The impact of daytime sleepiness on the school performance of college students with attention deficit hyperactivity disorder (ADHD): a prospective longitudinal study

JOSHUA M. LANGBERG[1], MELISSA R. DVORSKY[1], STEPHEN P. BECKER[2] and STEPHEN J. MOLITOR[1]

[1]Virginia Commonwealth University, Richmond, VA, USA and [2]Miami University, Oxford, OH, USA

Keywords
academic functioning, attention deficit hyperactivity disorder, college, daytime sleepiness, grades

Correspondence
Joshua M. Langberg, Department of Psychology, Virginia Commonwealth University, 806 W. Franklin Street, Richmond, VA 23284, USA.
Tel.: +1 804-828-6273;
fax: +1 804-828-2237;
e-mail: jlangberg@vcu.edu

Accepted in revised form 20 November 2013; received 18 September 2013

DOI: 10.1111/jsr.12121

SUMMARY

This prospective longitudinal study evaluated the impact of daytime sleepiness on the school performance of 62 college students diagnosed comprehensively with attention deficit hyperactivity disorder. The primary goal of the study was to determine if self-reported daytime sleepiness rated at the beginning of the academic year could predict academic and overall functioning at the end of the academic year while also considering potentially important covariates, including symptoms of inattention, hyperactivity and impulsivity, medication status and whether or not students lived at home or on-campus. Self-reported daytime sleepiness predicted longitudinally school maladjustment, overall functional impairment and the number of D and F grades (i.e. poor and failing) students received in courses above and beyond both self- and parent-report of symptoms, but did not predict overall grade point average. Living at home served as a protective factor and was associated with less school maladjustment and overall impairment. Gender was the only significant predictor in the overall grade point average model, with female gender associated with higher overall grades. The implications of these findings for monitoring and treatment of sleep disturbances in college students with attention deficit hyperactivity disorder are discussed.

INTRODUCTION

Sleep disturbances are common in childhood and adolescence and impact multiple aspects of academic functioning negatively, including school grades, academic achievement and homework performance (Beebe *et al.*, 2010; Langberg *et al.*, 2013; Perez-Chada *et al.*, 2007). The impact of sleep on academics has been demonstrated with rating scales and objective sleep measurement tools (e.g. overnight polysomnography and actigraphy), as well as in studies where sleep has been manipulated/restricted experimentally (e.g. Astill *et al.*, 2012; Fallone *et al.*, 2005). While many different types of sleep disturbance have been shown to be related to academic functioning (e.g. short-term deprivation, sleep quality and sleep duration), a recent meta-analysis suggests that daytime sleepiness exhibits the strongest association with academic performance (Dewald *et al.*, 2010).

The relationship between daytime sleepiness and academics appears to be particularly relevant for adolescents diagnosed with attention deficit hyperactivity disorder (ADHD). Adolescents with ADHD exhibit considerable impairment with academic performance and achievement, including significantly lower school grades and achievement scores and higher rates of school dropout in comparison to their same-aged peers (Molina *et al.*, 2009). Adolescents and young adults with ADHD have also been shown to exhibit high rates of sleep problems, with prevalence rates ranging from 25 to 50% (Owens, 2009; Sung *et al.*, 2008). Meta-analyses suggest that youth with ADHD have higher daytime sleepiness, more movements during sleep and higher apnea–hypopnea indexes than controls (Cortese *et al.*, 2006; Sadeh *et al.*, 2006). However, there is less compelling evidence for differences in sleep-onset, bedtime resistance, sleep architecture or breathing disorders once potential moderating factors such as comorbidities are taken into consideration (Cortese *et al.*, 2006; Sadeh *et al.*, 2006). Importantly, multiple double-blind placebo-controlled trials have documented that the high prevalence of sleep disturbances in youth with ADHD cannot be attributed solely to stimulant medication use (see Huang *et al.*, 2011 for a review).

Despite the high prevalence of both sleep problems and academic impairment in individuals with ADHD, there has been minimal research examining the relationship between these constructs. Specifically, although it is clear that ADHD symptoms predict longitudinally the presence of academic impairment (Langberg *et al.*, 2011; Massetti *et al.*, 2008), it is unknown whether sleep disturbances are also contributing factors. If this turns out to be the case, such results would have significant implications for evidence-based ADHD interventions which do not currently address sleep.

To our knowledge, there are only two published studies focused on the relationship between sleep and academics in ADHD samples. In an elementary school-age sample of children with ADHD, Mayes *et al.* (2008) reported that sleep disturbances did not predict standardized achievement scores once intelligence and ADHD symptoms were considered in the model. In contrast, in a sample of middle-school students diagnosed with ADHD, Langberg *et al.* (2013) found that self-reported daytime sleepiness predicted parent and teacher ratings of homework problems, academic impairment and academic competences above and beyond symptoms of ADHD, although daytime sleepiness did not predict grade point average (GPA). Therefore, it appears that the relationship between sleep and academics may depend upon how academic functioning is measured, with achievement tests possibly being less sensitive to sleep disturbances (Beebe *et al.*, 2010). Further, the age of the sample may be important, with the link between sleep and academics becoming progressively stronger in adolescence, as youth have increasing autonomy over sleep behaviours (Beebe, 2011; Drake *et al.*, 2003).

