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The Influence of Sleep Quantity on Externalizing Behaviors in Adolescents: The Mediating Effect of Inhibition

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Abstract

Adolescents are particularly vulnerable to sleep disruptions due both to hormonal changes (causing a shift in circadian rhythms, Pieters et al., 2015) and to school and extra-curricular commitments leading to sleep restriction (Carskadon, 2011). Sleep quantity, in turn, has been independently linked to low response inhibition as well as externalizing behaviors (Lowe et al., 2017; Gregory & Sadeh, 2012). This study aims to build upon these findings by testing the hypothesis that decreased inhibition will mediate the relationship between low quantity of sleep and externalizing behaviors. A representative sample of adolescents in Chicago, Illinois was recruited to participate in a larger study of stress processes. Ninety-four of the participants were randomly selected from the larger study to also take part in a 4-day actigraph watch collection to track sleep quantity. Regression analyses identified associations between sleep quantity and inhibition and externalizing symptoms, whereas there were no associations identified between sleep quantity and inhibition. Results of mediational analyses wherein inhibition was tested as a mediator of the effects of sleep quantity on externalizing symptoms were not significant. Yet, the findings of this study can inform prevention and intervention strategies for at-risk youth as well as guide future research on risk and protective factors.

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Introduction

A connection has been established between adolescence and externalizing behaviors, and between sleep quantity and externalizing behaviors. Decreased sleep may be one reason why externalizing behaviors increase during this period of vulnerability. A potential mechanism through which sleep predicts increased externalizing behaviors is lower inhibition. This study aims to investigate the potential influence sleep quantity has on inhibition as a possible mediator of sleep effects on externalizing problems during adolescence, to better inform intervention and prevention efforts.

Externalizing Behaviors

Externalizing behaviors are problematic actions that are enacted on the environment, characterized by "prominent impulsive, disruptive conduct, and substance use symptoms" (American Psychiatric Association, 2013). Frick and colleagues (1993) conducted a meta-analysis of factor-analyses within 44 studies examining externalizing behaviors with over 28,000 adolescents and concluded that externalizing behaviors are characterized by opposition, aggression, property violations, and status violations. Aggression involves physical or verbal actions that threaten or cause harm to other children, adults, or animals (Liu, 2004). Property and status violations are delinquent behaviors, or acts that involve breaking the law or social expectations (Liu, 2004). Externalizing behaviors are more common in boys and increase over the course of adolescence (Scaramella et al., 1999). A variety of factors may influence the continuity and severity of externalizing behaviors, one of which may be sleep quantity.

Sleep during Adolescence

Sleep is defined as “a condition of body and mind that typically recurs for several hours every night, in which the nervous system is relatively inactive, the eyes closed, the postural muscles relaxed, and consciousness practically suspended” (“Sleep”, 2021). Nine to ten hours is the current sleep recommendation for adolescents; unfortunately, it is estimated that only 20% are meeting this goal (Sosnowski et al., 2016). Additionally, poor sleep appears to be more common in girls than boys (Galland et al., 2017). Adolescence marks a transition, physically and socially, which has an impact on sleep patterns (Sosnowski et al., 2016). The increased independence and decreased parental monitoring combined with pubertal changes leads to an increase in sleeping problems at this age (Sosnowski et al., 2016).

On a biological and social level, puberty brings a set of challenges to an individual’s sleep patterns (Pieters et al., 2015, p. 380). First, it is well documented that adolescents experience a delayed phase preference, wherein they prefer to sleep and wake at later times while school start times are generally quite early (Pieters et al., 2015). Next, the transition to high school may result in a subsequent increase in academic and social responsibilities that may impede a healthy bedtime, resulting in decreased total sleep time (Pieters et al., 2015). There also may be a large discrepancy in sleep schedules between weekdays and weekends, interfering with regulation of circadian signals and internal sleep drive (Pieters et al., 2015). These factors, a delayed phase rhythm, increased social demands, and heightened academic pressure all contribute to difficulties sleeping in this age group. More recent findings have depicted the adverse effect of screen time on sleep quantity, wherein adolescents engaging in technology use before bed sleep less and have more problems with their sleep quality (Arora et al., 2013; Galvan, 2020). The literature has found that 11 - 47% of adolescents experience troubles falling and staying asleep, and 20 - 25% report excessive daytime sleepiness, and nonrestorative sleep (Pieters et al., 2015).

Particularly salient in the sample utilized in the present study, there is emerging evidence of the presence of sleep disparities. Cultural, social, and systemic factors shape sleep practices (Patel et al., 2010). Sleep quantity can be correlated with socioeconomic class, such that individuals of a low socioeconomic status report lower quality sleep (Patel et al., 2010). A cross-sectional study with 9,714 participants, 65.7% white and 73.1% above the poverty line, found that white individuals living in poverty had comparatively significantly worse sleep than those of a higher SES (Patel et al., 2010). However, African American individuals above the poverty line received poorer sleep compared to their white counterparts as well as lower SES African Americans (Patel et al., 2010). Across the literature, poverty has been found to contribute to lower quantity of sleep, independent of race (McElfish et al., 2021). A longitudinal study conducted by Sheehan and colleagues found that among their 2720 participants (M age = 6.8) living in historically impoverished neighborhoods had poorer sleep and a lower sleep quantity (Sheehan et al., 2017). El-Sheikh and colleagues (2013) assessed SES and objectively collected sleep quantity data among 276 youth (M age = 9.44); results demonstrated a significant relationship between lower SES and poorer sleep, as well as greater parent-reported sleep difficulties. This study found that race moderated the connection, wherein SES had a greater, negative impact African American youth than white youth (El-Sheikh et al., 2017). Independent of race, low-income youth face a greater number of risk factors specific to their environment, including inadequate housing, toxins, pollution, exposure to violence, noise, and overcrowding (Evans & Kim, 2007). Additionally, low SES parents engage in more harsh and unresponsive parenting practices, and these families report increased conflict and a higher risk of separation.

These experiences negatively alter the physiological processes, contributing to poorer physical and behavioral health outcomes (Evans & Kim, 2007).

Sleep and Externalizing Problems

The relationship between insufficient sleep and externalizing behaviors is relatively well established. At least 16 studies have connected the neurological and cognitive effects of inadequate sleep to externalizing problems (Armstrong et al, 2014; Barclay et al., 2011; Becker et al., 2015; Clinkinbeard et al., 2011; Gregory & Sadeh, 2012; Jiskrova et al., 2019; Merikanto et al., 2017; Peach & Gaultney, 2013; Pieters et al., 2015; Quach et al., 2018; Sosnowski et al., 2016; Susman et al., 2007; Wong et al., 2009; Wong et al., 2010). For example, Clinkinbeard and colleagues (2010) found that adolescents getting five or less hours of sleep were significantly more likely to engage in delinquent behavior than those obtaining at least eight hours. Most of these studies have been cross-sectional but two longitudinal studies have reported similar patterns (Gregory & O'Connor, 2002; Pieters et al., 2015). In particular, Pieters and colleagues (2015) and Gregory and O'Connor (2002) have found sleep problems to be an antecedent to the development of externalizing problems in adolescence.

