>
<td>Occupation</td>
<td>Machinery operators, drivers, technicians, laborers</td>
<td>Professionals, community and personal service workers</td>
</tr>
<tr>
<td>Industry</td>
<td>Manufacturing, construction, transportation/warehousing</td>
<td>Education, healthcare</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td>Fall from an elevation, motor vehicle crashes</td>
<td>Fall from the same level, struck by/against</td>
</tr>
<tr>
<td>Claim Costs</td>
<td>![Up arrow]</td>
<td>![Down arrow]</td>
</tr>
<tr>
<td>Duration of work incapacity (mean)</td>
<td>68 days</td>
<td>41 days</td>
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</table>
Conclusions

• Need for approaches to prevention tailored to sex/gender considerations, industry, occupation

• Education is needed about the nature of re-injury after TBI and workplace context for return to work
Return to work after work-related TBI
Return to work after work-related traumatic brain injury

Angela Colantonio\textsuperscript{a,b,*}, Sara Salehi\textsuperscript{c}, Vicki Kristman\textsuperscript{d,e}, J. David Cassidy\textsuperscript{f}, Angela Carter\textsuperscript{b}, Oshin Vartanian\textsuperscript{g}, Mark Bayley\textsuperscript{b}, Bonnie Kirsh\textsuperscript{a}, Debbie Hébert\textsuperscript{a,b}, John Lewko\textsuperscript{b}, Olena Kubrak\textsuperscript{i}, Steve Mantis\textsuperscript{j} and Lee Vernich\textsuperscript{k}

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\textsuperscript{j}Research Action Alliance on the Consequences of Work Injury, Thunder Bay, ON, Canada
\textsuperscript{k}Research Service Unit, Dalla Lana School of Public Health, University of Toronto, Toronto, ON, Canada
Objectives

- Employment loss can negatively impact self-identify, autonomy, and emotional well-being
- Return to work (RTW): important goal in rehabilitation process
- Study’s objectives:
  - Compare patient profile of injured workers following TBI who have RTW to those who hadn’t
  - Identify RTW facilitators and barriers including demographic, clinical, psychosocial, environmental, and occupational factors
Methods

- Retrospective cohort study

- Participants recruited from TRI’s Neurology Services in 2010 who underwent a comprehensive assessment after referred by Ontario WSIB

- Telephone interview, with mail-in option in 2011
Perceived facilitators of RTW (n=25)

1. support from family/friends - 92%
2. support from treatment providers - 80%
3. job modifications/employer accommodation – 76%
4. medication use – 72%
5. partial recovery from injury – 72%
6. support from co-workers – 68%
7. workplace commitment to health and safety – 64%
8. early contact from employer – 48%
9. access to RTW planners/coordination – 44%
10. supervisor trained in RTW planning – 44%
Perceived barriers of RTW (n=51)

Factors most frequently selected to have hindered RTW by the participants:

1. difficulty thinking and concentrating - 92%
2. fatigue/reduced tolerance and endurance – 96%
3. pain - 88%
4. headaches – 86%
5. sleep disturbance – 82%
6. dizziness or balance problems – 80%
7. emotional/psychological issues – 76%
Return-to-work challenges following a work-related mild TBI: The injured worker perspective

Elizabeth Mansfield, Mary Stergiou-Kita, John David Cassidy, Mark Bayley, Steve Mantis, Vicki Kristman, Bonnie Kirsh, Manuel Gomez, Mark G. Jeschke, Oshin Vartanian, Joel Moody & Angela Colantonio

To cite this article: Elizabeth Mansfield, Mary Stergiou-Kita, John David Cassidy, Mark Bayley, Steve Mantis, Vicki Kristman, Bonnie Kirsh, Manuel Gomez, Mark G. Jeschke, Oshin Vartanian, Joel Moody & Angela Colantonio (2015) Return-to-work challenges following a work-related mild TBI: The injured worker perspective, Brain Injury, 29:11, 1362-1369, DOI: 10.3109/02699052.2015.1053524
When a TBI is work-related, RTW is characterized by several distinct features

