Theses and Dissertations   Graduate School

2020

Caffeine Use and Associations with Sleep in Adolescents with and without Attention-Deficit/Hyperactivity Disorder (ADHD)

Caroline N. Cusick

Caffeine Use and Associations with Sleep in Adolescents with and without Attention-Deficit/Hyperactivity Disorder

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University.

By

Caroline N. Cusick,
Bachelor of Science
University of Maryland, College Park, May 2016

Director: Joshua M. Langberg, Ph.D.,
Professor, Department of Psychology

Virginia Commonwealth University
Richmond, VA
April, 2020

Acknowledgement

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ADHD = Attention-Deficit/Hyperactivity Disorder

NHNES = National Health and Nutrition Examination Survey

DSM = Diagnostic and Statistical Manual of Mental Disorders

BMI = Body Mass Index

PSG = Polysomnography

WASO = Wake After Sleep Onset

P-ChIPS = Parent Version - Children's Interview for Psychiatric Syndromes

REDCap = Research Electronic Data Capture

SHS = Sleep Habits Survey

SDSC = Sleep Disturbance Scale for Children

MCAR = Missing Completely at Random

CFI = Comparative Fit Index

RMSEA = Root Mean Square Error Approximation

SRMR = Standardized Root Mean Square Residual

SD = Standard Deviation

ODD = Oppositional Defiant Disorder

CD = Conduct Disorder

AAP = American Academy of Pediatrics

SES = Socioeconomic Status

Abstract

CAFFEINE USE AND ASSOCIATIONS WITH SLEEP IN ADOLESCENTS WITH AND WITHOUT ATTENTION-DEFICIT/HYPERACTIVITY DISORDER

By Caroline Cusick, B.S.

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University.

Virginia Commonwealth University, 2020.

Major Director: Joshua Langberg, Ph.D., Professor, Department of Psychology

The objective of this study was to compare caffeine consumption in the morning, afternoon, and evening in adolescents with and without Attention-Deficit/Hyperactivity Disorder (ADHD) and examine associations with sleep functioning. Participants were 302 adolescents (ages 12-14) with (n=140) and without (n=162) ADHD. Adolescents wore actigraph watches to assess total sleep time and wake after sleep onset and reported on their sleep-wake problems and the number of caffeinated beverages consumed per day in the morning, afternoon, and evening. Parents reported on adolescents' difficulties initiating and maintaining sleep. Chi-square analyses, odds ratios, and path analyses were conducted. Analyses controlled for sex, medication status, and pubertal development. Adolescents with ADHD were 2.47 times more likely to consume caffeine in the afternoon and evening than adolescents without ADHD. Path analyses indicated significant associations between afternoon caffeine use and more self-reported sleep problems for adolescents with and without ADHD, and an association between evening caffeine use and self-reported sleep problems only in adolescents with ADHD. Afternoon caffeine use was also associated with parent-reported sleep problems in adolescents with ADHD but not in adolescents without ADHD. Caffeine use was not associated with actigraphy-assessed sleep. This is the first study to show that adolescents with ADHD consume more caffeine than their

peers during later times of the day. Additionally, caffeine use is more consistently associated

with poorer subjective sleep functioning in adolescents with ADHD compared to adolescents

without ADHD. Pediatricians and mental health professionals should assess for caffeine use in

adolescents with ADHD and co-occurring sleep problems.

Caffeine is one of the most widely available and consumed psychoactive substances in the world (Turton et al., 2016). Caffeine is most commonly ingested via beverages such as tea, coffee, soda, and energy drinks (Heckman, Weil, & Gonzalez de Mejia, 2010). However, caffeine is also found naturally in cocoa beans/chocolate, and is added into a variety of food products, dietary supplements, medications, and health and beauty products (Temple et al., 2017). Much of the research thus far on the effects of caffeine has been conducted in adults (Temple, 2009), and caffeine has been linked with changes in attention/arousal, information processing, mood, appetite, sleep, and cardiovascular health (Barry et al., 2005; Temple et al., 2017). Caffeine use in children and adolescents has long been understudied, and has only recently began to gain more attention.

Caffeine Use in Adolescents

Reports from the National Health and Nutrition Examination survey indicate that over 75% of adolescents ages 12 - 17 years old consume caffeine regularly, ingesting on average 50 milligrams per day (Ahluwalia & Herrick, 2015). In contrast, children ages 6 -12 years consume on average 25 milligrams per day (Ahluwalia & Herrick, 2015). This increase is likely accounted for by shifts in sources of caffeine. During childhood, caffeine is often initiated in low doses through soda (Temple et al., 2017). However, during adolescence individuals begin to consuming coffee and energy drinks containing higher levels of caffeine (Temple et al., 2017). Branum, Rossen, and Schoendorf (2014) examined United States national trends of caffeine consumption in children and adolescents between 1999 and 2010. Overall, they found that average caffeine consumption has remained stable among children and adolescents, however, the proportion of caffeine intake from soda has decreased, whereas the proportion from coffee and

energy drinks has increased (Branum et al., 2014). There is evidence to suggest that energy drink consumption has been increasing steadily since the mid-1990s (Bailey, Saldanha, Gahche, & Dwyer, 2014). More recent trends have yet to be published, but data collection is underway through the National Health and Nutrition Examination Survey (NHANES; Temple, 2019).

In addition to changes in the sources of caffeine consumed, there are also noticeable increases in the frequency of consumption during adolescence (Turton et al., 2016), which is likely driven by several factors. First, as teens begin to develop habits more similar to those of adults, they begin to consume caffeine more often and more habitually (Temple, 2019). Second, the transition from childhood into adolescence is often accompanied by less supervision and more independence in food/beverage choices. With the emergence of vending machines selling caffeinated beverages in schools, teens have unrestricted access to caffeinated beverages throughout the day (Orbeta, Overpeck, Ramcharran, Kogan, & Ledsky, 2006). Finally, with heavy personalized online advertising of caffeinated beverages (Bryant-Ludden & Wolfson, 2010), caffeine consumption has become more prominent in adolescent culture. For example, Kumar, Onufrak, Zytnick, Kingsley, and Park (2015) found that almost 50% of adolescents ages 12 -15 years old reported seeing at least one energy drink advertisement per day.

Research examining the impact of caffeine use on children and adolescents has found some evidence supporting positive effects of caffeine usage. A study by Bernstein and colleagues (1994) found that children (mean age 10.1 ± 1.4 years) demonstrated performance improvements in tests of sustained attention after caffeine administration compared to a placebo group. Similarly, research examining performance in boys (mean age 10.6 ± 2.5 years), found that those who received caffeine had significant increases in motor activity and speech rate, decreased reaction time, and fewer errors on tasks of sustained attention than those in a placebo group

(Elkins et al., 1981; Rapoport et al., 1981). Additionally, although not directly tested in youths, there is some evidence that caffeine consumption is associated with certain health benefits, such as increased concentration, endurance, and athletic performance (Ahluwalia & Herrick, 2015). However, research has also found caffeine to be associated with negative outcomes in children and adolescents.

Multiple studies found that caffeine intake is associated with reports of increased nervousness, jitteriness, and fidgetiness (Bernstein et al., 1998; Elkins et al., 1981; Rapoport et al., 1981). However, these same studies found that caffeine had little to no effect on self-reported mood and symptoms of anxiety (Bernstein et al., 1998; Elkins et al., 1981). A study by Savoca and colleagues (2005) found that increased caffeine intake was associated with higher blood pressure in a sample of adolescents ages 15-19 years old. There is also some evidence to suggest that caffeine consumption in high doses is associated with daily headaches in children and adolescents (Hering-Hanit & Gadoth, 2003). Overall, there are a limited number of studies examining the effects of caffeine on children and adolescents, and the results are mixed. Many of the studies use a range of ages (i.e. both children and adolescents) and there is little standardization in the measurement of caffeine consumption. It is likely that the impact of caffeine varies depending upon child age and the outcome of interest. An area that has recently gained more attention, is the effects of caffeine on sleep in adolescent populations.

Adolescents and Sleep

Adolescence is a period of life often associated with sleep problems. The American Academy of Pediatrics recognizes insufficient sleep in adolescents as an important public health issue and one of the most common and important remediable health risks (American Academy of Pediatrics, 2014). Maslowsky and Ozer (2014) analyzed sleep duration changes over time in a

nationally representative sample of 15,701 individuals ages 13-32 years old. They found that sleep duration declines across adolescence. At age 13, participants obtained on average 8.5 hours of sleep per night, whereas at age 17, participants obtained on average 7.5 hours of sleep per night (Maslowsky & Ozer, 2014). Similarly, Gillen-O'Neel, Huynh, & Fuligni (2013) found that adolescents in 12th grade slept on average 41.4 fewer minutes than they did while in 9th grade. Research indicates that even one hour of reduced sleep can negatively impact the functioning of youths (Sadeh et al., 2003).

Sleep remains of vital importance in adolescence in order to ensure that proper growth and maturation occurs during this critical period of development (Brand & Kirov, 2011). However, neurophysiological and contextual changes occur during adolescence that impact sleep functioning. For example, there is a marked shift in circadian phase preference towards "eveningness" chronotypes (i.e. preference for later bed-times and wake-times seemingly independent of environmental factors; Colrain & Baker, 2011). At the same time, adolescents are often required to wake up earlier. Indeed, early school start times have been described as a "systemic countermeasure" against sufficient sleep in adolescents (Owens et al., 2014). There is a substantial body of research linking earlier school start times with decreased sleep duration and increased daytime sleepiness in youths (American Academy of Pediatrics, 2014). This is especially problematic when considering increased homework demands and extracurricular activities, including sports, clubs, and jobs, which typically occur after school, leading teens to stay up later in order to complete all responsibilities (Becker, Langberg, & Byars, 2015; Owens & Adolescent Work Group, 2014). Use of electronics, particularly before bedtime, is another important factor negatively impacting sleep in adolescents. The average adolescent engages in several hours of screen time daily (Rideout, Pai, Saphir, Pritchett, & Rudd, 2015). Hale and

Guan (2014) systematically reviewed the literature examining associations between screen time (i.e. television, computers, video games, and mobile devices) and sleep functioning in youths. In 90% of the studies examined, screen time was adversely associated with a variety of sleep outcomes, including delayed sleep onset and shortened sleep duration (Hale & Guan, 2015).

Caffeine Use in Adolescents and Sleep

As a result of poor and insufficient sleep that arises during adolescence, teens may turn to caffeine as a means to stay energized and focused. This is compounded by the fact that advertisements of caffeinated beverages geared towards adolescents often target those who are receiving insufficient sleep and market the beverage as a method of increasing arousal (Temple, 2009). Caffeine typically has a half-life of 3-7 hours in adults, and the half-life may be longer in young children (Temple et al., 2017). This may pose a problem for sleep when adolescents consume caffeine in the afternoon or evening hours. Although most research examining caffeine and sleep has been conducted in adult samples (James et al., 2011), there is a growing body of evidence supporting the detrimental effects of caffeine on sleep functioning in adolescents.