Following this logic, the negative impact of sleep disturbances on academics should be particularly relevant for college students with ADHD. The transition to college is associated with significantly reduced adult supervision and monitoring surrounding sleep. In general college student samples, prevalence rates for poor sleep quality approach 60% (Lund *et al.*, 2010) and there is a clear link between sufficient sleep and academic performance on college campuses (e.g. Gomes *et al.*, 2011). However, to date, the impact of daytime sleepiness on the functioning of college students with ADHD has not been examined. This is an important question, given that students with ADHD are increasingly pursuing postsecondary education and are experiencing a host of negative academic outcomes, including high rates of dropout (Weyandt and DuPaul, 2013).

Accordingly, the purpose of this study was to evaluate longitudinally the impact of daytime sleepiness on the functioning of college students with ADHD. This study examined the link between self-reported daytime sleepiness, rated at the beginning of the school year, with multiple measures of functioning collected at the end of the school year. Further, this study sought to determine whether sleepiness contributed to academics above and beyond both self- and parent-rated ADHD symptoms and other variables that could potentially impact sleep and academic performance, such as whether or not students lived on-campus and their ADHD medication status. The sample included in this study was diagnosed rigorously with ADHD using both parent- and self-report diagnostic interviews and standardized rating scales. This is important, as most previous research with college students with ADHD has relied upon self-report alone to establish diagnoses. Self-reported diagnoses have questionable validity, at best, due to concerns regarding students' ability to report retrospectively on childhood symptoms and impairments and malingering (Sollman *et al.*, 2010). Consistent with Langberg *et al.* (2013) and research with general college student samples (e.g. Clegg-Kraynok *et al.*, 2011), we hypothesized that daytime sleepiness would predict end-of-year ratings of impairment, but would not predict GPA, above and beyond baseline ADHD symptoms and covariates.

METHODS

Participants

Participants were 68 undergraduate students enrolled in a large public university in Virginia. In total, 139 students responded, expressed interest in the study and completed a telephone screen. Of these, 94 were eligible based on the telephone screen (previous diagnosis of ADHD or at least four inattentive symptoms endorsed) and completed the inclusion/exclusion evaluation. Sixty-eight participants met full study criteria and were enrolled. Given the focus on academic functioning, we limited the sample for the current study to those students taking at least three courses ($\geq$9 credit hours), resulting in a final sample of 62. These 62 participants ranged in age from 17 to 30 years [mean = 19.50, standard deviation (SD) = 2.46]; slightly more than half were male (n = 35). Forty-four participants (71%) self-identified as Caucasian; the remaining participants were either African American (n = 6), Hispanic (n = 6) or multi-racial (n = 6). Approximately half the participants (n = 32) were in their first year of college, with the remaining participants in their second (n = 16), third (n = 9) or fourth (n = 5) year. Based on the procedures described below, 35 participants were diagnosed with DSM-IV ADHD, predominately inattentive type (ADHD-I), and 27 participants were diagnosed with ADHD, combined type (ADHD-C). Forty-one participants self-reported taking psychotrophic medication. Thirty-six participants reported taking medication specifically for ADHD and five reported taking medication for other psychological issues (e.g. anxiety or depression).

Procedure

The study was approved by the university Institutional Review Board (IRB); student participants signed informed consent and their parents/guardians provided verbal consent. The inclusionary criteria included attendance at the university where the research was being conducted and meeting full

diagnostic criteria for ADHD-I or ADHD-C. Diagnosis was determined through separate administration to both the student and their parent/guardian of both parts I and II of the *Conners' Adult ADHD Diagnostic Interview for the DSM-IV* (CAADID; Epstein and Kollins, 2006; Epstein *et al*., 2000). The CAADID interview assesses both current and childhood symptoms and impairment as well as age of onset and pervasiveness of symptoms across time. Part I of the interview provides a detailed patient history and part II is the ADHD diagnostic interview.

Strict diagnostic inclusion criteria were adhered to in this study. Specifically, parents/guardians had to endorse at least six symptoms in an ADHD domain on the CAADID as present and impairing during childhood for a student to be included. Further, the student and their parents/guardians had to endorse a total of six symptoms in a domain as currently present and impairing on the CAADID. For documentation of current ADHD symptoms, we allowed parent interview data to be supplemented with student self-report and vice versa. However, both the parent and student had to endorse a minimum of four symptoms in a domain as currently present and impairing for supplementing to occur.