While the relationship between insufficient sleep and externalizing behaviors is relatively well established, the underlying mechanisms that explain the connection are not well understood. There is limited literature examining potential mediators in the association between low sleep quantity and externalizing behaviors (Gregory & Sadeh, 2012). This study aims to explore inhibition as one such possible mediator.

Inhibition

Inhibition is part of executive functioning, which refers to the cognitive processes involved in planning, starting, and regulating goal-directed actions (Wong et al., 2010). Inhibition (or response inhibition) is the ability to use cognitive skills and new information to perform a less natural response (Wong et al., 2010). Inhibition is tied to planning and self-regulation (Wong et al., 2010).

Broadly, executive functioning is negatively impacted by low sleep quantity and quality. While the evidence is still emerging, it is likely that sleep problems predict challenges with executive functioning in developing children, explaining the relationship between poor daytime functioning and low sleep quality (Turnbull et al., 2013). Executive functioning skills require cognitive energy and a level of intentionality; when an individual is tired from a poor night's sleep, their capacity for utilizing EF skills is compromised (Turnbull et al., 2013). This may be particularly true for children and adolescents as these brain areas and behavioral pathways are still developing (Turnbull et al., 2013). Anderson and colleagues (2008) found that sleepiness was significantly related to both parent-reported and performance measured deficits in global executive functioning among a sample of 236 adolescents (M age = 13.6).

Inhibition works through the prefrontal cortex (PFC); and, one night of sleep loss leads to deficits in PFC functioning (Anderson & Platten, 2011). A key predictor of inhibition is emotion regulation, which is also disrupted by decreased sleep (Anderson & Platten, 2011). Following loss of sleep, there is an increase in amygdala activity in response to negative events, which is difficult to tamper given the reduced PFC functionality (Anderson & Platten, 2011). This amplification of emotional responses following negative events leads to greater emotional reactivity and impulsivity (Anderson & Platten, 2011).

Most studies of sleep effects on inhibition have been conducted with adult samples. This research shows that low sleep quantity has a negative impact on cognitive processes, such as inhibition (Durmer & Dinges, 2005). Specifically, the abilities to suppress the dominant response, fix a mistake directly after making it, and make smart decisions after receiving unexpected information are affected by reduced sleep (Chuah et al., 2006; Harrison & Horne, 2000; Tsai et al., 2005). There are many studies supporting the connection between total sleep deprivation of at least one night and decreased inhibition (Drummond et al., 2006; Kaliyaperumal et al., 2017; van Peer et al., 2019). Additionally, this finding has been replicated with partial sleep deprivation, 6 hours of sleep in comparison to 9 hours (Demos et al., 2016; Mao et al., 2021). A meta-analysis assessing 15 studies experimentally measuring inhibition through neuropsychological tasks in adults found a significant negative effect of decreased quantities of sleep on inhibition (Lowe et al., 2017). When considering all 62 studies, the same meta-analysis determined that restricted sleep produces consequential cognitive deficits, with behavioral inhibition being one of the most affected domains (Lowe et al., 2017).

Although the literature on adolescents is limited, within the adult literature, many studies have utilized young adult samples. The close proximity in age with the population of interest increases the applicability of findings to this younger age group. For example, in a sample with a mean age of 22, a single night of sleep loss (36 hours) significantly decreased inhibition when measured through an experimental task (Anderson & Platten, 2011).

Finally, the cross-sectional research in adolescents explicitly investigating the impact of sleep on inhibition explicitly is sparse. To our knowledge, only three studies have been conducted with youth. Fallone and colleagues (2001) measured sleep in 82 children (M age = 12) for 5 nights, after which they were assigned to restrict their sleep to four hours or maintain ten hours of sleep. Behavior and performance assessments demonstrated an increase in inattentiveness but no notable difference in inhibition (Fallone et al., 2001). Following that, Sadeh and colleagues (2003) conducted a study with 77 children (M age = 10.6) wherein subjects were either assigned to lengthen or decrease their sleep by one hour for three nights. Children that restricted their sleep preformed more poorly on response inhibition, along with other cognitive tasks, compared to those in the sleep extension group (Sadeh et al., 2003). A functional magnetic imaging study conducted in 46 adolescents (M age = 15.23) illustrated deficits in brain activation among areas linked to inhibition during tests of cognitive control following poor quality sleep (Telzer et al., 2013).

Deficits in executive functioning have been linked to regulation and behavior difficulties (Woltering et al., 2015). Studies have found that children with behavior problems are more likely to have poorer executive functioning skills (Hughes & Ensor, 2010; Woltering et al., 2015). There is some evidence that inhibition may be particularly impaired in individuals with externalizing behaviors, likely due to a lack of self-regulation (Dolan & Lennox, 2013; Woltering et al., 2015). Much of the research linking inhibition with externalizing behaviors has been conducted with young children. Schoemaker and colleagues (2013) conducted a meta-analysis of 22 studies of pre-school children and reported a moderate effect size for the relationship between inhibition and externalizing behavior. Further, there is mounting evidence that these findings extend to older youth. In particular, at least four longitudinal studies (Bohlin et al., 2012; Boyd et al., 2020; Nigg et al., 1999, Williams et al., 2009) have linked inhibition with externalizing problems in school-aged children. For example, Bohlin and colleagues (2012) found that poor inhibition at age five predicted externalizing outcomes at age ten.

Two longitudinal studies have replicated these findings with adolescents (Wang et al., 2016; Young et al., 2009). Wang and colleagues (2016) determined that low response inhibition among adolescents predicted future externalizing problems at an 18 month follow up. And, Young and colleagues (2009) found that inhibitory deficits produced an increased vulnerability to the development of externalizing disorders; the longitudinal nature of the study combined with utilizing a sample of twins demonstrated the relationship could be attributed to both genetic and environmental features. Additional research is needed to understand the role of inhibition in relation to externalizing symptoms during the vulnerable adolescent period. This study is designed to achieve this aim.

To our knowledge, one study has been conducted utilizing all of the aforementioned constructs (sleep quantity, externalizing, and inhibition). Basch and colleagues (2019) utilized a sample of 150 young adolescents (M age = 13.6); 40% identified as African American, 36.1% as white, 11.6% Hispanic and 7.1% biracial. Participants completed self-report sleep/wake reports, Behavioral Rating Inventory of Executive Function (BRIEF Scale), and the Pediatric Symptom Checklist (Basch et al., 2019). The subjective sleep measure utilized a likehart scale for participants to rate their sleeping behaviors, a lower score indicated a more maladaptive sleep/wake pattern (Basch et al., 2019). Their model determined that poor inhibitory control was related to more problematic sleep patterns, and poorer inhibition significantly correlated with increased externalizing behaviors (Basch et al., 2019). Maladaptive sleep schedules partially mediated the relationship of low inhibition and higher rates of externalizing (Basch et al., 2019). Demographic variables were significantly related to externalizing problems and were included as covariates. This study concluded that sleep may be the mechanism that inhibition impacts the development of externalizing disorders (Basch et al., 2019). However, this study was cross-sectional, so it is possible that the direction of effects was different than that hypothesized by the authors (Basch et al., 2019).

Summary of Rationale

Although a number of studies have investigated sleep and externalizing problems or inhibition and externalizing problems or sleep and inhibition, this will be the first study to test inhibition as a mediator of the relationship between sleep and externalizing problems. Findings from studies connecting the variables independently provide a strong rationale for this investigation. This study aims to build upon that foundation by testing inhibition as a mediator of the association between sleep quantity and externalizing behaviors in a sample of adolescents.

Hypothesis 1: Lower quantity of sleep at time 1 will predict higher frequency of externalizing behaviors at time 1.

Hypothesis 2: Lower inhibition scores at time 1 will predict higher externalizing behaviors at time 1.

Hypothesis 3: Lower time 1 inhibition scores will mediate the relationship between time 1 sleep quantity and time 1 externalizing behaviors.

As sample size permits, each of these hypotheses will be re-tested with time 2 externalizing data:

Hypothesis 4: Lower quantity of sleep will predict higher frequency of youth self-report externalizing behaviors at time 2 controlling for externalizing behaviors at time 1.

Hypothesis 5: Lower inhibition scores at time 1 will predict higher externalizing behaviors at time 2 controlling for externalizing behaviors at time 1.

Hypothesis 6: Lower time 1 inhibition scores will mediate the relationship between time 1 sleep quantity and time 2 externalizing behaviors controlling for time 1 externalizing behaviors.

The mediating and dependent variables used in the proposed study assess specified behaviors present over the previous 6 months. Given the test-retest reliability, it is plausible to assume these constructs are stable across a period of five days (Mashhadi et al., 2017; McCandless & O'Laughlin, 2007; Petty et al., 2008). Thus, despite the measures being administered before the actigraphy, we propose the model be considered in its nonsequential form.

Method

Participants

Three hundred and seventy-nine adolescents were recruited from three racially and socio-economically diverse elementary schools and one high school in Chicago, IL. The average age of the sample was 14.31 years old at time 1; 54.9% were female, 18.3% identified as Black, 6.1% identified as Asian, 22% identified as White, and 2.4% identified as mixed race. 23.2% of participants considered themselves as Hispanic or Latinx. 34.1% of the sample classified themselves as middleclass, 14.6% as working class, and 1.2% as poor. Ninety-four of these students were randomly selected to wear actigraph watches (to track sleep; Heissel et al, 2018, p. 323). There were no data collected for 12 of these participants due to an unreturned watch or recording malfunctions (Heissel et al, 2018, p. 323); sixty-four of the remaining 82 actigraph watch participants also completed the Youth self-report and BRIEF scale at time one. Descriptive statistics are displayed in Table 1. The average age of the actigraph sample was

14.23 years old at time 1; 54.9% were female, 24.6% identified as Black, 7.9% identified as Asian, 11.4% identified as White, 6.2% identified as another non-Hispanic race, and 27.6% identified as Hispanic. Mean score for Hollingshead Social Striatum scores was 42.4, with 1.4% being unskilled laborers, 7.4% machine operators or semi-skilled workers, 11% identified as skilled craftsmen, clerical or sales workers, 16.9% of parents falling into the category of medium business or minor professional, and 11.4% being major business or professional workers. Actigraph watches calculated average sleep quantity across the study period to be 6.54 hours; average quantity on the night with the shortest sleep was calculated to be 5.44 hours (Table 1). Participants mean YSR externalizing score was .35 (SD = .31) and mean BRIEF inhibit scores were 19.30 (SD = 4.86) (Table 1).

Recruitment of participants for the larger study was conducted by research assistants at participating schools. They described the study to potential participants, reviewed and distributed consent forms, and answered any questions students might have. Consent forms outlined the study and research goals. Students were compensated for participation in the study with a $50 gift card for their responses and a $10 gift card for returning their parents responses. Parents were invited to complete parent measures and were compensated with a $10 gift card. As an added incentive, parents were entered into a lottery for an additional $100 gift card. Adolescents who completed the full day of data collection were also entered into a lottery for an additional $100 gift card. Participants in the sub study (focused on collection of sleep data) were further compensated with a $50 gift card, and (if they completed the measures on time), they were entered into a lottery for an iPod touch. For time 2, participating youth were contacted directly about a second Saturday data collection roughly six months after the first. If a participant was unable to attend the follow-up data collection at DePaul University, they were offered the opportunity to complete the survey portion only of the study at their school. Participants received a $20 gift card for participation in the survey portion only of the study.

Procedure

Data collection took place at DePaul University in Chicago, IL on a Saturday and lasted 8.5 hours. Time 1 sessions were offered every weekend until all participants attended. Each Saturday roughly 50-60 students attended; upon arrival, they were separated into groups of 12-16. Each group had 2 to 3 adults supervising. Participants were randomly assigned to varying sequences of survey completion, recreation time, and a stress interview. For example, one group of students completed the stress interview first, then went on to the survey, and finished with recreation time, whereas others completed the survey first, recreation second, and finished with the stress interview. Questionnaires were administered in a group format. The surveys took approximately 90 minutes to complete and were administered by trained research staff. The same procedure was followed 6 months later for the second wave of data collection. Following the completion of the surveys, participants were randomly selected to participate in the actigraph sub-study (Heissel et al., 2018). Participants in this sub-study wore an actigraph watch for four nights starting on a Saturday (Heissel et al., 2018). They were instructed to press a button at bedtime and upon waking each day (Heissel et al., 2018).

Materials

Actiwatch. The Acti-Watch-64 was used to track sleep quantity over four consecutive days (Heissel et al, 2018, p. 323). The watch uses Actiware Sleep software to calculate various sleep variables using 1-min epochs and tracking movements for 10 minutes of inactivity (signifying sleep; Heissel et al, 2018, p. 323). The software calculates bedtime, sleep latency, wake time, and sleep duration (Heissel et al, 2018, p. 323). The present study utilized sleep duration data. Actigraphy is a more accessible, comparable version of polysomnography, the gold standard sleep measurement tool, and it provides more accurate data than subjective self-reports of sleep quantity (Marino et al., 2013). The independent variable, sleep quantity, was represented by the average hours of sleep the participant slept across the four-day data collection period. The night with the lowest sleep quantity was determined and utilized for analyses. Entries of participants who were not able to complete the study, did not return their watch, or had watch malfunctions were excluded from analysis.

