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Longitudinal relationships of sleep and inhibitory control deficits to early adolescent cigarette and alcohol use

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ABSTRACT

Research in older adolescents suggests insufficient sleep may increase substance use initiation risk. This study tested whether sleep duration and dysregulation of sleep-wake patterns in late-elementary school youth were prospectively associated with cigarette and alcohol use initiation and how sleep-related changes in inhibitory control mediate these relationships. Average sleep duration at 4th grade predicted 6th grade cigarette but not alcohol use, however indirect effects were identified through 5th grade inhibitory control to both cigarette and alcohol use. Indirect effects were also identified through inhibitory control for relationships between 4th grade weekend bed-time delay and 6th grade cigarette or alcohol use, and for relationships between 4th grade weekend wake-time delay and 6th grade cigarette or alcohol use. Reductions in nightly sleep increased risk of cigarette use. Findings suggest a pathway linking both reduced sleep duration and greater weekend shifting of sleep patterns to future substance use through sleep-related inhibitory control deficits.

1. Introduction

Substance use initiation during early adolescence has been associated with numerous long-term health risks, including elevated risk of dependence or abuse later in life (Dawson, Goldstein, Chou, Ruan, & Grant, 2008; Lopez-Quintero et al., 2011). Approximately 7.7% of US middle school students have tried a tobacco product (Arrazola et al., 2015) and 27% have tried alcohol (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2017). Despite substantial reductions in adolescent cigarette smoking and alcohol use over recent decades, both substances remain leading causes of preventable death in the US and worldwide (Yoon, Bastian, Anderson, Collins, & Jaffe, 2014).

Recent research with high school youth suggests that insufficient sleep may constitute an important predictor of both cigarette and alcohol use (Pasch, Laska, Lytle, & Moe, 2010). Sleep has multiple parameters, the most studied of which include average nightly duration and differences in wake and bed-times between weekdays and weekends. For example, a study by Pasch and colleagues identified prospective relationships between weekday, but not weekend sleep hours and both cigarette

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and alcohol use in a middle and high school-aged cohort (Pasch, Latimer, Cance, Moe, & Lytle, 2012). This study extended two previous cross-sectional studies by prospectively linking self-reported sleep duration (Fischer, Nagai, & Teixeira, 2008; Pasch et al., 2010), sleep problems (Patten, Choi, Gillin, & Pierce, 2000), and shifting of weekend bedtime relative to weekday bedtime (O'Brien & Mindell, 2005), to increased rates of substance use among middle and high school students. Proposed were two mechanisms through which these effects may occur: sleep-related deficits in emotional regulation, and sleep-related deficits in other executive functions (EFs), most notably inhibitory control.

EFs are associated with both sleep behavior (Durmer & Dinges, 2005; Killgore, 2010) and youth substance use (Pentz & Riggs, 2013; Riggs, Spruijt-Metz, Chou, & Pentz, 2012) and have been shown to support emotional regulation, inhibition of impulsive behaviors and promotion of adaptive self-regulatory and goal-directed behaviors, which may facilitate choosing alternatives to substance use (Pentz & Riggs, 2013). Furthermore work by Wong et al. demonstrated prospective associations between parent-reported childhood (age 3–8) sleep problems and illicit substance use outcomes in young adulthood (age 18–20), mediated by performance on a computerized inhibitory control task in late adolescence (age 15–17) (Wong, Brower, Nigg, & Zucker, 2010). Taken together, these findings suggest that EFs—particularly the subdomain of inhibitory control—may also mediate effects of reduced sleep duration or greater sleep dysregulation on substance use initiation risk in early adolescence—a critical developmental period associated with substance use experimentation. However, this hypothesis has not yet been formally tested.

A recent review by Hasler et al. proposes a framework through which weekend shifts in sleep-wake patterns may influence adolescent substance use behaviors through impaired self-regulation (Hasler, Soehner, & Clark, 2015). In their view, early school start times and children's chronobiological tendency toward later bed and wake times across adolescence (Crowley, Acebo, & Carskadon, 2007) lead to misalignment of children's natural circadian rhythms. Since the circadian rhythms governing sleep during childhood adapt more readily to delayed bedtimes than advanced wake-times (Dahl & Lewin, 2002), children who delay their bed-times on weekends relative to weeknights, typically experience greater difficulty falling asleep and sleep loss on weeknights (Hasler et al., 2015). Converging neuroscientific evidence suggests that such sleep disruptions selectively impair reward processing, leading to increased sensitivity to rewards and devaluation of potential losses (Holm et al., 2009). Such a shift would thus predispose children toward novel, risk-taking behaviors, such as the alcohol and cigarette initiation outcomes observed in the present study. Within this paradigm, a child's ability to inhibit a prepotent behavioral response which is biased toward risk-taking as a result of sleep loss may serve a key mediational role within the substance use initiation pathway.

As such, the aims of the present study were: **1)** To determine whether the prospective relationships between reduced sleep duration and increased substance use risk identified by Pasch et al. operate similarly in late-elementary age youth who are first initiating substance use compared to the middle or high school youth previously studied, and **2)** To test whether sleep-related changes in inhibitory control or other EF subdomains mediate these prospective relationships between sleep patterns and substance use initiation risk.

2. Methods

2.1. Background

Study data were gleaned from the fourth (baseline), fifth, and sixth grade waves of assessment in *Pathways to Health*, a cluster randomized control trial for the prevention of multiple obesity-related behaviors (Sakuma, Riggs, & Pentz, 2012).

2.2. Participants

Participants were 1005 4th grade assented students with full active parental consent to participate in the study. Of these, 709 participants had complete data for all three years and constituted the analysis sample for the present study. Of the 296 participants who did not have complete data, 249 (85%) were lost due to families moving out of the study area, 18 (6%) were lost due to student, parent, or administrator decline at a follow-up assessment, and 29 (10%) were lost due to student absence on days of assessment. When compared to the 709 study participants the 296 participants lost to follow-up were more likely to be Hispanic (33% vs. 26%; $p < 0.05$) and low SES (35% vs. 21%; $p < 0.001$). The two groups did not differ significantly on any other study variables. The final analytic sample was 50% female, 26% Hispanic and 21% low-SES with a mean age of 9.27 (SE = 0.47; range 8–11 years) at fourth grade. These students represent 75 classrooms and 24 Southern California schools. All human subjects procedures were approved by the appropriate Institutional Review Board.

2.3. Measure

Data for the study were drawn from a 145-item self-report survey administered to children during an in-school assessment period. The survey included the following variables: