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The College Experience: Exploring the Relationship between Sleep, Executive Function, and Alcohol Use

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Introduction

College students are susceptible to stress due to new social environments, identity exploration, and increased work and class demands (Dyson & Renk, 2006). The most common interpersonal, intrapersonal, academic, and environmental sources of stress for college students include change in sleep habits (89%), vacations/breaks (82%), change in eating habits (74%), increased work loads (73%), and new responsibilities (73%), financial difficulties (71%) and change in social activities (71%) (Ross, Niebling, & Heckert, 1999). Furthermore, stress can lead to reports of overall poor functioning in college students (Dyson & Renk, 2006; Hawkins & Shaw, 1992). Understanding stressors is of particular importance, as college-related stressors are associated with anxiety and depression (Rawson et al., 1994), academic performance (Pettit & Debarr, 2011), retention (Cope & Hannah, 1975), problem solving abilities (Priester & Clum, 1993), and health (Hudd, Dumlao, Erdmann-Sager, Murray, Phan, Soukas, & Yokozuka, 2000).

Stress may lead to sleep problems, which in turn leads to more stress – this is the reality of a college student (Levine, 2013; Pilcher & Walters, 1997). As a result of college-related stressors, undergraduates sleep less (Pilcher & Walters, 1997), have a variable sleep schedule (Brown, Buboltz, & Soper, 2002), and approximately 60% of college students report (a) poor sleep quality, (b) frequent reliance on alcohol and over-the-counter medications, and (c) sleeping below the recommended 8 and 9 hours for young adults and adolescents, respectively (Kloss, Nash, Walsh, Culnan, Horsey, & Sexton-Radek, 2015). Stress increases due to sleep deprivation; the sleep process inhibits all parts of the HPA axis, a major contributor to stress (Levine, 2013).

One coping technique that students use to cope with college-related stressors is self-medication with alcohol (Vitiello, 1997). Self-medication is seeking a substance in order to reduce a symptom (Galanter, 1998). Many college students self-medicate with drugs due to their disinhibiting effect (Verdejo-García, Bechara, Recknor, & Pérez-García, 2006). Alcohol is one drug that college students are at particular risk for developing hazardous habits toward (Kokotailo, Egan, Gangnon, Brown, Mundt, & Fleming, 2004). Students use alcohol in order to enhance positive emotions and to cope with negative emotions (Read et al, 2003). Self-medication is not the only reason that college students drink. They also use alcohol as a social lubricant – that is, they expect that social outcomes will be more enjoyable and positive if they drink (Read et al, 2003). Since one source of stress for college students is a changing social support network, this social lubrication effect lends some support to the idea that college students self-medicate using alcohol (Dyson & Renk, 2006; Read et al., 2003). Furthermore, many college students report drinking as a result of negative affect, further supporting the idea that drinking may be used as self-medication (Read et al, 2003). However, alcohol is related to many hazards in the college population, such as poor academic performance, vehicle accidents, and multiple kinds of violence

(Kokotailo, Egan, Gangnon, Brown, Mundt, & Fleming, 2004).

While alcohol consumption inhibits overall functioning, alcohol use/abuse disrupts sleep (Roehrs & Roth, 2001; Vitiello, 1997). Although it decreases sleep latency, overall sleep quality is decreased with alcohol use (Vitiello, 1997). Considering up to 90% of adults drink, almost every adult will be affected by alcohol's effects on sleep quality during their life (Vitiello, 1997). Approximately 80% of college students drink alcohol (Holloway & Holloway, 2013). Alcohol's detrimental effects on sleep quality are in part due to its reduction of time spent in REM sleep during the first half of the night, and an increase in time spent in light sleep during the second half of the night (Roehrs & Roth, 2001; Vitiello, 1997). Furthermore, alcohol consumption increases wakefulness and shifting between sleep stages during the night, and increases the number of sleep-related respiratory disturbances (Roehrs & Roth, 2001; Vitiello, 1997). These respiratory disturbances can be similar to those present in sleep apnea. Sleep apnea sufferers report more sleepiness and daytime dysfunction and worse cognitive performance than controls (Engleman, 2004; Naismith, Winter, Gotsopoulos, Hickie, & Cistulli, 2004). Additionally, alcohol and sleep have an interaction, in that alcohol's effects worsen with increased sleep debt (Vitiello, 1997). Sleep debt is defined as "the effect of not getting enough sleep; a large amount causes mental or physical exhaustion (Levine, 2013)." Since many college students have a significant sleep debt – up to 24-48 hours around exam time – many are subject to alcohol's worsened effects (Hawkins & Shaw, 1992; Pilcher & Walters, 1997).