Pollack and Bright (2003) surveyed the caffeine consumption patterns of adolescents ages 12-15 years old and found that caffeine consumption was associated with more disrupted sleep. Specifically, high caffeine users had more interrupted sleep and overall, sleep was increasingly interrupted on nights after caffeine use (Pollak & Bright, 2003). Higher caffeine intake was also associated with decreased sleep duration and increased daytime sleepiness in their sample (Pollack & Bright, 2003). Similarly, Orbeta and colleagues (2006) examined sleep functioning in high versus low caffeine consumers ages 11-17 years old. They found that high consumers were almost 2 times more likely to report difficulties sleeping and feeling tired in the morning than those classified as low consumers (Orbeta et al., 2006). Drescher, Goodwin, Silva,

and Quan (2011) found that increased caffeine use was associated with decreased parent reported adolescent sleep duration, however, this was only significant in older adolescents (i.e. greater than 13.3 years old). Finally, Fischer, Nagai, and Teixeria (2009) examined a variety of demographic and lifestyle factors potentially associated with sleep duration in adolescents, such as age, sex, tobacco use, alcohol use, physical activity, and caffeine consumption. Interestingly, there was no association between caffeine consumption and sleep duration above and beyond the effects of the other variables (Fischer et al., 2008). These results point to the complex associations between caffeine use, sleep functioning, and other lifestyle factors.

Based on research in adult populations, there is support for the notion that the time of day caffeine is consumed plays an important role in determining the impact on sleep functioning. Drapeau and colleagues (2006) examined the effects of caffeine administered 1-3 hours before bedtime on sleep functioning in adults. Compared to those in a placebo group, participants that consumed caffeine before bedtime experienced longer sleep latency and decreased sleep efficiency, sleep duration, and time spent in stage 2 sleep (Drapeau et al., 2006). Additionally, Drake, Roehrs, Shambroom, and Roth (2013) experimentally assessed whether caffeine administered at varying hours before bed (i.e. 0, 3, 6 hours) differentially impacts sleep functioning in adults. Drake and colleagues (2013) found that caffeine administered between 0 and 3 hours prior to sleep had negative associations with several aspects of sleep, including both subjectively and objectively assessed total sleep time and sleep efficiency. Additionally, certain sleep disturbances were detected even when caffeine was consumed up to 6 hours prior to bedtime (Drake et al., 2013). Unfortunately, similar studies have not been conducted in adolescent populations. It is an important area for future research as there is reason to believe that the time of day of caffeine consumption can differentially impact sleep functioning.

ADHD and Sleep

When thinking about caffeine use and sleep in adolescents, a population that may be particularly at risk is adolescents with Attention-Deficit/Hyperactivity Disorder (ADHD). ADHD is a neurodevelopmental disorder characterized by developmentally inappropriate levels of inattentiveness, distractibility, and hyperactivity (American Psychiatric Association, 2013). Behavioral sleep disturbances in individuals with ADHD are well-documented and were even considered to be a core feature of the disorder in earlier versions of the Diagnostic and Statistical Manual of Mental Disorders (DSM; Becker et al., 2015). Importantly, sleep problems arise in individuals with ADHD regardless of their medication status, and are documented above and beyond the effects of stimulant medication (Becker et al., 2015). As previously mentioned, adolescence is a time where various biological and social factors combine to negatively impact sleep. Many of these factors are compounded in adolescents with ADHD, who tend to experience difficulties in domains that may lead to later bedtimes and sleep disturbance. For example, adolescents with ADHD experience high rates of homework problems (Coghill et al., 2008) and technology use (Bourchtein et al., 2019) compared to their peers without ADHD. Additionally, research in both adults and children suggests that individuals with ADHD have a greater preference for eveningness chronotypes (Durmuş et al., 2017).

Cortese, Faraone, Konofal, and Lecendreux (2009) conducted an influential meta-analysis that summarized the existing literature to date comparing behavioral sleep difficulties in youth with and without ADHD. The authors found that youth with ADHD experienced more sleep difficulties than youth without ADHD across a variety of objectively and subjectively measured sleep domains (Cortese et al., 2009). Most prevalent were parent-reported problematic sleep behaviors around bedtime and in the early morning, and poor sleep efficiency and

fragmented sleep as assessed by actigraphy and polysomnography (Cortese et al., 2009).

However, it should be noted that the samples in the reviewed studies were mostly comprised of

children (between 8 and 12 years old). Although the results of this meta-analysis are compelling,

it is important to consider better understand sleep in populations of adolescents with ADHD

given work in typically developing samples showing sleep problems are most severe during this

period.

The literature examining sleep functioning in adolescents with ADHD is growing,

although limited in some respects. Several studies have employed samples of individuals with

"high" and "low" symptoms of ADHD (i.e., evaluated ADHD symptoms continuously) and

compared sleep functioning between these groups. For example, Hysing, Lundervold, Posserud,

and Sivertsen (2016) examined 9,846 adolescents between the ages of 16 - 19 years old, and

compared self-reported sleep problems between those with high versus low self-reported ADHD

symptoms. They found that symptoms of ADHD were linked to shorter sleep duration, longer

sleep latency and nocturnal wake time, and greater sleep deficiency (Hysing et al., 2016).

Additionally, Lam and Yang (2008) examined a sample of 1,429 adolescents between the ages of

14 and 15 years old and found that increased symptoms of ADHD were associated with shorter

sleep duration, even while controlling for body mass index (BMI) and snoring. These results

point to the associations between high ADHD symptoms and poor sleep functioning. However,

the most compelling research for the unique problems in individuals with ADHD come from

comparative studies with individuals comprehensively diagnosed with ADHD.

Prehn-Kristensen and colleagues (2014) assessed 24 adolescent boys 10 - 14 years old

using DSM-IV-TR criteria for ADHD and examined sleep functioning via polysomnography

(PSG). They found that adolescents with ADHD displayed increased sleep onset latency and

reduced sleep efficiency compared to those without ADHD (Prehn-Kristensen et al., 2014).

However, no differences were found on several other PSG-derived aspects of sleep functioning,

such as total sleep time, number of night awakening, and time in bed (Prehn-Kristensen et al.,

2014). Becker, Langberg, Eadeh, Isaacson, and Bourchtein (2019) compared the sleep patterns of

162 adolescents comprehensively diagnosed with ADHD with 140 comparison adolescents.

After controlling pubertal development, sex, medication use, and presence of an internalizing

disorder, they found that those with ADHD experienced shorter school night sleep duration

assessed via both sleep diary and actigraphy (Becker et al., 2019). Additionally, adolescents with

ADHD had significantly higher rates of adolescent- and parent-reported daytime sleepiness and

parent-reported difficulties initiating and maintaining sleep, and total sleep disturbance (Becker

et al., 2019). Taken together, these results indicate that adolescents with ADHD typically

experience worse sleep than their peers across a variety of sleep domains.

ADHD and Caffeine Use

Despite the fact that ADHD is characterized by difficulties with attention and sleep

disturbance, there has been minimal research on caffeine use behaviors in individuals with

ADHD, particularly in adolescent populations. A majority of the literature thus far has examined

caffeine as a potential treatment for symptoms of ADHD. It has been theorized that caffeine

helps alleviate symptoms of ADHD due to its ability to increase attention and arousal (Temple et

al., 2017). Current research suggests that ADHD is associated with altered activity in

dopaminergic and norepinephrinic systems located in specific areas of the brain related to

executive functioning, such as the prefrontal cortex (Swanson et al., 2007). Stimulant

medications, including methylphenidate and amphetamines, are the most commonly prescribed

medications for individuals with ADHD (Zuvekas & Vitiello, 2012). Stimulants typically work

by increasing levels of dopamine and/or norepinephrine in key areas of the brain (Advokat et al., 2014). Caffeine is also classified as a stimulant, and increases dopamine production in the brain via adenosine receptors (Advokat et al., 2014), and therefore has been examined as a potential treatment for ADHD.

Despite the similar mechanisms between caffeine and traditional stimulant medications for ADHD, there is little empirical support for caffeine's effectiveness as a treatment. It is important to note that much of this research was conducted in the 1970s and 1980s, and entirely in child populations (Grimes et al., 2015). Leon (2000) reviewed the existing literature and determined that caffeine was associated with a reduction in ADHD symptomatology in some domains compared to no treatment or placebo. However, methylphenidate and amphetamines outperformed caffeine in all domains of functioning examined (Leon, 2000). There has also been some research on the use of caffeine as a treatment in animal models of ADHD (i.e. spontaneously hypertensive rats; França, Takahashi, Cunha, & Prediger, 2018). In this study, caffeine had some utility in decreasing cognitive and emotional symptoms associated with ADHD in animals (França et al., 2018), however, more research is needed in human populations, and with adolescents in particular.

Although the support for caffeine as a treatment for ADHD is generally unclear and lacking empirical support, there is evidence that individuals with ADHD self-medicate with caffeine (Temple, 2009). Importantly, very little research has examined naturalistic behaviors, habits, or consequences of caffeine use in adolescents with ADHD (i.e., outside of the context of a treatment study). Only one study (Walker et al., 2010) has examined caffeine use behaviors in adolescents with ADHD, finding that adolescents with ADHD were almost two times more likely to consume high levels of caffeine than adolescents without ADHD. However, this study

did not evaluate the association between caffeine use and sleep outcomes and did not assess for time of day when caffeine was consumed. As previously noted, time of day is an important factor to consider when assessing the effects of caffeine consumption.

Present Study and Aims

As summarized above, adolescents with ADHD are at increased risk for behavioral sleep problems and there is some evidence indicating these individuals may be more likely to use caffeine. However, there is little information about the nature of caffeine use in adolescents with ADHD and how it compares to adolescents without ADHD. Additionally, whether caffeine use is uniquely associated with sleep problems in adolescents with ADHD is unknown. Caffeine use is most commonly associated with sleep onset disruptions and decreased sleep quality (Temple et al., 2017). Specifically, the presence of caffeine in the body may inhibit sleep onset, produce increased sleep problems throughout the night, and subsequently lead to more sleepiness during the day. These difficulties may also result in a lower total sleep time and an increased wake after sleep onset (WASO; Clark & Landolt, 2017; Drake et al., 2013). Accordingly, a multimethod, multi-rater approach to assessing sleep will be utilized, evaluating sleep via adolescent-report, parent-report, and actigraphy. Specifically, sleep problems will be assessed through adolescent-report of sleep-wake problems, which evaluates difficulties falling asleep and daytime sleepiness, parent-report of initiating and maintaining sleep difficulties, and actigraphy derived total sleep time and WASO.

