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EMPIRICAL RESEARCH

Psychosocial Adjustment Throughout University: A Longitudinal Investigation of the Roles of Sleep Quality and Emotion Dysregulation

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Abstract
Sleep problems and emotion dysregulation are associated with depressive symptoms and alcohol use but little research has examined the long-term associations and the direction of effects between these factors. We examined these relationships with 1132 undergraduates (70.5% female) over 5 years. Sleep problems and emotion dysregulation, sleep problems and depressive symptoms, and emotion dysregulation and depressive symptoms were all related bidirectionally. Tests of indirect effects indicated that sleep problems predicted depressive symptoms over time (and vice versa) via emotion dysregulation and emotion dysregulation predicted depressive symptoms over time (and vice versa) via sleep problems. The results highlight the need to assess direction of effects, given that many factors that are typically seen as "predictors" also can be framed as "outcomes".

Keywords Sleep · Depression · Emotion dysregulation · Alcohol

Introduction

Emerging adulthood (i.e., late teens to the late 20s; Arnett and Fishel 2013) is a time during which many changes occur (Arnett 2000). One significant change that many emerging adults experience is the transition to university. Although many students do well in university, others experience difficulties such as sleep problems (Buboltz et al. 2001) and emotion dysregulation (Srivastava et al. 2009). Both sleep problems and emotion dysregulation are thought to be transdiagnostic, in that they are hypothesized to underlie many adjustment difficulties (e.g., Markarian et al. 2013; Zawadzki 2015). Of concern, difficulties in adjustment during emerging adulthood can persist and extend to adulthood (e.g., Arnett 2000; Erikson 1968), making sleep problems and emotion dysregulation important issues to study among this population. Little work, however, has examined long-lasting associations among sleep problems, emotion dysregulation, and adjustment. Two main goals of the current study, therefore, were to examine: 1) the association between sleep problems and emotion dysregulation over time, and 2) whether sleep problems and emotion dysregulation are associated with adjustment difficulties in the long-term (i.e., over a period of 5 years).

Associations Between Sleep Problems and Emotion Dysregulation

Sleep problems are defined in our study as experiencing difficulty with various areas of sleep (e.g., problems falling asleep), as well as sleep dissatisfaction. With regard to emotion dysregulation, Thompson (1994) defined emotion regulation as, "the extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotion reactions, especially their intensive and temporal features, to accomplish one's goals" (p. 28); thus, emotion dysregulation in our study is defined as difficulty with regulating their emotions in stressful situations.

Although a large volume of research has indicated that sleep problems and emotion dysregulation are associated (Cerolini et al. 2015), researchers have tended to interpret these *concurrent* associations in only one of two ways. The

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first way is that sleep problems predict emotion dysregulation (Mauss et al. 2013; Pickett et al. 2016). The rationale for this explanation of the association is that sleep deprivation (or relatedly, sleep problems) may alter the manner in which emotions are processed (e.g., Yoo et al. 2007). The second way is the opposite direction of effects; that is, that emotion dysregulation predicts sleep problems (Hoag et al. 2016). One rationale for this association is that emotion dysregulation is thought to increase cognitive arousal and, as a result, hinder sleep (Espie et al. 2006). Inferences about the direction of effects between sleep problems and emotion dysregulation, however, cannot be assumed by cross-sectional research. Longitudinal research is needed to address this question.

There is limited longitudinal work in this area. One recent study with a sample of community adults found that over 6 months, sleep predicted greater emotion dysregulation over time (O'Leary et al. 2016). However, O'Leary et al. (2016) examined this question at only two time points, 6 months apart, and did not test for the *opposite* direction of effects (i.e., does emotion dysregulation predict sleep?). Of interest, a longitudinal study by Tavernier and Willoughby (2014a, b) found support for a bidirectional relationship between emotion dysregulation and sleep problems (i.e., sleep problems predicted greater emotion dysregulation 1 year later, and emotion dysregulation predicted more sleep problems 1 year later), although these associations were not tested simultaneously. These results are consistent with both explanations for interpreting the association between the two factors (Gruber and Cassoff 2014). Long-term associations between sleep problems and emotion dysregulation, as well as how they are related to indicators of adjustment, however, need to be examined. Two adjustment indicators that are particularly important throughout university are alcohol use and depressive symptoms. Binge drinking occurs at the highest levels among university students (Johnston et al. 2007; Willoughby et al. 2013), and mental health problems, such as depression, are prevalent among university students (Center for Behavioral Health Statistics and Quality 2015; Pearson et al. 2013). Thus, the present study examined these two adjustment indicators.

