College Students with ADHD at Greater Risk for Sleep Disorders

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Abstract

The pediatric literature indicates that children with ADHD are at greater risk for sleep problems, daytime sleepiness, and some sleep disorders than children with no diagnosed disability. It has not been determined whether this pattern holds true among emerging adults, and whether comorbid sleep disorders with ADHD predict GPA. The present study used a validated survey to screen 1085 freshmen college students for risk for sleep disorders, sleepiness, and sleep patterns. Risk for a sleep disorder among those who had been diagnosed with ADHD or a learning disability (an additional control group with a different disability) were compared to students without a diagnosed disability. Students with ADHD were at greater risk for insomnia and restless legs syndrome/periodic limb movement disorder. Both an ADHD diagnosis and risk for insomnia or a circadian rhythm disorder predicted lower GPA, but the two predictors did not interact. Implications of the associations of ADHD and risk for sleep disorders among emerging adults are discussed.

Keywords: Sleep disorder, college students, ADHD, insomnia, PLMD/RLS

Children with ADHD, symptoms of ADHD, or conduct problems are more likely to have disrupted sleep (Owens, 2009), shorter sleep duration (Touchette et al., 2007), and are at greater risk for some sleep disorders (e.g. Owens, Maxim, Nobile, McGuinn, & Msall. 2000). The findings are mixed, with some studies finding little association of sleep problems with ADHD (e.g. Hansen, Skirbekk, Oerbeck, Richter, & Kristensen, 2011), while others do find associations with sleep disorders (e.g. Picchietti, England, Walters, Willis & Verrico 1998). A few studies have found ADHD-related differences in polysomnograpy-measured characteristics of sleep (such as increased limb movement during sleep; Sadeh, Pergamin, & Bar-Haim, 2006), while others find few or no objective differences in sleep patterns (Cooper, Tyler, Wallace, & Burgess, 2004; Sangal, Owens, & Sangal 2005). There is little investigation into whether this association between sleep disorders and ADHD is also found among college students, and whether sleep disorders interact with ADHD status to compromise academic success in this population. The purpose of the present study was to examine whether this pattern of findings among children generalized to emerging adults.

Weyandt and DuPaul (2008) estimated the prevalence of ADHD among adults to be 2%-4%. College students with ADHD face academic and psychological challenges, aside from any that may be related to sleep problems. Heiligenstein, Guenther, Levy, Savino, and Fulwiler (1999) reported lower grades in this population, and they are less likely to attend and graduate from college (Advokat & Vinci, 2012). Shaw-Zirt, Popali-Lehane, Chaplin and Bergman (2005) found lowered self-esteem and social skills among those with ADHD. If the association of ADHD and sleep problems seen in the pediatric literature is found among college students, these students may face an additional, often undiagnosed or untreated, challenge to academic success.

The prevalence of sleep disorders in a college population is not well established. Gaultney (2010) reported that 29% of a general college population were at risk for some type of sleep disorder (as measured with a validated survey), although it is possible that some of these students were misinterpreting behavioral or environmental conditions that are not conducive to sleep as symptoms of sleep disorders. Taylor et al. (2011) found 9% of college students had insomnia.

An assessment of adolescents from ages 15-18 found that 25% reported symptoms of insomnia, but only 4% met the clinical criteria for insomnia disorder (Ohayon, Roberts, Zulley, Smirne, & Priest, 2000).

The cost of ignoring sleep problems at any age is high. Sleepiness, poor sleep quality, insufficient, or inconsistent sleep have been associated in the adolescent literature with deficits in attention and academic performance (Pagel, Forister, & Kwiatkowski, 2007), drowsy driving (Cummings, Koelsell, Moffat, & Rivara, 2001), risk-taking (O'Brien & Mindell, 2005), social relationships (Carney, Edinger, Meyer, Lindman, & Istre, 2006), and health (Smaldone, Honig, & Byrne, 2006).

Behavioral and Cognitive Outcomes Associated With Sleep Problems in Children

Much more evidence supports a link between ADHD and sleep among children. A review by Owens (2009) of over 50 studies of children suggested that sleep disorders may co-occur with ADHD, and that the sleep disorder may contribute to hyperactivity and inattentiveness. Several sleep disorders in particular have been associated with behavior and/or academic problems in children, including sleep disordered breathing (SDB) and periodic limb movement disorder (PLMD)/ restless legs syndrome (RLS). SDB is an umbrella term that includes obstructive sleep apnea (OSA), central apneas, upper airway resistance syndrome, and primary snoring. Although classified as separate disorders, both RLS and PLMD are characterized by abnormal leg movements that may interfere with sleep quality and/or quantity (Ohayon & Roth, 2002).