Poor sleep quality can, in turn, affect executive functions (Naismith, Winter, Gotsopoulos, Hickie, & Cistulli, 2004; Levine, 2013). Such poor sleep results in college students exhibiting cognitive deficits, especially in the executive functions (Benitez & Gunstad, 2010; Pilcher & Walters, 1997; Trockel, Barnes, & Egget, D. L. 2000). Barkley defined executive functions as being "…composed of the major classes of behavior towards oneself used in self-regulation" (2001). Executive functions include many higher-order functions, such as motivation, problem-solving, behavioral inhibition, planning, and working memory (Barkley, 2001). Of these various functions, poor sleep quality and overall sleep deprivation have been shown to reduce working memory, reaction time, and attention (Benitez & Gunstad, 2010; Naismith, Winter, Gotsopoulos, Hickie, & Cistulli, 2004; Pilcher & Walters, 1997; Van Dongen, Maislin, Mullington, & Dinges, 2003). Measures of poor sleep quality and sleep deprivation have also been found to be related to measures of overall cognitive deficits (Benitez & Gunstad, 2010; Engleman & Douglas, 2004).

Alcohol is also related to poor executive functioning (Pihl, Paylan, Gentes-Hawn, & Hoaken, 2003; Galanter, 1998). Indeed, drug use and dependence of any kind is correlated with lower performance on measures of executive functioning (Verdejo-García, Bechara, Recknor, & Pérez-García, 2006). Since college students

consume more alcohol than most other populations, they are particularly at risk for these detrimental effects of alcohol (Kokotailo, Egan, Gangnon, Brown, Mundt, & Fleming, 2004).

While extant research documents (a) the relationship between alcohol consumption and sleep problems and (b) the relationship between sleep problems and executive functions, very few studies have examined the relationships among sleep problems, alcohol consumption, and executive functions. The current study seeks to elucidate the relationship among overall sleep quality, alcohol use/abuse, and executive functions in college students. Specifically, the study aims to understand the extent to which hazardous drinking mediates the relationship between sleep and executive functioning. To this end, it is hypothesized that there will be (1) a positive relationship between sleep and executive functions, (2) a positive relationship between hazardous alcohol use, and (3) a positive relationship between hazardous alcohol use and executive dysfunction. Furthermore, it is expected that there will be a negative relationship between hazardous drinking will mediate the relationship between sleep quality and executive dysfunctions.

Methods

Participants

Undergraduate students at least 18 years of age and enrolled in an introductory psychology course at a southeastern university were invited to complete an online study. The current study had 322 participants. Forty participants did not complete the entire study, and were excluded from all analyses. Of the 284 participants with complete data, 49.4% were male, 47.8% were female, and 0.3% identified as transgendered. In our sample, 77% of the participants were white, 7.1% were African-American, 5.0% were Asian, 2.5% were Hispanic, and 4.9% were "other." The class standing of the participants was as follows: 57.1% were freshmen, 23.9% were sophomores, 9.9% were juniors, 5.3% were seniors, and 0.3% preferred not to provide information regarding classification status. The age range was 18 to 45, with a mean age of 19.81 (SD=3.830) years. Sample demographics are presented in Table 1.

Procedures

Participants were administered the following self-report measures on Qualtrics, a web-based survey tool: Demographic Questionnaire (DQ), Pittsburgh Sleep Quality Index (PSQI), the Alcohol Use Disorders Identification Test (AUDIT), and the Barkley Deficits in Executive Function Scale-Long Form (BDEFS-LF). A brief demographics questionnaire was used to collect demographic information. All participants received extra credit points in their psychology classes for their participation.

Measures

DQ

The DQ is a brief measure created by the research team to assess sample basic

demographic information (e.g., age, ethnicity, gender) and college standing/classification (e.g., freshman, sophomore, junior, etc.).

PSQI

The PSQI is a self-report measure that assesses sleep quality over the past month (Buysse et al, 1989). It has seven subsections that, when scored, provide a total score reflecting overall sleep quality. The subsections assess subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction. Scores range from 0 to 21, with high scores relating to worse sleep quality. Scores for individual questions are on a Likert scale, with values ranging from 0 to 3. The measure exhibits very good internal consistency (Crohnbach's alpha=0.83), test-retest reliability (all p-values <.05), and validity (Buyssee et al, 1989).