Externalizing Behaviors. Adolescents completed the Youth Self-Report (YSR), a self-report questionnaire developed to assess mental health problems in youth ages 11-18, at two time points. Each item is rated on a 3-point Likert scale: Not true (0), Somewhat/sometimes true (1), and Very/Often True (2). The YSR has 11 subscales: Delinquent Behavior, Aggressive Behavior, Withdrawn, Somatic Complaints, Anxious/Depressed, Social Problems, Thought Problems, Attention Problems, Externalizing Broad-band Scale (includes Delinquent and Aggressive Behaviors), Internalizing Broad-band Scale (includes Withdrawn, Somatic Complaints, and Anxiety/Depressed Problems), and Total Problems" (Southammakosane et al., 2013). The Achenbach Externalizing Broad-band Scale will be used in this study. It has excellent psychometric properties including the capacity to predict risky behavioral patterns and more specific diagnoses from childhood into adolescence (Petty et al., 2008). For each participant, externalizing scores from time 1 were summed and externalizing scores from time 2 were summed using SPSS syntax. A higher score indicates a greater number of externalizing behaviors.

Inhibition. Adolescents completed the Behavior Rating Inventory of Executive Function (BRIEF) designed to screen for executive dysfunction and assess domains of executive functioning (Gioia et al., 2000). There are three clinical scales in total, and the Inhibit Scale will be utilized for this study (Gioia et al., 2000). The Inhibit Scale includes 28 items and evaluates inhibitory and impulse control (Gioia et al., 2000). Children scoring high on this scale lack self-control in comparison to their peers, experience trouble staying in an assigned place, frequently interrupt others, and need greater levels of supervision (Gioia et al., 2000). Sample items for the Inhibit Scale include “talks at the wrong times” and “gets out of control more than friends” (Gioia et al., 2000). The BRIEF has demonstrated good psychometric properties including the ability to distinguish between different components of executive functioning (Mashhadi et al., 2017; McCandless & O’Laughlin, 2007). Scores were calculated by summing items from the BRIEF inhibition subscale. Analyses were conducted using raw scores.

Demographics. Race/ethnicity and socioeconomic status were examined as potential control variables. Hollingshead social stratum scores were used to establish participant’s socioeconomic status. Scores on the HHSS range from one to five, wherein one is the least skilled worker and five works at a large business or another specialized form of employment. Race was assessed through a self-report question with 7 choices: Black or African-American, Asian or Asian-American, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, White or Caucasian, Mixed (parents from two different groups) and other. Sex was assessed using self-report sex, female and male.

Results

Table 1.

Descriptive statistics

	n	M	SD
YSR Externalizing T1	69	.35	.32
Brief Inhibit T1	73	19.68	4.92
Average sleep quantity	82	6.54	.87
Shortest sleep	82	5.44	1.19

Demographic Analyses

As established in the introduction, externalizing behaviors, inhibition and sleep quantity can be impacted by race, gender and socioeconomic status. To assess the potential influence of these variables, one-way ANOVAs were conducted. A one way ANOVA (Table 2) revealed no significant difference in sex in average sleep quantity, f(1, 52) = 3.59, p = .06, time 1 externalizing scores, f(1,47) = 1.77, p = .676, time 2 externalizing, f(1, 27) = .50, p = .48, or inhibition, f(1, 49) = *.05,* p = .82 t. There were no significant differences across races in average sleep quantity, f(4, 72) = 1.60, p = .18, time 1 externalizing scores, f(4, 59) = 1.39, p = .25, time 2 externalizing, f(4, 30) = .69, p = .61, or inhibition, f(4, 63) = .43, p = .78 (Table 3). Similarly, neither average sleep quantity, f(4, 42) = 1.16, p = .23, time 1 externalizing scores, f(4, 38) = .922, p = .46, nor time 1 inhibition, f(4, 39) = .55, p = .70, differed as a function of Hollingshead social striatum scores (table 4). Additionally, correlations were run to investigate a potential association of age with the independent, dependent, or mediating variables (Table 6).

Correlations among Study Variables

Correlations were run to assess relationships among variables. Age was not significantly related to any of the constructs. As expected, correlations demonstrated continuity for scores across time points, such that time 1 and time 2 externalizing were correlated as well as time 1 and time 2 inhibition. This demonstrates test-retest reliability of the YSR externalizing measure and BRIEF inhibition scale. Similarly, inhibition at both time points was correlated with externalizing at both time points. Unexpectedly, actigraph sleep quantity and inhibition were not related. Actigraph measured sleep quantity was correlated to self-reported sleep quantity, supporting the utilization of self-report sleep quantity to increase the sample size for supplementary analyses. Self-report sleep quantity and actigraph shortest sleep quantity were not related to the mediator or dependent variables.

ANOVA - Gender

		Sum of Squares	df	Mean Square	F	Sig.
YSR EXTERNALIZING - Time 1	Between Groups	.017	1	.017	.177	.676
	Within Groups	4.621	47	.098		
	Total	4.638	48			
YSR EXTERNALIZING - Time 2	Between Groups	.024	1	.024	.504	.484
	Within Groups	1.290	27	.048		
	Total	1.314	28			
Time 1 Brief Inhibit sum	Between Groups	1.361	1	1.361	.054	.817
	Within Groups	1231.619	49	25.135		
	Total	1232.980	50			
Brief Inhibit - Brief Scale - Time 2	Between Groups	3.008	1	3.008	.282	.599
	Within Groups	298.458	28	10.659		
	Total	301.467	29			
Self Report Sleep Quantity T1	Between Groups	1.214	1	1.214	.363	.550
	Within Groups	147.090	44	3.343		
	Total	148.304	45			
avgsle	Between Groups	2.734	1	2.734	3.590	.064
	Within Groups	39.595	52	.761		
	Total	42.329	53			
short	Between Groups	3.234	1	3.234	2.547	.117
	Within Groups	66.039	52	1.270		
	Total	69.273	53			

Table 2.