Sleep disorders in children can present with deficits in cognitive ability, academic success, or behavior. For example, children with SDB perform worse in school, and parents and teachers report worse daytime behavior (e.g. Beebe, Ris, Kramer, Long, & Amin, 2010). Urschitz et al. (2004) found that children who snored (sometimes used as a marker for SDB in research) had greater parent-reported hyperactivity, inattention, sleepiness, behavior, social, and emotional difficulties. While SDB has been connected with both behavioral and cognitive outcomes, RLS and PLMD have been associated primarily with behavior problems. Gaultney, Merchant, and Gringras (2009) found that parents of children who had been diagnosed with PLMD (based on currently-recommended criteria) reported more behavior problems than did parents of children diagnosed with SDB.

Behavioral and Cognitive Outcomes Associated With Sleep Problems in Adolescents and Adults

In addition to the findings in the pediatric literature, some evidence suggests sleep issues among adults and adolescents with ADHD. Sobanski, Schredl, Kettler, and Alm (2008) examined sleep among adults with ADHD relative to matched controls with no psychopathology or sleep disorders. They found that the sleep architecture and other sleep parameters (based on two nights of polysomnography as well as subjective reports) differed between the two groups. Participants with ADHD demonstrated worse quality of sleep (more awakenings, a lower percentage of time in bed actually spent asleep) and a lower percentage of rapid eye movement sleep. Shur-Fen Gau and Chiang (2009) studied Taiwanese adolescents diagnosed with persistent ADHD or sub-threshold ADHD during childhood and controls. Self-reported data indicated that those with childhood ADHD experienced more sleep problems (such as symptoms of insomnia, bruxism, snoring, and nightmares) than did controls.

As appears to be the case in the pediatric literature, sleep problems can predict compromised academic outcomes in this older age group. Gaultney (2010) found that college students who appeared to be at risk for a sleep disorder were also more likely to be at academic risk (GPA < 2.0). Pagel and Kwiatkowski (2010) examined sleep characteristics among students in middle school, high school, or college. They found that self-reported restless legs and periodic limb movements predicted lower GPA in middle school students. Difficulties initiating and maintaining sleep (which may indicate insomnia or PLMD) predicted lower grades among college students. These studies, however, included a general population of students and did not examine whether the ADHD-sleep association found among children generalized to college students. Cohen-Zion and Ancoli-Israel (2004) reviewed 47 studies of associations between ADHD and sleep problems among children and adolescents ages 3-19. Parent-reported sleep problems were common among both medicated and non-medicated participants. Although the findings weren't unanimous, the data suggested ADHD-related increased nighttime activity, reduced rapid eye movement sleep, and increased daytime sleepiness, and possibly increased periodic limb movements during sleep.

The present study examined risk for sleep disorders among college students who had previously been diagnosed with ADHD relative to those diagnosed with

a learning disability ([LD]; a comparison disability that can also compromise academic success), and a comparison group without a known disability. Based on the pediatric literature, we expected that college students who had been diagnosed with ADHD would report lower sleep duration, more daytime sleepiness, and be at greater risk for sleep disorders relative to those with LD or those not diagnosed with a disability. Specifically, they would be at greater risk for OSA and RLS/PLMD. We further expected that students at risk for a sleep disorder would have lower GPA, and that risk for a sleep disorder would moderate the association of ADHD status with GPA.

Method

Participants

New, fulltime freshmen students at a large university in the southeast United States were invited to take part in the study. Participants were limited to new freshmen students for several reasons. Many students who begin college do not continue to graduation at the same institution. For example, only about 25% of entering freshmen in 2008 continued to graduation at the present institution within a four-year period, with another 34% still enrolled but not yet graduated (University of North Carolina General Assembly, 2014). Given the evidence that poor sleep predicts many aspects of emotional, physical, and academic health, early identification and remediation may improve a variety of health and academic outcomes. It is not unusual for grades to be low during the freshman year of college (Grove & Wasserman, 2004). If poor sleep contributes to academic difficulty, the ability to identify students at risk for sleep disorders early in their academic career may inform timely interventions designed to improve retention and graduation rates. Additionally, many entering freshmen are experiencing new social, personal, and academic challenges both from the transition from high school to college and from parental authority/oversight to personal responsibility. Beginning college has been associated with increases in stress and anxiety (Rawson & Bloomer, 1994) that can both interfere with and be exacerbated by poor sleep as well as compromise grades. Freshmen, therefore, are at risk for both sleep and academic problems, yet still early enough in their academic career that identifying and eliminating barriers to success may improve their academic outcome.