AUDIT

The AUDIT is a 10-item self-report measure that measures both hazardous drinking and alcohol use disorders in the past year (Babor et al., 2001). It covers consumption (questions 1-3), dependence (questions 4-6), and alcohol-related problems (qestions 7-10) (Kokotillo et al, 2004). Questions are on a Likert scale with questions 1-8 having points of 0, 1, 2, 3, 4 and question 9 and 10 having scores of 0, 2, or 4 (Babor et al., 2001). Scores range from 0 to 40, with a score of 8 indicating possible drinking problems (Kokotillo et al., 2004). It has been established as a highly sensitive measure, with good test-retest reliability and internal consistency (Reinert & Allen, 2002). It has also been validated with college students, showing better validity and sensitivity than other alcohol questionnaires (Kokotailo et al, 2004). The clinical cutoff when using the AUDIT with college students is a score of 8 (Kokotailo et al., 2004).

BDEFS-LF

The BDEFS-LF is an 89-item self-report questionnaire of executive functioning over the past six months (Allee-Smith, Winters, Drake, & Joslin, 2013). It consists of five subscales: time management, organization/problem solving, restraint, motivation, and emotional regulation. Each question has four responses on a Likert scale (1- never or rarely, 2-sometimes, 3- often, 4-very often). These values are added up to a score for each section, a total score, and a symptom count (total of 3's and 4's). Internal consistency was good (Crohnbach's alpha=.91-0.96), as was test-retest reliability (p<.001), and both construct and criterion validity (Allee-Smith, Winters, Drake, & Joslin, 2013).

Results

Sample Characteristics

The average score on the AUDIT was 4.40 with a standard deviation of 5.32. A clinical significance cutoff is set at 6 for college students, so the average was not above this cutoff (Kokotilo et al, 2004). The average score on the BDEFS-LF was 138.99, with a standard deviation of 42.21. The mean score on the PSQI was 5.79 with a standard deviation of 3.16. This average is above the 5-point cutoff and indicates significant sleep problems (Beaudreau et al., 2011). See Table 1 for means and standard deviations for study variables.

Correlational Analyses

Pearson-product moment correlations were run among the total scores and subscales of the AUDIT, BDEFS-LF, PSQI. The correlation coefficient between the PSQI Total Score and the BDEFS-LF Total Score was significant (r=0.460, p<.01). The correlation between the PSQI Total Score and the AUDIT Total Score was similarly significant (r=0.165, p<.01). The BDEFS-LF Total Score and the AUDIT Total Score were also significantly correlated (r=0.341, p<.01). All subscales of the BDEFS-LF were positively correlated with the BDEFS-LF Total Score (p<.01). Additionally, all BDEFS-LF subscales were positively correlated with each other (p<.01). The BDEFS-LF Total Score also positively correlated with all subscales of the PSQI (p<.05). All subscales of the PSQI were positively correlated with the PSQI Total Score (p<.01). The PSQI Total Score was also positively correlated with all BDEFS-LF subscales (p<.01). The PSQI subscales were positively correlated with each other (p<.05), with the exception of Meds Use, which was not significantly correlated with any variables except BDEFS-LF Total Score (p<.05), PSQI Total Score (p<.01), BDEFS-LF Organization (p<.05), and BDEFS-LF Self-Restraint (p<.05) subscales. Nearly all of the other subscales of the BDEFS-LF and the PSQI were significantly positively correlated with each other (p<.05), except BDEFS-LF Organization and Motivation subscales and PSQI Sleep Efficiency. The AUDIT Total Score was positively correlated with all BDEFS-LF subscales (p<.01), and significantly positively correlated with the Sleep Quality (p<.01), Sleep Duration (p<.05), and Daytime Dysfunction (p<.05) subscales of the PSQI. See Table 2 for more details.

Mediation

Since the three study variable totals were significantly correlated with each other, a mediation analysis was run. The mediation was run using the PROCESS macro (Hayes, 2013). This macro was used to test whether the PSQI total score was indirectly related to the BDEFS-LF total score via its influence on the AUDIT total score.

In the first step of the mediation model, the regression of the PSQI total score and BDEFS-LF total score, disregarding the mediator, was significant (b=6.120, p<.001). The second step showed that the regression between the PSQI total score and the mediator, the AUDIT total score, was significant (a=0.276, p<.01). Step three of

the mediation analysis revealed that the mediator, AUDIT total score, controlling for the BDEFS-LF total score was significant as well (b=2.373, $p<0.001$). Step four of the process showed that, even after controlling for the mediating variable (hazardous alcohol use), the relationship between PSQI total score and the BDEFS-LF total score was still significant (c'=5.464, $p<.001$). A Sobel test was run and found the mediation in the model (effect=0.656, SE=0.260, Z=2.519, $p<.05$). The significance of the Sobel test indicates that the AUDIT total score was a partial mediator between the PSQI total score and the BDEFS-LF total score, accounting for 29.80% of the variation between PSQI and BDEFS-LF total scores. These findings are summarized in Table 3 and Figure 1.