1. Workers typically return to the pre-injury workplace following a wrMTBI
2. Tensions in the workplace may escalate if employers face increased costs following an occupational injury
3. The legitimacy of an injury claim might be questioned
4. Injured workers could return to workplaces where unsafe hazards and practices have not been addressed
5. When a MTBI takes place in the workplace, the injury is a public event and eliminates the individual’s choice whether to disclose a brain injury, a stigmatizing condition that can have negative effects on one’s career
Recommendations

- Increasing knowledge of employers, co-workers and workers’ compensation representatives related to physical, cognitive and psychosocial impairments resulting from MTBI so injured workers can receive appropriate supports, and mitigate discrimination, stigmatization and re-injury.

- Structural and social elements of workplace and compensation environments should inform strategies to break down barriers to successful return to work following a wrMTBI.

- Greater OHS focus on preventing re-injury following a wrMTBI.
ORIGINAL RESEARCH

Gender Influences on Return to Work After Mild Traumatic Brain Injury

Mary Stergiou-Kita, PhD, OT\textsuperscript{a,b,c} Elizabeth Mansfield, PhD\textsuperscript{b} Sandra Sokoloff, MLIS\textsuperscript{a} Angela Colantonio, PhD, OT\textsuperscript{a,b}

From the \textsuperscript{a}Department of Occupational Science and Occupational Therapy, University of Toronto, Toronto, ON; \textsuperscript{b}Toronto Rehabilitation Institute, University Health Network, Toronto, ON; and \textsuperscript{c}Institute of Work and Health, Toronto, ON, Canada.
Key Findings

6 men and 6 women with mild TBI

- “Breadwinner”, occupational roles important for both men and women
- Women were more proactive in seeking and requesting medical assistance
- More positive return to work experiences in “feminine” versus “masculine” work environments
- Employer and co worker relations were critical elements in return to work
Knowledge Translation
Heads Up: What you need to know about concussions in the workplace
Canadian Centre for Occupational Health and Safety

Heads-Up: What You Need to Know About Concussions in the Workplace

In recent years, concussions in professional athletes have received significant media attention. However, concussions can occur anywhere, including in the workplace. Statistics reveal that the number of time loss claims for work-related concussions increased by 371% in Ontario from 2004 to 2013. This increase is likely due in part to increased reporting and awareness of this injury. However, research shows that there is a general lack of understanding about concussion and how it is managed at the workplace.

What are concussions?

http://www.ccohs.ca/newsletters/hsreport/issues/2015/05/ezine.html#hsreport-ontopic
Work-related brain injury app

Designed by the “Traumatic brain injury in the workplace: Innovations for prevention” research team

- Serves as an educational resource on TBI in the workplace for employees and employers
- Currently in development; to be available through iTunes and Google Play Stores in summer/fall 2016
Guidelines for Concussion/mTBI & Persistent Symptoms: Second Edition

© 2013, Ontario Neurotrauma Foundation


Future aim is to include a gendered approach
Supplement to
Archives of
Physical Medicine and Rehabilitation

IN THIS ISSUE:
Sex, Gender, and Traumatic Brain Injury

Archives of
Physical Medicine and Rehabilitation

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Task Force on Girls and Women with ABI

The Task Force on Girls and Women with ABI evolved from 2010 meeting in Montreal, and is generously supported by the American Congress of Rehabilitation Medicine

Co-Chairs:
Angela Colantonio, PhD, FACRM & Yelena Goldin, PhD
Sex and Gender Analysis Resources

CIHR Institute of Gender and Health

Sex and gender in biomedical research

http://www.cihr-irsc-igh-isfh.ca/?lang=en

NIH Office of Research on Women’s Health

The science of sex and gender in human health

https://sexandgendercourse.od.nih.gov/

SCIENCE FACT OR SCIENCE FICTION:
TRAUMATIC BRAIN INJURY: DOES GENDER MATTER?

http://www.cihr-irsc.gc.ca/e/49000.html
www.abiresearch.utoronto.ca
angela.colantonio@utoronto.ca

Thank you

Additional Supporters:
TRAUMATIC BRAIN INJURY, SLEEP DISORDERS AND RETURN TO WORK-RELATED OUTCOMES: PART 2

Tatyana Mollayeva, MD, PhD
Postdoctoral research fellow
Rehabilitation Sciences Institute
Toronto Rehab-University Health Network
Why to study sleep in traumatic brain injury (TBI)?