Although 1110 students opened the survey, GPA and disability status information were available for 1089. Of these 1089 students, four had a dual diagnosis of ADHD and LD, and were dropped from the analyses. The final sample, therefore, consisted of 59 diagnosed with ADHD, 16 previously diagnosed with LD, and 1010 with neither ADHD nor LD (N_{total}=1085). Sixty-six percent of participants with ADHD and 19% of those with LD thought the disability affected their school work either moderately or considerably. Participants were not asked about treatment or medications.

Missing data for those who did not finish the survey (~13%) were imputed using serial means in order to avoid potential bias due to listwise deletion of cases (e.g. Roth, 1994). Descriptive data are available in Tables 1 and 2. Gender of students who began the survey did not differ from those who completed the survey. The non-completers were more likely to be minority students. We explored replacement of missing risk for sleep disorder scores (yes/no) in two ways. Participants with missing data were assigned a designation of "no disorder" in order to be conservative. Secondly, we imputed values for the scales used to determine risk for sleep disorder, then determined status using the imputed scales. The resulting percentages of risk for each disorder were nearly identical, and the pattern of results the same. Risk scores generated using the latter method are reported here.

Materials

The primary outcome of interest was risk for sleep disorders. The Sleep-50 survey (Spoormaker, Verbeek, van den Bout, & Klip, 2005) was used to estimate risk for sleep disorders. This survey has been validated by polysomnography, and used to estimate prevalence of sleep disorders among college students. The survey generates scales of symptoms of several sleep disorders as well as a daytime impact scale. Risk for a specific disorder is based on established cut-off values for the symptoms of that disorder in combination with extent of daytime impact; therefore risk for a disorder reflects both the occurrence and severity of symptoms and severity of daytime impact. Risk scores for OSA, insomnia, RLS/PLMD (the survey collapses across risk for these two limb-related disorders) and circadian rhythm disorder ([CRD]; a mismatch between physiological readiness to fall asleep and required sleep schedule, including shift work and delayed sleep phase syndrome) were included in this report, and reported

Table 1

Descriptive Data

	No Known Disability (*N = 1010)*			ADHD (*n*=59)			LD (*n*=16)		
	M	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Age	18.60	1.68	17-50	18.49	1.21	17-26	18.44	.63	17-19
GPA	2.92	.84	0-4	2.60	.81	0-3.75	2.85	.98	0-4
Typical Sleep Duration									
Weekday	6.42	1.38	0-16	6.03	1.47	3-10	6.47	1.38	4-10
Weekend	9.72	1.85	0-20	9.62	1.90	4-13	9.38	2.53	2-13
Daytime Sleepiness	9.17	3.56	0-24	8.21	4.46	0-20	8.51	4.46	0-18

	Percent (count)	Percent (count)	Percent (count)
Male	26 (263)	44 (26)	44 (7)
Minority Race/Ethnicity	47 (474)	10 (6)	12 (2)
GPA<2.00	11 (115)	17 (10)	12 (2)
Risk for			
Sleep Apnea	10 (97)	14 (8)	6 (1)
Insomnia	23 (234)	37 (22)	25 (4)
RLS/PLMD	15 (149)	25 (15)	6 (1)
CRD	13 (131)	20 (12)	1 (2)

Note. RLS/PLMD: Restless Legs Syndrome/Periodic Limb Movement Disorder; CRD: Circadian Rhythm Disorder; "weekend" is operationalized as a night when participants did not have work or school the following day

Table 2

Characteristics of Participants at Risk for Sleep Disorder or No Known Sleep Disorder