Aim 1: Compare rates of caffeine use in adolescents with and without ADHD at varying times of the day. The first aim of this study is to build upon previous research by Walker and colleagues (2010) examining caffeine use behaviors in adolescents with and without ADHD. In the current study, more nuanced information of caffeine consumption will be

examined. Specifically, differences in caffeine consumption at various times of the day, including morning (before 12 PM), afternoon (between 12 - 4 PM), and evening (after 4 PM) will be evaluated. Medication status will be included as covariate, in order to account for any potential interactional effects. Sex and pubertal development will also be included as covariates in order to account for developmental differences in caffeine metabolism and gender differences in subjective and physiological responses to caffeine (Temple & Ziegler, 2011).

Hypothesis 1: Given previous findings by Walker and colleagues (2010) that adolescents with ADHD are more likely to consume caffeine than non-ADHD peers, it is hypothesized that adolescents with ADHD in this sample will be more likely to consume caffeine at all times of the day.

Aim 2: Examine associations between afternoon and evening caffeine use and sleep functioning. The next aim of the study is to assess whether caffeine use is uniquely associated with sleep functioning in adolescents with ADHD compared to adolescents without ADHD. Given the focus on sleep problems, morning caffeine use will not be evaluated for the purposes of the study in order to focus on times of problematic caffeine use (i.e. later in the day) when caffeine is likely to still be in the system by bedtime. These analyses will focus on whether caffeine use in the afternoon and the evening is associated with self-reported sleep wake problems, parent-reported initiating and maintaining sleep difficulties, and actigraphy derived WASO and total sleep time, controlling for sex, pubertal development, and medication status. These covariates were chosen given the established differences in sleep that emerge during pubertal maturation between males and females (Johnson et al., 2006), as well as to control for any effects of pharmacological treatments that may impact sleep functioning (Becker et al.,

2015). Additionally, males and females exhibit differences in sleep patterns during adolescence (Lee et al., 1999).

      Hypothesis 2: Given the prediction that adolescents with ADHD may consume significantly more caffeine in the afternoons and evenings, it is hypothesized that there will be there will be significant associations between caffeine and sleep for adolescents with ADHD but not for the comparison group. Specifically, adolescents without ADHD are unlikely to be consuming enough caffeine in the later hours to negatively impact sleep.

Methods

Participants

      Participants include 302 adolescents (167 male, 135 females) in eighth grade (ages 12-14 years) recruited as part of a study evaluating sleep functioning across the transition from middle to high school. The study focused on ADHD and sleep and adolescent with ADHD and a comparison control were specifically recruited. Approximately half of the participants (53.6%; $n= 162$) were diagnosed with ADHD (57 female, 105 male) and half (46.4%; $n= 140$) were in the comparison group (78 females and 62 males). In the overall sample, most participants identified as White (81.8%), with the remaining participants identifying as Black (5.3%), Asian (4.6%), American Indian/Alaska Native (0.3%), or Biracial/Multiracial (7.9%). 4.6% of participants identified as Hispanic/Latino. All participants had an estimated IQ ≥ 80 based on the Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II; Wechsler, 2011).

Procedures

      All procedures were approved by an Institutional Review Board. Participants were initially recruited during the fall semester of their 8th grade year at two sites in the Southeastern and Midwestern United States. Potential participants were recruited via flyers provided to

schools and emails sent out by school administrators. The study sought to recruit approximately equal numbers of adolescents with and without ADHD. Therefore, two sets of recruitment materials were used, with one set specifically directed toward youth with attention difficulties and/or ADHD.

Parents who contacted the investigators in response to recruitment activities through local schools completed an eligibility phone screening. Those meeting the screening criteria were scheduled for an evaluation to determine eligibility. Recruitment materials targeted towards individuals with ADHD specified that participants may either have a previous diagnosis of ADHD or symptoms of ADHD. To be eligible for the ADHD group, participants had to meet full DSM-5 diagnostic criteria for either ADHD Predominantly Inattentive Presentation or ADHD Combined Presentation based on the Parent Version - Children's Interview for Psychiatric Syndromes (P-ChIPS; Weller, Weller, Fristad, Rooney, & Schecter, 2000) conducted during the initial evaluation. Specifically, this required: (1) six or more symptoms of inattention at clinically significant levels; (2) presence of ADHD symptoms prior to age 12 years; (3) presence of ADHD symptoms in two or more settings (e.g., home, school); (4) evidence that symptoms contribute to impairment in home, academic, and/or social functioning according to the P-ChIPS or parent or teacher report on the Impairment Rating Scale (Fabiano et al., 2006), wherein scores ≥ 3 indicate impairment; and (5) symptoms of ADHD were not better explained by another mental disorder (e.g., anxiety, depression). Participants meeting criteria for ADHD Predominantly Hyperactive-Impulsive Presentation were not included given the low prevalence of this presentation in adolescence and ongoing concerns about its validity after early elementary school (Willcutt, 2012; Willcutt et al., 2012). To be eligible for the comparison group, participants were required to have fewer than four symptoms of ADHD in each domain (i.e., inattention and

14

hyperactivity/impulsivity) on the P-ChIPS. To be eligible for either group, participants had to have an estimated IQ ≥ 80, take core classes in a regular education setting, and could not have a diagnosis of autism, bipolar disorder, a dissociative disorder, a psychotic disorder, or an organic sleep disorder per parent report on a phone screen.

Parent and adolescent ratings were collected online during the in-person baseline assessment visit using Research Electronic Data Capture (REDCap; Harris et al., 2009). Following the in-person visit, the participants were instructed to wear actigraph watches on their wrist continuously for at least two weeks.

Measures

Caffeine Use. The Caffeine Use Questionnaire is a self-report measure assessing the frequency of caffeine consumption in the past 30 days. This measure was adapted from questions used in study by Walker and colleagues (2010), which were originally derived from the standard items from the Centers for Disease Control and Prevention's Youth Risk Behavior Survey on adolescent diet (Brener et al., 2002). Participants were asked to report on the average number of caffeinated beverages they consumed per day in the morning ("before 12 PM"), afternoon ("between 12 and 4 PM"), and evening ("after 4 PM") during the past 30 days.

Sleep Habits Survey. The Sleep Habits Survey (SHS; Wolfson & Carskadon, 1998) is a self-report measure of sleep functioning validated for use in youth ages 10-19 years old (Wolfson et al., 2003). Items in the survey are summed, with higher scores indicating worse functioning in the corresponding area of sleep. For the present study, the 10-item sleep-wake problems subscale will be used, which specifically assesses the frequency of a number of sleep-related problems in the past two weeks, such as falling asleep in class, staying up late, and having a hard time falling asleep. Items for this subscale are rated on a 5-point Likert scale (1 = never; 5= every day/night).

15

Sleep Disturbance Scale for Children. The Sleep Disturbance Scale for Children (SDSC; Bruni et al., 1996) is a 26-item parent-rated measure of sleep functioning validated in youth ages 6-15 years old. For the present study, the difficulties initiating and maintaining sleep subscale was used, which specifically assesses the frequency of a number of sleep-related behaviors in the past 6 months, such as typical total sleep time (1= *9-11 hours*, 2= *8-9 hours*, 3= *7-8 hours*, 4= *5-7 hours*, 5= *less than 5 hours*), sleep onset latency (1= *less than 15 min*, 2= *15-30 min*, 3= *30-45 min*, 4= *45-60 min*, 5= *more than 60 min*) and difficulties falling and staying asleep (5-point Likert scale, 1 = *neve*r; 5= *always*).

Actigraphy. Participants wore ActiGraph GT9X Link on their non-dominant wrist continuously for approximately two weeks. After the actigraph period, data were downloaded using Actilife software version 6. Sixty-second epoch lengths were used to score the actigraph data. Data were first validated using the wear-time sensor and a validation algorithm, and then sleep scores were calculated with the Sadeh sleep scoring algorithm (Sadeh et al., 1994) by individually adding sleep periods to each night the device was worn for each participant. Adolescent daily sleep diaries were used to aid in adding sleep periods by verifying sleep and wake times. The first actigraph variable that will be used in the present study is total sleep time, which was calculated by assessing the total time from sleep onset to offset. This methodology has been shown to be the most accurate approximation of actigraphy-derived measure of total sleep (Short et al., 2012). This variable has shown validity when compared to polysomnography in adolescent samples (Moore & Meltzer, 2008). The second actigraph variable included in the analyses is wake after sleep onset (WASO), which assesses the amount of time in minutes spent awake after falling asleep on a given evening.

Covariates

Pubertal Development. The Physical Development Scale (Petersen, Crockett, Richards, & Boxer, 1988) is a validated self-report measure assessing pubertal development in adolescents. There are separate forms for males and females to complete (six items on each); a mean score of five items pertaining specifically to physical indicators of puberty was calculated for analyses.

Medication Use. A modified version of the Services for Children and Adolescents Parent Interview (Jensen et al., 2004) was used, which is a clinician-administered interview that asks parents whether their children are receiving a variety of pharmacological and nonpharmacological treatments and adapted for this study to include sleep medication. In the present study, current medication use for attention, emotional/behavioral difficulties, or sleep problems was included as a binary (yes/no) variable.

<center>**Analytic Plan**</center>

Missing Data

Missing data will be assessed to determine the total proportion of data that is missing from all variables of interest before analyses begin. Little's Missing Completely at Random (MCAR) test will be used to ensure that data is not missing from subjects in a systematic manner, which could skew analyses and lead to incorrect interpretation of data (Little & Rubin, 2019). In previous analyses utilizing baseline data from this sample (Bourchtein et al., 2019), less than 2% of data were missing.

Aim 1

The caffeine measure assesses how many caffeinated beverages were consumed per day in the past 30 days. The response choices are ordered categorical, with some of the response choices representing range, preventing the scale from being evaluated continuously. For each

time period (i.e. morning, afternoon, evening), caffeine use variables will be categorized into "no caffeine per day", "less than 1 drink per day", or "1 or more drinks per day". Responses were categorized in this manner to allow for comparison with Walker et al. (2010) which followed similar procedures. Chi-square tests will be calculated in order to compare adolescents with and without ADHD on the number of caffeinated consumed per day during the three times of day (morning, afternoon, and evening). Odds ratios and 95% confidence intervals will be computed using logistic regression analyses in order to determine the change in likelihood of adolescent caffeine use at various times of the day and whether it is associated with ADHD status. Sex, pubertal development, and medication status will be included as covariates.