These four constructs are of particular importance for students because all of these factors are associated with success in school. For example, sleep quality is bidirectionally associated with social ties in university over time (Tavernier and Willoughby 2014a) and it can promote intrapersonal adjustment throughout the university years (Tavernier and Willoughby 2014b). Further, Singleton and Wolfson (2009) found that both alcohol use and feeling tired throughout the day (specifically, tiredness as a result of poor sleep patterns stemming from alcohol use) were associated with a lower grade point average (GPA) in university. Finally, emotion dysregulation is associated with lower levels of satisfaction in both social and academic domains for university students (Srivastava et al. 2009) and depression is associated with lowered academic performance (Hysenbegasi et al. 2005).

Sleep, Emotion Dysregulation and Psychosocial Adjustment: Direct Effects

A substantial amount of concurrent research has indicated that sleep problems are associated with both depressive symptoms (Armstrong and Oomen-Early 2009; Conti et al. 2014; Lund et al. 2010; Orzech et al. 2011; Tempesta et al. 2010) and alcohol use (DeMartini and Fucito 2014; Digdon and Landry 2013; Kenney et al. 2014; Singleton and Wolfson 2009; Valerio et al. 2016). With regard to the relationship between sleep problems and alcohol use, the relationship is less than straightforward. Ebrahim et al. (2013) conducted a literature review and found that, for healthy individuals, consuming alcohol before sleeping is associated with reduced time to fall asleep, increased numbers of awakenings throughout the night, and less overall REM sleep at moderate and high levels of alcohol consumption (for a similar discussion, see the review by Roehrs and Roth (2001)). However, Roehrs et al. (1999) found that, for those diagnosed with insomnia, some alcohol use before sleeping may provide some benefits in sleep quality. Finally, individuals with alcohol dependence are more likely to report having insomnia or symptoms of insomnia than those without alcohol dependence (Crum et al. 2004).

Emotion dysregulation also is associated with depressive symptoms (Nolen-Hoeksema and Aldao 2011; Zawadzki 2015) and alcohol use (Dragan 2015; Dvorak et al. 2014; Fischer et al. 2007; Kuvaas et al. 2014). Similar to the research on sleep problems and emotion dysregulation, however, much of this work has been cross-sectional and has assumed the direction of effects, or in the case of experimental research has only examined one direction of the effects (e.g., emotion dysregulation to mood; Ehring et al. 2010; Hopp et al. 2011). Some past research has examined longitudinal links between these factors, but the results tend to be inconsistent.

Sleep problems and depressive symptoms

Longitudinal work has indicated that adults ($M_{age} = 41.3$ years) with low levels of depression *and* insomnia tended to display higher levels of depressive symptoms the next year (Jansson-Fröjmark and Lindblom 2008). Furthermore, individuals without insomnia but with high levels of depression were more likely to develop insomnia the following year (Goldman-Mellor et al. 2014). These studies, however, focused on adults in general and not university

students, and did not test both directions of effects simultaneously. Goldman-Mellor et al. (2014) also did not test the alternate direction of effects (i.e., whether insomnia predicts the onset of depression). These limitations are addressed in the current study.

Sleep problems and alcohol use

Longitudinal work has found that children who were overtired (maternal ratings) were more likely to engage in problematic drinking behaviours in young adulthood than those who did not experience overtiredness in childhood, suggesting that there may be a long-lasting relationship between these two factors (Wong et al. 2010). Other research has indicated that sleep quality and quantity did not predict alcohol use over time (Galambos et al. 2013), but individuals who drank frequently during the week tended to go to bed later (Galambos et al. 2009; Galambos et al. 2013) and sleep for less time that night than those who did not drink during the day (Galambos et al. 2009). Finally, Haario et al. (2013) found that individuals with insomnia at Time 1 tended to have higher alcohol use at Time 2, and that high levels of alcohol use at Time 1 were associated with insomnia at Time 2 (note that these analyses were not tested simultaneously). Overall, these results suggest that there may be long-lasting effects between sleep problems and adjustment (for a review see Alvaro et al. 2013).

Emotion dysregulation and depressive symptoms

Longitudinal work in this area suggests that the relationship between emotion dysregulation and depression is complex and results tend to be mixed. Nezlek and Kuppens (2008) found that effective emotion regulation is associated with positive mood, compared to ineffective emotion regulation. Work by Berking et al. (2014) indicated that emotion dysregulation predicted more depressive symptoms 5 years later (although the alternative direction of effects was not significant). In contrast, Berking et al. (2008) found that emotion regulation only predicted lower negative affect and anxiety, and higher positive affect, but it was *not* associated with depressive symptoms over time (again, the alternative direction of effects also was not significant). Although these results suggest there may be stronger evidence for a unidirectional relationship between these two factors, the study by Nezlek and Kuppens (2008) did not use a direct measure of depression, had a small sample size, and did not test the alternative direction of effects, and the studies by Berking et al. (2008, 2014) utilized samples that were not university students (mean ages were ~35 years old). Examining these issues in a large sample of young adults in university is important.

Emotion dysregulation and alcohol use

With regard to longitudinal work, one short-term study (i.e., a 30-day daily diary study) examining relationships between emotion dysregulation and alcohol use found that participants who engaged in the co-use of drugs (i.e., alcohol and marijuana) at night were less likely to use effective regulation strategies and more likely to use poor emotion regulation strategies the following day (Weiss et al. 2016); note that these results were not found when only alcohol use was included in the analysis, but the measure of alcohol was dichotomized into either any alcohol use *or* binge drinking). Given the above literature, a goal of the present longitudinal study was to directly assess bidirectionality and long-term effects among sleep problems, emotion dysregulation, alcohol use and depressive symptoms over time.

Sleep, Emotion Dysregulation and Psychosocial Adjustment: Indirect Effects

Given the mixed findings and inconsistent results in the literature reviewed above, it may be that there is a mechanism by which these factors are associated and past research has been unable to find consistent associations because a piece of the puzzle was missing. As there likely is a bidirectional relationship between sleep problems and emotion dysregulation and both of these factors are hypothesized to have a transdiagnostic nature (Fairholme et al. 2013), it may be that each factor could be a mechanism through with the other predicts adjustment. That is, it may be that sleep problems predict difficulties in adjustment (i.e., depressive symptoms and alcohol use) over time through emotion dysregulation. Alternatively, it may be that emotion dysregulation predicts difficulties in adjustment over time via sleep problems.

Emotion dysregulation as a mechanism

One potential explanation for emotion dysregulation as a mechanism is that sleep deprivation (or relatedly, sleep problems) may alter the manner in which emotions are processed (e.g., Yoo et al. 2007). Yoo et al. (2007) found that individuals who were sleep deprived displayed more reactivity in their amygdala when viewing negative stimuli than did a control group. Furthermore, compared to the control group, the sleep-deprived individuals displayed reduced pre-frontal cortex activity. Yoo et al. (2007) suggested that sleep-deprived individuals' regulatory abilities were unable to dampen these neural responses to emotional stimuli. Given this, it may be that sleep problems promote increased emotion dysregulation, which then is associated with more depressive symptoms and alcohol use over time.

Indeed, one previous study by O'Leary et al. (2016) found that sleep problems predicted depressive symptoms over time via emotion dysregulation. The indirect path from emotion dysregulation to depressive symptoms, however, was measured concurrently, and the overall model was only over two time periods spanning 6 months. Although these results provide preliminary insight, we sought to examine these relationships over the long-term. Specifically, we extended this work in the present study by examining whether sleep problems indirectly predict depressive symptoms via emotion dysregulation over a period of 5 years. Furthermore, given that emotion dysregulation also predicts alcohol use (Weiss et al. 2016), we tested the indirect relationship from sleep problems to alcohol use over time via emotion dysregulation. Finally, as both adjustment indicators (i.e., depressive symptoms and alcohol use) also predict sleep, the alternative direction for indirect effects also were tested (e.g., alcohol use/depressive symptoms predicting sleep problems over time via emotion dysregulation).

Sleep problems as a mechanism

A second potential mechanism is that increased cognitive arousal may alter sleep (for a discussion of this, see Espie et al. 2006). In an experiment by Gross and Borkovec (1982), participants – all of whom had good sleep – were divided into three groups: The first group had the highest cognitive load (i.e., they were asked to give a speech on a *specific topic* after their nap), the second group was a control group (i.e., they were asked to give a speech after their nap) and the third group was a control group (i.e., they were told to nap). The results indicated that the first group had more problems sleeping than the second and third groups, suggesting that increased stress and cognitive arousal may impede sleep (Gross and Borkovec 1982). One could expect then, that emotion dysregulation – or the inability to effectively regulate one's emotions – may be a factor that would impede sleep, given the inability to regulate arousal. Thus, we examined whether this is the case by testing whether emotion dysregulation indirectly predicts depressive symptoms and alcohol use via sleep problems over a period of 5 years. Finally, as both adjustment indicators (i.e., depressive symptoms and alcohol use) also predict emotion dysregulation, the alternative direction for indirect effects also was tested (e.g., alcohol use/depressive symptoms predicting emotion dysregulation over time via sleep problems).

The Current Study

The current study had three goals. The first goal was to examine whether sleep problems and emotion dysregulation are bidirectionally associated. The second goal was to examine whether sleep problems and emotion dysregulation are directly associated with depressive symptoms and alcohol use in the long-term (i.e., over a period of 5 years). The third goal was to examine whether a) emotion dysregulation is a mechanism by which sleep predicts depressive symptoms and alcohol use over time (and vice versa), and b) sleep problems are a mechanism by which emotion dysregulation predicts depressive symptoms and alcohol use over time (and vice versa). To address these goals, we conducted an autoregressive cross-lag path analysis which allowed us to examine bidirectional associations and indirect effects between each of these factors.