ANOVA - Race

		Sum of Squares	df	Mean Square	F	Sig.
YSR EXTERNALIZING - Time 1	Between Groups	.585	4	.146	1.398	.246
	Within Groups	6.170	59	.105		
	Total	6.755	63			
YSR EXTERNALIZING - Time 2	Between Groups	.190	4	.047	.688	.606
	Within Groups	2.067	30	.069		
	Total	2.256	34			
Time 1 Brief Inhibit sum	Between Groups	43.990	4	10.997	.433	.784
	Within Groups	1601.231	63	25.416		
	Total	1645.221	67			
Brief Inhibit - Brief Scale - Time 2	Between Groups	26.180	4	6.545	.647	.633
	Within Groups	303.299	30	10.110		
	Total	329.479	34			
Self Report Sleep Quantity T1	Between Groups	10.534	4	2.634	1.009	.409
	Within Groups	172.339	66	2.611		
	Total	182.873	70			
avgsle	Between Groups	4.790	4	1.197	1.597	.184
	Within Groups	53.973	72	.750		
	Total	58.763	76			
short	Between Groups	9.316	4	2.329	1.677	.165
	Within Groups	99.989	72	1.389		
	Total	109.305	76			

Table 3.

ANOVA - HHSS

		Sum of Squares	df	Mean Square	F	Sig.
YSR EXTERNALIZING - Time 1	Between Groups	.367	4	.092	.922	.461
	Within Groups	3.784	38	.100		
	Total	4.151	42			
YSR EXTERNALIZING - Time 2	Between Groups	.127	4	.032	.588	.675
	Within Groups	1.029	19	.054		
	Total	1.156	23			
Time 1 Brief Inhibit sum	Between Groups	60.824	4	15.206	.550	.700
	Within Groups	1078.813	39	27.662		
	Total	1139.636	43			
Brief Inhibit - Brief Scale - Time 2	Between Groups	21.485	4	5.371	.440	.778
	Within Groups	243.875	20	12.194		
	Total	265.360	24			
Self Report Sleep Quantity T1	Between Groups	6.636	4	1.659	.444	.776
	Within Groups	130.839	35	3.738		
	Total	137.475	39			
avgsle	Between Groups	4.652	4	1.163	1.479	.226
	Within Groups	33.021	42	.786		
	Total	37.673	46			
short	Between Groups	3.388	4	.847	.681	.609
	Within Groups	52.200	42	1.243		
	Total	55.588	46			

***Table 4*.**

***Table 5*.** Correlation matrix

Correlations Among and Descriptive Statistics For Key Study Variables

Variables	*M* (*SD*)	Age	T1 Externalizing	T2 Externalizing	T1 Inhibit	T2 Inhibit	Average Sleep Quantity	Shortest Sleep Quantity
Age	14.23 (4.51)		-.15	.25	-.02	.264	.06	-.15
T1 Externalizing	.35 (.31)			.55**	.80**	.49**	-.24*	-.19
T2 Externalizing	.26 (.24)				.42**	.54**	-.18	-.30
T1 inhibit	19.3 (4.86)					.69**	-.11	-.05
T2 Inhibit	11.92 (3.15)						-.30	-.21
Average Sleep Quantity	6.54 (.87)							-.64**
Shortest Sleep quantity	5.44 (1.19)							

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Primary Analyses

Regression Assumptions. Before running the regression model, the assumptions of regression were verified. In particular, tests for multicollinearity and homoscedasticity were conducted using SPSS and satisfied.

Hypothesis 1. Hypothesis 1 stated that lower sleep quantity would predict a higher number of externalizing behaviors at time 1 data collection. Time 1 sleep quantity data from the actigraph watches were regressed on averaged Youth Self-report Externalizing time 1 scores. The hypothesis was supported by a statistically significant negative association between sleep quantity and externalizing behaviors (β = -.09, se = .04, 95%CI[-.18, .00], p = .05).

Hypothesis 2. Hypothesis 2 stated that lower inhibition would predict a higher number of self-reported externalizing behaviors during time 1 data collection. Time 1 inhibition data from the BRIEF were regressed on averaged Youth Self-report Externalizing time 1 scores. The hypothesis was supported with a significant association between inhibition and externalizing behaviors (β = .05, se = .00, 95%CI[.04, .06], p = .00).

Hypotheses 3 and 6. Hypothesis 3 and 6 involved mediational model testing. Results for these analyses are summarized in the Model Testing section below.

Hypothesis 4. Hypothesis 4 stated that lower time 1 sleep quantity would predict higher time 2 youth self-report externalizing behaviors with time 1 externalizing symptoms controlled. Sleep quantity data from the actigraph watches were regressed on averaged youth self-report externalizing time 2 scores controlling for externalizing time 1 scores. The hypothesis was not supported due to a non-significant relationship between time 1 sleep quantity and time 2 externalizing behaviors controlling for time 1 externalizing behaviors, (β = .02, se = .05, 95%CI[-.09, .12], p = .74).

Hypothesis 5. Hypothesis 5 stated that lower inhibition scores at time 1 would predict higher externalizing behaviors at time 2 with time 1 externalizing behaviors controlled. Time 1 inhibition scores were regressed on time 2 externalizing scores controlling for time 1 externalizing scores. This hypothesis was not supported due to an insignificant relationship between time 1 inhibition and time 2 externalizing scores controlling for time 1 externalizing scores, (β = .01, se = .01, 95%CI[-.01, .02], p = .44)

Model Testing

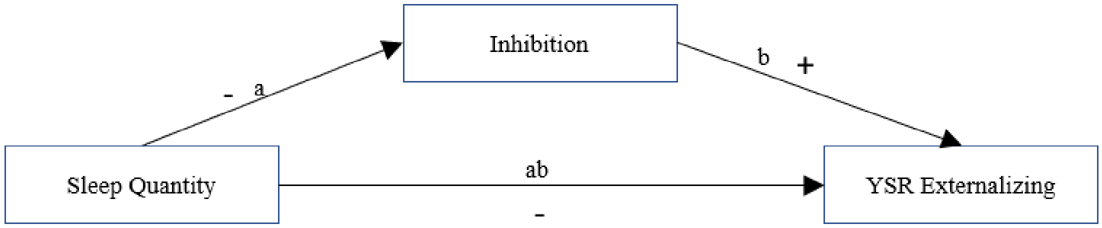


Figure 1. Predicted mediated path between sleep quantity and externalizing behavior.

Analyses

Hypothesis 3. Hypothesis 3 stated that the relationship between sleep quantity and time 1 externalizing behaviors would be mediated by inhibition (shown in Table 7). This hypothesis was tested using PROCESS mediation analyses as recommended by Hayes (Hayes, 2018). The outcome variable was Youth Self-Report externalizing broadband scores and the predictor variable was sleep quantity. The mediating variable was BRIEF inhibition subscale scores. It was predicted that lower time 1 sleep quantity would predict higher time 1 externalizing behavior (*ab* path), and that there would be a significant negative association between time 1 sleep quantity and time 1 inhibition (*a path)*, and a significant indirect effect of time 1 sleep quantity on time 1 youth self-report externalizing behavior via low inhibition scores (*ab)*. Mediation was tested using Preacher and Hayes SPSS PROCESS approach (Preacher & Hayes, 2004). This method does not utilize the causal steps approach, thus, does not require significant a and b paths (Hayes, 2017). Support for the hypothesis is established when indirect effects, the product of a and b paths, are significantly different than zero (Hayes, 2017).