Aim 2

Multi-group path analyses will be conducted in Mplus Version 7 (Muthén & Muthén, 1998). Two models will be run to examine the effects of caffeine use on sleep functioning, the first model will caffeine use in the afternoon and the second will examine caffeine use in the evening, with both models predicting four sleep functioning outcomes. Group status (ADHD or comparison) will be used as the grouping variable for each path analysis. Sex, pubertal development, and medication status will be included as covariates. Model fit statistics will compare the models with paths free to vary across the groups (i.e., examining differential relations between caffeine use and sleep outcomes across the two groups) versus fixed to be equal across groups (i.e., assuming these relations to be the same for the two groups). A nonsignificant chi-square change statistic would indicate that the fixed model should be retained in favor of parsimony. Model fit will be examined for the retained models using several indices: Comparative Fit Index (CFI), the Root Mean Square Error Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR). CFI values greater than .90 suggest good fit.

RMSEA values less than .06 indicate good fit, values less than .10 indicate adequate fit, and values greater than .10 indicate poor fit. SRMR values less than 1.00 suggest good fit (Brown, 2015; Hu & Bentler, 1999).

<div align="center">

Results

</div>

Missing Data

Missing data were minimal, with less than 1% of data missing with the exception of total sleep time and WASO, which had 3.6% missing data. Little's MCAR test resulted in a nonsignificant p-value, which demonstrated that data were missing in a random fashion. Assumptions of normality were met for all variables with all skewness values less than 2 and kurtosis values less than 7 (Kim, 2013). Demographic characteristics are shown in Table 1.

Table 1. Sample Characteristics

	Total Sample ($N = 302$) $M \pm SD$	ADHD Group ($N = 162$) $M \pm SD$	Comparison Group ($N = 140$) $M \pm SD$
Age	13.17 ± 0.40	13.17 ± 0.41	13.18 ± 0.40
Pubertal Development			
Female	3.07 ± 0.62	3.11 ± 0.57	3.05 ± 0.66
Male	2.34 ± 0.58	2.31 ± 0.56	2.39 ± 0.61
Primary Household Income	$93,073 \pm 34,856$	$84,875 \pm 35,864$	$102,500 \pm 31,213$
	N (%)	N (%)	N (%)
Sex			
Male	167 (55.3)	105 (64.8)	62 (44.3)
Female	135 (44.7)	57 (35.2)	78 (55.7)
ADHD Presentation			
Predominantly Inattentive	-	120 (74.1%)	-
Combined	-	42 (25.9%)	-
Race			
White	247 (81.8)	129 (79.6)	118 (84.3)
Black	16 (5.3)	12 (7.4)	4 (2.9)
Asian	14 (4.6)	4 (2.5)	10 (7.1)
American Indian/Alaskan	1 (0.3)	1 (0.6)	0 (0)
Biracial/Multiracial	24 (7.9)	16 (9.9)	8 (5.7)
Hispanic/Latinx	14 (4.6)	7 (4.3)	7 (5.0)
Medication Use	120 (39.7)	105 (64.8)	15 (10.7)
Comorbid psychiatric diagnoses[a]	107 (35.4)	74 (45.7)	33 (23.6)
Any externalizing (ODD/CD)	41 (13.6)	35 (21.6)	6 (4.3)

Any anxiety	73 (24.2)	46 (28.4)	27 (19.3)
Any depression	24 (7.9)	16 (9.9)	8 (5.7)

Note. SD=Standard Deviation. ODD = Oppositional Defiant Disorder. CD = Conduct Disorder. Income presented in US dollars.

[a]Presence of comorbid mental health diagnosis based on parent or adolescent report (only parents were administered ODD and PTSD modules) during the diagnostic interview.

Aim 1: Caffeine Use Comparison based on Group Status

Chi-square tests compared adolescents with and without ADHD on the number of caffeinated beverages consumed during the three times of day (Table 2). Caffeine use in the morning did not significantly differ between groups, χ^2 (2) = 4.92, p =.086. However, adolescents with ADHD were more likely to consume one or more caffeinated beverages in the afternoon, χ^2 (2) = 14.94, p =.001, and evening, χ^2 (2) = 7.81, p =.020 than adolescents without ADHD. Logistic regression analyses controlling for sex, pubertal development, and medication use, revealed that there were no significant increases in likelihood of caffeine consumption based on group status when examining no caffeine consumption or less than one beverage per day for morning, afternoon, or evening (Table 2). However, when examining use in the afternoon and evening for consuming at least one caffeinated beverage, adolescents with ADHD were 2.47 times more likely than adolescents without ADHD to consume at least one caffeinated beverage per day in the afternoon (95% confidence interval: 1.04-5.85) and at least one caffeinated beverage per day in the evening (95% confidence interval: 1.07-5.69). Approximately 81% of the participants with ADHD who consumed one or more caffeinated beverages in the afternoon also consumed one or more beverages in the evening.

Table 2. Chi-Square Tests and Odds Ratios for Number of Caffeinated Beverages Drank Per Day in Past 30 Days

			No Caffeine	Less than one	One or more	χ^2
Morning						
	Comparison	n (%)	70 (50.0%)	55 (39.3%)	15 (10.7%)	4.92
	ADHD	n (%)	70 (43.8%)	58 (36.3%)	32 (20.0%)	
		Odds Ratio	1.08	0.75	1.53	
Afternoon						
	Comparison	n (%)	65 (46.4%)	65 (46.4%)	10 (7.1%)	14.94**
	ADHD	n (%)	56 (35.0%)	67 (41.9%)	37 (23.1%)	
		Odds Ratio	0.80	0.84	2.47*	
Evening						
	Comparison	n (%)	70 (50.0%)	58 (41.4%)	12 (8.6%)	7.81*
	ADHD	n (%)	69 (43.1%)	59 (36.9%)	32 (20.0%)	
		Odds Ratio	0.91	0.71	2.47*	

*$p <.05$, **$p<.01$, ***$p<.001$

Note. Sex, pubertal developmental, and medication status were entered as covariates for odds ratios.

Aim 2: Caffeine Use and Associations with Sleep Functioning

In the path analysis examining caffeine use in the afternoon and evening in relation to sleep functioning, model fit statistics confirmed that allowing paths to be free across groups resulted in significantly better fit than fixing these paths across groups, $\Delta\chi^2 (4) = 138.80$, $p <.001$, and $\Delta\chi^2 (4) = 144.91$, $p <.001$, respectively. Model fit for the afternoon was good on one index (SRMR = 0.04) and adequate on two indices (RMSEA = 1.00, CFI = 0.90). Model fit for the evening was good on all three indices (SRMR = 0.03, RMSEA = .035, CFI = 0.99).

For adolescents in both the ADHD and comparison groups, consuming at least one caffeinated beverage per day in the afternoon was associated with higher levels of self-reported sleep-wake problems (Figure 1). For adolescents in the ADHD group, consuming at least one caffeinated beverage in the afternoon was also associated with higher levels of parent-reported initiating and maintaining sleep difficulties. This association was not significant for adolescents

in the comparison group. Caffeine consumption in the afternoon was not significantly associated

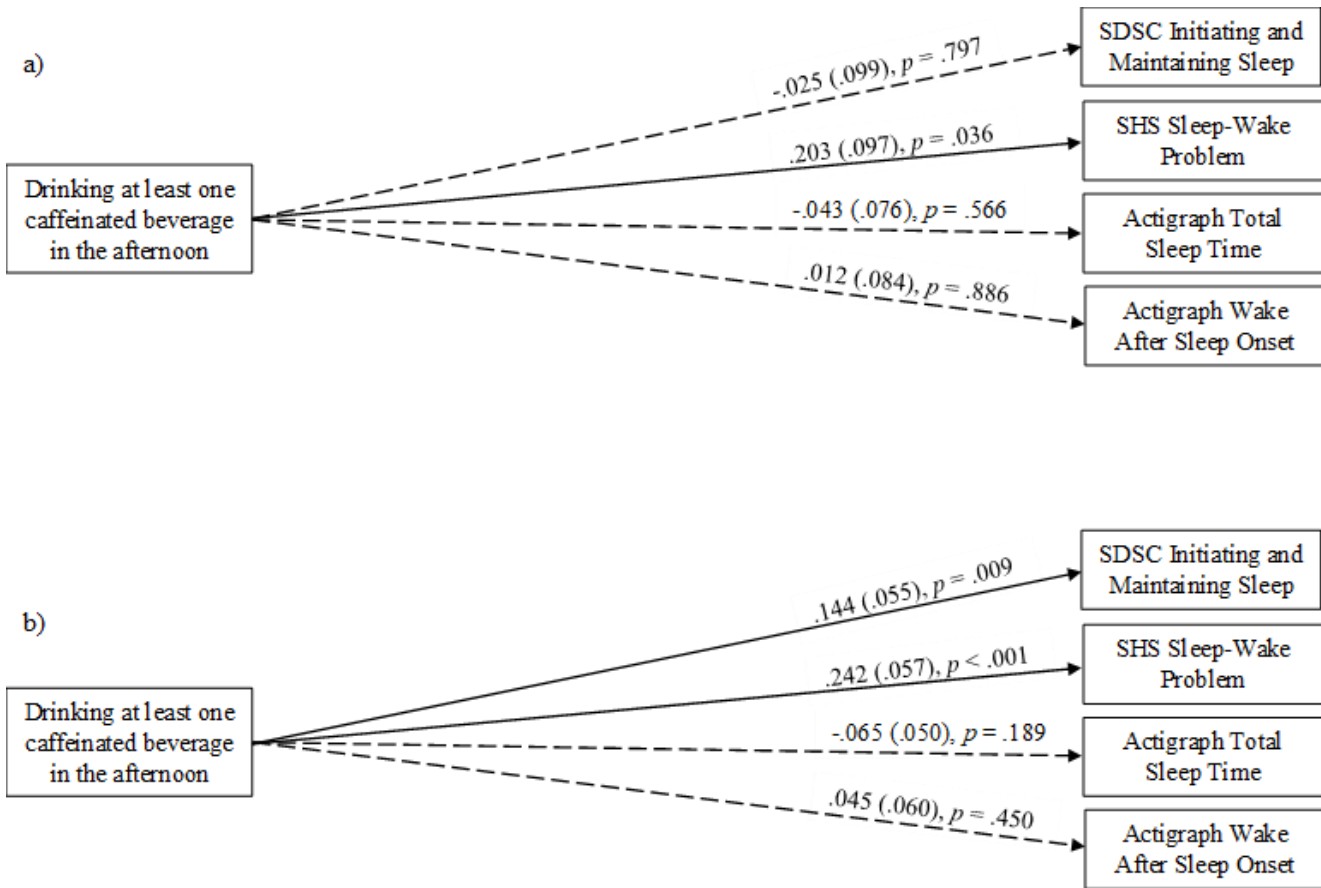with actigraphy total sleep time or WASO for either group.

