

## **Sleep and exercise: Longitudinal associations throughout recovery from adolescent concussion**

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**Introduction:** Higher volumes of moderate-to-vigorous physical activity (MVPA) and reduced time in bed awake (i.e., insomnia) are associated with faster time to symptom resolution after concussion. Bidirectional associations likely exist between exercise and sleep throughout recovery. Our purpose was to understand how sub-acute post-concussion MVPA and time in bed awake bidirectionally affect subsequent MVPA and time in bed awake later in recovery.

**Methods:** We prospectively enrolled 10–18-year-olds in an observational study of post-concussion sleep and physical activity. Participants were provided wrist-worn actigraphy devices within 18-days of concussion which they were instructed to wear during all exercise and sleep for a 14-day monitoring period after study enrollment. We recorded min/day spent in moderate-to-vigorous physical activity (MVPA) and min/night spent in bed awake. Daily MVPA and time in bed awake were averaged for days 1-7 and 8-14 of the monitoring period independently.

We used structural equation modeling to develop a cross-lagged panel model; Variables of interest included: MVPA days 1-7, MVPA days 8-14, time awake days 1-7, and time awake days 8-14. Cross-lagged models use regression analyses to determine how variables at one timepoint (i.e., days 1-7) affect variables at a second timepoint (i.e., days 8-14).

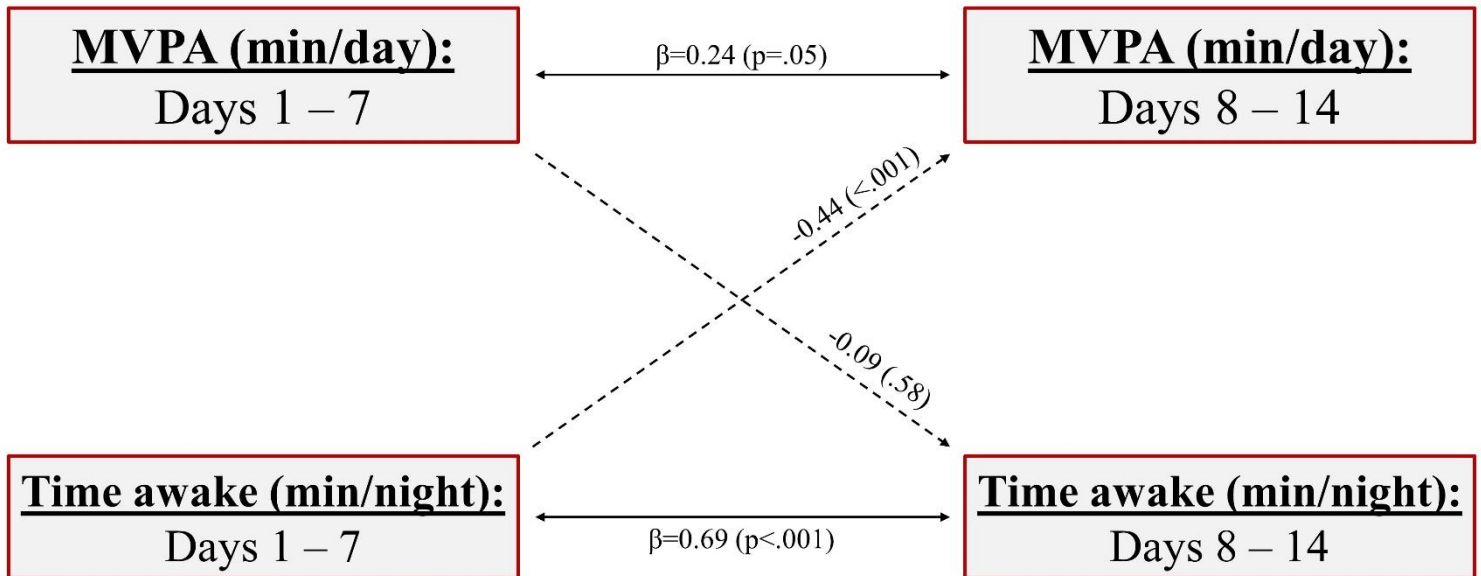
**Results:** We enrolled 49 adolescents (15.01±1.6 years old, 55% female) 7.63±3.7 days post-concussion. Across the entire sample, mean MVPA was 29.7±24.9 min/day for days 1-7 and 33.8±45.3 min/day for days 8-14. Mean time in bed awake was 61.1±16.1 min/night for days 1-7 and 62.6±19.6 min/night for days 8-14. Cross-lagged coefficients indicate that a ten-minute increase in time in bed awake during days 1-7 was significantly associated with a 4.4-minute decrease in MVPA time during days 8-14 ( $p<.001$ ). The inverse relationship (MVPA during days 1-7 and time awake during days 8-14) was non-statistically significant ( $p=.58$ ).

**Discussion:** Greater time in bed awake during days 1-7 was associated with reduced MVPA during days 8-14. Inversely, early engagement in MVPA was not associated with substantial changes in sleep later in recovery.

**Significance:** This analysis demonstrates the importance of reducing time in bed awake early after concussion to increase MVPA time later in recovery to improve recovery outcomes. Clinicians may continue to address concussion-induced sleep disturbances through evidence-based treatments.

## References:

1. Rademacher et al., *J Sport Rehabil.* 2023; 9:1-7. doi: 10.1123/jsr.2023-0022
2. Neely et al., *Phys Med & Rehabil.* 2022. doi: 10.1002/pmrj.23939
3. Howell et al., *J Child Neurol.* 2019; 34(5):256-261. doi: 10.1177/0883073818824000.



**Figure.** Cross-lagged panel model describing cross-lagged effects (dashed arrows) and autoregressive effects (solid arrows). Data are presented as: cross-lagged or autoregressive coefficient (p-value).

### ***Simple interpretation:***

Cross-lagged effects indicate that time spent in bed awake during days 1-7 significantly predicts time spent in MVPA during days 8-14. However, MVPA time during days 1-7 is not significantly associated with time in bed awake during days 8-14.

Autoregressive effects indicate that time spent in bed awake is relatively stable between days 1-7 and 8-14; whereas time spent in MVPA is less stable across time and potentially more susceptible to within-subjects longitudinal change (i.e., individual patient MVPA may change over time).