What is a traumatic brain injury?
CNN - Sep 23, 2016
On Thursday, Scott's mother told CNN affiliate WCSC about a "near-death" ... A traumatic brain injury usually results from a blow to the head, such as a direct ... drowsiness, having trouble sleeping or sleeping more than usual, ...

Sleep disturbances after traumatic brain injury
Clinical Advisor - Jun 19, 2017
Traumatic brain injuries (TBIs) have become a hot topic since the 2015 film Concussion. An internet search brings up a bevy of articles about ...

Traumatic Brain Injury Can Cause Long-term Sleep Problems and ...
Newsweek - Apr 27, 2016
Traumatic Brain Injury Can Cause Long-term Sleep Problems and Excessive Daytime Sleepiness. By Jessica Firger On 4/27/16 at 5:57 PM.

Traumatic brain injuries linked with lasting sleep problems
CBS News - Apr 27, 2016

Sleep Disorders Among Troops Are More Damaging Than We Realize Task & Purpose - Apr 25, 2016
More so than even the amputations and traumatic brain injuries that ..... to stay awake and maintain alertness during daytime sleep periods, and ...

Long after brain trauma, sleep problems persist
Los Angeles Times - Apr 27, 2016
At least 18 months after sustaining a traumatic brain injury, first-time concussion victims continue to need more sleep and to suffer more daytime ...

Sleep Problems Persist in Patients With Traumatic Brain Injury
Neurology Advisor - Apr 28, 2016
Natural history and significance of sleep dysfunction in mild (m)TBI

- mTBI: *disturbed sleep* is common; a population-based longitudinal study (n=346):<10 % had sleep difficulties pre-injury, 65% had at 2 wks, and 41 % at 1 year post-injury\(^1\)

- Strong association btw *disturbed sleep* in mTBI and *psychiatric disorders*, physical and cognitive impairments, overall functioning\(^2,3\)


Relevance of sleep research in work-related (wr) mTBI

- Practical context #1: **safety concern**, i.e., particularly where there is a limited time to decide and act (i.e., high risk occupations: mining, transportation, policing, etc.)
- Practical context #2: **functional capacity**, i.e., inability to function at desired level
- Practical context #3: **regulatory** perspective on return-to-work after the injury
- **Scientific knowledge gaps**: individual differences in insufficient sleep-related performance impairment; effect of inadequate sleep, behaviour, role of disturbed circadian pacemaker on recovery post injury
The gap: sleep after wr mTBI

- Sleep function in wr mTBI and its relationship to clinical and non-clinical outcomes

- The project: *Disorders of sleep and wakefulness in Ontario workers with wr mTBI*
Research program goals

• Describe the study population: workers with delayed recovery from mTBI, and their sleep

• Investigate associations between sleep and relevant clinical and functional outcomes:
  ▪ Chronic pain
  ▪ Fatigue, alertness, and sleepiness
  ▪ Community integration, and perceived disability

• Highlight factors associated with insomnia, and those that drive deviations in sleep structure in persons with mTBI
Study participants (injured workers)

Supplementary figure 1. Flow chart depicting process of selection of participating individuals’ data for analysis. Traumatic brain injury; TBI
Results

- N=94
- Median **time since injury** = 197 days (Q1-Q3: 139-416)
- Mean **age** (SD)=45.2±9.9
- N **males** (%)= 58 (62)
- N **married/common law** (%)= 69 (73)
- N w/ **dependent children in household** (%)= 55 (61)

**Education, N(%):**
- ≤high school=34 (36)
- High school/college or prof degree= 32 (34)
- ≥university= 24 (27)

- N **native language English** (%)= 77 (82)
- Mean **pre-disability weekly income** (SD)= $1056 (510)
Pre-morbid diagnoses

- Adjustment disorder
- Anxiety disorder
- Cognitive disorder
- Mood disorder
- Previous head trauma
- Sleep disorder
- Somatoform (including...)
- Substance-related...