Figure 1. Relations between drinking caffeinated beverages in the afternoon and sleep problems for the a) Comparison and b) ADHD Group. SHS = Sleep Habits Survey. SDSC = Sleep Disturbance Scale for Children. Standardized coefficients shown outside parentheses; standard errors are shown inside parentheses. Dashed paths are nonsignificant. Covariances are not included for readability.

For adolescents in the comparison group, consuming at least one caffeinated beverage per

day in the evening was not associated with any sleep functioning outcomes (Figure 2). For

adolescents in the ADHD group, caffeine use in the evening was significantly associated with

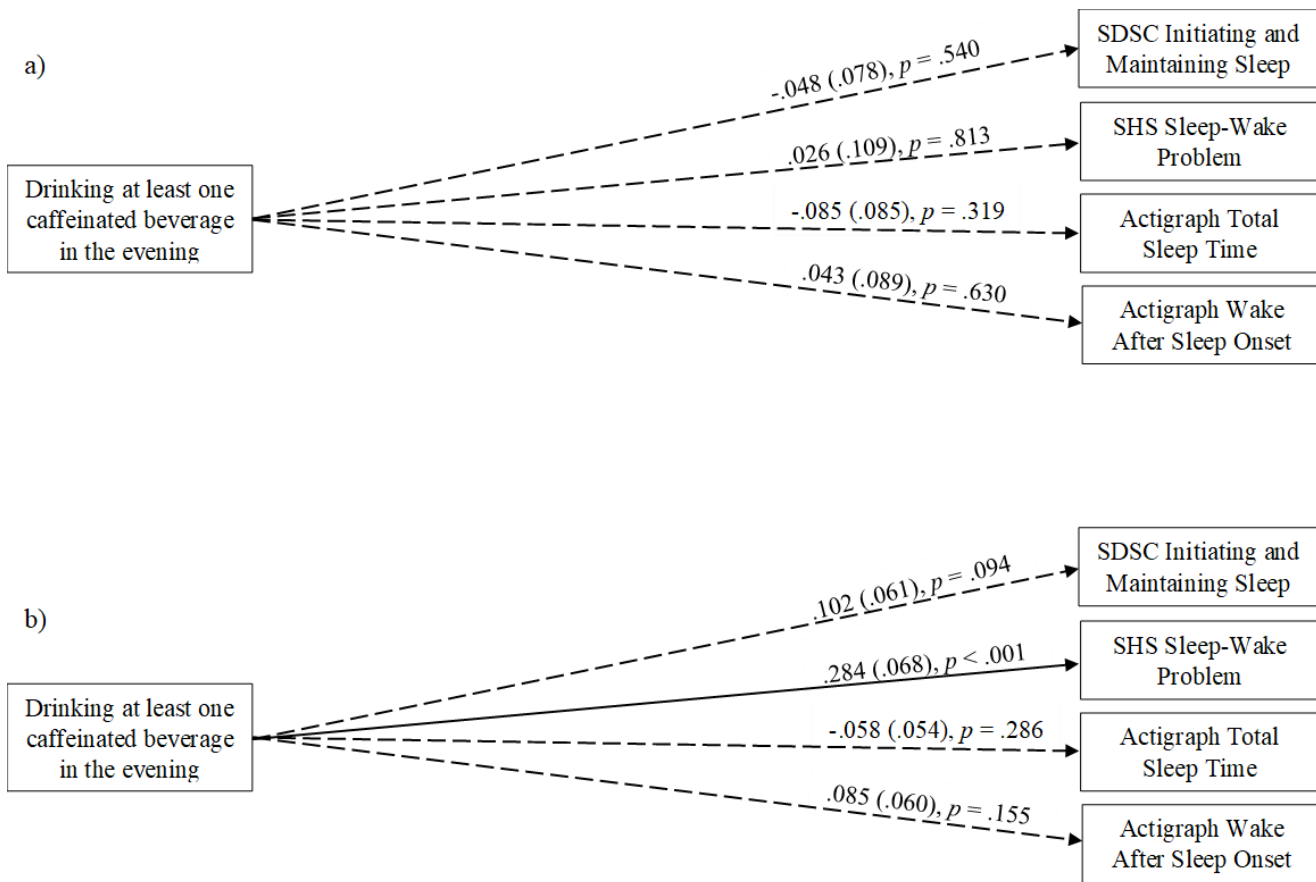higher levels of self-reported sleep-wake problems.

Figure 2. Relations between drinking caffeinated beverages in the evening and sleep problems for the a) Comparison and b) ADHD Group. SHS = Sleep Habits Survey. SDSC = Sleep Disturbance Scale for Children. Standardized coefficients shown outside parentheses; standard errors are shown inside parentheses. Dashed paths are nonsignificant. Covariances are not included for readability.

Given the potential for clinically relevant associations between medication use and caffeine use, we explored the impact of medication further. First, we assessed whether there were differences in caffeine consumption between participants who took ADHD medication versus participants who did not take ADHD medication. Chi-square tests did not reveal any significant differences (see Table 3). In terms of the role of medication as covariate in the caffeine to sleep models for adolescents with ADHD, medication use as a covariate was only significant for the paths between afternoon and evening caffeine use and WASO; afternoon, .100 (.048), $p = .039$, and evening, .106 (.048) $p = .029$.

Table 3. Chi-Square Tests to Examine Medication Differences in Number of Caffeinated Beverages Drank Per Day in Past 30 Days

			No caffeine	Less than one	One or more	χ^2
Morning						
	ADHD Medication	n (%)	38 (40.9%)	39 (41.9%)	16 (17.2%)	1.83
	No ADHD Medication	n (%)	102 (49.3%)	74 (35.7%)	31 (15.0%)	
Afternoon						
	ADHD Medication	n (%)	34 (36.6%)	38 (40.9%)	21 (22.6%)	4.89
	No ADHD Medication	n (%)	87 (42.0%)	94 (45.4%)	26 (12.6%)	
Evening						
	ADHD Medication	n (%)	41 (44.1%)	37 (39.8%)	15 (16.1%)	0.36
	No ADHD Medication	n (%)	98 (47.3%)	80 (38.6%)	29 (14.0%)	

Discussion

This study builds on prior literature by comparing rates of caffeine use at various times of the day in adolescents with and without ADHD and evaluating whether caffeine use is uniquely associated with sleep functioning in adolescents with ADHD.

Caffeine Use in Adolescents with ADHD

In this sample, adolescents with ADHD were 2.47 times more likely than adolescents without ADHD to consume one or more caffeinated beverages in the afternoon and evening. Notably, these findings are consistent with the only other study to evaluate caffeine use in adolescents with ADHD, which reported that adolescents with ADHD were 2.08 times more likely to consume high levels of caffeine as compared to adolescents without ADHD (Walker et

al., 2010). Previous research evaluated caffeine use broadly, across the day (Walker et al., 2010). The results of the present study demonstrate that time of day and the amount consumed are important to consider when studying caffeine use. Specifically, group differences were only found when examining consumption of one or more drinks per day during the afternoon and evening periods. There were no significant between group differences during the morning hours or when examining rates of consumption of less than one caffeinated beverage per day or no caffeine per day. The American Academy of Pediatrics (AAP) recommends that adolescents not exceed more than 100 mg of caffeine per day, which is equivalent to approximately one cup of coffee, and advises against the consumption of any quantity of energy drinks (Center for Disease Control and Prevention, 2016). Different types of caffeine consumption were not directly assessed in this study, however, consumption of one or more of any caffeinated beverages per day points towards problematic amounts of caffeine for over 20% of adolescents with ADHD in this study. Importantly, there was 81% overlap in the participants with ADHD who consumed high amounts of caffeine in both the afternoon and evening, which implies a pattern of problematic use that occurs in the middle of the day and continues into the evening. This highlights the importance of identifying adolescents with ADHD who are regular consumers of caffeine and further understanding patterns of use.

Interestingly, the greatest difference in time of day of consumption was found during the afternoon period. The afternoon is likely a time where teens' caffeine consumption is not directly supervised by parents and adolescents are in a position where they have more freedom to choose the beverages they consume (e.g. during lunchtime or between classes). During the evening, adolescents are more often in the company of their caregivers and may have more restrictions placed on how much caffeine they consume. The afternoon and evening are times of day when

there are high demands to pay attention, during class or while completing homework. It is possible that adolescents with ADHD are using caffeine as a form of self-medication in order to increase concentration. Research in a normative sample of adolescents found that the teens were most likely to consume caffeine as a means to "get through the day" and were most likely to consume their first beverage of the day around 2 PM (Bryant-Ludden & Wolfson, 2010). Adolescents with ADHD struggle with sustained attention and may be more likely to turn to caffeine use to increase attention in the afternoon and evening hours.

Caffeine Use and Sleep Functioning

This was the first study to examine associations between caffeine use and sleep functioning in adolescents with ADHD. Results demonstrate that caffeine use in the afternoon is associated with adolescent-reported sleep-wake problems in both adolescents with and without ADHD. Interestingly, there were associations between afternoon caffeine use and parent-reported initiating and maintaining sleep problems only for adolescents in the ADHD group. Similarly, when examining the association between evening caffeine use and sleep, there were only significant associations for adolescent-reported sleep-wake problems in the ADHD group. It may be that due to the increased consumption of caffeine during the later parts of the day, caffeine is having a stronger negative impact on sleep functioning in these individuals.

It is important to note that the overall magnitude of the effects were small, which may be a reflection of the low number of adolescents who consumed one or more caffeine drinks in the afternoon or evening. The adolescents in this sample were 12 – 14 years old, which may account for the low levels of caffeine consumption and smaller impact on sleep. This is consistent with prior work in typically developing samples which found significant associations between caffeine use and sleep functioning only in adolescents over the age of 13 (Drescher et al., 2011).

26

Caffeine consumption increases with age. For example, Miller, Dermen, & Lucke (2018) examined energy drink consumption patterns in 602 adolescents and found that middle adolescents (i.e. 16 – 17 years old) reported a significantly higher prevalence of recent use of energy drinks compared to early adolescents (i.e. 13 – 15 years old). Overall, it will important to evaluate patterns of caffeine use and associations with sleep in older adolescents with higher rates of caffeine use.