Method

Participants

Participants in the current study were 1132 undergraduate students (70.5% female) enrolled at a mid-sized university in southwestern Ontario, Canada, who were part of a larger longitudinal study. At the first assessment, all participants were in their first year of university, $M_{age} = 19.06$ years, $SD = 11.17$ months, range 17.75–25.51 years. SES data indicated that mean levels of education for mothers and fathers fell between *some college, university, or apprenticeship program* and *completed a college/apprenticeship and/or technical diploma*, $M = 3.71$ (see Table 1 for breakdown by parent education). The sample was composed predominantly of students who were born in Canada (84.9%).

Procedure

First-year university students from various academic disciplines were invited to complete a survey examining factors related to stress, coping, and adjustment to university by way of posters, classroom announcements, website posting, and visits to on-campus student residences. The participants were given course credit or monetary compensation for their participation at Time 1 and monetary compensation only at Times 2 to 5. At Times 2, 3, 4 and 5, all students who participated in the first assessment were invited to participate again by way of e-mails. The study was approved by the University Ethics Board prior to survey administration at all five assessments, and all participants provided informed consent prior to participation. The survey was administered by trained research assistants.

Missing Data Analysis

Missing data occurred within each assessment time point because some students did not answer every question

Table 1 Participant characteristics

Education	Mother's education (%)	Father's education (%)
Did not finish high school	5.2	9.5
Finished high school	18.6	17.5
Some college, university, or apprenticeship program	16.0	12.0
Completed a college/apprenticeship diploma (e.g., electrician) and/or technical diploma (e.g., graphic design, hair dressing	21.0	20.8
Completed a university undergraduate degree	20.9	18.2
Completed a professional degree (e.g., masters, PhD, med doc, lawyer)	11.7	13.8
Other/Missing	6.6	8.2

(average missing data at Times 1, 2, 3, 4 and 5 were 4.69, 1.62, 0.98, 1.59 and 3.99% respectively) and because some students did not complete all waves of the survey. The participant retention rate was 65.9%. Out of all the participants, 50.4% completed all 5 waves, 18.5% completed 4 waves, 8.0% completed 3 waves, 7.7% completed 2 waves, and 15.4% completed only 1 wave. Missingness across waves (e.g., completing 1, 2, 3, 4 or 5 waves) was associated with some study variables. Specifically, participants who completed all 5 time periods were more likely to be female than those who completed only 1 wave, $p = .004$, or 2 waves, $p < .001$. Participants who completed all 5 waves drank less alcohol at Time 1, $M = 3.65$, than participants who completed 1 wave, $M = 4.09$, $p = .002$, 3 waves, $M = 4.13$, $p = .014$, or 4 waves, $M = 4.01$, $p = .015$. Participants who completed all 5 waves also drank less alcohol at Time 2, $M = 3.84$, than participants who completed 3 waves, $M = 4.43$, $p = .002$, or 4 waves, $M = 4.21$, $p = .008$.

Missing data were estimated using the full information maximum likelihood (FIML) estimation method. As all the study measures were included in the primary analyses, the variables associated with missingness (i.e., sex and alcohol use) were used in the FIML estimation process (Little 2013). FIML retains cases that are missing survey waves, thus avoiding the biased parameter estimates that can occur with pairwise or listwise deletion (Schafer and Graham 2002).

Measures

Measures included demographic variables (sex, parent education and whether participants were born in Canada), emotion dysregulation, sleep problems, depressive symptoms and alcohol use. Demographic variables were assessed only at Time 1, whereas all other study variables were assessed at Time 1, 2, 3, 4, and 5.

Demographics

Sex (1 = *male* or 2 = *female*), parental education (one item per parent, averaged for participants reporting on both parents, with a scale from 1 = *did not finish high school* to 6 = *professional degree*) and whether participants were born in Canada (*Were you born in Canada?* 1 = yes or 2 = no) were assessed at Time 1, and were used as covariates in all analyses.

Emotion dysregulation

Emotion dysregulation was assessed at each time point with six items from the Difficulties in Emotion Regulation Scale (e.g., *When I'm upset or stressed, I have difficulty concentrating*; Gratz and Roemer 2004). The responses were based on a five-point Likert scale ranging from 1 (*almost never*) to 5 (*almost always*). Cronbach's alphas at Time 1, 2, 3, 4 and 5 were .725, .742, .762, .780, and .781, respectively. Higher scores indicated more emotion dysregulation.