Flyers describing the study were included in the orientation packets of all incoming freshman, e-mailed to students currently receiving ADHD accommodations, and posted in the Disability Services Office at Student Health and in all university dormitories. The flyers stated that students with difficulties with attention and concentration and/or students with a diagnosis of ADHD were eligible to receive a free diagnostic evaluation. Baseline measures were completed by parents and students at the beginning of the school year (August). Follow-up measures were completed by students at the end of the school year (May; 9 months postbaseline).

Baseline measures

ADHD symptoms

Attention deficit hyperactivity disorder symptoms were assessed using the *Barkley Adult ADHD Rating Scale-IV* (BAARS-IV; Barkley, 2011a). The BAARS-IV has self- and parent-report versions that include the 18 DSM symptoms of ADHD. Each item was rated using a four-point scale (1 = never or rarely, 4 = very often). The BAARS-IV scales demonstrate satisfactory internal consistency and test–retest reliability (Barkley, 2011a). In order to reduce the number of predictor variables included in the analyses (given sample size constraints), a total score of current ADHD symptoms was used in the current study, with self- and parent-reported ADHD considered separately (α = 0.84 and 0.85, respectively).

Daytime sleepiness

The *Pediatric Daytime Sleepiness Scale* (PDSS; Drake *et al*., 2003) was developed and validated specifically as a self-report measure to examine the relationship between daytime sleepiness and academic functioning. The PDSS is one of six sleep measures to meet criteria as 'well-established' according to the American Psychological Association (APA) Division 54 evidence-based assessment criteria (Lewandowski *et al*., 2011). The PDSS consists of eight items loading onto a single factor. Participants rate each item on a scale from 4 (always) to 0 (never). The PDSS total score was examined in the present study (α = 0.96).

Follow-up measures

School maladjustment

Participants completed the *Behavior Assessment System for Children*, 2nd edn, *Self-Report of Personality—College Version* (BASC-2: SRP-College Version; Reynolds and Kamphaus, 2004). Items were rated on a four-point rating scale (1 = never; 2 = sometimes; 3 = often; 4 = almost always). The school maladjustment subscale from the BASC-2: SRP-College was examined in the present study and internal consistency was α = 0.79.

Overall functioning

Participants completed the *Barkley Functional Impairment Scale* (BFIS; Barkley, 2011b), which assesses psychosocial impairment in 15 domains of major life activities. The BFIS is a norm-referenced measure (n > 1200) with high internal consistency (0.97) and test–retest reliability (0.72). Participants rated impairment in each major life activity on a 10-point Likert scale ranging from 0 (not impaired) to 9 (severely impaired). A total impairment score (sum of all 15 domains of functioning) was examined in the present study (α = 0.96).

GPA

Participants' spring semester GPA was used as an objective measure of academic functioning and was coded based upon a system developed and refined in past work with adolescents and young adults (Molina *et al*., 2009). For all students, A = 4.0, B = 3.0, C = 2.0, D = 1.0 and F = 0. Both overall GPA and number of Ds and Fs in courses were examined as dependent variables in this study. Further, we separated the sample using a 2.0 GPA as a cutpoint. A GPA of 2.0 was selected as this represents a 'D' average and has been used in previous studies (e.g. Frazier *et al*., 2007), because students below 2.0 are typically placed on academic probation.

Analytical approach

First, we examined whether participants with ADHD-I or ADHD-C differed on their ratings of daytime sleepiness. Next, correlation analyses were conducted to examine which participant demographics/characteristics were associated

significantly with academic functioning outcome variables. The demographic/characteristic variables examined included, gender, race/ethnicity, year in school, living status (home or campus) and ADHD medication status. Demographic variables that were correlated significantly ($P < 0.05$) with an academic outcome variable were included as covariates.

Finally, the longitudinal associations examining baseline (beginning of the school year) ADHD symptoms (both self- and parent-reported) and daytime sleepiness in relation to follow-up (end of school year) academic functioning were evaluated by estimating path models using Mplus version 6.11 (Muthén and Muthén, 1998–2010). Given our limited sample size, separate path models were conducted for each of the four academic outcomes of interest (i.e. GPA, number of Ds and Fs, school maladjustment and overall impairment were not included together in a single path model). In line with best practice recommendations (Arbuckle, 1996), full information maximum likelihood (FIML) estimation was used to accommodate the few instances of missing data. Because the estimated path models were fully saturated (i.e. 0 degrees of freedom), they demonstrated a perfect fit to the data, and so model fit statistics are not reported. Path models provide standardized path coefficients that correspond closely to correlation coefficients (Peterson and Brown, 2005) and can be interpreted as a measure of effect size, with values ≤ 0.10 considered a small effect, values of 0.30 considered a medium effect and values ≥ 0.50 considered a large effect (Cohen, 1988).