Bootstrap confidence intervals were used to calculate the indirect and direct effects within the mediation model (Hayes, 2017). Five thousand bootstrap samples were used for percentile confidence intervals based on Hayes' recommendation to consider irregularities in sampling distribution (Hayes, 2017). Bootstrap confidence intervals are significant if 0 is not included in the range (Hayes, 2017). In the present analyses results, inhibition was positively correlated with externalizing problems (β = .05, se = .01, p = .000, 95%CI [.03, .06]). The direct effect of sleep quantity on externalizing problems was not significant (β = -.06, se = .03, p = .08, 95% C.I. [-.13, .00]). The indirect effect of sleep quantity on time 1 externalizing problems, via inhibition, was not statistically significant (β = -.04, se = .04, 95% C.I. [-.12, .04]) as the 95% bootstrapped confidence interval contained zero. Thus, the mediation hypothesis was not supported.

Hypothesis 6. Hypothesis 6 stated that time 1 inhibition scores would mediate the relationship between time 1 sleep quantity and time 2 externalizing behaviors controlling for time 1 externalizing behaviors. This hypothesis was also tested with the mediation analyses recommended by Hayes (shown in Table 8). In the present analyses results, inhibition was not correlated with externalizing problems (β = .01, se = .01, p = .44, 95%CI [-.01, .03]). The direct effect of sleep quantity on time 2 externalizing problems was not significant (β = .01, se = .05, p = .82, 95% C.I. [-.10, .12]). The hypothesis was not supported due to an insignificant indirect effect of sleep quantity on time 2 externalizing problems, via inhibition, as determined by a 95% confidence interval that contained zero (β = .01, se = .02, 95% C.I. [-.01, .05]). Taken together, the mediation hypothesis was not supported.

Table 6.

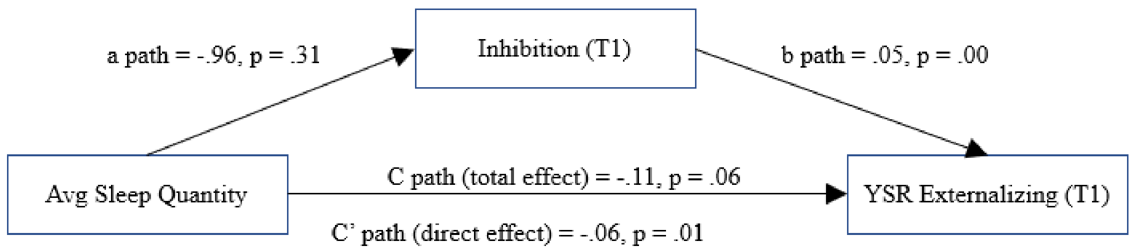
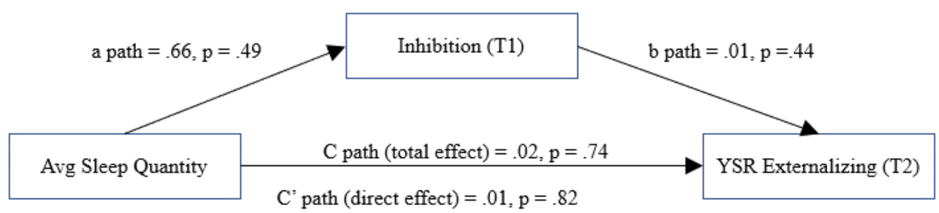


Table 7.



Supplemental Analyses

Two additional sets of analyses were conducted to assess the extent to which measurement and methodological factors may have contributed to the findings. First, primary hypotheses were re-tested using shortest night sleep rather than average night sleep as the sleep variable. Results for primary hypotheses did not differ from those with the original measure. See Appendix A for complete results of these analyses.

Second, primary hypotheses were re-tested using self-report sleep instead of actigraph watch data as the sleep variable. This allowed for a larger sample size of 264 participants. Demographics of these participants are provided in Appendix A. Results for these analyses did not differ from those with the original sample except that: 1) age was negatively correlated with sleep at time 1 indicating that older youth reported less sleep, 2) gender was associated with externalizing at time 2 indicating that boys reported more symptoms, 3) sleep was not associated with time 1 externalizing symptoms and 4) actigraph watches calculated average sleep quantity across the study period to be 6.54 hours, whereas self-report sleep quantity averaged 7.10 hours per night. See Appendix A for complete results of the supplemental analyses.

Discussion

Adolescents are particularly vulnerable to sleep disruptions and to externalizing problems (Carskadon, 2011; Pieters et al., 2015). Sleep has been linked to both reduced inhibition and increased externalizing behavior (Lowe et al., 2017; Gregory & Sadeh, 2012). This study sought to explore links between each of these variables and to test inhibition as a mediator of the relationship between poor sleep and externalizing problems. Results of each study finding are summarized and interpreted below.

Demographic and Descriptive Findings

The demographics of our sample were racially and ethnically diverse. Existing literature in the domain of sleep psychology is biased towards adults and white samples; thus, this study offers insight into population behaviors through a more diverse sample than previously utilized. Taken together, our study provides a valuable perspective into the influence of sleep in historically underrepresented youth. To examine the potential impact of race and socioeconomic status, one-way ANOVAs were utilized. No significant differences emerged as a function of race, HHSS group, gender, or age in the original sample, but older youth reported less sleep and boys reported more externalizing problems in the larger sample used for the supplemental analyses.

The sex differences in externalizing symptoms found in the larger supplemental sample fit with prior literature (Keiley et al., 2000, Newman et al., 1996). Previous work has demonstrated greater externalizing behaviors in boys (Keiley et al., 2000, Newman et al., 1996). Age findings are also consistent with prior literature indicating that older youth sleep less than younger youth (Paruthi et al., 2016).

Descriptive findings demonstrated that youth were sleeping significantly less than the American Academy of Sleep Medicine's official recommendation of 9-10 hours for adolescents (Paruthi et al., 2016). On average, actigraph watches calculated total sleep time to be around 6.5 hours, whereas the shortest night averaged around 5.44 hours. These findings suggest this sample is reporting less sleep than other published studies investigating the same age group. Kaur and Bhoday (2017) found that adolescents were getting an average of 7 hours of sleep per night. However, trend analyses have demonstrated a rapid decline in adolescent sleep quantity over time across the globe in a variety of populations (Matricciani et al. 2017). These findings are concerning; consequences associated with insufficient sleep during adolescence include, but are not limited to, attention and behavior problems, greater injuries, and poor physical health (Owens & Weiss, 2012).

Sleep and Inhibition

Our findings did not support our hypothesis that reduced sleep quantity would predict inhibition. This lack of association held up both for actigraphy and supplemental self-report sleep data and across both time points.