Sleep problems

Sleep problems were assessed at each time point using an adapted version of the Insomnia Severity Index (ISI; Morin 1993). Participants indicated the extent to which they experienced difficulty 1) falling asleep, 2) staying asleep, 3) waking up too early, 4) staying awake, 5) satisfaction with their sleep patterns, and 6) whether their sleep patterns interfere with daily functioning. Response options for items 1–4 ranged from 1 (*no problem*) to 5 (*very severe problems*), item 5 response options ranged from 1 (*very satisfied*) to 5 (*very dissatisfied*), and item 6 response options ranged from 1 (*rarely interferes*) to 4 (*very often interferes*). Item 6 was recoded to have a range of 1 to 5 so that all variables were on the same scale. These six items were averaged to create a composite variable. Cronbach's alphas at Time 1, 2, 3, 4 and 5 were .768, .766, .794, .787, and .804, respectively. Higher scores indicated more sleep problems.

Alcohol use

Alcohol use was assessed by asking participants how many drinks they have, on average, when they are drinking alcohol.

Table 2 Descriptive statistics for study variables

Measures	Time 1 *M* (*SD*)	Time 2 *M* (*SD*)	Time 3 *M* (*SD*)	Time 4 *M* (*SD*)	Time 5 *M* (*SD*)
Sleep problems	2.401 (.753)	2.462 (.748)	2.384 (.770)	2.327 (.753)	2.227 (.753)
Emotion dysregulation	2.784 (.752)	2.853 (.759)	2.850 (.760)	2.800 (.773)	2.687 (.787)
Depressive symptoms	19.844 (10.899)	19.576 (11.424)	19.457 (11.791)	18.495 (11.499)	17.605 (11.702)
Binge drinking	3.844 (1.376)	3.952 (1.246)	3.807 (1.243)	3.669 (1.228)	3.426 (1.154)
Covariates					
Sex	70.5% female				
Parent education	3.709 (1.298)				
Born in Canada	84.9%				

Responses options ranged from 1 (*less than 1 drink*) to 6 (*over 10 drinks*). Higher scores indicate more alcohol use.

Depressive symptoms

Depressive symptoms were measured using The Center for Epidemiologic Studies Depression – Revised Scale (Eaton et al. 2004; Radloff 1977; Van Dam and Earleywine 2011; e.g., *I thought my life had been a failure*). Response options for these items ranged from 1 (*none of the time*) to 5 (*most of the time*). One item (*My sleep was restless*) was excluded so that the association between depressive symptoms and sleep problems was not inflated. Ratings were rescored so that the CESD-R had the same range (0–60) as the original CESD (Radloff 1977) and summed such that higher scores indicated greater depressive symptoms. Cronbach's alphas at Times 1, 2, 3, 4 and 5 were .910, .924, .926, .931, and .934 respectively.

Results

Statistical analyses were carried out using SPSS version 23 and R in RStudio version 1.1.383.

Preliminary Analyses

Descriptive statistics for all study variables are listed in Table 2. There were significant differences between males and females on sleep problems (Times 1 and 2), emotion dysregulation (Times 1, 2, 3 and 4), alcohol use (Times 1, 2, 3, 4 and 5), and depressive symptoms (Times 1 and 2), *p*s < .025, such that females reported more sleep problems, more emotion dysregulation, less alcohol use, and more depressive symptoms than did males. At all five time periods, students born in Canada engaged in more alcohol use than did students who were not born in Canada, *p*s < .001, and reported fewer depressive symptoms at Time 4 than did students who were not born in Canada, $p < .040$.

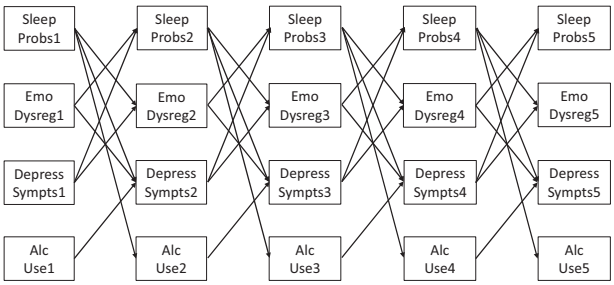

Fig. 1 Significant cross-lag paths between study variables. Emo Dysreg = emotion dysregulation, Sleep Probs = sleep problems; Depress Sympts = depressive symptoms; Alc Use = drinking amount; 1 = Time 1; 2 = Time 2; 3 = Time 3; 4 = Time 4; 5 = Time 5

Primary Analyses

An auto-regressive cross-lag path analysis examining the associations among sleep problems, emotion dysregulation, depressive symptoms, and alcohol use across Times 1, 2, 3, 4 and 5 was conducted using R and the Lavaan package (Rosseel 2012) – see Fig. 1. Overall model fit was determined using the comparative fit index (CFI) and the root mean square error of approximation (RMSEA) indicators (Hu and Bentler 1999). The cut-off criteria recommended for a well-specified model are a CFI > .95 and a RMSEA < .06, simultaneously (Hu and Bentler 1999). Across the five time periods, lag-1 cross-lag paths among all 4 variables, lag-1 autoregressive paths, and concurrent associations among all 4 variables within each wave were included. Sex, parental education, and whether or not the participant was born in Canada were included as covariates, with correlations specified between the covariates and each variable at Time 1, and paths estimated between the covariates and each variable at Times 2, 3, 4 and 5. Any statistically significant, paths, therefore, would be accounting for the correlations among the variables within a wave, and controlling for previous scores on the outcome variables, covariates, as well as the other predictors in the model.