Discussion

The current study sought to elucidate the relationship among overall sleep quality, alcohol use/abuse, and executive functions in college students. Our hypothesis that there would be a positive correlation between sleep quality and executive functioning as measured by the PSQI and BDEFS-LF was supported ($r=0.460$, $p<.01$). This data is consistent with findings by other researchers (Benitez & Gunstad, 2012; Engleman & Douglas, 2004; Naismith et al., 2004; Van Dongen et al., 2003). The hypothesis that there would be a significant positive correlation between executive functioning and hazardous alcohol use (measured by the AUDIT) was correct ($r=0.341$, $p<.01$). This data supported relationships found by other researchers as well (Galanter, 1998; Paschall & Freisthler, 1995; Pihl, Paylan, Gentes-Hawn, & Hoaken, 2003; Verdejo-Garcia et al, 2006). There was also a significant correlation between poor sleep quality and hazardous drinking ($r=0.165$, $p<.01$), supporting our third hypothesis. These results support conclusions drawn by numerous other studies (Vitiello, 1997; Roehrs & Roth, 2001; Galanter, 1998). When a mediation analysis was run between these variables, it was found that there was a partial mediation. Hazardous alcohol use partially mediated the relationship between sleep quality and executive functioning (ab=0.656±0.284, 95% CI [0.214, 1.392]).

The PSQI Total Score had a mean of 5.79±3.16, which was higher than the clinical significance cutoff score of five. This indicates that on average, college students have impaired sleep. This finding indicates that there is a great need for a better understanding of college sleep habits – in order to hopefully improve this average – and a better knowledge of factors that influence sleep. The mean for the AUDIT Total Score, which was significantly correlated with the PSQI, was 4.40±5.32. This finding was below the clinical cutoff of eight, but the large standard deviation was a bit of a drawback in the study, as just one standard deviation contained both a score of zero and a score above eight. The mean of the BDEFS-LF Total score was 138.99±42.21. The maximum score (indicating maximum executive

dysfunction) is 356, so the sample is not impaired overall.

The subscales of the BDEFS-LF are as follows: Time Management (μ=35.93 ± 12.55), Organization (μ=28.28 ± 9.34), Self-Restraint (μ=35.93 ± 12.55), Motivation (μ=37.14 ± 12.68), and Emotion Regulation (μ=17.16 ± 6.52). All of these subscales are correlated with the AUDIT Total Score (p<.01), the PSQI Total Score (p<.05), and the BDEFS-LF Total Score (p<.01). This indicates that they may make good targets for future mediation analyses. The PSQI subscales, Sleep Quality (μ=1.02 ± 0.74), Sleep Latency (μ=1.3 ± 0.989), Sleep Duration (μ=0.74 ± 0.78), Sleep Efficiency (μ=0.61 ± 0.92), Sleep Disturbance (μ=1.11 ± 0.52), Medication Use (μ=0.34 ± 0.78), and Daytime Dysfunction (μ=0.74 ±0.75), may make good targets for future mediation analyses (with the exception of Medication Use) as well, since they are also positively correlate with AUDIT Total Score (p<.05), PSQI Total Score (p<.05), and BDEFS-LF Total Score (p<.05). The only drawback is that all of these subscales have large standard deviations, making it more difficult to get significant results.

The results of the current study may be used to support the implementation for sleep hygiene training, which has been shown to increase sleep quality (Brown, Buboltz, & Soper, 2002). Since sleep and executive functioning are related, improving sleep quality may positively impact executive functioning. The results suggest that hazardous drinking intervention programs may improve sleep quality and executive functioning – and thus overall health. By implementing programs such as these, universities could help their students.

A number of limitations must be placed on the study given methodological and design issues. First, the study relied on self-report measures exclusively. Although measures used in the study are validated with college and/or young adult samples, the use of experimental and/or additional quantitative measures are future avenues for research. It is important to do experimental and quantitative research in order to make sure they corroborate self-report measures. Each type of research explores a different aspect of the relationship, and as such all are needed in order to fully understand the relationship. Furthermore, participants occasionally do not report the truth on self-report measures; it is much more difficult to lie on experimental and quantitative tasks. Another possible source of error in the study was the sample. The sample consisted of freshmen in an Introduction to Psychology course, limiting the external validity of the study. Furthermore, the students were primarily freshmen or sophomores (mean age=19.79±3.826), which could have skewed the results of the study, since college freshmen report more stress and worse coping techniques than upperclassmen (Brougham et al., 2009). This means that the relationship between sleep, executive functioning, and alcohol use in juniors and seniors is not explored as thoroughly. Another study limitation is that the sample is primarily composed of Caucasian students at a Southeastern University, further limiting its external validity. Since there has been some research that indicates a difference in sleep quality dependent on ethnicity (Patel et