RESULTS

Effects of ADHD subtype

Independent-sample *t*-tests indicated that participants with ADHD-I and participants with ADHD-C did not differ significantly on their self-ratings of daytime sleepiness, $P > 0.05$.

Correlation analyses

Variable means, standard deviations and intercorrelations are presented in Table 1. Females had higher GPAs and fewer Ds and Fs than males, so gender was included as a covariate in the path models predicting these outcomes. Participants who lived at home had lower levels of school maladjustment and overall impairment in comparison to participants not living at home, so housing status was covaried in path models predicting these outcomes. Participant age, race and medication status were not correlated significantly with any of the outcome variables and therefore are not considered further.

Path models

As described above, a separate path model was estimated for each of the outcome variables. In each path model, parent- and self-reported ADHD symptoms and daytime sleepiness were regressed on the outcome of interest.

GPA

The path model predicting GPA is displayed in Fig. 1. As shown, being male was associated with having a lower GPA ($\beta = -0.40$, $P = 0.001$). Neither parent-/youth-reported ADHD symptoms nor daytime sleepiness at baseline was a significant predictor of spring semester GPA.

Number of D and F grades received

The path model predicting number of Ds and Fs received during the spring semester is displayed in Fig. 2. Being male was associated with receiving more Ds and Fs ($\beta = 0.30$, $P = 0.01$). In addition, daytime sleepiness significantly predicted receiving more Ds and Fs ($\beta = 0.33$,

Table 1 Correlations of participant characteristics and baseline ADHD symptoms and daytime sleepiness with follow-up academic functioning

Variable	*Mean ± SD*	*GPA (2.30 ± 1.17)*	*Number of Ds and Fs (0.71 ± 1.01)*	*School maladjustment (51.93 ± 9.34)*	*Overall impairment (47.58 ± 24.58)*
Age (years)	19.5 ± 2.46	−0.14	−0.09	−0.15	0.22
Sex	–	−0.35**	0.30*	0.08	−0.04
Race	–	−0.02	0.13	0.06	−0.14
Medication status	–	0.02	0.19	−0.23	−0.14
Housing status	–	−0.06	−0.01	−0.35**	−0.40**
PR ADHD symptoms	2.36 ± 0.49	−0.09	−0.04	−0.12	0.33*
SR ADHD symptoms	2.60 ± 0.47	−0.08	−0.15	0.03	0.37**
SR daytime sleepiness	18.01 ± 4.30	−0.12	0.38**	0.49***	0.32*

GPA, grade point average; PR, parent-report; SD, standard deviation; SR, self-report.
$n = 62$. For sex, female = 0, male = 1. For race, non-Caucasian = 0, Caucasian = 1. For medication status, not taking medication for attention deficit hyperactivity disorder (ADHD) = 0, taking medication for ADHD = 1. For housing status, 0 = participant not living at home, 1 = participant living at home.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

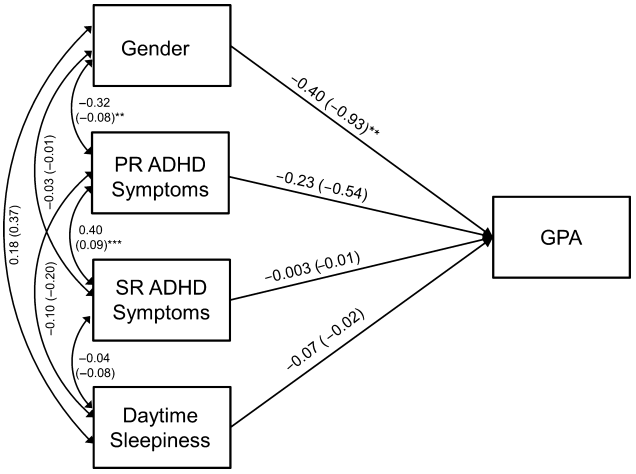

Figure 1. Estimated path model predicting grade point average (GPA). Standardized parameter estimates are reported outside parentheses; unstandardized parameter estimates are reported inside parentheses. For gender, female = 0, male = 1.

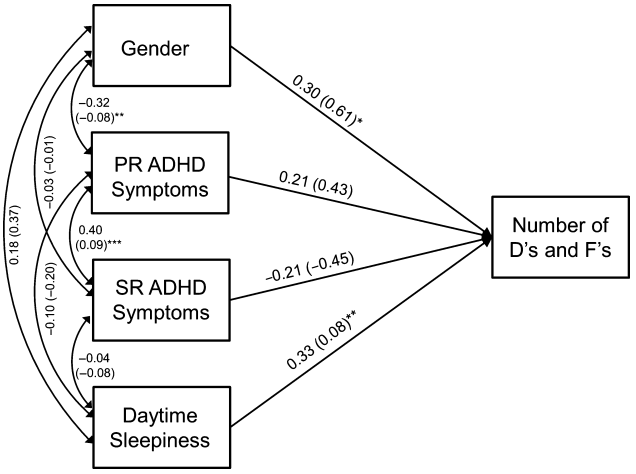

Figure 2. Estimated path model predicting number of D and F grades received. Standardized parameter estimates are reported outside parentheses; unstandardized parameter estimates are reported inside parentheses. For gender, female = 0, male = 1.