Table 3 Beta weights of study variables from Time 1 to Time 2 of the constrained model

			b	*ß*	*SE*	*p*
EmoDysreg1	→	Sleep2	.042	.042	.016	.010
EmoDysreg1	→	Depression2	1.330	.087	.018	<.001
EmoDysreg1	→	Alcohol2	−.023	−.013	.014	.326
Sleep1	→	EmoDysreg2	.068	.067	.016	<.001
Sleep1	→	Depression2	1.490	.098	.017	<.001
Sleep1	→	Alcohol2	.044	.026	.013	.045
Depression1	→	Sleep2	.006	.081	.017	<.001
Depression1	→	EmoDysreg2	.006	.088	.018	<.001
Depression1	→	Alcohol2	−.002	−.016	.014	.265
Alcohol1	→	Sleep2	.007	.012	.015	.410
Alcohol1	→	EmoDysreg2	−.010	−.019	.015	.215
Alcohol1	→	Depression2	−.274	−.033	.016	.040
EmoDysreg1	→	EmoDysreg2	.527	.517	.025	<.001
Sleep1	→	Sleep2	.541	.535	.024	<.001
Depression1	→	Depression2	.453	.431	.028	<.001
Alcohol1	→	Alcohol2	.660	.715	.017	<.001

b unstandardized betas, *ß* standardized betas, *SE* standard error for *ß*, *p* significance value for *b*, *EmoDysreg* emotion dysregulation, *sleep* sleep

problems, *depression* depressive symptoms, *alcohol* drinking amount, 1 = Time 1; 2 = Time 2. Only the results from Time 1 to Time 2 are shown as results

were constrained across time. Covariate results can be obtained from the author

The results of a Chi-Square Difference Test of Relative Fit indicated that the patterns of association among the variables were invariant across time, χ^2_{diff} (36) = 38.08, p = .375. Thus, subsequent analyses were based on the model that was constrained over time, rather than free-to-vary, as this was the more parsimonious model. The constrained model fit was adequate, $\chi^2(132) = 875.247$, $p < .001$, CFI = .924, RMSEA = .071, 90% CI [.066–.075], $p < .001$. Table 3 shows beta weights for all paths in the model for all 4 key study variables (model results are displayed in Fig. 1; only paths from Times 1 to 2 are shown as the results are invariant across time).

With regard to the first goal of the study (whether sleep problems and emotion dysregulation are associated bidirectionally), results revealed a statistically significant bidirectional association between sleep problems and emotion dysregulation such that sleep problems predicted more emotion dysregulation over time, controlling for previous emotion dysregulation, and emotion dysregulation predicted more sleep problems over time, controlling for previous sleep problems.

With regard to the second goal of the study (i.e., whether sleep problems and emotion dysregulation are associated with depressive symptoms and alcohol use in the long-term), there was a significant bidirectional association between sleep problems and depressive symptoms such that sleep problems predicted more depressive symptoms over time, controlling for previous depressive symptoms, and depressive symptoms predicted more sleep problems over time, controlling for previous sleep problems. There also was a significant bidirectional association between emotion dysregulation and depressive symptoms such that emotion dysregulation predicted more depressive symptoms over time, controlling for previous depressive symptoms, and depressive symptoms predicted more emotion dysregulation over time, controlling for previous emotion dysregulation.

The results indicated two unidirectional associations as well. First, sleep problems predicted more alcohol use over time, controlling for previous alcohol use, and alcohol use predicted less depressive symptoms over time, controlling for previous depressive symptoms. Of note, alcohol use did not predict sleep problems or emotion dysregulation over time (emotion dysregulation also did not predict alcohol use over time); finally, depressive symptoms did not predict alcohol use over time.

With regard to the third goal of the study (i.e., whether sleep problems and emotion dysregulation may be mechanisms by which the other predicts adjustment over time), we conducted tests of indirect effects using the lavaan package (Rosseel 2012) in R with bootstrapping (1000 runs). These results indicated that sleep problems at Time 1 predicted depressive symptoms at Time 3 through emotion dysregulation at Time 2, $ß = .006$ [95% CI = .003–.009], p = .001. Sleep problems at Time 1 also predicted depressive symptoms at Time 4 through emotion dysregulation at Times 2 and 3, $ß = .003$ [95% CI = .001–.005], $p = .001$, and sleep problems at Time 1 predicted depressive symptoms at Time 5 through emotion dysregulation at Times 2, 3 and 4, $ß = .002$ [95% CI = .001–.003], $p = .002$. The indirect effect of sleep problems on alcohol use via emotion dysregulation was not tested as emotion dysregulation did not predict alcohol use over time.