	No Apparent Risk for Sleep Disorder *N*=727 *M(SD)*	Risk for Sleep Apnea *N*=106 *M(SD)*	Risk for Insomnia *N*=260 *M(SD)*	Risk for RLS/ PLMD *N*=165 *M(SD)*	Risk for CRD *N*=145 *M(SD)*
GPA	2.98 (.80)	2.66 (.88)	2.70 (.94)	2.71 (.95)	2.61 (.98)
Typical Sleep Duration					
Weekday	6.57 (1.21)	6.05 (1.70)	6.02 (1.67)	6.15 (1.68)	6.15 (1.68)
Weekend	9.72 (1.53)	9.74 (2.17)	9.56 (2.47)	9.81 (2.31)	9.93 (2.44)
Daytime Sleepiness	8.51 (3.31)	11.28 (3.96)	10.26 (4.09)	10.86 (3.82)	10.88 (4.25)

Note. RLS/PLMD: Restless Legs Syndrome/Periodic Limb Movement Disorder; CRD: Circadian Rhythm Disorder; "weekend" is operationalized as a night when participants did not have work or school the following day. Risk groups are not mutually exclusive, so sample sizes do not add to 1085.

Table 3

Bivariate Correlations

	GPA	Weekday Duration	Weekend Duration	Sleepiness	Apnea	Insomnia	Risk for RLS/PLMD
GPA	--						
Typical Sleep Duration							
Weekday	-.03	--					
Weekend	.03	.38**	--				
Daytime Sleepiness	-.07*	-.10**	.03	--			
At Risk for							
Apnea	-.10*	-.12**	.02	.18**	--		
Insomnia	-.12*	-.22**	-.02	.16**	.35**	--	
RLS/PLMD	-.09**	-.11**	.04	.20**	.40**	.45**	--
CRD	-.12	-.25**	.08**	.16**	.29**	.42**	.29**

Note. RLS/PLMD: Restless Legs Syndrome/Periodic Limb Movement Disorder; CRD: Circadian Rhythm Disorder; *p<.05, **p<.01; correlations with categorical variables are Spearman's rho; "weekend" is operationalized as a night when participants did not have work or school the following day

as dichotomous variables. Although scales for nightmares, sleepwalking, and sleep state misperception can be derived from the survey, incidence of these disorders was low. In addition, a narcolepsy scale is available, but it appears to be less reliable than the other scales (Gaultney 2010; Spoormaker et al. 2005), so it was not reported here. Psychometric properties of the Sleep-50 are acceptable (internal consistency [Chronbach's alpha = .85]; test-retest reliability [*r*=.78]; sensitivity .71 to .85; specificity .69-.88).

Given reports in the literature about sleep disruption associated with ADHD (e.g. Gamble et al., 2013), several aspects of sleep and sleepiness were examined in addition to risk for sleep disorders in order to characterize the participants. We asked participants to estimate typical sleep duration when the participant did not have school or work the next day (weekend), duration when the participant did have school or work the next day (weekday), and time of day when they think they function best (morning, evening, both, neither).Typical daytime sleepiness was measured using the Epworth Sleepiness Scale (Johns, 1991). Participants were asked how likely they would be to fall asleep during the day (0=would never doze, 3=high chance of dozing) in different circumstances, such as stopped at a traffic light or sitting and reading) and the responses summed. A score > 9 indicates a meaningful level of sleepiness, and a score >16 indicates a dangerous level of sleepiness. The scale has been widely reported in the literature as an acceptable measure of daytime sleepiness (Johns, 1992).

Disability status (ADHD or LD) was determined by self-report. Participants indicated whether they had received a diagnosis of either disorder from a health care professional. We obtained each student's GPA at the end of the semester from the university in the form of de-identified data. Descriptive information included demographic information and typical amount of time spent studying/week.

Procedure

All new, full-time freshmen students were contacted by email during their first semester (September or February of the 2011-2012 academic year). Reminders were sent a month later to those who had not yet responded. Students were given a link and a password in the email that led to the survey, and were able to access the survey at the time and place of their choosing. The project was approved by the university institutional review board. Data from the Sleep-50 were reviewed at the end of the academic year, and students who appeared to be at risk for a sleep disorder were notified of this by email (stressing that the survey could not diagnose a disorder) and offered referrals to local sleep physicians upon request.