$P = 0.003$) when ADHD symptom severity variables were also included in the model. Parent- and self-reported ADHD symptoms did not predict number of Ds and Fs received.

Given the finding that sleepiness predicted Ds and Fs but did not predict overall GPA, we explored the possibility that the relation between sleepiness and grades is stronger for students with poor grades in comparison to students with moderate to high grades. To explore this hypothesis, we separated the sample using a 2.0 GPA as a cutpoint. *Post-hoc* analyses revealed that the correlation between PDSS and GPA was stronger for participants in the <2.0 GPA group ($r = 0.26$) in comparison to participants in the ≥2.0 GPA group ($r = 0.09$).

School maladjustment

The path model predicting BASC school maladjustment is displayed in Fig. 3. Living away from home was associated with greater school maladjustment ($\beta = -0.27$, $P = 0.02$) than living at home. In addition, daytime sleepiness significantly predicted greater school maladjustment ($\beta = 0.39$, $P < 0.001$) when ADHD symptom severity variables were also included in the model. Parent- and self-reported ADHD symptoms did not predict school maladjustment.

Functional impairment

The path model predicting BFIS overall impairment is displayed in Fig. 4. As with school maladjustment, living away from home was associated with greater overall impairment ($\beta = -0.24$, $P = 0.03$) than living at home. In addition, daytime sleepiness significantly predicted greater overall impairment ($\beta = 0.30$, $P = 0.007$) when ADHD symptom severity variables were also included in the model. Self-reported ADHD symptom severity was also a significant predictor of overall impairment ($\beta = 0.24$, $P = 0.03$).

DISCUSSION

To the best of our knowledge, this is the first prospective longitudinal study to evaluate the impact of daytime sleepiness on the academic functioning and overall impairment of college students diagnosed with ADHD. This is an important area of research, because while more students with ADHD are attending college, many are struggling academically and failing to graduate (Weyandt and DuPaul, 2013). The results of this study suggest that daytime sleepiness is a significant predictor of academic and overall functional impairment in college students with ADHD. Specifically, self-reported

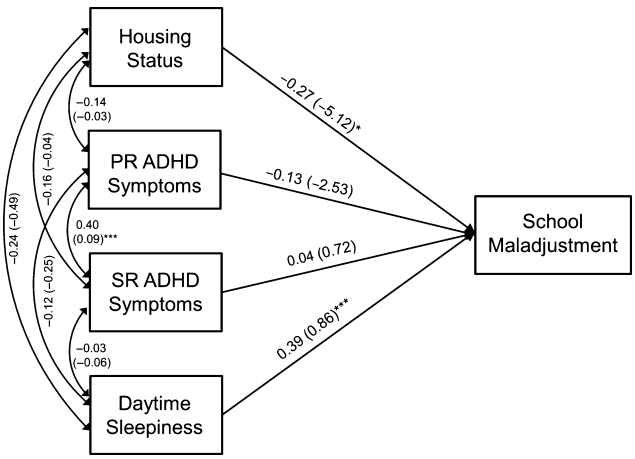

Figure 3. Estimated path model predicting school maladjustment. Standardized parameter estimates are reported outside parentheses; unstandardized parameter estimates are reported inside parentheses. For housing status, 0 = participant not living at home, 1 = participant living at home.

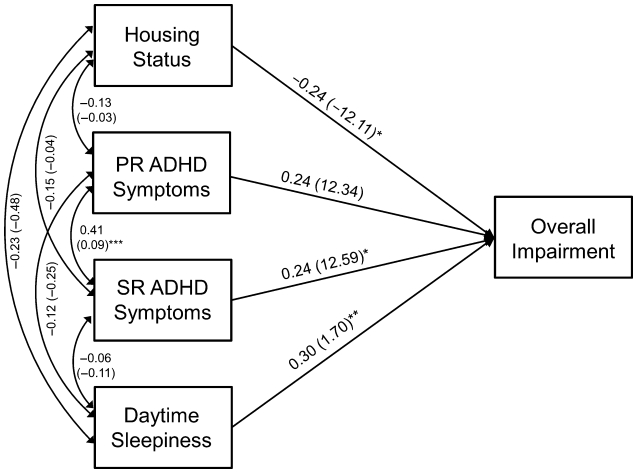

Figure 4. Estimated path model predicting overall functional impairment. Standardized parameter estimates are reported outside parentheses; unstandardized parameter estimates are reported inside parentheses. For housing status, 0 = participant not living at home, 1 = participant living at home.

daytime sleepiness, rated at the beginning of the school year, predicted self-report of school maladjustment and overall functional impairment at the end of the school year. The relationship between sleep and academics was significant even after considering other potentially important factors, such as gender, self- and parent-report of ADHD symptom severity and medication status. Daytime sleepiness also predicted the number of D and F grades students received, although it did not predict overall GPA.