It is important to note that there were no significant associations between caffeine use in the afternoon or evening and actigraphy derived total sleep time or WASO for either adolescents with or without ADHD. This is consistent with previous research which examined sleep functioning based on adolescent-report and actigraphy in a sample of 14 adolescents with ADHD compared to 21 healthy controls (Mullin, Harvey, & Hinshaw 2011). Although the authors noted low power in their analyses, they did not find any significant differences on actigraphy or self-reported total sleep time between the ADHD group and the control group (Mullin et al., 2011). It may be that caffeine consumption is not impacting the total hours slept, but rather, is impacting subjective experiences of sleep and/or behavioral sleep functioning. Despite literature suggesting associations between caffeine use and increased WASO (e.g., Clark & Landolt, 2017; Pollack & Bright, 2003), this study did not find significant associations in either the comparison or ADHD group. Of note, the Pollack and Bright (2003) sample of adolescents had much higher levels of caffeine consumption as compared to the present sample. Additional research utilizing samples of adolescents with ADHD who are frequent and regular caffeine consumers is needed in order to more fully understand problematic caffeine use and the complex relationship with sleep.

Strengths and Limitations

The present study has several strengths, including a large sample of adolescents comprehensively evaluated for ADHD, providing well-defined groups for comparison. Another important strength is the inclusion of multiple informants and measures of sleep. Additionally, this study is unique within the caffeine literature in that it assesses caffeine consumption at multiple times of the day rather than average or global use over the day.

A limitation of this study is the measure of caffeine use. First, the item choices on the questionnaire are ordered categorical and do not assess the exact number of caffeinated beverages consumed continuously. Further, the measure does not provide detailed information about which specific types of caffeine (e.g., soda, coffee, energy drinks) are being consumed by adolescents with and without ADHD. Research suggests that milligrams of caffeine per beverage dictates the effects of caffeine on the body and therefore sleep functioning (Lodato et al., 2013). An additional limitation with the caffeine measure is that it does not allow data to be collapsed across times of the day (i.e., morning, afternoon, and evening) because some of the response choices represent a range. It will be important in future work to assess the actual caffeine dosage (e.g., milligrams per day) consumed to better understand that impact on sleep. Further, future research should examine the different types of caffeine consumed by adolescents with ADHD and both global and specific time of day use in order to develop a more comprehensive understanding of caffeine and its effect on sleep in this population.

Another important limitation is that the sample primarily consisted of White adolescents from relatively high-income families. This may limit the generalizability of the findings (e.g., to financially disadvantaged or racially/ethnically diverse adolescents). Regarding racial/ethnic differences in caffeine consumption, Loftfield and colleagues (2016) found that the prevalence of

coffee drinking differed by race/ethnicity in sample of 6,219 adults in the United States. Specifically, they found that non-Hispanic White adults were significantly more likely to consume coffee and consumed higher amounts of coffee per day when compared to Hispanic adults and non-Hispanic Black adults (Loftfield et al., 2016). As such, research on the impact of caffeine use on sleep is needed in more racially and ethnically diverse samples to confirm these findings.

Finally, due to the cross-sectional nature of this study, no assumptions can be made about the directionality of associations. It is unclear whether increased caffeine use precedes sleep problems or whether individuals with worse sleep may be more likely to turn to caffeine. It has been suggested that that there may be a cyclic relationship between caffeine use and sleep problems (Temple, 2019). Specifically, caffeine use during the day disrupts sleep, which therefore causes more caffeine use the following day, which disrupts sleep, and so on (Temple, 2019). Longitudinal research is needed to understand the direction of these associations.

Future Directions

Despite the abundance of research linking caffeine use and sleep problems in children, adolescents, and adults (Clark & Landolt, 2017), there is little research using longitudinal designs in any population. Interestingly, the majority of the literature assessing long term outcomes of caffeine use on sleep is in nurses and shift workers, given that this population often uses caffeine to facilitate staying alert during nightshifts (Waage et al., 2014). In many ways, adolescents with ADHD are also an at-risk population for high levels of caffeine consumption given that impulsivity is a core feature of the disorder and that caffeine may help combat attention deficits. For example, adolescents and young adults with ADHD are significantly more likely to escalate to heavy (i.e. daily) smoking (Sibley et al., 2014) and to engage in binge

drinking (Molina, Pelham, Gnagy, Thompson, & Marshal, 2007). Data from the present study suggests that adolescents with ADHD may be at-risk for similar patterns of caffeine consumption. Research is needed to evaluate why this may be the case. Specifically, research is needed to understand the reasons adolescents with ADHD consume caffeine and the subjective impact that caffeine has on their attention and functioning.

The impact of medication use on the association between caffeine use and sleep in adolescents with ADHD should also be further explored. In the path analyses examining caffeine use and sleep in this study, it was found that medication use was associated with WASO for individuals in the ADHD group. However, chi-square analyses found no significant differences in caffeine consumption based upon ADHD medication status. Taken together, these results suggest that medication use could serve as a moderator between caffeine use and sleep and future research is needed to explore this possibility.

More detailed caffeine measurement is needed in order to better understand caffeine use habits of adolescents with and without ADHD. Milligrams of caffeine per beverage is an important consideration, and this information is typically collected via self-report detailing the exact caffeinated product and quantity consumed, which is then converted into milligrams post data collection (Heckman et al., 2010). Unfortunately, a limitation of this technique is that there can be variability within a product, even when the serving size and the method of preparation is held constant (Bonnar & Gradisar, 2015). For example, a study by McCusker, Goldberg, and Cone (2003) evaluated the caffeine content of six 16 ounce Starbucks "Breakfast Blend" coffees that were brewed on six consecutive days, and found the caffeine content to range from 259.2 milligrams to 546.4 milligrams. Energy drinks also pose similar measurement challenges as the caffeine content is unregulated in the United States (Bonnar & Gradisar, 2015). Regardless,

detailed information about caffeine consumption is warranted while researching the effects of caffeine (Heckman et al., 2014).

Finally, an interesting area for future research includes how racial/ethnic identity and socioeconomic status (SES) impacts the relation between caffeine use and sleep, especially for individuals with ADHD. As previously mentioned, caffeine consumption habits can vary across cultures. A comprehensive analysis of caffeinated beverage consumption across 90 countries found that consumption habits vary greatly depending on factors such as geographical origin, culture, lifestyle, social behavior, and economic status (Reyes & Cornelis, 2018). Within the United States, ADHD has historically been disproportionally diagnosed in children from racial minority groups and low income families (Jurbergs, Palcic, & Kelley, 2010). There are also links between unhealthy eating behaviors (i.e. soda) and low SES (Hamasha, Warren, Levy, Broffitt, & Kanellis, 2006) as well as low SES and poor sleep (Bagley, Kelly, Buckhalt, El-Sheikh, 2015). Future research is needed with samples that are more financially and racially/ethnically diverse that the present sample, in order to evaluate the impact of SES, race, and ethnicity, on rates of caffeine consumption and the link between caffeine and sleep in adolescents with ADHD.

Conclusion

Overall, the results of this study suggest that adolescents with ADHD are consuming more caffeine than their non-ADHD peers in the afternoon and evening, and that there are unique associations between caffeine use and adolescent and parent-reported sleep problems in this population. Future research is needed in order to better understand the types of caffeine and quantity of caffeine being consumed in addition to reasons for use in adolescents with ADHD. Interestingly, research suggests that although adolescents are aware of the positive effects associated with caffeine use (i.e. increased energy, less sleepiness, improved concentration), they

have little awareness of the negative health consequences (Bryant-Ludden & Wolfson, 2010).

These findings suggest a need for parents and health care providers to educate adolescents about

AAP caffeine use recommendations and implications for sleep.

References

Advokat, C. D., Comaty, J. E., & Julien, R. M. (2014). *Julien's Primer of Drug Action: A Comprehensive Guide to the Actions, Uses, and Side Effects of Psychoactive Drugs* (13th ed.). Worth Publishers.

Ahluwalia, N., & Herrick, K. (2015). Caffeine intake from food and beverage sources and trends among children and adolescents in the United States: Review of national quantitative studies from 1999 to 2011. *Advances in Nutrition*, *6*(1), 102–111. https://doi.org/10.3945/an.114.007401

American Academy of Pediatric, Adolescence, C. O., & Health, C. on S. (2014). School start times for adolescents. *Pediatrics*, *134*(3), 642–649. https://doi.org/10.1542/peds.2014-1697

American Psychiatric Association. (2013). Neurodevelopmental Disorders. In *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.). Author. https://doi.org/10.1176/appi.books.9780890425596.dsm05

Bagley, E. J., Kelly, R. J., Buckhalt, J. A., & El-Sheikh, M. (2015). What keeps low-SES children from sleeping well: The role of presleep worries and sleep environment. *Sleep Medicine*, *16*(4), 496–502. https://doi.org/10.1016/j.sleep.2014.10.008

Bailey, R. L., Saldanha, L. G., Gahche, J. J., & Dwyer, J. T. (2014). Estimating caffeine intake from energy drinks and dietary supplements in the United States. *Nutrition Reviews*, *72*(suppl_1), 9–13. https://doi.org/10.1111/nure.12138

Barry, R., Rushby, J., Wallace, M., Clarke, A., Johnstone, S., & Zlojutro, I. (2005). Caffeine effects on resting-state arousal. *Clinical Neurophysiology*, *116*(11), 2693–2700. https://doi.org/10.1016/j.clinph.2005.08.008

Becker, S. P., Langberg, J. M., & Byars, K. C. (2015). Advancing a biopsychosocial and

contextual model of sleep in adolescence: A review and introduction to the special issue.

Journal of Youth and Adolescence, *44*(2), 239–270. https://doi.org/10.1007/s10964-014-

0248-y

Becker, S. P., Langberg, J. M., Eadeh, H.-M., Isaacson, P. A., & Bourchtein, E. (2019). Sleep

and daytime sleepiness in adolescents with and without ADHD: Differences across

ratings, daily diary, and actigraphy. *Journal of Child Psychology and Psychiatry*,

Advanced Online Publication. https://doi.org/10.1111/jcpp.13061

Bernstein, G. A., Carroll, M. E., Dean, N. W., Crosby, R. D., Perwien, A. R., & Benowitz, N. L.

(1998). Caffeine withdrawal in normal school-age children. *Journal of the American

Academy of Child & Adolescent Psychiatry*, *37*(8), 858–865.

https://doi.org/10.1097/00004583-199808000-00016

Bonnar, D., & Gradisar, M. (2015). Caffeine and sleep in adolescents: A systematic review.

Journal of Caffeine Research, *5*(3), 105–114. https://doi.org/10.1089/jcr.2014.0036

Bourchtein, E., Langberg, J. M., Cusick, C. N., Breaux, R. P., Smith, Z. R., & Becker, S. P.