A test of indirect effects also indicated that depressive symptoms at Time 1 predicted sleep problems at Time 3 through emotion dysregulation at Time 2, $ß = .004$ [95% CI = .001–.007], $p = .017$. Depressive symptoms at Time 1 predicted sleep problems at Time 4 through emotion dysregulation at Times 2 and 3, $ß = .002$ [95% CI = .0004–.004], $p = .017$, and depressive symptoms at Time 1 predicted sleep problems at Time 5 through emotion dysregulation at Times 2, 3 and 4, $ß = .001$ [95% CI = .0002–.002], $p = .018$.The indirect effect of alcohol use on sleep problems via emotion dysregulation was not tested as alcohol use did not predict emotion dysregulation over time.

With regard to sleep problems as a potential mechanism, tests of indirect effects indicated that emotion dysregulation

at Time 1 predicted depressive symptoms at Time 3 via sleep problems at Time 2, $\beta = .004$ [95% CI = .001–.008], $p = .017$. Emotion dysregulation at Time 1 predicted depressive symptoms at Time 4 via sleep problems at Times 2 and 3, $\beta = .002$ [95% CI = .0005–.005], $p = .018$, and emotion dysregulation at Time 1 predicted depressive symptoms at Time 5 via sleep problems at Times 2, 3 and 4, $\beta = .001$ [95% CI = .0003–.003], $p = .019$.

Depressive symptoms at Time 1 predicted emotion dysregulation at Time 3 via sleep problems at Time 2, $\beta = .005$ [95% CI = .003–.010], $p = .001$. Depressive symptoms at Time 1 predicted emotion dysregulation at Time 4 via sleep problems at Times 2 and 3, $\beta = .003$ [95% CI = .002–.005], $p = .001$, and depressive symptoms at Time 1 predicted emotion dysregulation at Time 5 via sleep problems at Times 2, 3 and 4, $\beta = .002$ [95% CI = .001–.003], $p = .001$. Emotion dysregulation at Time 1 did not predict alcohol use at Times 3, 4 or 5 via sleep problems at any time point, $ps > .112$, and the effect of alcohol use predicting emotion dysregulation over time via sleep problems was not tested as alcohol use did not predict sleep problems over time.

Discussion

Past literature has indicated that both sleep problems and emotion dysregulation are associated with depressive symptoms and alcohol use – two important indicators of adjustment for university students (Center for Behavioral Health Statistics and Quality 2015). Of importance, little research has examined mechanisms by which these factors may be associated over time. Given that both sleep problems and emotion dysregulation are hypothesized to be transdiagnostic in nature (Fairholme et al. 2013), we examined whether they *both* act as mechanisms by which the other predicts depressive symptoms and/or alcohol use. To address these issues, we examined associations among sleep problems, emotion dysregulation and adjustment difficulties over time.

Overall, we found multiple bidirectional associations among sleep problems, emotion dysregulation and depressive symptoms. We also found support for both sleep problems and emotion dysregulation operating as mechanisms in the link between different adjustment difficulties. For example, we found that sleep problems predicted depressive symptoms over time via emotion dysregulation, and that emotion dysregulation predicted depressive symptoms over time via sleep problems. We also found the alternative direction of effects (i.e., depressive symptoms predicted sleep problems over time via emotion dysregulation, and depressive symptoms predicted emotion dysregulation over time via sleep problems).

These results have important implications. First, our results support the hypothesis that sleep problems and emotion dysregulation are transdiagnostic (Markarian et al. 2013; Zawadzki 2015). Specifically, both sleep and emotion dysregulation were mutually reinforcing as was shown by their bidirectional relationship over time. Further, both of these factors were associated with depressive symptoms over time, and sleep problems were associated with alcohol use. Thus, they highlight crucial areas that universities can target when supporting students, particularly given the long-term nature of the effects (i.e., 5 years). Second, research questions often are framed by hypotheses set up with distinct measures of independent variables (or predictors) and dependent variables (or outcomes). Indeed, in the present study, the research questions were framed as an examination of how challenges experienced by many university students (i.e., sleep problems and emotion dysregulation) may impact on adjustment (i.e., depressive symptoms and alcohol use). However, given the nature of the results of this study and the fact that the majority of the associations were bidirectional (namely the associations among sleep problems, emotion dysregulation and depressive symptoms), it may be more appropriate for future research to not frame these factors *only* as predictors or outcomes. In fact, noting that many factors that are associated with mental health are both predictors *and* outcomes provides individuals hoping to reduce mental health problems among university students more areas to address– in other words, there may be more areas in which individuals *can* be aided.