%n
Mechanism of mild wrTBI

- Fall (%N): 37%
- Struck by object or person (%N): 31%
- Struck against object (%N): 19%
- Motor-vehicle accident (%N): 12%
- Other (%N): 1%
## Results

### #MVCs in past 5 years

<table>
<thead>
<tr>
<th>#MVCs</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.3%</td>
</tr>
<tr>
<td>2</td>
<td>8.5%</td>
</tr>
<tr>
<td>≥3</td>
<td>3.2%</td>
</tr>
</tbody>
</table>

### Shift-work rotation

<table>
<thead>
<tr>
<th>Shift-work</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>47.9%</td>
</tr>
<tr>
<td>Rotating</td>
<td>84.4%</td>
</tr>
<tr>
<td>Night</td>
<td>36.3%</td>
</tr>
</tbody>
</table>

### #work-related injuries in past 5 years

<table>
<thead>
<tr>
<th>#Injuries</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>63.8%</td>
</tr>
<tr>
<td>2</td>
<td>17%</td>
</tr>
<tr>
<td>≥3</td>
<td>10.6%</td>
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</table>

### Accident involvement due to sleepiness

<table>
<thead>
<tr>
<th>Sleepiness</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Yes</td>
<td>8.5%</td>
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</table>

### Pre-/post-morbid sleep disorders

<table>
<thead>
<tr>
<th>Sleep Disorders</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>SA</td>
<td>10.6%</td>
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### Treated?

<table>
<thead>
<tr>
<th>Treated?</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Yes</td>
<td>80%</td>
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### Gain weight since injury

<table>
<thead>
<tr>
<th>Gain Weight</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Yes</td>
<td>68.5%</td>
</tr>
</tbody>
</table>

1 Statcan 2005
# Results

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<tr>
<th>Work status</th>
<th>Disability</th>
<th>Part-time/full-time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>57%</td>
<td>43%</td>
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<table>
<thead>
<tr>
<th>GAF score</th>
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<tbody>
<tr>
<td>51-60</td>
<td>32%</td>
<td></td>
</tr>
<tr>
<td>61-70</td>
<td>63%</td>
<td></td>
</tr>
<tr>
<td>71-80</td>
<td>5.7%</td>
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<thead>
<tr>
<th>Tension with</th>
<th></th>
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<tbody>
<tr>
<td>Employer</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td>WSIB</td>
<td>15%</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Previous WSIB claims</th>
<th>Yes</th>
<th>9%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family difficulties</td>
<td>Yes</td>
<td>62%</td>
</tr>
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</table>
Methods: diagnostic modeling¹

- Diagnostic modeling study aims to derive a model by selecting the relevant variables and combining them statistically into a multivariable model.

- We developed *frameworks* of outcomes (chronic pain, fatigues/alertness/sleepiness, community (re)integration, work disability) with *sleep/insomnia* as a primary hypothesized predictor.

- We tested these frameworks in workers with established diagnosis of w/mTBI/concussion.

---

Sleep and chronic pain

Concussion/mild traumatic brain injury-related chronic pain in males and females: A diagnostic modelling study

Tatyana Mollayeva, MD, RST, RPSGT, PhD\textsuperscript{a,b,c,*}, J. David Cassidy, PhD, DrMedSc\textsuperscript{d,e}, Colin M. Shapiro, FRCPC, MBBCh, PhD\textsuperscript{f,g}, Shirin Mollayeva, HonsBSc, MSc student\textsuperscript{h}, Angela Colantonio, OT (Reg.), PhD\textsuperscript{a,b,c}

**Main objective:**
- Investigate how sleep-related factors associate with chronic pain in males and females with wr mTBI
Hypothesis

Figure 1. Multidimensional construct of pain in traumatic brain injury. Modified from Price (1999), Brennan, Carr & Cousins (2007), and Guindon & Hohmann (2009). Unidirectional arrows between constructs (i.e., circles) and from constructs to items (i.e., rectangles) represent reflective models, and from items to constructs, formative models. Bidirectional arrows represent a combination of reflective and formative elements.
Chronic pain in **males**: stepwise linear regression analysis procedure

**Input:**
- Education
- English first language
- Marital status
- Working status
- Tension winoer
- Working>40 hours/week

**Model 1:** Cultural/ethnic
- Time since injury
- Injury occupation
- Weekly salary
- DSM-IV-TR possible/probable malingered cognitive disorder
- DSM-IV-TR substance-related disorder

**Model 2:** Behavioral/environmental
- DSM-IV-TR adjustment disorder
- DSM-IV-TR anxiety disorder
- DSM-IV-TR mood disorder
- Depression (PHQ-9)
- Anxiety (HADS-A)

**Model 3:** Psychological/psychosocial
- Mechanism of injury (falls from elevation, exposure to explosion, caught/crushed/jammed in, under or between objects)
- Restlessness
- Insomnia
- Balance issues
- Sleep issues

**Model 4:** Physiological/biomedical
- Total # of comorbid disorders
- Total # of medications
- Arthritis
- Use of narcotic analgesics, TCAs, SSRIs, recreational drugs

**Model 5:** Medication effect

**Significant (p≤0.1):**
- R²adj=28%
  - Education
  - English first language
  - Working status
  - Tension winoer
  - Working>40 hours/week

- R²adj=9%
  - Time since injury

- R²adj=23%
  - Depression (PHQ-9)
  - Anxiety (HADS-A)

- R²adj=35%
  - Mechanism of injury (exposure to explosion, falls from elevation)
  - Insomnia

- R²adj=11%
  - Total # of comorbid disorders
  - Total # of medications

**Final model:**
- R²adj=60%
  - English first language
  - Working status
  - Tension winoer
  - Anxiety (HADS-A)
  - Insomnia (ISI)
  - Mechanism of injury (exposure to explosion, falls from elevation)
  - Total # of comorbid disorders
  - Total # of medications
  - Use of SSRIs

*Each model age-adjusted*

*Figure 4. Flow diagram depicting the stepwise multiple regression analysis of pain in males. Each model age-adjusted.*

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Note: The image contains a flow diagram that illustrates the stepwise regression analysis process for chronic pain in males, with each model age-adjusted. The diagram categorizes various factors into models based on cultural, behavioral, psychological, physiological, and medication effects, and depicts the significant variables at each step of the regression analysis.
Chronic pain in females: stepwise linear regression analysis procedure

Figure 5. Flow diagram depicting the stepwise multiple regression analysis of pain in females; **each model age-adjusted **included due to consistently reported associations.
Highlights

- Pain construct **complex** in wr mTBI/concussion

<table>
<thead>
<tr>
<th>VARIABLES WITHIN</th>
<th>VARIANCE IN PAIN EXPLAINED, %</th>
<th>MALES, VARIANCE IN PAIN EXPLAINED, %</th>
<th>FEMALES, VARIANCE IN PAIN EXPLAINED, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CULTURAL/SOCIAL</td>
<td>23</td>
<td>28</td>
<td>19</td>
</tr>
<tr>
<td>ENVIRONMENTAL/BEHAVIOURAL</td>
<td>11</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>PATHO-/PSYCHOLOGICAL</td>
<td>15</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>INJURY-RELATED/PHYSIOLOGICAL</td>
<td>21</td>
<td>35</td>
<td>18</td>
</tr>
<tr>
<td>PHYSICAL/MEDICAL</td>
<td>20</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>FINAL MODEL, FULLY ADJUSTED</td>
<td>34</td>
<td>60</td>
<td>46</td>
</tr>
</tbody>
</table>

- Most significant covariates of pain in **males**: **insomnia** (24.5%), mechanism of injury falls from elevation (11%); in **females**: lower education (18%) and **# of SRBD risk factors** (13.4%)

- Final models outlined several covariates, clinical and non-clinical, worthy of further study; multidisciplinary approach is required for the diagnosis and management of pain in wr-mTBI/concussion
Fatigue, alertness, sleepiness in wrTBI