(2019). Technology Use and Sleep in Adolescents With and Without Attention-

Deficit/Hyperactivity Disorder. *Journal of Pediatric Psychology*, *44*(5), 517–526.

https://doi.org/10.1093/jpepsy/jsy101

Brand, S., & Kirov, R. (2011). Sleep and its importance in adolescence and in common

adolescent somatic and psychiatric conditions. *International Journal of General

Medicine*, *4*, 425–442. https://doi.org/10.2147/IJGM.S11557

Branum, A. M., Rossen, L. M., & Schoendorf, K. C. (2014). Trends in caffeine intake among US children and adolescents. *Pediatrics*, *133*(3), 386–393. https://doi.org/10.1542/peds.2013-2877

Brener, N. D., Kann, L., McManus, T., Kinchen, S. A., Sundberg, E. C., & Ross, J. G. (2002). Reliability of the 1999 Youth Risk Behavior Survey Questionnaire. *Journal of Adolescent Health*, *31*(4), 336–342. https://doi.org/10.1016/S1054-139X(02)00339-7

Brown, T. A. (2015). *Confirmatory Factor Analysis for Applied Research* (2nd ed.). Guilford.

Bruni, O., Ottaviano, S., Guidetti, V., Romoli, M., Innocenzi, M., Cortesi, F., & Giannotti, F. (1996). The Sleep Disturbance Scale for Children (SDSC) construction and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. *Journal of Sleep Research*, *5*(4), 251–261. https://doi.org/10.1111/j.1365-2869.1996.00251.x

Bryant Ludden, A., & Wolfson, A. R. (2010). Understanding adolescent caffeine use: Connecting use patterns with expectancies, reasons, and sleep. *Health Education & Behavior*, *37*(3), 330–342. https://doi.org/10.1177/1090198109341783

Center for Disease Control and Prevention. (2016, March 22). *Energy Drinks | Healthy Schools | CDC*. https://www.cdc.gov/healthyschools/nutrition/energy.htm

Clark, I., & Landolt, H. P. (2017). Coffee, caffeine, and sleep: A systematic review of epidemiological studies and randomized controlled trials. *Sleep Medicine Reviews*, *31*, 70–78. https://doi.org/10.1016/j.smrv.2016.01.006

Coghill, D., Soutullo, C., d'Aubuisson, C., Preuss, U., Lindback, T., Silverberg, M., & Buitelaar, J. (2008). Impact of attention-deficit/hyperactivity disorder on the patient and family: Results from a European survey. *Child and Adolescent Psychiatry and Mental Health*, *2*(1), 31. https://doi.org/10.1186/1753-2000-2-31

Colrain, I. M., & Baker, F. C. (2011). Changes in sleep as a function of adolescent development. *Neuropsychology Review*, *21*(1), 5–21. https://doi.org/10.1007/s11065-010-9155-5

Cortese, S., Faraone, S. V., Konofal, E., & Lecendreux, M. (2009). Sleep in children with attention-deficit/hyperactivity disorder: Meta-analysis of subjective and objective studies. *Journal of the American Academy of Child & Adolescent Psychiatry*, *48*(9), 894–908. https://doi.org/10.1097/CHI.0b013e3181ac09c9

Drake, C., Roehrs, T., Shambroom, J., & Roth, T. (2013). Caffeine effects on sleep taken 0, 3, or 6 hours before going to bed. *Journal of Clinical Sleep Medicine*, *9*(11), 1195–1200. https://doi.org/10.5664/jcsm.3170

Drapeau, C., Hamel-Hebert, I., Robillard, R., Selmaoui, B., Filipini, D., & Carrier, J. (2006). Challenging sleep in aging: The effects of 200 mg of caffeine during the evening in young and middle-aged moderate caffeine consumers. *Journal of Sleep Research*, *15*(2), 133–141. https://doi.org/10.1111/j.1365-2869.2006.00518.x

Drescher, A. A., Goodwin, J. L., Silva, G. E., & Quan, S. F. (2011). Caffeine and screen time in adolescence: Associations with short sleep and obesity. *Journal of Clinical Sleep Medicine*, *7*(4), 337–342. https://doi.org/10.5664/jcsm.1182

Durmuş, F. B., Arman, A. R., & Ayaz, A. B. (2017). Chronotype and its relationship with sleep disorders in children with attention deficit hyperactivity disorder. *Chronobiology International*, *34*(7), 886–894. https://doi.org/10.1080/07420528.2017.1329207

Elkins, R. N., Rapoport, J. L., Zahn, T. P., Buchsbaum, M. S., Weingartner, H., Kopin, I. J., Langer, D., & Johnson, C. (1981). Acute effects of caffeine in normal prepubertal boys. *American Journal of Psychiatry*, *138*(2), 178–183. https://doi.org/10.1176/ajp.138.2.178

Fabiano, G. A., William E. Pelham, Jr., Waschbusch, D. A., Gnagy, E. M., Lahey, B. B., Chronis, A. M., Onyango, A. N., Kipp, H., Lopez-Williams, A., & Burrows-MacLean, L. (2006). A Practical Measure of Impairment: Psychometric Properties of the Impairment Rating Scale in Samples of Children With Attention Deficit Hyperactivity Disorder and Two School-Based Samples. *Journal of Clinical Child & Adolescent Psychology*, *35*(3), 369–385. https://doi.org/10.1207/s15374424jccp3503_3

Fischer, P. F. M., Nagai, R., & Teixeira, L. R. (2008). Explaining sleep duration in adolescents: The impact of socio-demographic and lifestyle factors and working status. *Chronobiology International*, *25*(2–3), 359–372. https://doi.org/10.1080/07420520802110639

França, A. P., Takahashi, R. N., Cunha, R. A., & Prediger, R. D. (2018). Promises of caffeine in attention-deficit/hyperactivity disorder: From animal models to clinical practice. *Journal of Caffeine and Adenosine Research*, *8*(4), 131–142. https://doi.org/10.1089/caff.2018.0016

Gillen-O'Neel, C., Huynh, V. W., & Fuligni, A. J. (2013). To study or to sleep? The academic costs of extra studying at the expense of sleep. *Child Development*, *84*(1), 133–142. https://doi.org/10.1111/j.1467-8624.2012.01834.x

Grimes, L. M., Kennedy, A. E., Labaton, R. S., Hine, J. F., & Warzak, W. J. (2015). Caffeine as an independent variable in behavioral research: Trends from the literature specific to ADHD. *Journal of Caffeine Research*, *5*(3), 95–104. https://doi.org/10.1089/jcr.2014.0032

Hale, L., & Guan, S. (2015). Screen time and sleep among school-aged children and adolescents: A systematic literature review. *Sleep Medicine Reviews*, *21*, 50–58. https://doi.org/10.1016/j.smrv.2014.07.007

Hamasha, A. A.-H., Warren, J. J., Levy, S. M., Broffitt, B., & Kanellis, M. J. (2006). Oral health behaviors of children in low and high socioeconomic status families. *Pediatric Dentistry*, 6.

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*, *42*(2), 377–381. https://doi.org/10.1016/j.jbi.2008.08.010

Heckman, M. A., Weil, J., & Mejia, E. G. D. (2010). Caffeine (1, 3, 7-trimethylxanthine) in foods: A comprehensive review on consumption, functionality, safety, and regulatory matters. *Journal of Food Science*, *75*(3), R77–R87. https://doi.org/10.1111/j.1750-3841.2010.01561.x

Hering-Hanit, R., & Gadoth, N. (2003). Caffeine-induced headache in children and adolescents. *Cephalalgia*, *23*(5), 332–335. https://doi.org/10.1046/j.1468-2982.2003.00576.x

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Hysing, M., Lundervold, A. J., Posserud, M.-B., & Sivertsen, B. (2016). Association between sleep problems and symptoms of attention deficit hyperactivity disorder in adolescence: Results from a large population-based study. *Behavioral Sleep Medicine*, *14*(5), 550–564. https://doi.org/10.1080/15402002.2015.1048448

James, J. E., Kristjánsson, Á. L., & Sigfúsdóttir, I. D. (2011). Adolescent substance use, sleep, and academic achievement: Evidence of harm due to caffeine. *Journal of Adolescence*, *34*(4), 665–673. https://doi.org/10.1016/j.adolescence.2010.09.006

Jensen, P. S., Eaton Hoagwood, K., Roper, M., Arnold, E., Odbert, C., Crowe, M., Molina, B., Hechtman, L., Hinshaw, S. P., Hoza, B., Newcorn, J., Swanson, J., & Wells, K. (2004). The services for children and adolescents–parent interview: Development and performance characteristics. *Journal of the American Academy of Child & Adolescent Psychiatry*, *43*(11), 1334–1344. https://doi.org/10.1097/01.chi.0000139557.16830.4e

Johnson, E. O., Roth, T., Schultz, L., & Breslau, N. (2006). Epidemiology of DSM-IV insomnia in adolescence: Lifetime prevalence, chronicity, and an emergent gender difference. *Pediatrics*, *117*(2), 247–256. https://doi.org/10.1542/peds.2004-2629

Jurbergs, N., Palcic, J. L., & Kelley, M. L. (2010). Daily behavior report cards with and without home-based consequences: Improving classroom behavior in low income, African American children with ADHD. *Child & Family Behavior Therapy*, *32*(3), 177–195. https://doi.org/10.1080/07317107.2010.500501

Kim, H.-Y. (2013). Statistical notes for clinical researchers: Assessing normal distribution (2) using skewness and kurtosis. *Restorative Dentistry & Endodontics*, *38*(1), 52. https://doi.org/10.5395/rde.2013.38.1.52

Kumar, G., Onufrak, S., Zytnick, D., Kingsley, B., & Park, S. (2015). Self-reported advertising exposure to sugar-sweetened beverages among US youth. *Public Health Nutrition*, *18*(7), 1173–1179. https://doi.org/10.1017/S1368980014001785

Lam, L. T., & Yang, L. (2008). Duration of Sleep and ADHD Tendency Among Adolescents in

China. *Journal of Attention Disorders*, *11*(4), 437–444.

https://doi.org/10.1177/1087054707299403

Lee, K. A., Mcenany, G., & Weekes, D. (1999). Gender differences in sleep patterns for early

adolescents. *Journal of Adolescent Health*, *24*(1), 16–20. https://doi.org/10.1016/S1054-

139X(98)00074-3

Leon, M. R. (2000). Effects of caffeine on cognitive, psychomotor, and affective performance of

children with Attention-Deficit/Hyperactivity Disorder. *Journal of Attention Disorders*,

4(1), 27–47. https://doi.org/10.1177/108705470000400103

Little, R., & Rubin, D. (2019). *Statistical Analysis with Missing Data* (3rd ed.). John Wiley &

Sons, Inc.

Lodato, F., Araújo, J., Barros, H., Lopes, C., Agodi, A., Barchitta, M., & Ramos, E. (2013).