Research investigating the connection between sleep quantity and inhibition among adolescents is still emerging. Deficits in executive functioning, including inhibition, following sleep loss and/or restriction have been demonstrated in young adult and adult populations (Lowe et al., 2017). But, only three studies have been conducted with children and adolescents and findings have been mixed. Sadeh and colleagues (2003) found sleep effects on inhibition in a sample of children with a mean age of 11 years, but Fallone and colleagues (2001) did not find effects in a sample of children with a mean age of 12. The only prior study that has been conducted with adolescents, to our knowledge, used a very different method (functional magnetic imaging). The authors (Telzer et al., 2013) found deficits in brain activation among areas linked to inhibition following poor sleep in adolescents with a mean age of 15 years.

This study is the first (to our knowledge) to test for sleep effects on inhibition in a sample of adolescents using traditional measures of inhibition. Thus, differences in findings could be attributable to developmental differences or to measurement differences across studies. With regard to development, during adolescence, the brain is highly plastic as it undergoes pronounced changes, particularly in the cortex (Fuhrmann et al., 2015). Speed and course of development is individualized and influenced by a variety of environmental factors (Fuhrmann et al., 2015). Studies have found differences between early, mid, and late adolescence in a variety of cognitive functions (Fuhrmann et al., 2015). Therefore, the lack of findings in the present study could be influenced by development.

Measurement differences might also explain differences in findings across studies. The present study utilized a youth self-report scale of executive functioning, rather than functional magnetic imaging as was used in the prior study assessing sleep and inhibition among adolescents. Furthermore, executive functioning could be impacted generally, with specific domains being adversely affected with high between individual variability. Additional studies of sleep and inhibition with adolescent samples using a variety of measures assessing both global and domain-specific deficits are needed to test these competing explanations for contradictory results.

Sleep and Externalizing Behaviors

Our findings supported our hypothesis that reduced sleep quantity would predict externalizing behaviors but only when sleep was measured objectively (using actigraphy) and only when both variables were measured at time 1. This finding held for both average and shortest night sleep and aligns with prior literature demonstrating a relationship between insufficient sleep and externalizing problems. This finding also extends previous findings through replication in a population of racially and ethnically diverse adolescents.

Analyses did not identify a relationship between time 1 sleep quantity and externalizing behaviors at time 2. Prior research has demonstrated both concurrent and longitudinal associations between sleep quantity and externalizing problems (Clinkinbeard et al., 2011; Gregory & O'Connor, 2002; Gregory & Sadeh, 2012, Pieters et al., 2004). It is unclear why the present study found only concurrent effects. Additional research with representative samples such as this one are needed to test for longitudinal effects of sleep on externalizing problems among adolescents.

Inhibition and Externalizing Behaviors

Our findings supported our hypothesis that reduced inhibition would predict externalizing behaviors but only when both variables were measured at the same point in time. These findings are consistent with extant literature linking inhibition to externalizing problems in youth ranging from pre-school (Schoemaker et al., 2013) to school-age (Bohlin et al., 2012; Boyd et al., 2020; Nigg et al., 1999, Williams et al., 2009) to adolescence (Wang et al., Young et al., 2009). And, they build upon the limited adolescent research in this area. Taken together with prior research, the findings suggest that inhibition may be an important precursor to externalizing behaviors during the vulnerable adolescent period, and, as such, an important target for intervention.

Unexpectedly, we did not replicate the results of two longitudinal studies that found prospective effects for inhibition on externalizing problems for adolescents (Wang et al., 2016; Young et al., 2009) nor did we find evidence that inhibition mediates the relationship between less sleep and more externalizing symptoms. As there have been very few studies in this area, additional research is needed to establish consistent patterns of effects or lack of effects.

Mediation Results

The mediation model testing inhibition as a mediator of the relationship between sleep quantity and externalizing behaviors was not significant. This lack of significant mediation effects was consistently found for both actigraphy and supplemental self-report sleep data and across both time points.

Analyses indicated a significant direct effect of sleep quantity on externalizing behaviors and a significant direct effect of inhibition on externalizing behaviors in this sample. But, inhibition did not mediate the relationship between less sleep and more externalizing behaviors. Given that this is the first study, to our knowledge, to test this mediational hypothesis and prior literature (as reviewed in the introduction) provides a strong foundation for it, additional research should be conducted before fully rejecting this mediational hypothesis. If additional studies replicate our findings, this will suggest that there are other factors that mediate the relationship between sleep quantity and the development of externalizing problems. Such mechanisms could include other domains of executive functioning, judgment, or negative mood, or academic disengagement.

Limitations

Beyond methodological issues that may have influenced the results as described above, a limitation of this study is that participants completed the Youth Self-report as well as the BRIEF inhibit scales prior to the actigraph collection period. This timing diverges from our hypothesized ordering of causal mediation However, the constructs were all measured within a few days of one other and the constructs that are assessed in the YSR and BRIEF scales evaluate the frequency of behaviors in the prior month. This suggests that there is likely stability to responses and validity in assessing the data in a non-sequential manner.

Directions for Future Research

Beyond specific research recommendations to test various interpretations of the results highlighted above, there are several general recommendations for research in this area. In particular, studies could be strengthened by utilizing several different or multiple measures as suggested here: First, with regard to the measurement of sleep, collecting daily behavior assessments each day of the actigraph data collection period, rather than averages across the previous month, could provide valuable information to contextualize sleep behaviors. Matos and colleague (2015) found that nearly half of the students in their study had high sleep variability across weekdays and weekends. High sleep variability between nights was related to skipping class, increased feelings of academic stress, fatigue, and sleep initiation difficulties (Matos et al., 2015). Future work could also compare differences in one night of sleep restriction to a longer period of time and measure sleep restriction using an experimental paradigm.

Second, while the YSR has good psychometric properties, it is worth noting that the literature suggests that respondents have difficulties reporting on frequency of behaviors, relative to distinguishing between behaviors (Schwartz, 2007). Third, incorporating other measures of executive functioning and additional domains could provide more specific information on contributors to sleep loss and externalizing behaviors. Additionally, conducting experimental assessments of inhibition could help conceptualize the relationship, or lack thereof, to sleep quantity in adolescent subjects.

Additional research of all kinds in this area is also needed with adolescent populations. The majority of the literature examining sleep duration in relation to inhibition and executive functioning has been conducted in college students and adults (Drummond et al., 2006; Durmer & Dinges, 2005; Kaliyaperumal et al., 2017; van Peer et al., 2019). And, while these studies offer valuable insight, adolescents may have differential, potentially more severe, outcomes in response to short and long-term sleep deprivation. Largely, the field of adolescent sleep psychology is still emerging, and upcoming research should work to replicate findings of adult populations in this demographic or discover new findings that apply specifically to this age group. Deciphering relationship among sleep, inhibition, and externalizing behaviors has the potential to improve academic, social, and psychological outcomes in adolescents through the development of research-based intervention and prevention strategies.