Main objective:
- To study the three perceived states among workers experiencing delayed recovery from concussion/mTBI
Biological, physiological, and behavioral causes of fatigue, alertness, sleepiness

TBI-specific

Factors impacting perception:
- Personality/stress coping ability
- Socio-economic status
- Age/sex
- Mental health
- General health
- Work load

Generic

Factors impacting examination:
- Time factor (time since injury, time of day)
- Cognitive/literacy level
- Somatization/symptom amplification
- Values/preferences
- Cultural appropriateness

Pre-/post-morbid

- Medical (psychiatric, cardiovascular, endocrine disorders, etc., multimorbidity)
- Sleep-related (primary/secondary)
- Homeostatic/circadian-driven mechanism
- Medication/drug effects, polypharmacy

Post-morbid

- Injury-related factors impacting neuronal metabolism (injury biomechanics, repeated injury, etc.)
- Inadequate sources of energy (vascular, metabolic disorders)
- Co-existed spinal cord impairments

Fatigue, alertness, sleepiness statistical modeling:
- Study across biological and behavioral levels of organizations
- Attention to the logic underlying measurement constructs
- Restricted interpretation to a priori-defined relationships

Mollayeva T, Shapiro CM, Cassidy JD, Mollayeva SM, Colantonio A. Assessment of concussion-related fatigue, alertness, and daytime sleepiness: A diagnostic modeling study. J Neurology, 2016 [under review]
Highlights

- Fatigue, alertness, and sleepiness constructs complex in mTBI

<table>
<thead>
<tr>
<th>VARIABLES WITHIN</th>
<th>FATIGUE, variance explained, %</th>
<th>ALERTNESS, variance explained, %</th>
<th>SLEEPINESS, variance explained, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOCIODEMOGRAPHIC</td>
<td>11</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>BRAIN-INJURY</td>
<td>29</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>MEDICAL</td>
<td>44</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>SLEEP-RELATED</td>
<td>31</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>SUBSTANCE/MEDICATION EFFECT</td>
<td>18</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

- Final models outlined several covariates, clinical and non-clinical, worthy of further study; multidisciplinary approach is required for the diagnosis and management of perceived states in chronic mTBI/concussion
Objectives:

- Develop model for the construct of community integration (CI) in TBI
- Investigate sleep in relation to CI in a sample of workers with delayed recovery from mTBI
Community integration
(work, social, family domains)

TBI
(mechanism, severity, previous brain injury)

Medication/substance effects
Psychological distress
Symptom load (e.g. pain)

Insomnia

Environmental characteristics (e.g. family, friends)
Non-medical factors (e.g. financial situation)
Personal characteristics (e.g. sociodemographic, clinical)
Flow chart: stepwise multiple regression analysis procedure

Model 1: Socio-demographic
(n=88)
Input*:
- Education
- English as first language
- Marital status
- Weekly salary

Input*:
- Anxiety (HADS-A)
- Axis IV-TR anxiety disorder
- Axis IV-TR substance-related disorder
- Depression (PHQ-9)
- Head and/or neck pain
- Insomnia (ISS)
- Pain (VAS-P)

Significant (p≤0.1):
- Education**
- English as first language
- Marital status***

Model 2: Clinical
(n=92)
Input*:
- Axis IV-TR possible/probable malingering
- Occupation at time of injury
- Previous claims

Input*:
- Axis IV-TR possible/probable malingering
- Sex***

Significant (p≤0.1):
- Insomnia (ISS)**
- Pain (VAS-P)**
- Sex*

Final model
(n=92)
Input*:
- Axis IV-TR possible/probable malingering
- Education
- English as first language
- Head and/or neck pain
- Insomnia (ISS)**
- Marital status***
- Sex*
- Time since injury**

Model 3: Claim-related
(n=92)
Input*:
- Extra-cranial injury/fracture/intracranial hematoma
- Mechanism of injury (e.g. struck by object/person, caught, crushed, etc.)
- Post-traumatic amnesia
- Previous head trauma
- Time since injury

Significant (p≤0.1):
- Time since injury**
- Struck by inanimate object*

Model 4: Injury-related
(n=92)
Highlights

- Variables independently associated with community integration in a fully adjusted regression model:
  - Insomnia
  - Head or neck pain
  - Being married or in a relationship
  - Time since injury
  - Diagnosis of possible/probable malingering

