Actigraphy Monitoring of Sleep Disturbance and Translations to Traumatic Brain Injury

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Introduction

- Sleep disturbance is often a primary predecessor and indicator of psychopathology such as Major Depressive Disorder (MDD)[1-3].
- Disturbed sleep is among the most frequent complaints following traumatic brain injury (TBI); increased disturbance is robustly associated with worsened outcomes, including depression, pain, and cognitive impairment[4-6].
- The actigraphy use study examined the relationship between sleep disturbance, specifically sleep efficiency (SE), and depressive symptoms.
- As an index of sleep fragmentation, SE better captures sleep quality than does total sleep time, and indicates disruptions to the restorative properties of sleep.
- The TBI study hypothesized that increased reported sleep disturbance following TBI would positively predict subsequent post-injury depressive symptoms.
- Objective and efficient methods to measure sleep are needed to better assess and treat TBI and MDD symptoms, improving the tracking of treatment outcomes.

Actigraphy Study - Methods

Participants

- 75 adults, fluent English speakers. 53 females (mean age = 24.6, SD = 4.5).
- Community sample recruited on a continuum of depressive symptoms.

Initial Questionnaires

- During initial meeting, subjects completed mood and sleep related surveys including the Pittsburgh Sleep Quality Index (PSQI) and the Beck Depression Inventory (BDI-II) assessment.
- Subjects were also assessed for depressive symptoms using the Mini International Psychiatric Interview (MINI).

Subjects wore Actiwatches & completed daily questionnaires for one week of standard daily activities.

Actigraphy

- During the first session, subjects received wrist worn accelerometers (Philips Actiwatch 2) which were worn for 7 days continuously.
- Subjects reported factors related to their sleep patterns in daily questionnaires.
- Actigraphy data was processed and reported with Philips Actiware Software.

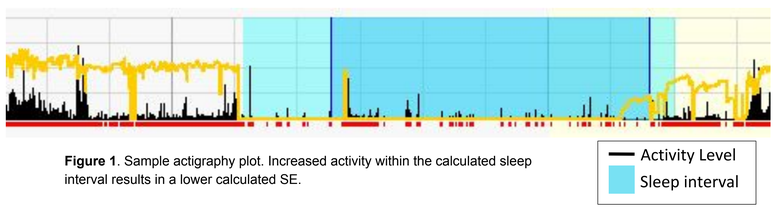

Figure 1. Sample actigraphy plot. Increased activity within the calculated sleep interval results in a lower calculated SE.

Efficiency Scoring

- Daily SE calculated from sleep intervals. Equals: nocturnal sleep time / total rest interval time.
- Overall SE is mean of each daily SE.

Actigraphy Study - Results

- Negative relationship between PSQI and SE (b = 0.907, p = 0.017). *25 participants were excluded for missing PSQI data.*
- Negative relationship between BDI-II and SE (b = 0.903, p = 0.012).
- Relationship between BDI-II and SE no longer significant after controlling for PSQI.

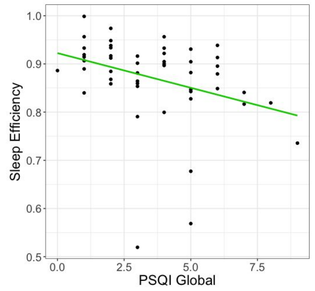

Figure 2. Sleep efficiency by PSQI Global.

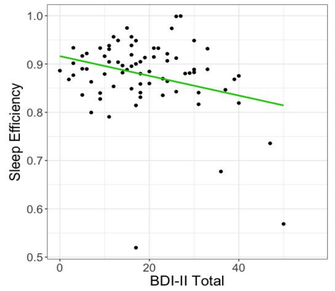

Figure 3. Sleep efficiency by BDI-II Total.

- In a linear mixed model with BDI-II and MDD Diagnosis as predictors, BDI was no longer a significant predictor of sleep efficiency (b = 0.0004, p = 0.73). MDD was trending (b = 0.09, p = 0.07).
- Significant interaction between BDI and MDD Diagnosis in predicting sleep efficiency (b = -0.005, p = 0.02). Stronger relationship between BDI-II and sleep efficiency in individuals with MDD.

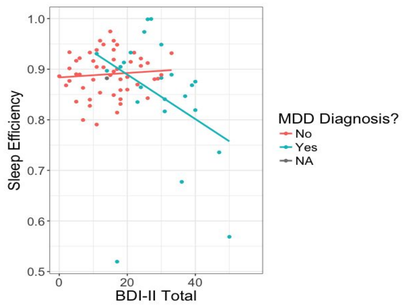

Figure 4. Sleep efficiency by BDI-II Total and MDD diagnosis.

TBI Study – Methods

Participants

- 305 adults from total sample of 599 in TRACK-TBI study[7], fluent English speakers. 90 females, 215 males (mean age = 42.7 SD = 17.7).
- Inclusion criteria: Age 18+, acute brain CT, ability to provide consent.
- Exclusion criteria: pregnancy, incarceration, significant physical trauma, pre-existing conditions that interfere with assessment (MRI contraindication, neurological disease, etc.).

Measures - Injury Severity at Intake; Outcomes 3- and 6-months post-injury.