The transition to college is a noteworthy developmental event for students with ADHD because of the rapid and immediate decline in external supports (e.g. living on one's own) and the marked increase in environmental demands (e.g. college level coursework). In college, students often become responsible for self-monitoring and regulating their own sleep/wake schedules. However, college students with ADHD exhibit significant difficulties with planning and self-regulation of behaviour and frequently make impulsive decisions (Weyandt and DuPaul, 2013). Accordingly, there is significant potential for college students with ADHD to exhibit sleep disturbances that impact functioning. Results from the present study confirm this assertion, and suggest that the negative impact of daytime sleepiness may go beyond the domain of academic functioning and also impact overall functioning. Specifically, daytime sleepiness predicted the BFIS total score, which assesses a wide range of activities including, but not limited to, educational activities, driving, interpersonal relationships and finance/money issues.

In this study, daytime sleepiness predicted the number of Ds and Fs students received but did not predict overall GPA (only gender predicted GPA in the correlation analyses and path model). In contrast, gender and daytime sleepiness were both significant predictors in the path model predicting number of Ds and Fs received. Further, *post-hoc* analyses revealed that the correlation between PDSS and GPA was stronger for participants in the <2.0 GPA group (r = 0.26) in comparison to participants in the ≥2.0 GPA group (r = 0.09). These findings suggest that the relationship between daytime sleepiness and GPA is stronger for students with poor grades in comparison to students with moderate to high grades. It is possible that a third variable not considered in these analyses is responsible for these results. For example, it could be that college students with a GPA below 2.0 are using/abusing alcohol and staying out late, resulting in daytime sleepiness and poor academic performance (see Future directions section).

Interestingly, living at home was significant in two of the final models (i.e. school maladjustment and overall impairment). Living at home appeared to serve as a buffer, or protective factor, and was associated with less severe impairment. This finding suggests that some college students with ADHD may not be ready developmentally to assume the burdens of self-regulation of sleep and academics with the transition to college and could benefit from additional monitoring/structure surrounding these activities.

Limitations

The primary limitation is the modest sample size (n = 62), which may have reduced our ability to detect effects. None the less, we were able to detect small to moderate effects in line with our a priori hypotheses, bolstering confidence in our results. In addition, all the students in this sample came from a single public university and, as such, until these findings are replicated it cannot be assumed that these results will generalize to college students with ADHD attending other universities. It is worth noting that the university where this study was conducted predominately serves in-state students (87%), is diverse (45% minority) and has average admissions standards [class of 2017 high school GPA mean = 3.27; scholastic ability test (SAT) mean = 1111]. Another limitation is that psychiatric comorbidities and learning disorders were not assessed formally as part of the study diagnostic evaluation (i.e. CAADID only assesses for ADHD, and BASC-2 provides symptom profiles but not diagnoses) and, as such, it is unknown how many participants met DSM criteria for comorbid conditions. Finally, this study relied upon self-report of daytime sleepiness using the PDSS and did not evaluate how students were sleeping during the night (e.g. sleep onset, maintenance or quality). Although the PDSS has been used in older adolescent samples, it was designed specifically for younger adolescents (aged 11–15), and the psychometric properties have not been evaluated in college or young adult samples. A stronger measurement approach would include multi-method assessment and objective measures of sleep.

Future directions

Additional longitudinal research is needed on the relationship between daytime sleepiness and functioning in college students with ADHD. In particular, mechanistic research is

needed that seeks to identify factors that may mediate or moderate the relationship between sleep and academics. Interestingly, the mechanisms thought to underlie the academic impairments of youth with ADHD, deficits in executive function (Miller *et al*., 2012), are very similar to the deficits thought to lead to poor school performance in youth with sleep disturbances (Beebe, 2011). Therefore, one possibility is that the impact of sleep on academics in college students with ADHD is mediated by executive function. Another important variable to consider in future research is alcohol use. College students with ADHD report higher rates of substance use, including alcohol, than those without ADHD (Baker *et al*., 2012). This is due probably to the risk-taking and impulsivity associated with ADHD (Walther *et al*., 2012). Global sleep quality has been found to predict alcohol use in college students (Kenney *et al*., 2012) and students with poor sleep report higher alcohol use (Lund *et al*., 2010). Accordingly, future research could examine whether alcohol use moderates the relationship between sleep and functional impairment in college students with ADHD. In addition, there is evidence supporting a link between ADHD and obesity (Cortese and Morcillo, 2010), and a positive association between obesity and excessive daytime sleepiness has been found in ADHD and non-ADHD samples (Cortese *et al*., 2007; Panossian and Veasey, 2012). Accordingly, one promising area for future research is on the interrelations of obesity, daytime sleepiness and academic functioning in individuals with ADHD.