- CIQ total and subscale scores similar to mean scores at one year post injury in more severe TBI samples\(^1,2\)

---


Main objective:

- Investigate how sleep dysfunction, characterized as insomnia, and other known factors, associate with work disability in persons with delayed recovery from mild wTBI.
Hypothesized relationships related to mTBI disability outcome. Red colour indicates the primary hypothesis, previously unexplored. Black colour indicates other tested relationships, previously described in the literature.
# Results: logistic model work disability

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unadjusted OR (95% CI)</th>
<th>Adjusted OR (95% CI)</th>
<th>Wald χ² statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insomnia Severity Score</td>
<td>1.21 (1.10, 1.34)</td>
<td>1.15 (1.02, 1.29)</td>
<td>5.22</td>
<td><strong>0.022</strong></td>
</tr>
<tr>
<td>Age (per 5 year increase)</td>
<td>1.05 (0.83, 1.33)</td>
<td>0.98 (0.75, 1.29)</td>
<td>0.07</td>
<td>0.790</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (ref)</td>
<td>1.00</td>
<td>1.00</td>
<td>0.01</td>
<td>0.914</td>
</tr>
<tr>
<td>Female</td>
<td>1.05 (0.40, 2.72)</td>
<td>0.86 (0.28, 2.67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working part- full time(ref)</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0003</td>
<td>0.061</td>
</tr>
<tr>
<td>On disability</td>
<td>2.67 (1.29, 7.89)</td>
<td>2.92 (0.96, 8.82)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression Scale Score</td>
<td>1.17 (1.08, 1.28)</td>
<td>1.11 (0.98, 1.25)</td>
<td>2.57</td>
<td>0.111</td>
</tr>
<tr>
<td>Anxiety Scale Score</td>
<td>1.16 (1.01-1.39)</td>
<td>1.16 (0.99, 1.35)</td>
<td>3.67</td>
<td>0.067</td>
</tr>
<tr>
<td>Pain Rating Scale</td>
<td>1.04 (0.99, 1.20)</td>
<td>0.97 (0.84, 1.13)</td>
<td>2.72</td>
<td>0.710</td>
</tr>
</tbody>
</table>
Highlights

- The odds of perceiving higher work disability were greater in those with more severe clinical insomnia

- Previous confounders (depression, anxiety, pain) were not significant after full adjustment

- Results highlight focus on addressing insomnia in mild wrTBI
Understanding insomnia in wr mTBI

Objectives:

- Elucidate demographic, injury-related, clinical, psychosocial, and behavioural factors associated with insomnia in persons with mTBI
Insomnia

- Complaint of inadequate sleep despite adequate opportunity\(^1\)
- Classified according to nature of sleep disruption and duration\(^1\):
  - Difficulty falling asleep
  - Difficulty maintaining sleep
  - Waking too early
  - Feeling unrefreshed upon awakening

\(^1\)Buysse DJ. Insomnia. JAMA 2013;309: 706-16.
Daytime consequences (i.e. sleepiness/fatigue/impaired alertness/cognition)

Medical factors (i.e. other medical disorders, pain)
Psychiatric factors (i.e. anxiety, depression)
Comorbid sleep disorders (i.e. sleep apnea, restless legs)
Medication/substance effect

Insomnia

Claim-related factors (i.e. tension with employer/WSIB)
Family-, social- related factors (i.e. family difficulties, social withdrawal)
Socio-demographic factors (i.e. age, sex, and education)
Behavioural factors (i.e. irregular sleep/wake schedule, nap)

Traumatic brain injury
**Highlights**

- Nearly 69% of workers with delayed recovery from mTBI had insomnia
- In a fully adjusted model insomnia associated with age, depression, previous head injury, and wake up timing instability=> **majority of covariates are modifiable**
- Multidisciplinary approach is required for proper differential diagnoses and management of insomnia
Limitations of studies 1-5

- We used patient-reported (PR) measures to study relevant outcomes in wr mTBI/concussion; non-response bias occurred at ≈ 5% on average across all measures.

