Chronic, but Not Acute, Sleep Duration Is Associated with Faster Cognitive Processing in Adolescents

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Adolescence is a critical period for neurodevelopment, marked by synaptic remodelling and maturation of cortical and subcortical networks supporting executive function, learning, and emotional regulation. Sleep modulates these neurocognitive systems, and insufficient or irregular sleep during this time is linked to deficits in attention, memory, and academic performance. However, the relative impact of acute versus chronic sleep patterns on cognition remains unclear. Tappigraphy (a smartphone-based AI method analyzing touchscreen interactions) offers unobtrusive, longitudinal monitoring of sleep and cognition in ecological settings. We analyzed tappigraphy data from 21 male adolescents (mean age ≈ 16.9 years) over 1404 nights (mean 67 nights/participant). Daily sleep duration and Speed Score (a tappigraphy-derived measure of processing speed) were assessed. Chronic sleep effects were tested via linear regression of participants' mean sleep duration against their mean Speed Score, adjusting for age. Longer average sleep was significantly associated with faster processing speed ($\beta = 2.08$, SE = 0.97, $p = 0.002$), explaining ~44% of interindividual variance. Acute effects were tested using repeated-measures correlation. A small but significant negative correlation was observed between nightly sleep deviations and next-day Speed Score ($r = -0.07$, $p = 0.015$), indicating minimal within-subject sensitivity to sleep variability. These findings suggest that adolescents may acutely compensate for sleep loss via transient hyperarousal mechanisms, as previously described by van Dongen and colleagues. However, chronic sleep restriction impairs cognitive efficiency. This highlights the importance of long-term sleep health for neurocognitive development and supports tappigraphy as a scalable approach for monitoring sleep and cognition.

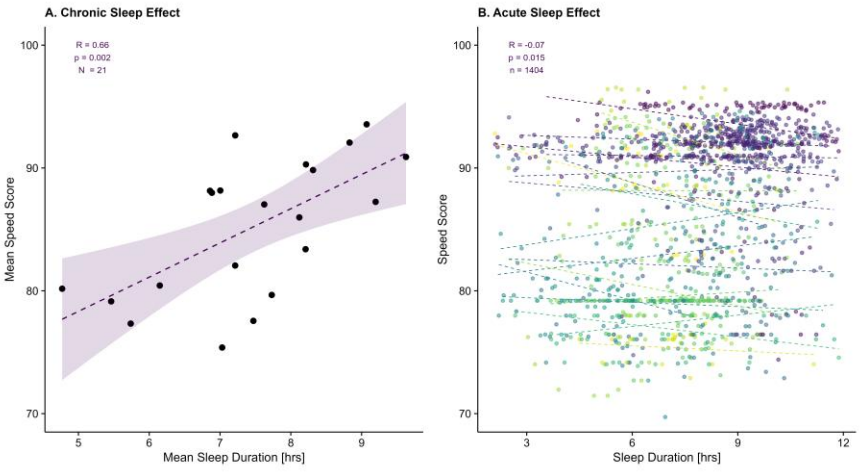

Figure 1. Chronic and acute associations between sleep duration and cognitive processing speed in adolescents. (A) Chronic sleep effects: Between-subject association between participants' mean sleep duration and mean Speed Score. Each point represents a participant's average across ≥15 nights (n = 21). A significant positive association was observed after adjusting for age ($\beta = 2.08$, SE = 0.97, $p = 0.045$; $R^2 = 0.44$), indicating that adolescents with longer habitual sleep durations exhibited faster cognitive processing. (B) Acute sleep effects: Within-subject association between nightly sleep duration and next-day Speed Score across 1404 nights. Colored points represent individual participants; dashed lines indicate within-subject linear trends. A small but significant negative correlation was observed (repeated-measures correlation: $r = -0.07$, $p = 0.015$), suggesting minimal sensitivity of cognitive speed to nightly sleep variation. Shaded areas represent 95% confidence intervals (CIs). Abbreviations: SE = standard error; CI = confidence interval.