In sum, it is now clear that excessive daytime sleepiness is common in individuals with ADHD and is associated with impairment in functioning. It will be important for future research to build upon the current study by using multiple measures of sleep while also considering potential moderating factors and mediating processes to further our understanding of how sleep functioning relates to subsequent school adjustment. Further, the causes of daytime sleepiness in individuals with ADHD remain largely unknown and research is needed that sheds light on factors that contribute to the presence of daytime sleepiness.

CONFLICTS OF INTEREST

No conflicts of interest declared.

REFERENCES

Arbuckle, J. L. Full information estimation in the presence of incomplete data. In: G. A. Marcoulides and R. E. Shumaker (Eds) *Advanced Structural Equation Modeling: Issues and Techniques*. Lawrence Erlbaum, Mahwah, NJ, 1996: 243–277.

Astill, R. G., Van der Heijden, K. B., Van IJzendoorn, M. H. and Van Someren, E. J. W. Sleep, cognition, and behavioral problems in school-age children: a century of research meta-analyzed. *Psychol. Bull*., 2012, 138: 1109–1138.

Baker, L., Prevatt, F. and Proctor, B. Drug and alcohol use in college students with and without ADHD. *J. Atten. Disord*., 2012, 16: 255–263.

Barkley, R. A. *Barkley Adult ADHD Rating Scale-IV (BAARS-IV)*. Guilford Press, New York, NY, 2011a.

Barkley, R. A. *The Barkley Functional Impairment Scale*. Guilford Press, New York, NY, 2011b.

Beebe, D. W. Cognitive, behavioral, and functional consequences of inadequate sleep in children and adolescents. *Pediatr. Clin. North Am*., 2011, 58: 649–665.

Beebe, D. W., Ris, M. D., Kramer, M. E., Long, E. and Amin, R. The association between sleep disordered breathing, academic grades, and cognitive and behavioral functioning among overweight subjects during middle to late childhood. *Sleep*, 2010, 33: 1447–1456.

Clegg-Kraynok, M. M., McBean, A. L. and Montgomery-Downs, H. E. Sleep quality and characteristics of college students who use prescription psychostimulants nonmedically. *Sleep Med*., 2011, 12: 598–602.

Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*, 2nd edn. Erlbaum, Hillsdale, NJ, 1988.

Cortese, S. and Morcillo, P. C. Comorbidity between ADHD and obesity: exploring shared mechanisms and clinical implications. *Postgrad. Med*., 2010, 122: 88–96.

Cortese, S., Konofal, E., Yateman, N., Mouren, M. and Lecendreux, M. Sleep and alertness in children with attention-deficit/hyperactivity disorder: a systematic review of the literature. *Sleep*, 2006, 29: 504–511.

Cortese, S., Maffeis, C., Konofal, E., *et al.* Parent reports of sleep/alertness problems and ADHD symptoms in a sample of obese adolescents. *J. Psychosom. Res*., 2007, 63: 587–590.

Dewald, J. F., Meijer, A. M., Oort, F. J., Kerkhof, G. A. and Bögels, S. M. The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: a meta-analytic review. *Sleep Med. Rev*., 2010, 14: 179–189.

Drake, C., Nickel, C., Burduvali, E., Roth, T., Jefferson, C. and Badia, P. The pediatric daytime sleepiness scale (PDSS): sleep habits and school outcomes in middle-school children. *Sleep*, 2003, 26: 455–458.

Epstein, J. N. and Kollins, S. H. Psychometric properties of an adult ADHD diagnostic interview. *J. Atten. Disord*., 2006, 9: 504–514.

Epstein, J. N., Johnson, D. and Conners, C. K. *Conners' Adult ADHD Diagnostic Interview for DSM-IV*. Multi-Health Systems Inc., North Tonawanda, NY, 2000.

Fallone, G., Acebo, C., Seifer, R. and Carskadon, M. A. Experimental restriction of sleep opportunity in children: effects on teacher ratings. *Sleep*, 2005, 28: 1561–1567.

Frazier, T. W., Youngstrom, E. A., Glutting, J. J. and Watkins, M. W. ADHD and achievement: meta-analysis of the child, adolescent, and adult literatures and a concomitant study with college students. *J. Learn. Dis*., 2007, 40: 49–65.