Data Analysis

Preliminary analyses included descriptive and correlational data for this sample, separately for those with ADHD, LD, or neither disability (Table 1) and separately by risk for sleep disorder (Table 2). Group comparisons of means using analysis of variance were not calculated since the sample sizes were quite different. Disability status was dummy coded, using "no known disability" as the reference group. By entering each disability term (ADHD only and LD only) separately in all regression analyses, we were able to compare students with each disability to students with no known disability. Regression analyses examined associations between disability status, sleep duration, and sleepiness (Table 4). Since risk for each of the four targeted sleep disorders were dichotomous variables, disability-related risk for each sleep disorder was examined using logistic regression (Table 5). A regression analysis examined the last prediction that risk for sleep disorders would predict GPA, and that risk for sleep disorders would moderate ADHD status (Table 6). Separate interaction terms of ADHD with each of the four sleep disorders were computed by multiplying ADHD status and risk for each sleep disorder.

Results

See Tables 1 and 2 for descriptive data and Table 3 for correlational data. Correlational analyses examined the validity of measures. Of interest were associations with GPA, sleep duration, and sleepiness. This sample reported an average sleepiness score of 9.11 (SD=3.64). Sleepier students had lower GPAs and greater likelihood of risk for each of the four sleep disorders. Sleep duration did not associate significantly with GPA. Three of the four sleep disorders were unrelated to weekend sleep. Risk for a circadian rhythm disorder predicted greater weekend sleep duration, likely indicating an effort to "catch up" on sleep over the weekend when participants could match their sleep time to their circadian rhythm. All three sleep disorders predicted less sleep during the week and lower GPA. The four sleep disorders reported here were moderately intercorrelated,

Table 4

Sleep Duration and Daytime Sleepiness Regressed on ADHD and LD Diagnoses (N=1085)

	B (SE)	β	*t*	95% CI
Epworth Sleepiness Scale, R^2=.004				
Constant	9.17 (.11)		80.24**	8.95 to 9.39
ADHD Diagnosis	-.96 (.49)	-.06	-1.98*	-1.92 to -.01
LD Diagnosis	-.66 (.82)	-.02	-.72	-2.46 to 1.13
Sleep Duration Weekday, R^2=.004				
Constant	6.42 (.04)		147.72**	6.34 to 6.51
ADHD Diagnosis	-.39 (.18)	-.06	-2.10*	-.75 to -.03
LD Diagnosis	.05 (.35)	.004	-.14	-.64 to .73
Sleep Duration Weekend, R^2=.001				
Constant	9.72 (.06)		165.92**	9.60 to 9.83
ADHD Diagnosis	-.09 (.25)	-.01	-.38	-.58 to .40
LD Diagnosis	-.34 (.47)	-.02	-.73	-1.26 to .58

Table 5

Binary Logistic Regression Predicting Risk for Sleep Disorder (N=1085)

	B	S.E.	OR	95% CI
Sleep Apnea (R^2=.002)[1]				
Constant	-2.24	.11	.11**	8.95 to 9.39
ADHD Diagnosis	.39	.40	1.48	.68 to 3.20
LD Diagnosis	-.47	1.04	.63	.08 to 4.80
Insomnia (R^2=.01)				
Constant	-1.20	.08	.30**	6.34 to 6.51
ADHD Diagnosis	.68	.28	1.97*	1.14 to 3.41
LD Diagnosis	.10	.58	1.10	.35 to 3.46
RLS/PLMD (R^2=.01)				
Constant	-1.75	.09	.17**	9.60 to 9.83
ADHD Diagnosis	.68	.31	1.97*	1.07 to 3.63
LD Diagnosis	-.95	1.04	.38	.05 to 2.94
CRD (R^2 = .004)				
Constant	-.4.90	.09	.15**	
ADHD Diagnosis	.56	.33	1.74	.92 to 3.30
LD Diagnosis	.04	.64	1.04	.30 to 3.64

Note. [1]Nagelkerke R^2; * p<.05; ** p<.01; RLS/PLMD: Restless Legs Syndrome/Periodic Limb Movement Disorder; CRD: Circadian Rhythm Disorder

Table 6

Predicting GPA Regressed on Disability Diagnosis and Risk for Sleep Disorder (N=1085; R^2_{total} = .03)

