Integrated Recovery Strategies: How Concurrent Sleep and Exercise Early in Concussion Recovery Relate to Symptom Resolution

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Disclosures: Mathew Wingerson (N), Katherine Smulligan (N), Samantha Magliato (N), Stacey Simon (N), Julie Wilson (N), David Howell (has received research funding for work not relevant to this submission: R03HD094560, R01HD108133, R01NS100952, R43NS108823, 1R13AR080451).

Background: Adolescents with concussion who exercise or have minimal sleep problems soon after injury tend to recover faster. However, exercise and sleep are often examined independently. Thus, we investigated: (1) relationships between concurrent sleep and exercise early in concussion recovery and symptom resolution time, and (2) factors predicting engagement in concurrent early sleep and exercise after concussion.

Methods: We reviewed medical records of 8-18-year-olds presenting within 21 days of concussion. We recorded demographics (age, sex, medical history), injury characteristics (time to clinical presentation, concussion history), initial cognitive and somatic symptom burden (via the health and behavior inventory [HBI]), and days to self-reported symptom resolution. Patients recorded whether they had begun exercise (yes/no) and experienced sleep problems (yes/no) in the time between injury and initial clinical presentation. Based on these responses, patients were grouped as: exercising and sleeping well (+Ex/+Sleep), exercising and sleeping poorly (+Ex/-Sleep), not exercising and sleeping well (-Ex/+Sleep), not exercising and sleeping poorly (-Ex/-Sleep). We constructed a Cox Proportional Hazards model with outcome of symptom resolution time (days post-concussion). Last, a single logistic regression predicted the odds of +Ex/+Sleep group membership (yes/no), including demographics, injury characteristics, and initial cognitive and somatic symptom burden as predictors. Model selection of stepwise elimination retained only predictors with $p<0.10$.

Results: Among 335 adolescents (14.4±2.3 years old; 38% female) assessed 8.6±5.4 days post-concussion, group distributions were as follows: +Ex/+Sleep: 46 (14%), -Ex/-Sleep: 96 (29%), -Ex/+Sleep: 184 (55%), and +Ex/-Sleep: 9 (3%). Demographics were similar across groups (Table 1). Compared to the +Ex/+Sleep group, the hazard of prolonged time to symptom resolution was increased by 2.02 (95% CI: 1.42-2.88) times for the -Ex/-Sleep group, 3.89 (95% CI: 1.81-8.33) times for the +Ex/-Sleep group, and 1.76 (95% CI: 1.27-2.44) times for the -Ex/+Sleep group (Figure 1). Logistic regression showed that a one-point increase in somatic symptom burden and one-day increase in time from injury to initial clinical presentation corresponded to a respective 12% (95% CI: 3-20%) reduction and 9% (95% CI: 3-16%) increase in odds of +Ex/+Sleep group membership. Cognitive symptom burden was not associated with odds of +Ex/+Sleep.

Discussion: Adolescents engaging in exercise and sleeping well after concussion recovered faster compared to those exhibiting one or neither behavior. Presenting later post-injury and with lower initial somatic, but not cognitive, symptom burden increased the odds of concurrent early exercise and sleep.

Significance: Clinicians may emphasize early exercise and quality sleep, with an understanding that symptom limitations may exist, to facilitate concussion recovery among adolescents.

Table 1. Sample demographics presented as Mean (Standard Deviation) for continuous variables or N (percent in group) for categorical variables.

Variable	M (SD) or N (%)
Age (years)	14.48 (2.3)
Sex (female)	127 (37.9%)
Concussion history (1 or more)	145 (43.3%)
History of sleep problems	28 (8.4%)
Initial symptom burden (HBI score)	19.58 (12.9)
Time between concussion and clinical presentation (days)	8.64 (5.3)
Time to symptom resolution (days)	21.46 (23.5)

Figure 1. Cox proportional hazards model.

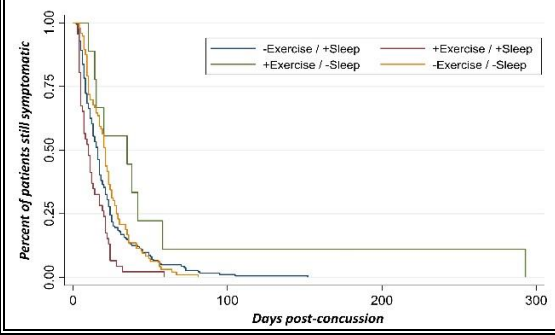

Table 2. Logistic regression predicting the odds of +Exercise/+Sleep group membership (vs membership in any other group). Results are presented as Odds Ratio, 95% Confidence Interval of the Odds Ratio, and p-value.

Predictor	Odds Ratio	95% Confidence Interval	P-value
Time between concussion and clinical presentation	1.09	1.03, 1.16	0.004
History of depression	4.56	0.83, 25.18	0.08
HBI cognitive symptoms	0.94	0.87, 1.00	0.06
HBI somatic symptoms	0.88	0.80, 0.97	0.01