al., 2010), it would be interesting to explore these relationships in a more diverse sample. A final drawback of the study is attrition. Of the 322 participants in the study, only 284 completed the PSQI and all other measures. It is possible that the participants who failed to complete the study could have changed the results, as inability to finish tasks is a marker for executive dysfunction (Barkley, 2001).

There has been quite a lot of research looking at college student drinking (Kokotailo et al., 2004; Paschall & Freisthler, 2003; Read et al., 2003), college student sleep habits (Hawkins & Shaw, 1992; Pilcher & Walters, 1997; Taylor et al., 2013; Trockel, Barnes, & Egget, 2000), and college student academics and executive functioning (Engleman & Douglas, 2004; Pilcher & Walters, 1997; Taylor et al., 2013; Trockel, Barnes, & Egget, 2000). However, there has been a lack of research examining mediations between these relationships. This paper explores the associations among these three all-important facets of college life. The partial mediation of hazardous alcohol use on the relationship between executive functioning and sleep quality suggests that further research should explore the relationship hazardous drinking has with global sleep quality and executive functioning in a college sample to validate the current results.

Future research could focus on differences based on class standing or ethnicity. It could also explore the effects of other mediating variables on the relationship between executive functioning and sleep quality, such as depression or anxiety, both of which were found to have a significant relationship in this study. By exploring multiple mediators, the relationships examined in this study could be understood more fully. Another avenue for future research lies in non-self-report measures. By measuring variables such as sleep, executive functioning, and alcohol abuse in a different way, the downfalls of self-report measures – such as social desirability bias – could be avoided, and the results made more quantifiable.

Finally, more research concerning the BDEFS-LF and PSQI subscales would be useful as well. The PSQI subscales, in particular, were not all correlated with the other variables. It would be interesting to look at the subscales that were significant and explore what portion of the relationship between the BDEFS-LF and the PSQI these subscales explain. It is possible that the relationship is due primarily to one or two of these subscales – future research could focus on finding which of these subscales are the most important. It is also possible that the relationships between some subscales are mediated by hazardous drinking; this is a possible avenue for more fully exploring the partial mediation found in this study. By coming to fully understand this relationship, we can begin to grasp the extent to which these three variables influence the quality of our lives.

References

Allee-Smith, P. J., Winters, R. R., Drake, A., & Joslin, A. K. (2013). Test Review: Barkley deficits in executive functioning scale (BDEFS). *Journal of Psychoeducational Assessment, 31*(1), 80-83. doi:10.1177/0734282912452651

Babor, T. F., Higgins-Biddle, J. C., Saunders, J. B., & Montiero, M. G. (2001). *The Alcohol Use Disorders Identification Test—Guidelines for Use in Primary Care* (2nd ed.). Geneva: World Health Organization.

Barkley, R. A. (2001). The Executive Functions and Self-Regulation: An Evolutionary Neuropsychological Perspective. *Neuropsychology Review, 11*(1), 1-29. Retrieved from http://www.einstein.in/

Beaudreau, S. A., Spira, A. P., Stewart, A., Kezirian, E. J., Lui, L., Ensrud, K., . . . For the Study of Osteoporotic Fractures. (2011, October 26). Validation of the Pittsburgh Sleep Quality Index and the Epworth Sleepiness Scale in Older Black and White Women. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3586742/

Benitez, A., & Gunstad, J. (2012). Poor Sleep Quality Diminishes Cognitive Functioning Independent of Depression and Anxiety in Healthy Young Adults. *The Clinical Neuropsychologist,* 214-223. doi:10.1080/13854046.2012.658439

Brougham, R. R., Zail, C. M., Mendoza, C. M., & Miller, J. R. (2009). Stress, Sex Differences, and Coping Strategies Among College Students. *Current Psychology, 28*(2), 85-97. doi:10.1007/s12144-009-9047-0

Brown, F. C., Buboltz, W. C., & Soper, B. (2002). Relationship of Sleep Hygiene Awareness, Sleep Hygiene Practices, and Sleep Quality in University Students. *Behavioral Medicine, 28*(1), 33-38. doi:10.1080/08964280209596396