		B (SE)	β	*t*	95% CI
GPA	R^2=.01				
Block 1					
Constant		2.92 (.03)		110.28**	2.87 to 2.97
ADHD Diagnosis		-.32 (.11)	-.09	-2.85**	-.54 to -.10
LD Diagnosis		-.07 (.21)	-.01	-.32	-.48 to .35
Block 2	R^2=.01				
Constant		3.00 (.03)		99.17**	2.94 to 2.97
ADHD Diagnosis		-.28 (.11)	-.07	-2.47*	-.50 to -.06
LD Diagnosis		-.07 (.21)	-.01	-.35	-.48 to .34
Risk for Apnea		-.10 (.10)	-.04	-1.03	-2.9 to .09
Risk for Insomnia		-.14 (.07)	-.07	2.01*	-.28 to -.004
Risk for RLS/PLMD		-.05 (.08)	-.02	-.61	-.21 to .11
Risk for CRD		-.21 (.08)	-.09	-2.55*	-.38 to -.05

Note. RLS/PLMD: Restless Legs Syndrome/Periodic Limb Movement Disorder; CRD: Circadian Rhythm Disorder; *p<.05, **p<.01

We expected that students who had previously been diagnosed with ADHD would report lower sleep duration, greater sleepiness, and greater risk for a sleep disorder. Table 4 presents regression analyses examining ADHD and LD diagnoses (each relative to those who did not report either diagnosis) as predictors of sleepiness and sleep duration. The ADHD and LD diagnosis terms were entered simultaneously. Neither students with ADHD nor those with LD reported more weekend sleep duration than the participants with no known disability. As expected, students diagnosed with ADHD reported less sleep during the week. Unexpectedly, a diagnosis of ADHD predicted less sleepiness during the day.

We hypothesized that students with ADHD would be at greater risk for OSA and RLS/PLMD. Table 5 presents logistic regression analyses predicting risk for each of the four disorders. Students with ADHD were at greater risk for two of the four sleep disorders (insomnia and RLS/PLMD). There was not a significant association of LD status with any sleep disorder.

We expected associations of GPA with diagnoses of ADHD, LD and risk for the four sleep disorders, and predicted an interaction of risk for sleep disorder and a diagnosis of ADHD. Diagnosis of ADHD or LD was entered in an initial block, risk for the four sleep disorders in a second block, and interaction terms of ADHD with each sleep disorder in a third block. The interaction terms did not increase amount of variability explained by the model either separately or as a block; therefore, only the main effect tests are reported here (see Table 6). Students with a diagnosis of ADHD and those at risk for insomnia or a circadian rhythm disorder had lower grades. Block 2, risk for sleep disorders, increased variability explained by 2% over and above variability explained by disability status. Specifically, risk for insomnia and risk for circadian rhythm disorder explained significant variability over and above that explained by a diagnosis of ADHD or LD. Risk for insomnia decreased GPA by 14%, and a circadian rhythm disorder decreased GPA by 21%. Beta scores, which reflect standardized data and can be compared, indicated that ADHD status,

risk for insomnia, and risk for circadian rhythm disorder were equally predictive of GPA.

Discussion

The present study hypothesized that college students with ADHD would report less sleep and more daytime sleepiness, would be at greater risk for sleep disorders (specifically OSA and RLS/PLMD), and that risk for sleep disorders would predict GPA and would function as a moderator of ADHD status on GPA. College students with ADHD reported less sleep during the week and were more likely to be at risk for insomnia and restless legs syndrome/periodic limb movement disorder. A diagnosis of ADHD, risk for insomnia, or risk for a circadian rhythm disorder predicted lower grades. Risk for any of the four sleep disorders did not moderate the association of ADHD with GPA, suggesting that ADHD and risk for at least some sleep disorders may be separate but perhaps equal obstacles to academic success. Variance associated with sleep disorders was over and above that associated with disability status. Findings from the present study indicate that the association of some sleep disorders with ADHD reported in the pediatric literature also applies to college students. These findings are consistent with earlier reports of an association of sleep problems (that may or may not indicate sleep disorders) with ADHD that is consistent from childhood to adulthood (Sobanski, et. al, 2008).