Gomes, A. A., Tavares, J. and de Azevedo, M. H. P. Sleep and academic performance in undergraduates: a multi-measure, multi-predictor approach. *Chronobiol. Int*., 2011, 28: 786–801.

Huang, Y. S., Tsai, M. H. and Guilleminault, C. Pharmacological treatment of ADHD and the short and long term effects on sleep. *Curr. Pharm. Des*., 2011, 17: 1450–1458.

Kenney, S. R., LaBrie, J. W., Hummer, J. F. and Pham, A. T. Global sleep quality as a moderator of alcohol consumption and consequences in college students. *Addict. Behav*., 2012, 37: 507–512.

Langberg, J. M., Molina, B. S. G., Arnold, L. E. *et al.* Patterns and predictors of adolescent academic achievement and performance in a sample of children with attention-deficit/hyperactivity disorder (ADHD). *J. Clin. Child Adolesc. Psychol*., 2011, 40: 519–531.

Langberg, J. M., Dvorsky, M. R., Marshall, S. and Evans, S. W. Clinical implications of daytime sleepiness for the academic performance of middle school age adolescents with ADHD. *J. Sleep Res*., 2013, 22: 542–548.

Lewandowski, A. S., Toliver-Sokol, M. and Palermo, T. M. Evidence-based review of subjective pediatric sleep measures. *J. Pediatr. Psychol*., 2011, 36: 780–793.

Lund, H. G., Reider, B. D., Whiting, A. B. and Prichard, J. R. Sleep patterns and predictors of disturbed sleep in a large population of college students. *J. Adolesc. Health*, 2010, 46: 124–132.

Massetti, G. M., Lahey, B. B., Pelham, W. E. *et al.* Academic achievement over 8 years among children who met modified criteria for attention-deficit/hyperactivity disorder at 4–6 years of age. *J. Abnorm. Child Psychol*., 2008, 36: 399–410.

Mayes, S. D., Calhoun, S. L., Bixler, E. O. and Vgontzas, A. N. Nonsignificance of sleep relative to IQ and neuropsychological scores in predicting academic achievement. *J. Dev. Behav. Pediatr*., 2008, 29: 206–212.

Miller, M., Nevado-Montenegro, A. J. and Hinshaw, S. P. Childhood executive function continues to predict outcomes in young adult females with and without childhood-diagnosed ADHD. *J. Abnorm. Child Psychol*., 2012, 40: 657–668.

Molina, B. S. G., Hinshaw, S. P., Swanson, J. M. *et al.* The MTA at 8 years: prospective follow-up of children treated for combined type ADHD in a multisite study. *J. Am. Acad. Child Adolesc. Psychiatry*, 2009, 48: 484–500.

Muthén, L. K. and Muthén, B. O. *Mplus User's Guide*, 6th edn. Muthén & Muthén, Los Angeles, CA, 1998–2010.

Owens, J. A. A clinical overview of sleep and attention-deficit/hyperactivity disorder in children and adolescents. *J. Can. Acad. Child Adolesc. Psychiatry*, 2009, 18: 92–102.

Panossian, L. A. and Veasey, S. C. Daytime sleepiness in obesity: mechanisms beyond obstructive sleep apnea—a review. *Sleep*, 2012, 35: 605–615.

Perez-Chada, D., Perez-Lloret, S., Videla, A. J. *et al.* Sleep disordered breathing and daytime sleepiness are associated with poor academic performance in teenagers. A study using the Pediatric Daytime Sleepiness Scale (PDSS). *Sleep*, 2007, 30: 1698–1703.

Peterson, R. A. and Brown, S. P. On the use of beta coefficients in meta-analysis. *J. Appl. Psychol*., 2005, 90: 175–181.

Reynolds, C. R. and Kamphaus, R. W. *Behavior Assessment System for Children, 2nd edn (BASC-2)*. AGS Publishing, Circle Pines, MN, 2004.

Sadeh, A., Pergamin, L. and Bar-Haim, Y. Sleep in children with attention-deficit hyperactivity disorder: a meta-analysis of polysomnographic studies. *Sleep Med. Rev*., 2006, 10: 381–398.

Sollman, M. J., Ranseen, J. D. and Berry, D. T. R. Detection of feigned ADHD in college students. *Psychol. Assess*., 2010, 22: 325–335.

Sung, V., Hiscock, H., Sciberras, E. and Efron, D. Sleep problems in children with attention-deficit/hyperactivity disorder: prevalence and the effect on the family. *Arch. Pediatr. Adolesc. Med*., 2008, 162: 336–342.

Walther, C. A., Cheong, J., Molina, B. S. *et al.* Substance use and delinquency among adolescents with childhood ADHD: the protective role of parenting. *Psychol. Addict. Behav*., 2012, 26: 585.

Weyandt, L. L. and DuPaul, G. J. *College Students with ADHD: Current Issues and Future Directions*. Springer, New York, NY, 2013.