Brown, F. C., Buboltz, W. C., & Soper, B. (2002). Relationship of Sleep Hygiene Awareness, Sleep Hygiene Practices, and Sleep Quality in University Students. *Behavioral Medicine, 28*(1), 33-38. doi:10.1080/08964280209596396

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28*(2), 193-213. doi:10.1016/0165-1781(89)90047-4

Carvalho, L. B., Prado, L. B., Ferrreira, V. R., Figueiredo, M. B., Jung, A., Morais, J. F., & Prado, G. F. (2013). Symptoms of sleep disorders and objective academic performance. *Sleep Medicine, 14*(9), 872-876. doi:10.1016/j.sleep.2013.05.011

Dyson, R., & Renk, K. (2006). Freshmen adaptation to university life: Depressive symptoms, stress, and coping. *Journal of Clinical Psychology, 62*(10), 1231-1244. doi:10.1002/jclp.20295

Engleman, H. M. (2004). Sleep {middle dot} 4: Sleepiness, cognitive function, and quality of life in obstructive sleep apnoea/hypopnoea syndrome. *Thorax, 59*(7), 618-622. doi:10.1136/thx.2003.015867

Galanter, M. (1998). Executive Cognitive Functioning in Alcohol Use Disorders. In *Recent Developments in Alcoholism: Vol. 14: The Consequences of Alcoholism: Medical, Neuropsychiatric, Economic, Cross-Cultural* (Vol. 14, pp. 230-237). New York: Springer.

Galanter, M. (1998). Sleep Disorders. In *Recent Developments in Alcoholism: Vol. 14: The Consequences of Alcoholism: Medical, Neuropsychiatric, Economic, Cross-Cultural* (Vol. 14, pp. 210-212). New York: Springer.

Hawkins, J., & Shaw, P. (1992). Self-Reported Sleep Quality in College Students: A Repeated Measures Approach. *Sleep, 15*(6), 545-549. Retrieved from http://www.journalsleep.org

Holloway, P. B., & Holloway, G. M. (2013). Alcohol Use in College. Retrieved April 22, 2015, from http://www1.villanova.edu/villanova/studentlife/counselingcenter/infosheets/alcoholuse.html

Kokotailo, P. K., Egan, J., Gangnon, R., Brown, D., Mundt, M., & Fleming, M. (2004). Validity of the Alcohol Use Disorders Identification Test in College Students. *Alcoholism: Clinical and Experimental Research, 28*(6), 914-920. doi:10.1097/01.ALC.0000128239.87611.F5

Levine, A. B. (2013). Chapter 8 Sleep. In B. Levine (Author), *Metabolic Syndrome and Cardiovascular Disease, Second Edition* (pp. 159-191). Hoboken, NJ: Blackwell Publishing.

Naismith, S., Winter, V., Gotsopoulos, H., Hickie, I., & Cistulli, P. (2004). Neurobehavioral Functioning in Obstructive Sleep Apnea: Differential Effects of Sleep Quality, Hypoxemia and Subjective Sleepiness. *Journal of Clinical and Experimental Neuropsychology (Neuropsychology, Development and Cognition: Section A), 26*(1), 43-54. doi:10.1076/jcen.26.1.43.23929

Paschall, M. J., & Freisthler, B. (2003). Does Heavy Drinking Affect Academic Performance in College? Findings from a Prospective Study of High Achievers. *Journal of Studies on Alcohol,* 515-519.

Patel, N. P., Grandner, M. A., Xie, D., Branas, C. C., & Gooneratne, N. (2010). "Sleep disparity" in the population: Poor sleep quality is strongly associated with poverty and ethnicity. *BMC Public Health,10*(1), 475. doi:10.1186/1471-2458-10-475

Pihl, R. O., Paylan, S. S., Gentes-Hawn, A., & Hoaken, P. N. (2003). Alcohol Affects Executive Cognitive Functioning Differentially on the Ascending Versus Descending Limb of the Blood Alcohol Concentration Curve. *Alcoholism: Clinical & Experimental Research, 27*(5), 773-779. doi:10.1097/01.ALC.0000065434.92204.A1

Pilcher, J. J., & Walters, A. S. (1997). How Sleep Deprivation Affects Psychological Variables Related to College Students' Cognitive Performance. *Journal of American College Health, 46*(3), 121-126. doi:10.1080/07448489709595597

Read, J. P., Wood, M. D., Kahler, C. W., Maddock, J. E., & Palfai, T. P. (2003). Examining the role of drinking motives in college student alcohol use and problems. *Psychology of Addictive Behaviors, 17*(1), 13-23. doi:10.1037/0893-164X.17.1.13

Reinert, D. F., & Allen, J. P. (2002). The Alcohol Use Disorders Identification Test (AUDIT): A Review of Recent Research. *Alcoholism: Clinical and Experimental Research, 26*(2), 272-279. doi:10.1111/j.1530-0277.2002.tb02534.x

Roehrs, T., & Roth, T. (2001). Sleep, sleepiness, sleep disorders and alcohol use and abuse. *Sleep Medicine Reviews, 5*(4), 287-297. doi:10.1053/smrv.2001.0162

Ross, S. E., Niebling, B. C., & Heckert, T. M. (1999). (Ross, Niebling, & Heckert, 1999). *College Student Journal, 33*(2), 312-318.