The specific hypothesis of connections between ADHD and both OSA and RLS/PLMD was partially supported; an association with RLS/PLMD but not OSA emerged. There is an inconsistency in the pediatric literature as to whether OSA is associated with ADHD. Data have reported associations between sleepiness, snoring, and symptoms of OSA with symptoms of ADHD (e.g. Chervin et al., 2002). Other studies, however, have concluded that there was better evidence for a connection between ADHD and periodic limb movement during sleep (Cohen-Zion & Ancoli-Smith, 2004). Our findings reflect this latter position. A possible explanation for the inconsistent reports in the literature may be the association of different types of ADHD (inattentive, hyperactive, or combined) with different sleep disorders (Miano, Parisi & Villa, 2012; Silvestri et al. 2009), or perhaps differences in severity or diagnostic accuracy (e.g. Gaultney et al. 2009).

Several explanations have been offered for linkages between ADHD and symptoms of sleep disorders. ADHD (or its treatment) may cause sleep disturbances, may be caused by the sleep disorder (e.g. the sleep disorder presents with symptoms characteristic of ADHD), or the two may have a common underlying cause. For example, the individual who is hyperactive during the day may display greater bedtime resistance (ADHD→sleep disorder; e.g. Gaultney, Terrell, & Gingras 2005). Difficulty settling down at night and falling asleep might partially explain the connection with insomnia found in these data. Likewise, the use of stimulant medication to treat ADHD may interfere with sleep; however, sleep disturbances have been reported in both medicated and non-medicated children with ADHD (O'Brien et al., 2003) and use of stimulant medication by adults with ADHD appeared to improve sleep (Sobanski, et al., 2008). The discomfort of RLS may exacerbate a tendency to fidget and be distracted (sleep disorder→ADHD). Likewise, the daytime sleepiness resulting from a sleep disorder may reduce ability to pay attention or to inhibit behavior. Sleepiness seems unlikely to explain the association reported here, however, since students diagnosed with ADHD reported less sleepiness than others. Finally, several studies (e.g. Picchietti et al., 1999; Wagner, Walters, & Fisher, 2004) have suggested that both ADHD and PLMD and/or RLS (which often co-occurs with PLMD) may be different manifestations of an underlying dopamine deficiency, which may, in turn, be due to insufficient or ineffective serum iron levels. Iron supplementation has been used in some cases to treat both PLMD (Simkajornboon, 2006) and ADHD (Konofal, Lecendreux, Arnulf, & Mouren, 2004; Konofal et al., 2008). At this time, dopaminergic therapy has not been shown to effectively treat ADHD (England et al., 2011).

The fact that students with ADHD did not appear to be at greater risk for circadian rhythm disorders is interesting. One study of adults has suggested that sleep problems in individuals with ADHD may be due to a circadian disruption. Van Veen, Kooij, Boonstra, Gordijn, & Van Someren (2012) found that participants with ADHD had delayed melatonin onset (melatonin is a hormone that initiates physiological changes preparatory to sleep) and longer sleep onset latency. In the present sample, the reported greater risk of insomnia may have reflected these students' delayed circadian rhythm rather than the inability to fall asleep (insomnia). The two disorders differ in that those with insomnia have difficulty initiating and/or maintaining sleep regardless of time of onset, whereas those with

a circadian delay fall asleep easily once their bodies are physiologically ready to sleep. When a delayed circadian rhythm is in conflict with scheduled responsibilities, the individuals may perceive the difficulty falling asleep early as insomnia. Furthermore, the fact that these students were all freshmen with a mean age of 18.6 indicates that they may have been affected by the typical delayed sleep phase during adolescence (Crowley, Acebo, & Carskadon, 2007). Had age been more variable, a circadian delay for those with ADHD may have been more apparent.

Likewise, the finding that those diagnosed with ADHD reported lower (less) sleepiness scores is surprising. Given that they reported getting less sleep during the week and were at greater risk for some sleep disorders relative to those without ADHD, the lower sleepiness score is not easily explained. Note, however, that the mean sleepiness score met the threshold of 9. This high level of sleepiness in the entire group may have obscured finer group distinctions. Overall, if these students were representative of freshmen in general, this age group may be experiencing drastic levels of sleepiness independently of disability or disorder status.