- Demographics (incl. medical history, e.g. prior TBI, history of depression).
- Glasgow Coma Scale (GCS): Level of consciousness, from 3 (most severe) to 15 (normal function). Scores ≥ 13 classified as mild TBI, < 13 as moderate/severe TBI.
- Sleep Disturbances: Two binary hypersomnia and insomnia questions, collapsed into composite, each ranging from 0 (no disturbance) to 2 (most disturbance).
- Sadness: Yes/No response. **3 Month Only.**
- Brief Symptom Inventory (BSI): Depression subscale (range 0-24). **6 Month Only.**

References

1. Diagnostic and Statistical Manual of Mental Disorders. 5. Arlington, VA: American Psychiatric Association; 2013.
2. Tsuno N, Besset A, Ritchie K. Sleep and depression. J Clin Psychiatry. 2005; 66:1254–69. [PubMed: 16259539]
3. Chen MC, Burley HW, Gotlib IH. Reduced sleep quality in healthy girls at risk for depression. J Sleep Res. 2012; 21:68–72. [PubMed: 21702865]
4. Wickwire EM, Williams SG, Roth T, et al. Sleep, Sleep Disorders, and Mild Traumatic Brain Injury. What We Know and What We Need to Know: Findings from a National Working Group. *Neurotherapeutics : the journal of the American Society for Experimental NeuroTherapeutics*. 2016;13(2):403-17.
5. Ouellet MC, Beaulieu-Bonneau S, Morin CM. Sleep-wake disturbances after traumatic brain injury. *The LancetNeurology*. 2015;14(7):746-57.
6. Gilbert KS, Kark SM, Gehrman P, Bogdanova Y. Sleep disturbances, TBI and PTSD: implications for treatment and recovery. *Clinical psychology review*. 2015;40:195-212.
7. TRACK-TBI. David M. Schnyer (UT Austin), Emerson Wickwire, Jennifer S. Albrecht (Univ. of Maryland), Wayne A. Gordon (Icahn School of Medicine at Mount Sinai, NYC), David O. Okonkwo (Univ. of Pittsburgh), Alex B. Valadka (Virginia Commonwealth Univ.), Mary Vassar, John Yue, Geoffrey T. Manley (UCSF).

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TBI Study – Results

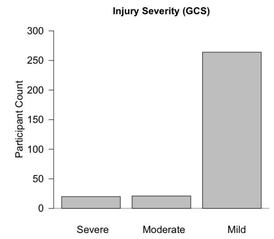

Figure 5. Distribution of GCS scores by category. Severe = 3-9, Moderate = 10-12, Mild = 13-15.

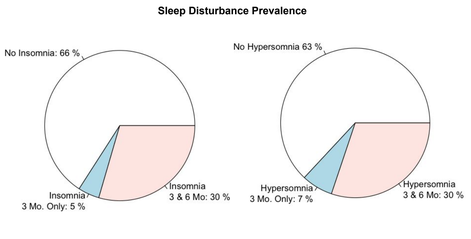

Figure 6. Proportion of the sample who reported symptoms of insomnia (left) and hypersomnia (right).

- Using Wilcoxon rank sum: significantly greater BSI scores relative to control for participants who reported insomnia (p > .001) and hypersomnia (p > .001).
- Models between sleep disturbance and BSI used **rate ratio** (RR) to measure associations between variables.
- RR significantly >1 = significant effect of given variable (95% CI shown).

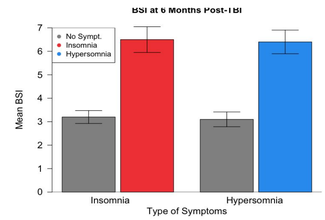

Figure 7. BSI 6-Months post-injury by 3-Month sleep disturbance.

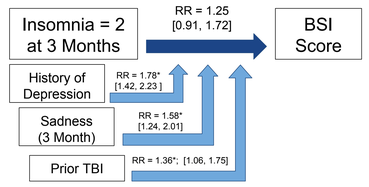

Figure 8. Illustration of regression model of insomnia at 3 months post-injury predicting BSI at 6-months post-injury.

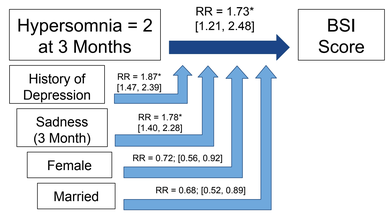

Figure 9. Illustration of regression model of hypersomnia at 3 months post-injury predicting BSI at 6-months post-injury.

- Potential confounding variables controlled for if: a) non-significant in bivariate analysis with BSI, and b) effect estimate was not changed by >10%.
- Hypersomnia, but not insomnia, significantly predicts depression at 6-months post-injury.
- Models which also include participants who reported one insomnia/hypersomnia symptom also yield similar results, and significant variables.

Discussion

- Findings from the actigraphy study suggest that individuals with more depressive symptoms experience a decreased quality of sleep, specifically SE.
- The TBI study found that symptoms of hypersomnia but not insomnia were predictive of depression, after adjusting for confounding variables.
- Unlike actigraphic measures of SE, the two-item insomnia scale used in the TBI study did not assess difficulties in maintaining sleep and so cannot be considered a comprehensive assessment.
- While the TBI study failed to confirm previous findings regarding depression and difficulties maintaining sleep, actigraphy supports this link.
- These results demonstrate the utility of actigraphy for accurately measuring sleep quality objectively in a naturalistic setting, a critical feature which could benefit future research and treatment monitoring with MDD and TBI populations.
- Additionally, the ability of actigraphy to identify poor SE on a continuum of depressive symptoms indicates its potential for detecting early signs of changing symptoms in depressed and TBI populations.