Taylor, D. J., Vatthauer, K. E., Bramoweth, A. D., Ruggero, C., & Roane, B. (2013). The Role of Sleep in Predicting College Academic Performance: Is it a Unique Predictor? *Behavioral Sleep Medicine, 11*(3), 159-172. doi:10.1080/15402002.2011.602776

Trockel, M. T., Barnes, M. D., & Egget, D. L. (2000). Health-Related Variables and Academic Performance Among First-Year College Students: Implications for Sleep and Other Behaviors. *Journal of American College Health, 49*(3), 125-131. doi:10.1080/07448480009596294

Van Dongen, H. P., PhD, Maislin, G., MS, MA, Mullington, J. M., PhD, & Dinges, D. F., PhD. (2003). The Cumulative Cost of Additional Wakefulness: Dose-Response Effects on Neurobehavioral Functions and Sleep Physiology From Chronic Sleep Restriction and Total Sleep Deprivation. *Sleep, 23*(2), 117-126. Retrieved January, 2015, from http://www.med.upenn.edu/uep/user_documents/VanDongen_etal_Sleep_26_2_2003.pdf

Verdejo-García, A., Bechara, A., Recknor, E. C., & Pérez-García, M. (2006). Executive dysfunction in substance dependent individuals during drug use and abstinence: An examination of the behavioral, cognitive and emotional correlates of addiction. *Journal of the International Neuropsychological Society, 12*(03). doi:10.1017/S1355617706060486

Vitiello, M. V. (1997). Sleep, alcohol and alcohol abuse. *Addiction Biology, 2*(2), 151-158. doi:10.1080/13556219772697

Table 1. Demographics

Variable	N	Range	Mean ± SD
Age	302	18-45	19.81±3.830
PSQI Total Score	284	0-18	5.79±3.16
AUDIT Total Score	305	0-26	4.40±5.32
BDEFS-LF Total Score	305	76-330	138.99±42.21
Variable	**N**	**Percentage**	
Ethnicity	314	-	
Caucasian	248	77.0	
African-American	23	7.1	
Hispanic	8	2.5	
Asian	16	5.0	
Multiracial	14	4.3	
Kurdish	1	0.3	
Other	1	0.3	
Gender	314	-	
Male	159	49.4	
Female	154	47.8	
Transgendered	1	0.3	