Clinical and Policy Implications

Findings have an array of implications for policy and intervention. At the policy level, the prevalence of short sleep is concerning, particularly when considering recommendations by top health and sleep organizations. The present study did not seek to understand barriers to adequate sleep. However, research suggests that there are multiple contributing factors, including but not limited to delayed sleep phase, increased social and academic demands, as well as early school start times (Pieters et al., 2015).

Current efforts to delay school start times are a viable path to increasing sleep quantity and could be implemented to improve behavioral outcomes in adolescents. Communities that have implemented the shift in school start time have seen improved outcomes in high schoolers. One study found that a 30-minute delay resulted in 45 additional minutes of sleep and the number of students sleeping eight or more hours each night increased by 38% (Owens et al., 2010). Another study found that delaying the school start time resulted in decreased disciplinary and attendance problems (Thacher & Onyper, 2016). The enactment of more far-reaching policy could standardize these benefits for youth across the country.

At the clinical level, the clear relationship between sleep and externalizing behaviors illuminates the importance of sleep education in prevention and intervention work. Ensuring that adolescents understand the implications of sleep loss, sleep hygiene practices, and sleep disorder symptoms could position them to be more resilient in the face of other risk factors. And, given the impact of sleep quantity on mood and behavior, it is crucial for clinicians to inquire about sleep patterns. Understanding how sleep quantity can impact adolescent mental health may provide a unique treatment target and allow clients to achieve better outcomes in therapy.

Summary and Conclusion

In conclusion, this study suggests that sleep quantity is related to externalizing problems, but the association is not mediated by inhibition. Combined with previous literature, these findings emphasize the negative consequences of poor and insufficient sleep on adolescents. Identifying sleep as a point of intervention could alleviate long-term ramifications of externalizing behaviors, including delinquency and injury. Given the prevalence of severe sleep deficits in adolescents, it is imperative that clinical work address sleep behaviors and policy be enacted to support adequate sleep.

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Appendix A. Full Results for Supplementary Analyses

Following tests of the original hypotheses, further analyses were run using shortest night sleep data and self-report sleep data. Descriptive statistics are displayed in Table 8 and 9. Actigraph watches calculated sleep quantity on the shortest night during data collection to be 5.44 hours; self-report sleep quantity averaged at 7.10 hours per night.

Results for Shortest Night Sleep Data

Retrospective Data: In an effort to best capture risk factors for externalizing behaviors, the shortest night sleep was extrapolated from the actigraph data and regression analyses were ran. ANOVAs and correlations were conducted to assess the influence of control variables on both the independent and dependent variables; no interactions emerged. There were 65 participants who completed all the measures and were included in analyses. Sleep quantity on the shortest night had a significant effect on time 1 externalizing problems, $\beta = -.05$, se = .02, $p = .05$, 95%CI[-.09, -.00]. Yet, no total effect was found, $\beta = -.06$, se = .04, $p = .13$, 95%CI[-.14, .02].

Prospective Data: Thirty-two participants completed time 2 measures. One-way ANOVAs and pearsons r correlations were conducted to assess the influence of control variables on time 2 variables. No significant interactions were found. Analyses controlled for time 1 externalizing. Effects were calculated using bootstrap estimation approach with 5000 samples in PROCESS (Hayes, 2018). The total effect did not reach significant, $\beta = -.06$, se = .04, $p = .13$, 95%CI[-.14, .02].

Table 8. *Descriptive statistics*

	n	M
Age	373	14.23
YSR Ext. T1	340	.35
YSR Ext T2	173	.27
BRIEF Inh T1	355	19.30
SR Sleep Quantity	311	4.10

Table 9. *Descriptive statistics*

	n	M	SD
Shortest sleep	82	5.44	1.19

Results for Self-Report Sleep Data

Retrospective Data: Given the short data collection period, it was hypothesized that self-report data may provide additional insight into sleep patterns of adolescents. The study collected self-report data from all participants, increasing the sample size for these analyses. Two hundred and sixty-four participants completed self-report sleep quantity items at time 1 (M = 7.10 hours). The mean time 1 externalizing scores were .31, and mean inhibition scores were 19.30. Average age was 14.23 years old; 44% of the sample was female. Of those who reported race, 40.7% were African American, 11.7% were Asian American, 27.6% were Caucasian, 1.4% were native American, and 4.7% identified as mixed. Regression analyses were used to investigate whether inhibition scores mediate the effect of self-report sleep quantity on externalizing problems at the time 1 data point. Independence from control variables was assessed using ANOVA. A pearsons r correlation demonstrated age was significantly related to self-report sleep quantity, r = -.16, p = .01, N = 294, indicating that older youth reported less sleep. Thus, mediation models controlled for age. Self-report sleep quantity was not related to inhibition (*β* = -.16, se = .22, p = .46, 95%CI[-.59, .27]) and was not related to externalizing problems (*β* = -.01, SE = .01, *p* = .17, 95%CI [-.03, .01]). Self-report sleep quantity at time 1 did not have a significant total effect, *β* = -.02, se = .01, p = .12, 95%CI[-.04, .01]. Indirect effects were calculated using bootstrap estimation approach with 5000 samples in PROCESS (Hayes, 2018).

Prospective Data: Regression analyses were used to assess the hypothesis that time 1 inhibition mediates the effect of self-reported sleep quantity and time 2 YSR externalizing scores. Eighty-nine participants completed all the measures of investigation for this query. To assess the influence of control variables on self-report sleep data, ANOVAs and correlations were ran. A pearsons r correlation found a significant negative correlation between self-report sleep quantity at time 1 and age, r = -.16, p = .01, N = 294. A one-way ANOVA revealed that there was a statistically significant difference in time 2 externalizing scores between genders, F(1, 125) = 5.64, p = .02, with males reporting more symptoms. Regression analyses were run with age, gender, and externalizing time 1 as a control variable while assessing the relationship between time 1 self-report sleep quantity, time 1 inhibition, and time 2 externalizing scores. Self-report sleep quantity at time 1 was not related to inhibition at time 1, *β* = .31, se = .33, p = .36, 95%CI[-.35, .97]. Inhibition and externalizing at time 2 were not related, *β* = .00, se = .01, *p* = .42 95%CI[-.01, .02]. Both the total effect, *β* = -.04, se = .02, *p* = .02, 95%CI[-.07, -.01], and the direct effect, β = -.04, se = .02, p = .02, 95%CI[-.07, -.01] were significant. However, the indirect effect did not reach significance, β = .00, SE = .00, 95%CI[-.00, .01].