The results of the current study highlight other notable findings. First, alcohol use did not predict sleep problems or emotion dysregulation over time. For this sample, then, alcohol use appears not to be associated with these common adjustment difficulties. However, given the complexities in the relationship between sleep problems and alcohol use (as noted in the introduction), this may not be surprising. Second, one unexpected result was that alcohol use predicted fewer depressive symptoms over time. Although this is surprising, the measure of alcohol use that was used in the current study was not frequency of drinking alcohol, but rather the *amount* of alcohol consumed when drinking. Perhaps individuals' alcohol use – which peaks in emerging adulthood, especially for those in university (Johnston et al. 2007; O'Malley and Johnston 2002) – was recreational and social (Roehling and Goldman 1987). In this case, alcohol use would not be expected to predict increases in depressive symptoms over time.

It is important to note that the results of the current study are based on a sample of emerging adults. Although these results speak to how sleep problems, emotion dysregulation, depressive symptoms and alcohol use are related for emerging adults, the manner in which these factors are related may differ for other age groups. Thus, this work

should be followed up in samples of young children, adolescents and older adults to examine whether there are differences in temporal precedence and evidence for unidirectional relationships between these factors. Furthermore, both sleep and the ability to regulate emotions are important at all age groups. For example, sleep problems are related to a variety of mental health problems in samples of both children and adolescents (for a review see Dueck et al. 2017), and the ability to regulate emotions continues to develop throughout life (e.g., McRae et al. 2012). Although some previous research has examined how sleep in childhood may impact on later mental health and behavior problems (e.g., Wong et al. 2010), these studies were unable to assess bidirectionality given that the variables were not measured at each time point. Thus, future work should measure all variables at each time point to examine mechanisms of change.

Finally, although these results highlight important findings, they also must be interpreted in light of some limitations. First, these data are based on self-report responses. Although it may have been beneficial to use more objective measures of sleep quality, individuals' *perception* of their sleep quality also is an important factor to measure. For example, Bei, Milgrom, Ericksen and Trinder (2010) examined both objective and subjective sleep quality in women both in their third trimester and after giving birth. They found that subjective sleep quality measures were associated with depression/anxiety before and after giving birth, whereas objective measures were much more weakly associated with these mood indicators only before giving birth (Bei et al. 2010). When directly examining relationships between objective and subjective sleep measures in individuals with either depression or no depression, Armitage et al. (1997) found that, in general, most sleep measures correlated well for both participant groups (e.g., time to fall asleep, amount of time in bed, and sleep duration); inconsistent estimates tended to be seen in the group with depression (for similar findings see Rotenberg et al. 2000). Thus, both factors are important to take into account.

Second, this sample is comprised only of university students. It would be important to extend these research questions to a sample of emerging adults that is not attending university, given potential differences in their behaviours. For example, individuals that do not attend university generally have lower rates of alcohol use compared to those who do attend university across a variety of drinking indicators (except in measures of daily use; O'Malley and Johnston 2002). In addition, although clinical levels of mental health issues may not differ between these groups (Blanco and Okuda 2008), a recent review paper indicated that depression was higher in college students than the general American population (Ibrahim et al. 2013). This extension would provide some insight into whether these results are unique to a subset of emerging adults, or whether it can be generalized to this age group. Finally, the significant results in the current study are normally interpreted as small effect sizes within the social sciences. However, in complex longitudinal cross-lagged models, small effect sizes are typical given that many factors are accounted for in the model (i.e., stability of measures across time and within-wave correlations between each measure; Adachi and Willoughby 2015).

Conclusion

The current study provides insight into the nature of the relationship between sleep problems and emotion dysregulation, and their associations with depressive symptoms and alcohol use over a period of 5 years. Of note, our results indicate that there are, indeed, direct and indirect effects between sleep problems, emotion dysregulation and depressive symptoms. Namely, both sleep problems and emotion dysregulation directly predict depressive symptoms over time, but they *also* both indirectly predict depressive symptoms over time *via each other*. Furthermore, the alternative direction of effects also was supported (i.e., depressive symptoms predicted sleep problems/emotion dysregulation over time via emotion dysregulation/sleep problems). These results address previous gaps in the literature, such as the lack of direct examinations of the direction of effects between these factors *simultaneously* and *over time*.

These results also highlight the need to conduct longitudinal work to assess the direction of effects and temporal precedence, given that many factors that are typically seen as "predictors" also can be framed as "outcomes". This provides important implications to the field of research in which predictors and outcomes of adjustment problems are vital. Specifically, practitioners and those hoping to reduce adjustment difficulties among students in university should be aware of the fact that these adjustment difficulties likely are bidirectional over time.

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Data Sharing Declaration This manuscript's data will not be deposited.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval The study was approved by the University Ethics Board prior to survey administration at all five assessments. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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