Table 2. Bivariate correlations among study variables

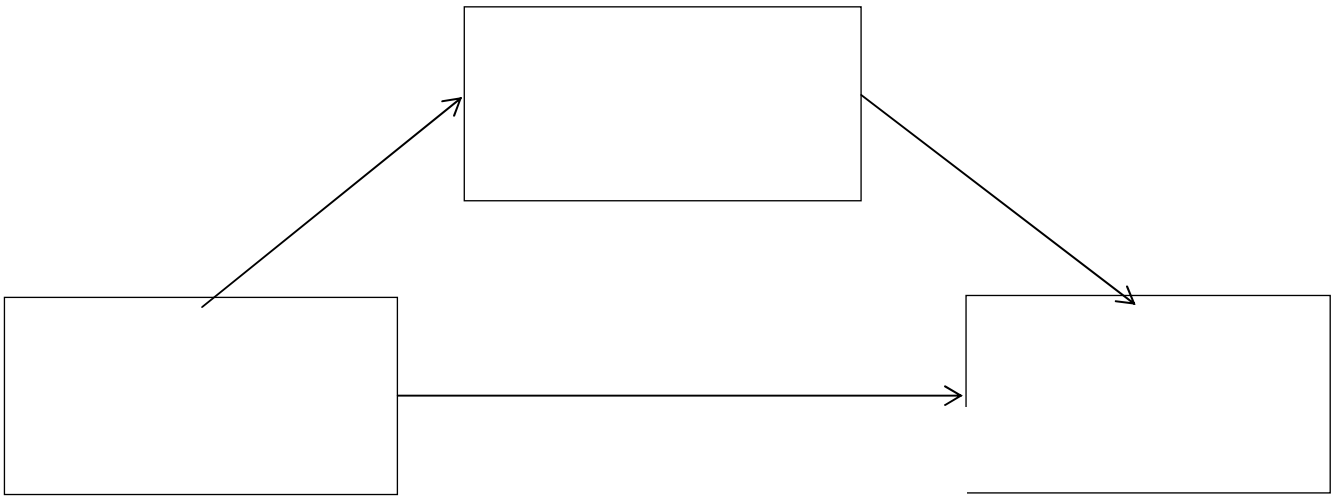
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. AUDIT Total Score	-														
2. BDEFS-LF Total Score	0.338**	-													
3. PSQI Total Score	0.163**	0.458**	-												
4. BDEFS-LF Time Management	0.298**	0.880**	0.456**	-											
5. BDEFS-LF Organization	0.227**	0.889**	0.363**	0.720**	-										
6. BDEFS-LF Self Restraint	0.346**	0.838**	0.353**	0.624**	0.656**	-									
7. BDEFS-LF Motivation	0.366**	0.854**	0.334**	0.770**	0.695**	0.665**	-								
8. BDEFS-LF Emotion Regulation	0.250**	0.800**	0.445**	0.581**	0.635**	0.693**	0.607**	-							
9. PSQI Sleep Quality	0.223**	0.375**	0.727**	0.380**	0.296**	0.250**	0.266**	0.405**	-						
10. PSQI Sleep Latency	0.059	0.256**	0.684**	0.272**	0.273**	0.093	0.187**	0.193**	0.503**	-					
11. PSQI Sleep Duration	0.140*	0.219**	0.610**	0.231**	0.134*	0.188**	0.133*	0.275**	0.429**	0.293**	-				
12. PSQI Sleep Efficiency	0.056	0.136*	0.614**	0.139*	0.054	0.145*	0.107	0.161**	0.235**	0.273**	0.485**	-			
13. PSQI Sleep Disturbance	0.055	0.259**	0.561**	0.252**	0.196**	0.196**	0.148*	0.316**	0.354**	0.312**	0.165**	0.243**	-		
14.PSQI Meds Use	0.048	0.134*	0.277**	0.110	0.127*	0.177**	0.103	0.071	0.051	0.046	-0.105	-0.063	0.110	-	
15. PSQI Daytime Dysfunction	0.169*	0.565**	0.548**	0.553**	0.492**	0.436**	0.447**	0.465**	0.418**	0.238**	0.215**	0.142*	0.292**	0.087	-
Mean	4.41	139.16	5.79	35.93	37.14	28.83	17.16	20.37	1.02	1.30	0.74	0.61	1.11	0.34	0.74
Standard Deviation	5.31	42.28	3.15	12.55	12.68	9.28	6.52	8.07	0.74	0.989	0.78	0.92	0.52	0.78	0.75
Range	0-26	76-330	0-18	20-84	23-95	19-66	0-48	0-50	0-3	0-3	0-3	0-3	0-3	0-3	0-3

Note. ***p<.001 **p<.01 *p<.05. PSQI= Pittsburgh Sleep Quality Index (N=284); AUDIT= Alcohol Use Disorders Identification Test (N=305); BDEFS-LF= Barkley Deficits in Executive Functioning Scale-Long Form (N=305)Alcohol Higher scores on the AUDIT indicate hazardous drinking. Higher scores on the BDEFS-LF indicate executive dysfunction. Higher scores on the PSQI indicate poor sleep quality.

Table 3. Mediation of the effects of sleep quality on executive functioning through hazardous alcohol use

		Consequent						
		M (Hazardous Drinking)				Y (Executive Function)		
Antecedent		Coeff.	SE	*p*		Coeff.	SE	*p*
X (Sleep Quality)	*a*	0.276	0.098	.0051	c'	5.464	0.672	<.001
M (Hazardous Drinking)		-	-	-	b	2.373	0.402	<.001
constant	i_1	2.826	0.645	<.001	i_2	97.066	4.514	<.001
		R^2=.027				R^2=0.298		
		F=7.982, *p*=.0051				F=60.058, *p*<.001		

Figure 1: Indirect effects models of PSQI predicting college student scores of the BDEFS-LF via hazardous drinking predicted by scores on the AUDIT.



Note. PSQI= Pittsburgh Sleep Quality Index (N=284); AUDIT= Alcohol Use Disorders Identification Test (N=305); BDEFS-LF= Barkley Deficits in Executive Functioning Scale-Long Form (N=305); CI= Confidence Interval. ***p<.001