Caffeine intake reduces sleep duration in adolescents. *Nutrition Research*, *33*(9), 726–

732. https://doi.org/10.1016/j.nutres.2013.06.005

Loftfield, E., Freedman, N. D., Dodd, K. W., Vogtmann, E., Xiao, Q., Sinha, R., & Graubard, B.

I. (2016). Coffee Drinking Is Widespread in the United States, but Usual Intake Varies by

key demographic and lifestyle factors. *The Journal of Nutrition*, *146*(9), 1762–1768.

https://doi.org/10.3945/jn.116.233940

Maslowsky, J., & Ozer, E. J. (2014). Developmental trends in sleep duration in adolescence and

young adulthood: Evidence from a national United States sample. *Journal of Adolescent

Health*, *54*(6), 691–697. https://doi.org/10.1016/j.jadohealth.2013.10.201

McCusker, R. R., Goldberger, B. A., & Cone, E. J. (2003). Caffeine Content of Specialty

 Coffees. *Journal of Analytical Toxicology*, *27*(7), 520–522.

 https://doi.org/10.1093/jat/27.7.520

Molina, B. S. G., Pelham, W. E., Gnagy, E. M., Thompson, A. L., & Marshal, M. P. (2007).

 Attention-deficit/hyperactivity disorder risk for heavy drinking and alcohol use disorder

 is age specific. *Alcoholism: Clinical and Experimental Research*, *31*(4), 643–654.

 https://doi.org/10.1111/j.1530-0277.2007.00349.x

Moore, M., & Meltzer, L. J. (2008). The sleepy adolescent: Causes and consequences of

 sleepiness in teens. *Paediatric Respiratory Reviews*, *9*(2), 114–121.

 https://doi.org/10.1016/j.prrv.2008.01.001

Mullin, B. C., Harvey, A. G., & Hinshaw, S. P. (2011). A preliminary study of sleep in

 adolescents with bipolar disorder, ADHD, and non-patient controls. *Bipolar Disorders*,

 13(4), 425–432. https://doi.org/10.1111/j.1399-5618.2011.00933.x

Muthén, L. K., & Muthén, B. O. (1998). *Mplus User's Guide* (7th ed.). Author.

Orbeta, R. L., Overpeck, M. D., Ramcharran, D., Kogan, M. D., & Ledsky, R. (2006). High

 caffeine intake in adolescents: Associations with difficulty sleeping and feeling tired in

 the morning. *Journal of Adolescent Health*, *38*(4), 451–453.

 https://doi.org/10.1016/j.jadohealth.2005.05.014

Owens, J., Adolescent Sleep Working Group, & Committee on Adolescence. (2014). Insufficient

 sleep in adolescents and young adults: An update on causes and consequences.

 Pediatrics, *134*(3), e921–e932. https://doi.org/10.1542/peds.2014-1696

Petersen, A. C., Crockett, L., Richards, M., & Boxer, A. (1988). A self-report measure of

    pubertal status: Reliability, validity, and initial norms. *Journal of Youth and Adolescence*,

    17(2), 117–133. https://doi.org/10.1007/BF01537962

Pollak, C. P., & Bright, D. E. (2003). Caffeine consumption and weekly sleep patterns in US

    seventh-, eighth-, and ninth-graders. *Pediatrics*, *111*(1), 42–46.

    https://doi.org/10.1542/peds.111.1.42

Prehn-Kristensen, A., Munz, M., Göder, R., Wilhelm, I., Korr, K., Vahl, W., Wiesner, C. D., &

    Baving, L. (2014). Transcranial Oscillatory Direct Current Stimulation During Sleep

    Improves Declarative Memory Consolidation in Children With Attention-

    deficit/hyperactivity Disorder to a Level Comparable to Healthy Controls. *Brain*

    Stimulation, *7*(6), 793–799. https://doi.org/10.1016/j.brs.2014.07.036

Rapoport, J. L., Jensvold, M., Elkins, R., Buchsbaum, M. S., Weingartner, H., Ludlow, C., Zahn,

    T. P., Berg, C. J., & Neims, A. H. (1981). Behavioral and cognitive effects of caffeine in

    boys and adult males. *The Journal of Nervous and Mental Disease*, *169*(11), 726–732.

    https://doi.org/10.1097/00005053-198111000-00007

Reyes, C. M., & Cornelis, M. C. (2018). Caffeine in the diet: Country-level consumption and

    guidelines. *Nutrients*, *10*(11). https://doi.org/10.3390/nu10111772

Rideout, V., Pai, S., Saphir, M., Pritchett, J., & Rudd, A. (2015). *The common sense censes:*

    Media use by tweens and teens. San Franciso, CA: Common Sense Media.

Sadeh, A., Gruber, R., & Raviv, A. (2003). The effects of sleep restriction and extension on

    school-age children: What a difference an hour makes. *Child Development*, *74*(2), 444–

    455. https://doi.org/10.1111/1467-8624.7402008

Sadeh, A., Sharkey, M., & Carskadon, M. A. (1994). Activity-based sleep-wake identification: An empirical test of methodological issues. *Sleep*, *17*(3), 201–207. https://doi.org/10.1093/sleep/17.3.201

Savoca, M. R., MacKey, M. L., Evans, C. D., Wilson, M., Ludwig, D. A., & Harshfield, G. A. (2005). Association of ambulatory blood pressure and dietary caffeine in adolescents. *American Journal of Hypertension*, *18*(1), 116–120. https://doi.org/10.1016/j.amjhyper.2004.08.011

Short, M., A., Gradisar, M., Lack, L., C., Wright, H., C., & Carskadon, M. A. (2012). The discrepancy between actigraphic and sleep diary measures of sleep in adolescents. *Sleep Medicine*, *13*(4), 378–384. https://doi.org/10.1016/j.sleep.2011.11.005

Swanson, J. M., Kinsbourne, M., Nigg, J., Lanphear, B., Stefanatos, G. A., Volkow, N., Taylor, E., Casey, B. J., Castellanos, F. X., & Wadhwa, P. D. (2007). Etiologic Subtypes of Attention-Deficit/Hyperactivity Disorder: Brain Imaging, Molecular Genetic and Environmental Factors and the Dopamine Hypothesis. *Neuropsychology Review*, *17*(1), 39–59. https://doi.org/10.1007/s11065-007-9019-9

Temple, J. L. (2009). Caffeine use in children: What we know, what we have left to learn, and why we should worry. *Neuroscience & Biobehavioral Reviews*, *33*(6), 793–806. https://doi.org/10.1016/j.neubiorev.2009.01.001

Temple, J. L. (2019). Review: Trends, safety, and recommendations for caffeine use in children and adolescents. *Journal of the American Academy of Child & Adolescent Psychiatry*, *58*(1), 36–45. https://doi.org/10.1016/j.jaac.2018.06.030

Temple, J. L., Bernard, C., Lipshultz, S. E., Czachor, J. D., Westphal, J. A., & Mestre, M. A. (2017). The safety of ingested caffeine: A comprehensive review. *Frontiers in Psychiatry*, *80*(8), 1–19. https://doi.org/10.3389/fpsyt.2017.00080

Temple, J. L., & Ziegler, A. M. (2011). Gender differences in subjective and physiological responses to caffeine and the role of steroid hormones. *Journal of Caffeine Research*, *1*(1), 41–48. https://doi.org/10.1089/jcr.2011.0005

Turton, P., Piché, L., & Battram, D. S. (2016). Adolescent attitudes and beliefs regarding caffeine and the consumption of caffeinated beverages. *Journal of Nutrition Education and Behavior*, *48*(3), 181-189.e1. https://doi.org/10.1016/j.jneb.2015.12.004

Waage, S., Pallesen, S., Moen, B. E., Magerøy, N., Flo, E., Di Milia, L., & Bjorvatn, B. (2014). Predictors of shift work disorder among nurses: A longitudinal study. *Sleep Medicine*, *15*(12), 1449–1455. https://doi.org/10.1016/j.sleep.2014.07.014

Walker, L. R., Abraham, A. A., & Tercyak, K. P. (2010). Adolescent caffeine use, ADHD, and cigarette smoking. *Children's Health Care*, *39*(1), 73–90. https://doi.org/10.1080/02739610903455186

Weller, E. B., Weller, R. A., Fristad, M. A., Rooney, M. T., & Schecter, J. (2000). Children's Interview for Psychiatric Syndromes (ChIPS). *Journal of the American Academy of Child & Adolescent Psychiatry*, *39*(1), 76–84. https://doi.org/10.1097/00004583-200001000-00019

Willcutt, E. G. (2012). The Prevalence of DSM-IV Attention-Deficit/Hyperactivity Disorder: A Meta-Analytic Review. *Neurotherapeutics*, *9*(3), 490–499. https://doi.org/10.1007/s13311-012-0135-8

Willcutt, E. G., Nigg, J. T., Pennington, B. F., Solanto, M. V., Rohde, L. A., Tannock, R., Loo,
S. K., Carlson, C. L., McBurnett, K., & Lahey, B. B. (2012). Validity of DSM-IV
attention–deficit/hyperactivity disorder symptom dimensions and subtypes. *Journal of
Abnormal Psychology*, *121*(4), 991–1010. https://doi.org/10.1037/a0027347

Wolfson, A. R., & Carskadon, M. A. (1998). Sleep schedules and daytime functioning in
adolescents. *Child Development*, *69*(4), 875–887. JSTOR.
https://doi.org/10.2307/1132351

Wolfson, A. R., Carskadon, M. A., Acebo, C., Seifer, R., Fallone, G., Labyak, S. E., & Martin, J.
L. (2003). Evidence for the validity of a sleep habits survey for adolescents. *Sleep*, *26*(2),
213–216. https://doi.org/10.1093/sleep/26.2.213

Zuvekas, S. H., & Vitiello, B. (2012). Stimulant Medication Use in Children: A 12-Year
Perspective. *American Journal of Psychiatry*, *169*(2), 160–166.
https://doi.org/10.1176/appi.ajp.2011.11030387

Caroline Nicole Cusick was born on May 18th, 1994 in Clinton, Maryland and is an American citizen. She graduated from Howard High School (Ellicott City, MD) in May 2012. She received a Bachelor of Science in Psychology from University of Maryland (College Park, MD) in May 2016 and graduated with high honors. Following graduation, she worked as a Clinical Research Coordinator at the Center for ADHD at Cincinnati Children's Hospital Medical Center from June 2016 to June 2018. She began working towards her doctoral degree in Clinical Psychology, specializing in children and adolescents, at Virginia Commonwealth University (Richmond, VA) in August, 2018, where she is mentored by Dr. Joshua Langberg.