- Preceding period of sleep deprivation in mTBI may change perception; longitudinal interplay between sleep and other variables remains to be determine.

- Cross-sectional investigation – cannot provide causal evidence.

- Sample representativeness.
Prospective evaluation of sleep function in injured workers with mTBI

Main objective:

• To examine deviations in sleep stage distribution in workers with mTBI relative to population age- and sex-specific norms, and the relationships between such deviations and brain injury-related, medical/psychiatric, and extrinsic factors
Hypothesis

Fig1. Hypothesized relationships related to mTBI sleep stage distribution in comparison to sex- and age-specific normative data.
Sleep stage deviations in mTBI in comparison to age- and sex-specific normative data
Highlights

- Vs. population norms, mTBI group exhibited significantly higher nocturnal wakefulness (i.e., WASO) \((p < 0.0001)\), lower N2 \((p<0.05)\) and REM sleep \((< 0.0001)\).

- In a fully adjusted models deviations in:
  - WASO associated with DSM-IV-TR adjustment disorder and BMI
  - N2 associated with education level and insomnia
  - REM associated with pre-sleep period of wakefulness and benzodiazepine use

- These changes related to patients’ reports of emotional and physical symptoms

- *Disruption of sleep stages is detrimental to mental and bodily functions*
Strength of the wr mTBI sleep research

• Studies are hypothesis-driven

• Interdisciplinary approach, crossing neural, psychosocial, clinical, and behavioural levels of complex constructs that could be context-dependent

• Diagnoses of work-related concussion/mTBI made by a team of clinicians trained in neurology, psychiatry, psychology and other relevant disciplines

• Our methodology approach identified novel previously-undescribed associations that could be replicated and worthy of further study
Key stakeholders in wr mTBI research/practice

- Healthcare providers
- Worker’s compensation or disability insurers
- Employers
- Government agencies, labour union groups
- Injured workers, their families
Implications for healthcare providers

- Sleep is disturbed in patients with wr mTBI, associated with adverse outcomes
- The construct of sleep disturbance is complex
- The question of whether sleep dysfunction is the cause, the consequence, or develops on its own after injury as the person ages and more comorbid conditions accumulate, remains to be answered
- Timely and proper differential diagnosis followed by highly specific treatment necessary
Implications for occupational health & safety and rehabilitation

- The effects of a multidisciplinary approach to treatment and rehabilitation of persons with TBI are well documented, however rates of returning to and remaining at work at 197 days post injury are still low (i.e., 57% remain on full disability)

- Prevention efforts are extremely important:
  - Primary (e.g., identification of workplace hazards)
  - Secondary (e.g., screening for sleep dysfunction)
  - Tertiary (e.g., appropriate treatment of associated disorders, including sleep disorders, and return to the workplace, with change of job duties if necessary)
Implications for the employer

- In Canada, past decades saw labour force growth by 21.7%, an estimated half comprising shift workers.
- Overall number of workplace injuries reported declined during this period, rate of injury remained constant for shift workers.
- This study – ~50% (n=110) workers with head trauma were performing shift work at the time of their injury, higher than reported for the entire Canadian workforce.
- New hypotheses – call for comprehensive investigation of the relationship between circadian displacement due to pre-morbid shift work and variables leading to workplace injury.
Implications for the insurer

- Sleep functioning post injury has important implications for health and safety at the workplace; rarely investigated in injured workers.

- Our research raises awareness on the prevalence and range of sleep disorders experienced by workers with delayed recovery from mTBI, and highlights a potential link to shift work based on the proportion of shift workers in the study sample.
Implications for aging with TBI at the workplace

- Sleep dysfunction is common in our sample of middle aged workers with mTBI and may go uninvestigated.
- Age was identified as a covariate for insomnia as well as sleep-related breathing disorder.
- Awareness of one’s own sleep quality and investigation by a professional can promote maximal recovery and potentially keep future accidents from occurring at the workplace and beyond.
THANK YOU

Acknowledgements: Ontario men and women with mTBI/concussion who participated in sleep research

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