Given the finding that risk for a sleep disorder predicted lower GPA, perhaps it would be useful for universities to recognize sleep disorders as a "respectable" and potentially treatable condition. Although not a recognized disability, these data suggest that sleep disorders may be an academic handicap that could be identified and perhaps treated. Connections between sleep disorders and general mental and physical health add weight to the suggestion that sleep disorders be recognized, identified, and intervention offered. Although it seems intuitive that treating a sleep disorder will improve college academic success, and ultimately retention and graduation, this has yet to be demonstrated empirically. Successful treatment of sleep disordered breathing in children (adenotonsilectomy in these examples) has predicted improved cognition (Friedman et al.2003), quality of life (Ye et al. 2010), behavior (Urschitz et al. 2004) and affect (Mitchell & Kelly 2007), all of which can play a role in academic outcomes. However, academic improvement subsequent to successful treatment of a sleep disorder is not assured. Gozal and Pope (2001) found that academic differences between snorers and non-snorers in 1st grade were still evident in 7th-8th grade regardless of current snoring status.

The findings reported here should be considered in light of several limitations. First, the variability explained by the regression analyses is quite small, and the significant findings influenced by sample size. Because of this, conclusions about connections between risk for sleep disorders and disability status, and associations with GPA are tentative. However, small effect sizes are not necessarily unimportant (for example, a difference of a GPA of 1.9 and 2.0 determines whether a student continues taking classes). The LD group was quite small; the lack of significant findings for that group could be due to low power.

Data reported by this sample of students probably overestimated the risk for sleep disorders in general. Prevalence for the disorders reported here are higher than those reported in the general adult population and higher than in other studies of college students (Gaultney, 2010). The high sleepiness level reported here may have contributed to over-reporting symptoms of sleep disorders. Although we did not recruit specifically among students with troubled sleep, it is likely that the students who completed the survey were those who were concerned about their sleep, thereby over-estimating prevalence of symptoms of sleep disorders. It is also possible that maladaptive sleep-related behaviors and conditions or circadian disruptions were misinterpreted as symptoms of insomnia.

We had no independent verification of a disability diagnosis; we depended on self-report of these conditions, with all the unreliability inherent to this type of data. Given this, we can't confirm that students accurately reported the presence or absence of a disability, nor the extent to which the disability limited academic success. We did not have data on whether or not a disability had been treated, and whether or not the treatment was effective. Likewise, the sleep survey used here, although validated against diagnoses of sleep disorders backed up by polysomnography, cannot diagnose a sleep disorder.

The total sample size in the present study was large and its diversity reflected that of the larger university community. However, males and non-minority students were over-represented (relative to the entire freshman class) among those with a diagnosis of ADHD or LD. It offered a preliminary consideration of self-reported risk for sleep disorders among students who reported a diagnosis of ADHD, and raised the possibility that sleep disorders are an equally legitimate threat to academic success. If additional

research supports these patterns, universities may wish to consider voluntary screening and interventions for sleep problems, particularly among those with ADHD or who are in academic jeopardy.

Implications for Practice

Given the association of sleep problems (disorders as well as environmental and behavioral) with GPA and increased risk of sleep disorders among students with ADHD, several practical applications of this information can be considered. Students with a known disability can be screened for sleep problems and appropriate intervention offered if indicated. For example, those with symptoms of a sleep disorder could be referred to a local sleep physician. If the problem appears to be behavioral or environmental, educational interventions can be made available. This has been tried at a few institutions with varying success. For example, brief interventions for poor sleep habits have been tried with varying success. Brown, Buboltz, and Soper (2010) proposed a Sleep Treatment and Education Program for Students (STEPS), finding that students in the treatment group reported improved sleep quality and hygiene six weeks after treatment.

A few institutions have tested interventions for insomnia. Taylor, Lichstein, Weinstock, Sanford, and Temple (2007) demonstrated improvement in indices of insomnia among a small sample of students following six sessions of cognitive-behavioral therapy. Morin, Beaulieu-Bonneau, LeBlanc, and Sevard (2005) pilot-tested a "self-help" form of insomnia therapy administered to 192 adults via correspondence. They found that a low-cost, easily-delivered form of therapy produced measurable improvements in symptoms of insomnia in a general population. Other efforts have targeted poor sleep hygiene rather than a sleep disorder. Orzech, Salafsky, and Hamilton (2011) reported a media campaign directed at college students. Posters promoting the positive effects of sleep were placed in residence halls and a student newspaper, a health education article containing summaries of articles on student sleep, along with sleep questions and answers, were delivered to students on campus. Students later reported improved sleep quality, earlier bedtime, extended sleep duration, shortened sleep onset latency, and better sleep quality following the intervention. Lund, Reider, Whiting, and Prichard (2010) tested an intervention that targeted sleep practices and stress management and found improved physical and mental health.

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